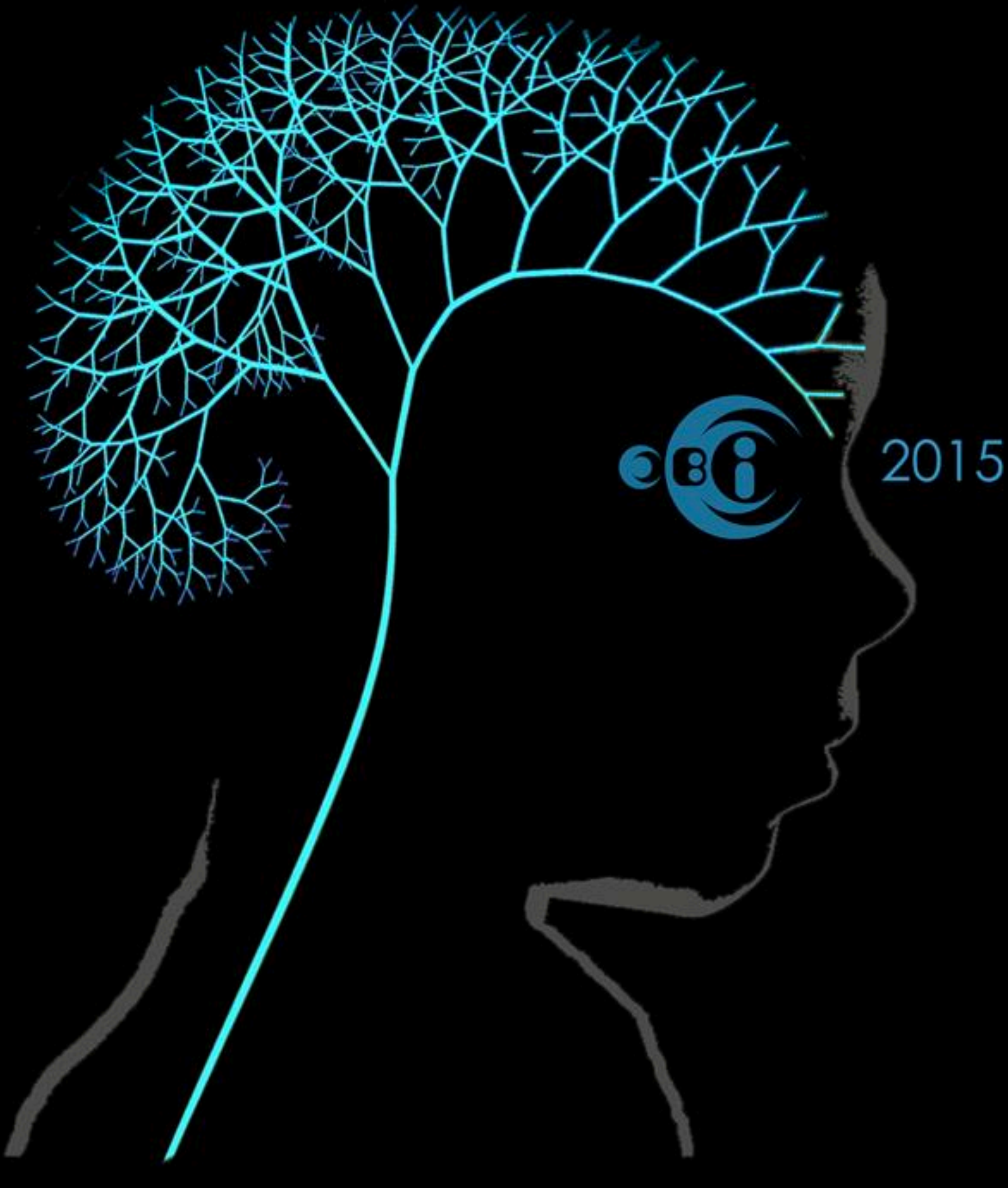
Annals of the

X Brazilian International Meeting on Cognitive Science - EBICC 2015



Joao E. Kogler Jr.
Osvaldo F. Pessoa Jr.
João Antonio de Moraes

ANNALS of EBICC 2015

EBICC 2015

X International Brazilian Meeting on Cognitive Science

Situated Embodied Cognition: Information and Autonomous Action

December 7 - 11, 2015 - São Paulo, Brazil

University of São Paulo - Polytechnic School of Engineering

João Eduardo Kogler Junior

Osvaldo Frota Pessoa Junior

João Antonio de Moraes

(Editors)

ANNALS OF EBICC 2015

X INTERNATIONAL BRAZILIAN MEETING ON COGNITIVE SCIENCE

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Contents

Preface

EBICC is an international meeting that has taken place in Brazil since its inception, in 1995. Organized by the Brazilian Society of Cognitive Science, the event is interdisciplinary in nature and brings together researchers in the fields of Cognitive Science and Philosophy of Mind. The EBICC acronym corresponds to the initials of the Portuguese words used to name it: Encontro Brasileiro Internacional de Ciência Cognitiva (in English: International Brazilian Meeting on Cognitive Science).

The 10th EBICC, organized and promoted by the Brazilian Society of Cognitive Science – SBCC, with the partnership of the Polytechnic School of Engineering of the University of São Paulo, took place on 7 - 11 December 2015, at the Polytechnic School of Engineering, in the campus of the University of São Paulo. The meeting, with a workshop style, comprised keynote conferences and roundtables for debates with experts. Its daily communication sessions featured oral presentations of complete works selected by reviewers from the scientific committee and a poster exhibition.

The central theme of the meeting was "situated and embodied cognition: information and autonomous action". This theme focuses on the situated and embodied view of cognition. The presented talks and works comprised also additional alternative views treated in the conferences and discussions. The main sub-theme is "information and autonomous action". This considered questions concerning the informational coupling between the cognitive agent and the environment. Around the central theme there several sub-themes targeted by the event were:

- Information, mind, and cognition.
- Information, structure, and cognition.
- Logic, information, and intelligence.
- Semiotics and cognition.
- Language, communication, and cognition.
- Perception, action, and attention.
- Art, emotion, neuromodulation, and cognition.
- Evolution of the concepts of cognition, mind, and brain.
- Computational and cognitive modeling.
- Machine learning, neuromathematics, and cognition.
- Cognitive architectures.
- Cognition, technology, and action.
- Agents, cognitive games and their educational and socio-cultural roles.
- Ubiquitous computing and its relations with cognition and society.

Seven papers listed in the *papers and posters index* beginning on page 47, were selected for publication in a special issue of the Eslevier's Journal of Cognitive Systems Research, published on June 2017, dedicated to EBICC 2015. These papers are included in this annals' volume for reference, however only their abstract pages are visible. The interested reader must look for the publication in the referred journal, indicated at the first page of each corresponding selected paper. We thank the journal's chief-editor, Dr. Peter Érdi for opening this opportunity for the dissemination of works presented in EBICC 2015.

Additionally, the paper by Samuel Bellini-Leite, selected as the best paper presented individually by a student, won the Marcelo Dascal Prize 2015, and was elected to be published in the book *Cognitive Science: Recent Advances and Recurring Problems*, edited by Fred Adams, Osvaldo Pessoa Jr. and Joao Kogler Jr., published by Vernon Press on June 2017. We thank Alex Krueger of Vernon Press for his kind support for publishing the book including this chapter.

We thank the Director of Polytechnic School, Professor José Roberto Castilho Piqueira for his commitment and personal effort in providing this partnership and support. We are largely indebted to several Departments of the University of São Paulo, for their joint effort and support in the local organization and production of the event, namely the Departments of Philosophy, of Electronic Systems Engineering, of Computer Engineering, and of Mechatronics. We thank Professors Antonio C. Seabra, Antonio M.Saraiva, José Reinaldo Silva, Ricardo L.A. Rocha and Vinicius Romanini, for their personal efforts on providing local resources and facilities for the event. We express our gratitude for the technical co-sponsorship of the IEEE Computational Intelligence Society provided by the South-Brazil Section Chapter, and we thank its President, Professor Emilio Del Moral Hernandez for his kind support. In addition, we thank Easy Chair for hosting EBICC 2015's paper submission and evaluation services, Eventbrite for hosting the subscription services, and LSI – Laboratory of Integrated Systems of the Polytechnic School of the University of São Paulo, for hosting the event web site.

Finally, we want to acknowledge and thank for the financial support provided by FAPESP, CAPES, NVIDIA Corporation, and CEST.

Many other people contributed for the success of the event, that lead to this book, and we apologize for not having acknowledged them nominally here, however provided a full list of contributors at the EBICC 2015 web site

João Antonio de Moraes

João Eduardo Kogler Junior

Osvaldo Frota Pessoa Junior

Keynote Talks Abstracts

Disentangling Three Concepts of Information in Cognitive Science

Andrea Scarantino , Georgia State University, United Sates of America

Ever since Dretske (1981) published his seminal Knowledge and the Flow of Information, philosophers have tried to develop an adequate theory of information. The Holy Grail of this research program is to make sense of information as a naturalistic commodity, and then use it to provide a reductive account of knowledge and other sophisticated mental capacities. This project requires disentangling a variety of concepts of information that are commonly conflated in cognitive science. In this talk, I will distinguish between what I call natural information, code-based referential information and evidence-based referential information, and provide tentative theories of each grounded in probability theory.

Thinking with friends: Reflexivity and Situated Cognition in Friendship

Claus Emmeche , Niels Bohr Institute and University of Copenhagen, Denmark

Can research in situated and embodied cognition inform the study of interpersonal relations like friendship? And conversely, can friendship studies from disciplinary and interdisciplinary perspectives inspire the research in cognitive science? These will be the guiding questions for this talk. The individual and social formation of a human self as a cognitive and emotional agent, from its emergence in early childhood through adolescence to adult life, has been described within philosophy, psychology and sociology as a product of developmental and social processes mediating a linguistic and social world. Focusing upon levels of information and sign action specific to humans, the formation of the personal self and the role of friendship and similar interpersonal relations in this process is explored through classic ideas of the friend as 'another self', and contemporary research on the interplay between individual subjectivity, social structure and interpersonal relations in a dynamics of human agency. Although processes of reflexivity and friendship follow general patterns in the formation of an emerging cognitive agent, such processes are socially heterogeneous and contingent upon different modes of reflexivity.

The non- image-forming visual system: its relation to sleep, circadian rhythm, pupillary reflex and other functions

Dora Selma Fix Ventura , Institute of Psychology, University of São Paulo, Brazil

The discovery of melanopsin in the retina provided answers to questions that had no response after decades of search. What controls the circadian rhythm of sleep and awakeness ? Why people have Winter depression? The replies to these questions were surprising. A new type of cell, that is directly activated by light, as the cones and rods are, was found in the retina. This cell type forms a subset of retinal ganglion cells – the intrinsically photosensitive retinal ganglion cells (ipRGCs). They are also known as melanopsin retinal ganglion cells (mRGCs), after the pigment that found in their soma and projections, which enables them to respond to light and is maximally activated by blue light, dominant in daylight. Research on the functions of these cells show that they give rise to a separate visual pathway, a non-image forming visual pathway. Thus in addition to the well known image forming visual pathways, initiated by the activation of rods and cones, we have a second type of pathway initiated by the ipRGCs whose neural circuits are related to non-image forming functions – pupillary light reflex, circadian rhythm, mood, and cognitive capacity. A brief review of these important discoveries and of our research on the topic will be presented.

A Slim Defense of Narrow Content

Frederick Adams , University of Delaware, United States of America

This talk considers Gabriel Segal's recent attacks on content externalism. Segal argues that the existence of empty kind terms refutes content externalism. He argues that an obvious rescue of saying that empty kind terms have no content might save the theory but for the fact that thoughts involving those empty kind terms are involved in perfectly meaningful behavior. Then Segal gives several examples of such terms and such meaningful behavior that they explain. Hence, he claims empty kind terms cannot be meaningless, and thus externalism is false. I show why Segal's examples and arguments still fail to establish that content externalism is false.

Explaining Cognition: The Cognitive Neuroscience Revolution

Gualtiero Piccinini , Center for Neurodynamics, University of Missouri - St.Louis, United States of America

I outline a framework of multilevel neurocognitive mechanisms that incorporates representation and computation. I argue that paradigmatic explanations in cognitive neuroscience fit this framework and thus that cognitive neuroscience constitutes a revolutionary break from traditional cognitive science. Whereas traditional cognitive scientific explanations were supposed to be distinct and autonomous from mechanistic explanations, neurocognitive explanations aim to be mechanistic through and through. Neurocognitive explanations aim to integrate computational and representational functions and structures across multiple levels of organization in order to explain cognition. To a large extent, practicing cognitive neuroscientists have already accepted this shift, but philosophical theory has not fully acknowledged and appreciated its significance. As a result, the explanatory framework underlying cognitive neuroscience has remained largely implicit. I explicate this framework and demonstrate its contrast with previous approaches.

Simulation and Adaptivity

João José Neto , Polytechnic School of Engineering, University of São Paulo, Brazil

Simulation is among the most popular computing techniques, feaqturing a multitude of applications in almost all areas of knowledge. Simulators and their variations turn computers into versatile tools that help their users to mimic behaviors in selectable degrees of fidelity that range from crude approximations to detailed and faithful reproductions, even in real time. In our current state of technology, an ambicious challenging goal remains steady in focus, despite its complexity and low feasibility: replicating the behavior of natural, biological and especially neuronal and cognitive processes. Rule-driven devices are those whose behavior can be fully encoded in a finite set of if..then rules, and for their simplicity, the behavior they describe can be easily interpreted by a computer program such as a simulator. Adaptivity is the feature that enables devices to self-modify the set of rules defining their behavior, without external intervention, just in response to its history. One may turn any rule-driven computing device into a corresponding adaptive one by allownig them to perform self-modifications, and their ease of simulation is then further improved by allowing them to change their own behavior by modifying their set of if..then rules. In order to do so, adaptivity is easily achieved with the help of a couple of functions: one for inserting new rules and another for erasing existing ones. Even under the limitations of current technology, the association of adaptivity to simulation (and to other standard techniques) has shown to be helpful to the search of solutions in the field of complex problems. Standard divide-and-conquer strategies usually help us to separately investigate, understand and explore the multitude of aspects considered of interest, by adequately modeling learning and cognition processes, and by upgrading them with extra features from adaptive methods. Therefore, adaptivity is not proposed here as a “magic” for solving all problems in this area, but it has already proved to be highly promising as an effective tool (when used in conjunction with standard techniques and methods) to make successful incursions into unexplored and hard-to-access fields of knowledge, as it happens in cognitive sciences.

Computational Complexity and Information Measure: the Turing and Shannon ways

José Roberto Castilho Piqueira , Polytechnic School, University of São Paulo, Brazil

This talk presents, in a qualitative way, the concepts of algorithmic computational complexity (Turing) and informational computational complexity (Shannon), emphasizing how independent thinking, with different nature, produced similar mathematical concepts with great utility for modern computation.

Can Brain Connectivity Analysis Help Understand Brain Functions ?

Koichi Sameshima , School of Medicine, University of São Paulo, Brazil

Neurons are the basic elements of the nervous system that connect to each other using structures called synapses, thru which send and receive chemical or electrical signals. To understand the human brain, with its more than 80 billion neurons, neuroscientists have been studying its structures and functional dynamics at multiple scales of organization from molecules, genes, cells, neuronal circuits, to neural networks in an attempt to unravel its complex interactions. It has long been known that the brain is functionally segregated and hierarchically organized. One of important experimental paradigms in neuroscience to uncover brain functions has been the study of how neurons or neural structures interact to process information and generate behavior. Since we introduced it in 2001, we have been studying a connectivity measure called partial directed coherence (PDC), that is closely related to the Granger causality, which we believe is a robust and clinically promising method to analyze brain connectivity and stage brain dynamics in the frequency domain. We will show that by combining well designed behavioral protocols with multisite/multichannel brain activity recording (e.g., EEG and BOLD signals) one can study novel aspects of neural information processing and brain functions thru PDC connectivity analysis. An interesting line of exploration is to understand neurological diseases and disorders that emerge with abnormal brain connectivity, such as epilepsy.

The Conception of Emotion According to Peirce

Lauro Frederico Barbosa Silveira , State University of São Paulo - Marília, Brazil

Peirce, along the years worked on the exerted role of emotions and sentiments for the foundation of thought and the scientific inquiry. Relevant researchers contributed with their reading attending to the elucidating dialogue on this relevant question. The reading of Peirce’s texts and of those produced by these commentators intends to collaborate to the evaluation of the sense and the relevance of theme in consideration.

A Neural Link-centred Approach to Brain Connectivity

Luiz Antonio Baccalá , Polytechnic School, University of São Paulo, Brazil

The last couple of decades has seen a methodological shift in the characterization of brain dynamics where the early prevalent search for areas of increased neural activity under stimulus, often termed neofrenology, is slowly being replaced by investigations that focus on how those areas interact. The general term connectivity has been used far and wide to describe this trend. Early on, however, the need was felt for qualifying what one means by connectivity with more precision. Adjectives like ‘effective’ and ‘functional’ connectivity are in common use today even though their application is often inconsistent throughout the literature. This fuzzy scenario has been recently compounded by the advent of Granger causality based connectivity estimators that expose the directionality of information flow in addition to the presence of mere correlation, leading to the need for establishing a more general and consistent classification of how one should interpret connectivity issues, we which address by touring the historical evolution of these ideas.

Autonomous Action in Complex Mechanical Systems: an Actual Dilemma ?

Maria Eunice Quilici Gonzalez , State University of São Paulo - Marília, Brazil

In this talk we analyze the relationship between situated and embedded information and autonomous action in complex mechanical systems such as self-organizing robots. This type of system involves nonlinear interactions that due to the degree of interdependence established between its elements, led to the emergency of order parameters that drive the elements that gave rise to them. Complex mechanical systems involving self-organization processes and circular causality, among others, characterize the contemporary neo-mechanicism. In this context, the issue that will drive this analysis can be so characterized: is it possible to reconcile autonomous action concepts and complex mechanical system? We argue that the paradigm of complexity, which brings together inter and trans-disciplinary perspectives in partner research fields of physics, biology, robotics, Science of Complex Systems, Cognitive Science, offers a fruitful conceptual resource for analysis of the problem at hand.

Neutral Monism from a Pragmatic Perspective

Sofia Inês Albornoz Stein , University of Vale do Rio dos Sinos, Brazil

We are facing now a widespread dilemma in the scientific community: either we accept the common descriptions made by humans of their own subjective experiences (their "talk about impressions") and correlate to what we can observe scientifically from the physical changes they have, taking them as parallel events, or we try to investigate, from a behaviorist point of view, what is happening physically and in terms of behavior given they are at the right position of perception, discarding the first-person mental description, by linking initial physical behavior to resulting physical behavior. Anyway, the link between subjective experiences and starting or ending physical behavior is yet to be discovered. This link, thought Russell (1921) by maintaining the neutral monism, to be found in particular neutral elements that synthesize sensations (mental) and sensory data (physical). Today, the neurosciences do not prove the existence of sensory data, but retain the empirical goal of finding a causal network that goes from the physical objects to the "mental" perception of them. This network must include various forms of "representations" of object properties. The observation of neuronal activation in the process of perception of physical objects led to the conclusion that perception goes through several stages and that, in a broad sense, the objects are actually built gradually in our brain, through the inter-relationships that are established between different parts of it, each performing a different function. I discuss, using recent literature, the possibility of interpreting Russell neutral monism - and criticize, to be able to use it partially - from a semantic and pragmatic perspective that relativizes discourse about mental events, making it plausible to think mental events as something knowable and describable from different perspectives, without thereby falling into idealism.

Round tables abstracts

Round table 1

Computational models for simulating cognition and behavior: reflections on its methods, scope, and underlying epistemology

Diego Zilio (UFES – coordinator)
Flávio Soares Correa da Silva (USP/IME)
Leonardo Lana de Carvalho (UFVJM)
Luciano Silva (U.P. Mackenzie)

a) On the Different Sorts of Artificial Intelligence: Deep, Shallow and Mimicking

Flávio Soares Corrêa da Silva
(Department of Computer Science – IME – University of São Paulo)

The field of Artificial Intelligence (AI) as we know it today started in 1956 in the United States, as an initiative of J. McCarthy and colleagues. It was planned to be multidisciplinary and has always aimed at the study of Intelligence through its reconstruction in human designed platforms. Around the same period and location, the field of Human-Computer Interaction (HCI) started to be structured around the notion of *Human Augmentation* proposed by D. Engelbart, among other scholars. For several years, AI and HCI were developed by separate, nearly disjoint research communities, carrying conflicting views about the most appropriate ways to bring together humans and digital/computational machines. Along the history of AI, some initiatives have taken the road of foundational scientific endeavor, while other have focused on the appropriation of techniques inspired by biological phenomena to design and build useful artifacts. Within the AI research community, some scholars have named the former initiatives *Deep AI*, and the latter *Shallow AI*. Deep AI refers to attempts and initiatives to isolate Intelligence as an observable phenomenon, and to build a deeper and broader understanding of this phenomenon through model building and simulation in man-made substrates. Shallow AI, in contrast, emphasizes the potentialities of techniques that emerge as a result of observing biological systems whose behavior can be deemed *intelligent*, as tools to build artifacts that, based on some appropriate metrics, can be considered improvements on previously existing artifacts for similar functionalities. A third possible road, in which digital artifacts could be designed to *mimic* intelligent behavior convincingly, was initially viewed as a road to be avoided, as the results of initiatives built this way could be taken as forgery and potentially unethical behavior. Recently, however, interesting methodological evolutions have taken place, aligning the fields of AI and HCI and clarifying that Deep, Shallow and Mimicked AI were not, in fact, as different as initially considered. By taking a more encompassing (and hence significantly more challenging) design stance, one can consider the design of social systems comprised by digital/computational artifacts as well as human participants. Such systems - frequently coined *Social Machines* - should be structured in such way that digital components are programmed and human components are incentivized effectively to cooperate. In order to build high quality social machines, one needs to build appropriate interaction networks and protocols; program the behavior of digital components based on well grounded (*deep*) models of intelligence; make sure that these models are computationally efficient (hence implemented according to the precepts of good *shallow* models of intelligence) and, finally, make sure that digital components can be perceived by human components as intelligent, so that social interactions can occur with the required fluidity. As a consequence, *mimicked* intelligence has been accepted as a third facet of intelligence that is required to build digital devices which may deserve to be accepted as intelligent in social interactions.

b) Emergent Signs, Enactive Cognition and Complex Systems

Leonardo Lana de Carvalho
(PPG Ciências Humanas, Universidade Federal do Vale do Jequitinhonha e Mucuri, Diamantina, MG)

We emphasize that any form of naturalization of phenomenology will be widely different from pure phenomenology. The concept of enaction would provide a natural alternative, strongly connected with biological scientific thinking and inspired by phenomenology, to explain cognition. The living being is presented to be a producer of itself. This is only possible with beings that produce the conditions of their own existence. The environment modifies or perturbs a structure whose function keeps this structure. In this sense, the living entity is described as a history of perpetuating in the world that takes place through its structural coupling and its operational closure. The evolution of the species occurs by means of a natural drift. The source of intelligence is the body in action, and we stress that the nature of cognition is to be in action ("en acción"). If a system is self-organized, structurally coupled in an environment, their actions are adaptive; these actions are intelligent in this environment. In this sense the theory of enaction do not need the concept of a "res cogitans" or "mental representation" to explain cognition. On the other hand, forms of material representations have been proposed by other theories in cognitive science with great success in modeling and synthesis of intelligent systems. The purpose of this paper is to defend a promising possibility of theoretical and practical alliance between the enactive theory of cognition and consistent notions with this theory of "information", "representation", "sign", etc. In our view, the key concept of this alliance is that of the emergent sign. The enactive approach received significant influence from connectionism, especially regarding the concepts of self-organization and emergent properties. The connectionism has sought solution to the problem with the concepts of microrepresentations (material symbols manipulated by the machine) and macrorepresentations (emerging patterns from the material symbolic activity in interaction with the environment). Maturana and Varela argue in this sense that "… interactions (once recurring) between unity and an environment consist of reciprocal disturbances. In these interactions, the environmental structure only triggers structural changes on autopoietic units (do not determine or inform), and vice versa for the environment." We argue that the main influence of enactive theory in computational thinking is the renewal of artificial intelligence that explores the concept of enactive theory. However, the overcoming of the "problem" of "enaction" versus "representation" means the introduction of a new paradigm in cognitive science, the complex systems paradigm to cognition. Steels begin to signal the transition from the enactive theory to the complex system theory of cognition. His work on the development of language, such as "Language as a Complex Adaptive System" from 2000, presents language as emerging from a complex network of interactions, conceived from the interaction of agents with their environment. We understand that another important article was published in 2003, titled "Intelligence with representation". In this paper, the author opposes Brooks, explaining that a semiotic notion of representation should be maintained. Mitchell (1998), in the article "A complex-systems perspective on the 'computation vs. dynamics' debate in cognitive science" argues that; "Most of these theories assume that information processing consists of the manipulation of explicit, static symbols rather than the autonomous interaction of emergent, active ones." We argue that enactive cognitive agency must contain an algorithm that should not be a reinforcement function, nor a problem-solving algorithm consisting on deduction and inference functions. Indeed, the construction of a world is sought as a way of being in the world.

Using Dreyfus's term, a "skillful coping" algorithm, or an autolelic principle. The agent would not be getting an input i or a reinforcement s, but the inputs would be better described as perturbations. Our point is that these perturbations lead to an internal building B that is, from the perspective of the history of the system, the effect of the agent coupling with the environment. This kind of B building block can be useful to the agent for reprogramming itself, its own algorithm (self-programming). According to Rocha & Hordijk (2005), this B can serve to guide the development of complex adaptive systems, such as a biological organism that makes use of its genetic code to guide its development. According to Steels (2003), this B can also be useful to agent architectures as signs in semiotic relationships under the aegis of cross or multi-scale levels of structural coupling processes. We stress the importance of enactive approach in the design of agents and agents as artificial autopoietic beings, understanding that previous approaches have very different cognitive architectures and that a prototypical model of enactive cognitive architecture is one of the major challenges today. Indeed, this is a sensitive matter and we would not have the space here to address this issue properly. However, we would like to notice that nowadays, it is an aspect that divides the community in embodied cognitive sciences, and it may even be signalling a transition to a complex systems theory of cognition. Crutchfield (1994) understands that new machine models are required to investigate the emergence and complex systems. According to the author, the complex systems approach of the computing machine consists of a particular notion of structure. The complex machine structure would be based on a "nonlinear mechanical computing processes". This malleable structure can be modified by means of mechanisms for transformation of the structure. These mechanisms of transformation would lead to a constant "reconstruction of the hierarchical machine" by itself. To connect the structural reconstruction processes, Crutchfield provides "evolutionary mechanics". Then, he suggests that this complex machine should be the standard model for the study of complex systems and emergence. Conclusively, we support that any cognitive agency to have enactive bases must actually conceive agent's structures as coupled to the environment. An autopoietic machine should be able to pass through natural drift. However, the constructions of complex machines need a coherent theory assimilating the concepts of enaction and material representation. We think that this theory is based on the concept of emergent signs or similar notions. Following Fodor (2000), perhaps the investigation of this reality is not interesting for some cognitive engineers. However, this research is profoundly important to cognitive science and philosophy of the mind. We argue that technological applications will surpass the expectations.

c) Algebraic Semiotics for Specification of Cognitive Aspects in Human-Computer Interaction

Luciano Silva
(U.P. Mackenzie, São Paulo)

In Human-Computer Interaction (HCI), there is a constant need for understanding the mechanisms of human perception linked to the interaction process with computers, whose result may yield important information for specifying and building interfaces with better usability and learning measurements. If communication processes with the interface are not accordingly planned with the observation of human factors, one may generate common problems such as difficulty in locating desired tasks as well as a long time and way to complete them. For example, the presence of functions that are not used and others not available, joined to the difficulty to remember the route to the tasks may compromise indices associated with the evaluation of an interface. Techniques of Cognitive Sciences can be used for the improvement on interface Project. They provide a mental user model which can be exploited to observe the intensity of requests from processes cognitive derived from users (experience, interpretation, memory and learning). One of the recurring problems in using these mental models is how to model them formally in such a way to promote their inclusion as components in the formal specification of an interface or in evaluation procedures. There are several approaches to this problem and Algebraic Semiotics has offered a viable environment not only for representing cognitive issues on interfaces but also to integrate them in evaluation procedures based on formal methods. Algebraic Semiotics provides a framework for quantitative and qualitative analysis of interfaces, design criteria for creating interfaces and a strong relation to dynamics algebraic semantics. Using a system of signs, the Algebraic Semiotics can address various cognitive aspects in an interface through precise algebraic definitions for sign system and representation, calculus of representation with laws about operations for combining representations and precise ways to compare quality of representations. Moreover, it is possible to extend the constructions of Semiotics Algebraic to include dynamic signs for user interaction (e.g. Hidden Algebra), combination of algebraic structures with Gibsonian affordances, narrative structures, social foundations, computational semiosis and choose ordering on representations.

d) Explaining Psychological Phenomena: The Role of Experimental and Artificial Simulations

Diego Zilio
(UFES – Federal University of Espírito Santo, Vitória, ES)

What is the role of simulation in explaining psychological phenomena? My goal in this talk is to discuss this question. I will start by analyzing the definition of “simulation” as representation through models. Two possible ways of simulating psychological phenomena arise from this definition: (a) simulation as experimental models usually adopted in experimental psychology in the study of human and non-human behavior; and (b) simulation as artificial models used in cognitive science aiming the implementation of cognitive processes in machines. Both alternatives will be discussed in the light of a biological oriented mechanistic conception of explanation. I will argue that experimental simulations are essential to the construction of psychological knowledge and must precede artificial simulation when possible. Artificial simulations, on the other hand, have at least two main functions: to contribute to the validation of the knowledge produced by experimental simulations and to create useful technologies aiming the resolution of human problems.

Round table 2

ICT and Society: Ethical issues on the influences of ICT in individuals' daily life

Arturo Forner Cordero (POLI-USP)
Guiou Kobayashi (UFABC)
João Antonio de Moraes (UNICAMP – coordinator)
Mariana Claudia Broens (UNESP/Marília)

a) Common spontaneous action in the context of the new informational technologies

Mariana C. Broens
(Department of Philosophy, State University of São Paulo, UNESP, campus Marília)

The objective of this communication is to investigate possible implications of the new informational technologies in human common action, especially in spontaneous actions of everyday life. In order to do so, I will characterize common spontaneous action as the result of the information offered by affordances present in the environment (GIBSON, 1986), without the need of mediation by mental representations. Following I will analyze possible difficulties to the cognitive modeling of this kind of action. Finally, I will discuss pragmatic implications in common spontaneous action of the generalized use of the new informational technologies, like Internet of Things, currently mediators of a meaningful part of human interactions in industrialized societies.

b) Ubiquitous systems and Internet of Things, and their impact on society and personal life

Guiou Kobayashi
(Federal University of ABC, UFABC).

Internet of Things (IoT) is a scenario where devices like sensors, actuators and other real world objects are connected over a network (like the Internet), with the capacity of exchange data with computer systems without necessarily requiring human intervention. Some of these devices are ubiquitous (as defined by Mark Weiser), meaning that they are designed to interact with humans, and others are pervasive and embedded in the environment and in the everyday objects and machines. With IoT, it will be possible for the computer systems to interact with the real physical world, including people, machines, and the environment. Sensors and actuators will provide feedback to the systems built for specific purposes (*purposeful systems*), allowing these systems to measure the effectiveness and efficiency that their actions have in the real world. It will be possible to develop systems intended for the purposes of *persuasion* for example, (improvement of *suggestion* systems already in use in e-commerce), with actions on real world provided by IoT. The improved data availability and accuracy, coupled with database integration capabilities and data mining might enable finer adjustment of the actions. IoT raises a new level of privacy and ethical concerns. Despite the widespread use of smartphones in industrialized societies, it is still possible to turn these devices off or disconnect them from the network. With IoT technology, however, the sensors might be everywhere and they might always be turned on. In this case, it will *not* be possible to disable them, because individuals are not the owners of the devices. Who owns the data collected by IoT in public places? How, and by whom, will the data be used? In today’s scenario, where a small number of Internet companies (Google, Microsoft, Facebook, etc.) can access all the available data on the net, these questions must be analyzed seriously.

c) Robots for care and assistance ethical implications in the ageing society

Arturo Forner Cordero
(Biomechatronics Lab, Mechatronics Department, Politechnic School of University of São Paulo, USP).

There are several ethical and legal issues (BOGUE, 2004a, 2004b) regarding the development and deployment of robots. In particular the military robots and more recently drones have received a lot of attention due to the ethical implications of their operation. An emerging area of robotics research focuses on service robots oriented to provide care, help, assistance, rehabilitation or training to the human user. In this group some authors include companion or pet robots such as Paro or Aibo. However, in my opinion, they must be considered separately due to the emotional problems they may elicit. In care robot design and the human-robot-interface there are two main ethical issues that are already well established: safety and privacy. For instance, in a class of care robots, such as exoskeletons, that have a strong physical and cognitive interaction with the user it is necessary to define safety mechanisms at several levels of the design. At the mechanical level there could be passive safety elements: including mechanical stops at the joints to prevent going beyond the range of motion of the subject or active: limiting the maximal forces/torques applied by the actuators. At the control level systems like impedance control or limiting functions can be used to avoid the generation of large torques, velocities and accelerations that could compromise the safety of the subject. Privacy is another issue already solved: as the robot gathers lots of information about the human user it is possible to have a privacy problem. This issue is commonly addressed in the Institutional Review Boards with respect to data obtained from experiments and the same solution can be applied to care robots. Departing from the obvious ethical problems, it is possible to include some methodology to integrate ethics into the design of exoskeletons (SULLINS, 2015). This methodology includes the evaluation of different aspects of the exoskeleton and its expected mode of operation. The practice and context of operation, the actors involved along with their levels of responsibility, the type of robot (rehabilitation, assistive, enabling) and the possible moral elements involved (WYNSBERGHE, 2013). This type of methodology will be presented with a case study about a lower limb exoskeleton designed to assist biped gait of paraplegic patients.

d) ICT, society, and the emergence of the *hybrid beings*

João Antonio de Moraes
(PhD Candidate of Philosophy, Institute of Philosophy and Human Sciences, State University of Campinas, UNICAMP).

Because of the increasing presence of ICTs in the individuals' daily life, new ways of being-in-the-world are emerging, changing current habits and influencing the way that individuals act and understand themselves in the world, both in relation to other individuals and to their environment. The Internet stands out as a catalyst to digital being-in-the-world. One of the most noteworthy and prominent changes associated with the influence of ICTs over individuals is in terms of communication, where individuals, who were until recently only receivers of information, have now become producers of information for a global network. In doing so, the new communication paradigm changes one's conception of the world and they become both actor within, and catalyst to, an immersed digital environment, thus constituting a bottom-up movement that is decentralized, an environment by which users are active participants. Beyond the communication aspect, there is a naturalization of new forms of action in the world in the process of digitalization, much like there is in any new dynamic of society where ICTs is more then tools. As Capurro (2010) remarks, “The view of computers as something ‘other’ is disappearing, i.e., they are less and less ‘some-thing’ or ‘other-than-us’ and permeate the world in which we – or, more precisely: some of us – live”. Moreover, with the development of ICTs and the disappearance of the boundary between physical and digital worlds, there is a direct influence of ICTs in the personal identity of individuals, where “in designing tools we are designing ways of being”. As expressed by Ihde (2004), there is a change in the life-world texture. With the notion of ICTs as “technologies of the *self*”, Floridi (2014) believe that ICTs has promoted changes in the self-undertanding of individuals within the world, in his/her relation to the others and his/her environment. In Floridi’s (2014) words: “The self is seen as a complex informational system, made of consciousness activities, memories, or narratives. And since ICTs can deeply affect such informational patterns, they are indeed powerful technologies of the self”. From such understanding, once you have new possibilities for action, and expressions within the world by individuals, there are new ways for influence and change individuals’ self-understanding. What little analysis has been offered towards understanding the influence that ICTs have had on the behavior and self- understanding of individuals and has been thus far largely restricted to user groups that include children and teenagers, namely the so-called Generation Z (“Z” in correspondence to zettabytes, the amount of information generated before 2010; GANTZ & DAVID, 2011). These individuals, often called “digital natives”, have never known access to a world without the presence and persistent influence of Google, Twitter, Wikipedia, and Facebook, where such terms are understood not as merely services but as verbs (FLORIDI, 2014). Generation Z was born into, and raised, surrounded by ICTs, and all of the above ‘novelties’ of information and communication are rendered through natural actions in the case of digital natives. It is in this scenario that we will argue that the *hybrid beings* appear as a result of the influence the dissemination of ICTs in individuals’ daily life, promoting the naturalization process and of the digitalization of the world, executing two expressions of the same world. As Moraes & Andrade (2015) argues the hybrid being is characterized by his/her ability to act without strangeness in a context in which ICTs are disseminated. Thus, action and an individual’s own personal identity is reinterpreted via mediation of ICTs, and this already becomes a part of his/her own existence. In other words, the hybrid being is the result of a process of an informational reinterpretation promoted by the inclusion of ICTs in the daily life of individuals, expressed in physical/digital dimensions. Questions on the characteristics and performances of *hybrid beings* in the world will also be discussed.

Round table 3

Advances and Perspectives in Cognitive Architectures

Ricardo Ribeiro Gudwin (UNICAMP – coordinator)
Márcio Lobo Netto (USP/Poli) / Mauro Muñoz (USP/Poli)
Angelo Conrado Loula (UEFS)

a) Toolkits or Frameworks : What is the Best Approach for Deploying a Cognitive Architecture?

Ricardo Ribeiro Gudwin.
(DCA-FEEC-UNICAMP - Department of Computer Engineering and Industrial Automation - School of Electrical and Computer Engineering - University of Campinas)

Artificial Minds are a special kind of control system for an autonomous agent, inspired in the functions and characteristics of animal or human minds. Cognitive Architectures are both theoretical models of artificial minds and software implementations of these models. Currently, there are many different cognitive architectures reported in the literature (see e.g. http://bicasociety.org/cogarch/architectures.htm for a comparative table of at least 26 different cognitive architectures), and some of them have their code available for sharing with the community. This code is available mainly in 2 different options, depending on the cognitive architecture: Toolkits or Frameworks. Cognitive Toolkits are a special kind of software library, where different versions of cognitive functions are provided as a repertoire of classes, which can be combined and used together in many different ways, and the overall behavior of the cognitive architecture will depend on the features chosen by the toolkit user in order to fully implement his/her specific cognitive architecture. Cognitive Frameworks, on the other side, are reusable software environments providing a complete implementation of a cognitive architecture, which are configurable in order to enable or disable specific cognitive features and capabilities available in the framework. Cognitive Frameworks contain some distinguishing features that separate them from Cognitive Toolkits: (a) *inversion of control*: in a framework, unlike in a toolkit, the overall program's flow of control is not dictated by the caller, but by the framework - the framework calls your code, not the opposite; (b) *default behavior*: a framework usually has a default behavior, which provides a basic set of cognitive functions to be used by the architecture if no additional configuration is provided;.(c) *configurability*: a framework can be configured and extended by the user, which might choose among alternative ways of providing a given functionality or provide additional functionalities not originally present in the framework.; (d) *non-modifiable code*: the framework code, in general, is not supposed to be modified, while accepting user-implemented extensions. In other words, users can extend the framework, but should not modify its code. The construction of a particular cognitive architecture suitable to a specific application (or a specific agent), will require different programming modes. In the case of a toolkit, the overall architecture will be set up by using the toolkit classes in order to perform a bottom-up construction process which will result in the final architecture. In the case of a framework, usually this construction is a top-down approach. There is a single point of contact with the framework's code, usually creating just a single object from the framework, and giving the control to it. All the user programming will be in providing extension classes which are plugged-in to the framework code and providing a configuration, usually by means of external files (e.g. XML or text files) providing the configuration information. In this work, we will present some concrete examples of toolkits and frameworks provided by different cognitive architectures, and will discuss the advantages and shortcomings of each of these programming modes, with the aim of building up a cognitive architecture for a specific application.

b) On the Emergence of Representational Processes in Communicative Cognitive Agents: Experiments and Analysis

Angelo Conrado Loula
(Intelligent and Cognitive Systems Lab - Universidade Estadual de Feira de Santana, UEFS)

Representations are a topic of interest in Artificial Intelligence (AI) since its foundation and remains as an important issue in current research. The initial concept that intelligent systems are capable of reasoning based on representations, following a formal logic approach to cognition, brought together a question on what such representations would be, an ontological issue, and a question on how they could be produced and interpreted, an epistemological issue. But the first answer was limited to determining the appropriate data structures, in a merely technical perspective, and on how to collect and insert data that would represent the knowledge on which inferences would be applied and new knowledge would be obtained. This lead to several criticisms, such as the Symbol Grounding Problem, that essentially challenged how something could actually represent something else for an intelligent system, and not only to the designer that provided the data to the system. On the other side, the so called Nouvelle AI proposed a new approach for intelligent systems, committed to situatedness and embodiment of cognition. In these new systems, embodied artificial agent are situated in an environment, establishing sense and act loops and interacting with other agents. Agents would build its cognitive competences as a consequence of its history of sensory-motor cycles and interactions, based on learning, adaptation and evolution. Nevertheless, there was a refusal to deal with representations in this new approach, maybe considered as a minor or unnecessary trait. Meanwhile, more recently, there has been a great variety of research on the emergence of communication and language among artificial agents, robotic and simulated ones. As a methodological principle, the cognitive or social process of interest is not previously present in a community of agents, but by means of interactive and adaptive processes it can emerge among the agents. But, even though communication and language are strongly related to representational processes, there has been little or no discussion on this issue in such research works.Based on the fact that communication can be seen as the production (by a speaker) and the interpretation (by an interpreter) of representations, it is fundamental to understand the characteristics and conditions for the emergence of diverse modalities of representational processes, associated with communication and their relation to other cognitive traits. As such, we take the research scenario on the emergence of communication in a community of artificial agents as a particularly relevant framework to study underlying representational process. We propose to present an approach to study representations in communicative cognitive agents, based on theoretical principles from C.S.Peirce semiotics, including a description of cognitive architectures that fulfill minimal requirements to implement representational processes. We also describe computational experiments involving the emergence of communication and representations, with an analysis of internal mechanisms of the agent's cognitive architecture, representation processes and evolutionary dynamics.

c) Issues in Artificial Cognitive System Architectures

Mauro Muñoz & Márcio Lobo Netto.
(Escola Politécnica - Universidade de São Paulo)

An important issue for artificial cognitive systems is how they deal with the problem of Symbol Grounding (SG) firstly pointed out by Harnard who recently reformulates it as: it ``is the problem of causally connecting symbols inside an autonomous system to their referents in the external world without the mediation of an external interpreter''. The SG problem motivated Taddeo to establish the zero semantical commitment condition (ZSCC) for cognitive system designs as: "a) no form of innatism is allowed; no semantic resources (some virtus semantica) should be presupposed as already pre-installed; and b) no form of externalism is allowed either; no semantic resources should be uploaded from the 'outside' by some deus ex machina already semantically-proficient.". Other important issue for an artificial cognitive system is its capacity to adapt itself to unknown situations. As a consequence the system architecture should be capable to expand its own cognitive structure. This capacity is captured by the Autonomous Mental Development (AMD) paradigm proposed by Weng: "With time, a brain-like natural or an artificial embodied system, under the control of its intrinsic developmental program (coded in the genes or artificially designed) develops mental capabilities through autonomous real-time interactions with its environments (including its own internal environment and components) by using its own sensors and effectors. Traditionally, a machine is not autonomous when it develops its skills, but a human is autonomous throughout its lifelong mental development." Facing those artificial cognitive system design issues the Piaget's theory about the human intelligence development seems not only to fulfill those premises, but also pointing to architectures based on the bottom-up cognitive complexity approach. Particularly, Piaget named as sensory-motor stage the initial development period. This stage prepares the cognitive apparatus to be capable to deal with symbols in a latter stage. Thus no symbolic representation or symbol usage by the apparatus is assumed by the sensory-motor development theory. The conformity of the piagetian theory with the ZSCC and the AMD seems to show a promising path to construct guidelines for cognitive system architectures focused on bottom-up approaches. When thinking in a cognitive system architecture from the bottom-up approach a new question arises: how a system interacting with its external environment exclusively through its sensory-motor signals can start to interact to the entities it imagines to be the cause of the signals it perceives and be affected by the actions it generates?

The basis for an artificial autonomous cognitive development systems architecture designs capable to extrapolate from signals interaction to object-concept interaction seems to be a relevant open issue.

Round table 4

Information, Context and Structure in Cognition.

João Eduardo Kogler Junior (USP/Poli – coordinator)
Marcos Fernando Lopes (USP/FFLCH).
Paulo Eduardo Santos (FEI).
Renato Teodoro Ramos (USP/FM).

a) Information: a claim for meaning

Renato Teodoro Ramos.
(School of Medicine – Department of Psychiatry - University of São Paulo).

The objective of this presentation is to discuss the concept of meaning in information theory from a neuro-cognitive perspective. This topic is of special interest for neurosciences because several neurological and psychological models conceive human brain as an information-processing machine. These approaches implicitly suggest a parallel between brains with other devices, like computers, for which the concept of information was developed. The seminal Shannon's proposal of informational entropy is a good example of this approach. In this model, the concept of information is related to the probability of occurrence of a given message in a communication system constituted by information source, transmission channel, and receiver. The main limitation for the use of this model for studying brains and behaviors is the assumed irrelevance of the message meaning. How information acquires meaning is a very complex question associated to the definition of semantic information. Despite the lack of consensus, semantic information has been defined in function of "well-formed, meaningful, and truthful data". What is not clearly stated in these semantic approaches is that the process that defines information as something significant occurs in the receiver component of the Shannon information system. The following propositions will be discussed: - The meaning of a message emerges in the receiver and any other stimuli running through the information system that is not capable of modifying the receiver's state is not information at all. - A measure of semantic information is essentially a measure of influence between agents. - The validity of a message is not a property of isolated agents or of the message itself. The ascription of trueness of information depends on the selection of influences according to some criteria. In biological systems, like human brains, evolutionary processes has imposed utilitarian constraints to select informational contents. - Brains "use" information to construct representations, predict future events, and improve survival chances. - The sophisticated psychological constructs classically associated with the concept of mental representation are essentially of the same nature of interactions of simple biological or computational elements.

b) Dictionaries' Core Defining Words Are More Frequent and Have More Meanings

Marcos Fernando Lopes
(Department of Linguistics, FFLCH, University of São Paulo).

From a dictionary's graph of defined and defining words one can compute a Grounding Kernel (Kernel) (about 10% of the dictionary) and Kernel Core (Core) (about 70% of the Kernel) from which all the rest of the words can be defined (Massé et al., 2008; Picard et al., 2009). For the Longman Dictionary of Contemporary English, several of the lexical semantic properties of the Kernel (and especially the Core) words differ significantly from the rest of the words in the dictionary. Other studies had shown that these words are learned earlier. Focusing exclusively on nouns, we now find that they have more senses, are more frequent in written corpora, more familiar, and more similar to one another internally. These emerging special properties of the Kernel and Core may cast some light on why the meanings of the rest of the words in the dictionary are grounded in this small subset from which they can be reached through definition alone. The present work was written in collaboration with: Alexandre Blondin-Massé, Mélanie Lord, Odile Marcotte, Philippe Vincent-Lamarre (Université du Québec à Montréal) and Stevan Harnad (Université du Québec à Montréal and Canada Research Chair in Cognitive Science).

c) Slicing Space with a Semantic Knife-Edge

Paulo Eduardo Santos.
(Artificial Intelligence in Automation Lab., Department of Electrical & Electronics Engineering – Centro Universitário FEI.)

The aim of this work is to investigate a representation and reasoning formalism capable modeling the vagueness, polysemy and ambiguity present in spatial descriptions of scenes using natural languages. The absence of precise specification (or vagueness) is present in various terms used for spatial descriptions, for instance, one of the first term a child learns to describe its environment (that is also a term that occurs is all languages [2]), the spatial demonstrative "that", expresses no precise location, apart from saying that the object in question is further from the speaker. The second issue of interest here (polysemy) is a characteristic of any natural language, since there are fewer spatial relations to express a large range of situations in any of the existing languages [3]. Finally, ambiguity can be exemplified by recent research on cognitive psychology that indicates that, in everyday human communication, people mix perspectives without signaling to the interlocutor [6]; besides, sketches of scenes constructed from verbal descriptions not always agree with the actual described scenes [4]. These issues are overlooked most of the time by human agents in normal speech, in fact they seem to be part of our understanding of the world. It may be the case that scene understanding from verbal descriptions presupposes the existence of a kind of constraint satisfaction and model building system in our minds that solves possible the inconsistencies in spatial descriptions. The development of algorithms for constraint satisfaction in spatial domains is at the kernel of the development of spatial algebras [5], that is within the interests of Qualitative Spatial Reasoning (QSR) [1], a subfield of Knowledge Representation in Artificial Intelligence. The aim of Qualitative Spatial Reasoning is to provide rigorous logical formalisms for the representation of spatial relations from elementary entities using qualitative relations. However, these formalisms are built upon very abstract notions that have no relation to the actual use of spatial expressions in natural languages. An opportunity thus emerges to investigate the construction of a QSR formalism whose semantics is capable of handling vagueness, polysemy and ambiguity, as present in the natural language descriptions of scenes. In order to construct such formalism we need to, first, list and compare the various findings from cognitive linguists that point to the way spatial expressions are used in common languages; second, find a common structure underlying our understanding of spatial expressions and, third, describe this common structure as an algebraic structure that provides the semantics for the spatial relations in a QSR formalism.

d) Geometry, information and action in the explanation of cognitive and perceptual processes

João Eduardo Kogler Junior.
(Polytechnic School of Engineering, Department of Electronic Systems, University of São Paulo)

Cognitive and perceptual processes are considered here as transformations operating on sensorial and internal data in order to detect and extract information useful for prediction for immediate or future use in the modulation of decision processes that generate actions. In this work, we argue about the role of invariants under such transformations relating them to context, in the search of a geometrical explanation for the relational structure underlying the mutual constraining among interacting components participating in the inferential mechanisms embedded in a cognitive/perceptive agent. The encoding of information and knowledge is related to this geometry, which will be claimed to meet requirements imposed by the interfaces between the agent and the external world, essentially concerning to its adherence to affordances, in the sense of the situated cognition paradigm. Some questions and issues related to this view will be discussed, considering the role of evolutionary and developmental processes as of paramount importance in the construction of this theoretical approach for explaining some aspects of cognition.

Round table 5

Machine Learning and Pobabilistic Modelling of Cognition and Behavior

Edson Satoshi Gomi (USP/Poli)
João Ricardo Sato (UFABC)
Nestor Caticha (USP/IF)
Peter M. E. Claessens (UFABC)

a) Why Bayesian Modeling?

Nestor Caticha
(Instituto de Física University of São Paulo)

Once we decide to model cognition using mathematics the natural question that emerges is: among the many mathematical structures at our disposal, which should be used? Cognition is a typical situation of incomplete information, since just as an example, sensorial information arises from just a subset of the possible information about the external world. It might happen that several possible states of the real world are compatible with the sensorial state. A few common sense demands lead to a mathematical structure that includes the theory of probabilities. These demands are: (D1) Transitivity: Under conditions D, if an agent believes in A|D more than in B|D, and in B|D more than in C|D, then the belief on A|D should be larger than that on C|D. (D2) If the belief on an assertion can be calculated in more than one way, demanding that the results are the same should avoid manifest inconsistencies. (D3) For all A, the belief in A|A should be the same and for all B mutually exclusive to A, the belief in A|B should be the same. (D4) There must be some function G that permits obtaining the belief about the logical product AB|D in terms of some subset of beliefs that include A|C, A|BC, B|C and B|AC but not necessarily all. (D5) There must be another analogous function F for the logical sum A+B|C. Implementation of these demands leads to probability theory or simple monotonical regraduations. It leads to Bayes theorem, permitting the introducion of prior knowledge and to take into account structural information about the architecture of the cognitive system. Of course this approach is not constrained to cognition, but has founded extended use including machine learning and data analysis in general. More generally, Bayesian Inference can be shown to be a special case of Entropic Inference.

b) "What Machines can learn from Doctors and Doctors from Machines: Lessons from Bayes Nets as Diagnostic Decision Support Systems in Tinnitus"

Peter M. E. Classens* ; Jangholi, Nargess; Ghodrati Toostani, Iman; Ganz Sanchez, Tanit
(* UFABC)

Medical doctors, through training and experience, attain high levels of efficiency and accuracy in diagnosis, in a process of probabilistic reasoning that narrows down a set of potential causes based on a limited amount of observable data. While medical symptoms or test results are individually generally insufficient to isolate the etiological basis of a complaint, in combination they provide sufficient information to identify a cause in a procedure that is not unlike sensor fusion. A normative model for determining hidden causes in a set of probabilistically dependent and interacting variables is provided by the class of Bayes nets, or Bayesian belief networks. This formalism, which combines elements of probability and graph theory, is therefore an interesting reference for comparison with human diagnostic decision making, not only for the final decision on the etiology of a case, but also in the intermediate steps chosen to reach the diagnostic conclusion.In this talk, virtues and cognitive shortcuts in medical decision making will be reviewed. A short introduction in causal inference using Bayes nets will be given, after which a study on the construction of a diagnostic decision support system for the differential diagnosis of tinnitus, a common disorder producing physical or subjective ringing or buzzing noises, will be presented. The formal analysis of decision under uncertainty as provided by Bayes nets point towards interesting points of convergence and divergence with human medical decision making. As basis for diagnostic support systems, Bayes nets have large potential but a few challenges to solve in implementation, as will be discussed.

c) Learning Representations through Deep Learning

Edson S. Gomi
(University of São Paulo (USP), Polytechnic School, Department of Computer Engineering)

The performance of machine learning algorithms has been highly dependent on a previous choice of abstract features obtained from the raw data. In order to enable the development of machine learning algorithms that identify features automatically, Deep Learning uses several composition and transformation layers to learn an appropriate representation for a given data. Successful representations have been obtained in Deep Learning experiments of recognition and classification tasks using text, speech, and image data. This talk will present the basic concepts and application examples, in order to give an overview of Deep Learning and its relationship with Neural Computation.

d) Brain networks maturation and psychopathology: an interdisciplinary approach

João Ricardo Sato
(UFABC)

In this lecture, we present recent findings in brain imaging and neurodevelopment in humans. The main focus is on the brain networks maturation during late childhood and pre-adolescence. We discuss about the emergence of functional networks and how they can be analyzed using statistical and computational methods. Findings based on developmental curves, graph theory metrics, signal processing and machine learning are presented. Finally, we demonstrate the association between neurodevelopmental disruptions and manifestations of psychopathology.

Round table 6

Computational Intelligence and Cognition

Emilio Del Moral Hernandez (USP/POLI – coordinator)
Francisco Javier Ropero Pelaez (UFABC)
João Henrique Ranhel Ribeiro (UFPE)

a) From Neuron Cells to Cognition: a Review

João Henrique Ranhel Ribeiro
(Federal University of Pernambuco, Department of Electronics and Systems)

Nervous systems give rise to animals' intelligent behavior and can make them cognitive agents. This presentation reviews the intelligence and the cognition concepts. A central topic in cognition is 'learning', meaning the agent's ability to modify its behavior during its lifetime, what is quite different from inborn stereotyped responses. Then, it is briefly discussed the learning types (supervised, unsupervised, reinforced and deep learning) and the biological neural bases underlying such learning mechanisms. I intend to show a new model of artificial spiking neural network that allows us to simulate the main natural mechanisms (neural plasticity and astrocytes). Two main issues is proposed for debate: first, how close can artificial neural networks be from biological networks? Second, to what extend is it important to mimicry natural neural networks? While deep-learning and other machine learning technics have obtained great success in many areas or Artificial Intelligence, we may ask if scientists can create different and more efficient cognitive machines than those based on biological neural mechanisms.

b) Rate-code neurons versus spiking neurons: where and when using each one

Francisco Javier Ropero Pelaez
(Federal University of ABC)

Although spiking-neurons models seems faithfully mimic real neurons' behavior, we believe that in many cases, neurons' spikes are dispensable. The reason is that spikes are, in most neurons, a means for modulating analog voltage-signals at the neuron's soma for allowing a faithful transmission of these signals along neuron's axon. Nowadays, one popular method of signal transmission is Pulse Density Modulation (PDM), which modulates analog signals in exactly the same way neurons modulates soma voltage-signals. The reason for modulating analog signals is avoiding attenuation and interference through a channel. As in artificial models there is no a physical transmission channel, there is neither attenuation nor interference and, therefore, there is no need of modulating processes like PDM or spikes. In most cases, rate-code models are simpler and faster than spiking models. Despite all these reasons, there are sophisticated brain processes in which temporal sequences are important and in which spiking neurons are necessary. Thalamic encoding processes and temporal binding in apical dendrites are examples of these sophisticated processes. The conclusion is that, for an efficient computation of biologically inspired networks, a rationale for where and when using rate-code and spiking neurons should be considered.

c) Diversity of Model Neurons and Implantable Electronic Devices

Emilio Del Moral Hernandez
(Polytechnic School of Engineering, Department of Electronic Systems University of São Paulo)

Spiking Model Neurons and Rate Coding Model Neurons are some of the most important directions in the current scenario of research in Artificial Neural Networks, and application, having produced important systems and devices, which are very relevant for automatic pattern recognition, fusion of heterogeneous multidimensional information, control, support for automatic decision, as well as, more recently, for the area of Brain-Machine-Interfaces and implantable devices for diagnosis and rehabilitation. At the same time, the enormous evolution of electronic systems and microelectronics observed in the recent decades, have allowed scientists and developers to conceive extremely compact systems, based on integrated circuits, signal processing, micro sensors and micro actuators, with huge potential for powerful information processing, sensing and control, conjugated with high adaptability to the environment changes and its variations. This talk addresses some of the important current issues in artificial neural networks in the context of electronic implementation for implantable devices and the potential impacts in terms of the future scenario of human to machine communication, medicine and neuroscience.

Round table 7

Linguagem, comunicação e cognição

André Leclerc (UFC/CNPq)
Leland McCleary (FFLCH/USP)
Evani Viotti (FFLCH/USP)
William Alfred Pickering (CLE/Unicamp)
Walter Teixeira Lima Junior (U.Metodista)

a) Spontaneous linguistic understanding

André Leclerc
(UFC/CNPq)

First, I will delimitate the concept SPONTANEOUS LINGUISTIC UNDERSTANDING, contrasting what it represents with hermeneutic practices, reflexive and inferential in nature, and with the understanding in a language not fully mastered. After that, I will criticise the epistemic view of linguistic understanding. Finally, I will try to develop the idea that linguistic understanding depends upon a more primitive form of understanding that I call the understanding of situations. This is why we understand so easily deviant sentences, ungrammatical or incomplete sentences, nonsenses, malapropisms, etc.

b) Linguistics in search of a semiotics of interaction

Leland McCleary (FFLCH/USP)
Evani Viotti (FFLCH/USP)

Saussure's famous binary options — langue over parole and synchrony over diachrony —laid the intellectual foundation for a linguistics that has been virtually impervious to increasing evidence from sister disciplines (including, but not limited to cognitive science) that language must share with life, and in particular with social life, the quality of being a self-organizing, dynamic complex system. The Chomskyan turn toward a 'cognitive' linguistics, with its option for the study of 'ideal speaker' competence to the exclusion of performance, further isolated linguistics from a view of language as an intrinsic feature of human sociality. Even versions of usage-based cognitive linguistics that have emerged in the wake of the 'embodiment' phase of cognitive science have remained committed to the binary Saussurean sign of 'signifier-signified' (e.g. Langacker, 2008), while at the same time arguing for the dissolution of such traditional distinctions as lexicon vs. grammar and word meaning vs. encyclopedic meaning. Thus, within linguistics there is currently a disconnect between established semiotic theories and those tendencies most inclined to incorporate (and contribute to) advances in the cognitive and social sciences, specifically theorizations of language originating at the interface with sociology, anthropology and psychology on such topics as multimodality and co-speech gesture, distributed agency and cognition, and interactional alignment and sequential organization across multiple time scales. Recently, these threads have been given theoretical coherence within a dynamic, neo-Peircean semiotics, in which semiosis is understood as an ongoing process which emerges in and through every interaction, including, but not limited to, the linguistic (Kockelman, 2005, 2013; Enfield, 2013). We hope to be able to illustrate the advantages of this dynamic, multimodal view of semiosis by analyzing excerpts of face-to-face interaction.

c) Linguistics and self-organization theory

William Alfred Pickering
(CLE/Unicamp)

Within linguistics, there has been a significant growth of interest in the theory of self-organization over the last twenty years. In my presentation at the EBICC 2015 meeting I will present concepts from the theory of self-organization, and indicate several important similarities between self-organizing complex systems and human languages. Through this comparison, I try to show the general plausibility of considering human languages as self-organizing complex systems. The implications of this approach for linguistics will be discussed, and I will argue that self-organization theory can bring unity and coherence to the understanding of various linguistic phenomena.

d) Social Communication, Cognition and Neuroscience

Walter Teixeira Lima Junior
(Metodista)

Social Communication has undergone huge influence of Sociology since its primordia as scientific field. In the last 60 years, the discipline has experimented various phases based on analysis of behavior through mass media artifacts. Media is the unique place to study the mass communication phenomena. With the same focus, psychology and linguistics, more strongly anchored in semiotics, has helped the field of Social Communication advances to understand how language processes are structured from media consumer behavior analysis. However, the behavior as theoretical edifice, behaviorism, was eclipsed in the 1980 and 1990, when neuroscience finally managed to advance beyond the use of the analogies to understanding the communication black-box. Advancing in concept that Language is systematic, and so it can be described in terms of rules and general principles, the neuroscience can help the Social Communication the understand the understanding how language interacts with other cognitive processes. This scientific field has advantage to be tested experimentally, helping to complement the theoretical scope in order to comprehend how the communication transfers information from media to person.

Round table 8

The mind-body problem: reductive and nonreductive physicalisms

Alfredo Pereira Jr. (Unesp/Botucatu)
Jonas Gonçalves Coelho (Unesp/Bauru)
Osvaldo Pessoa Jr. (FFLCH/USP – coordinator)

a) The hydro-ionic wave: a new model of cognitive and affective processing in the brain

Alfredo Pereira Jr.
(Department of Education – Bioscience Institute – Univ Estadual Paulista (UNESP), campus Botucatu, SP.)

Beyond the "Neuron Doctrine" formulated by Ramon y Cajal – proposing that neurons are the structural and functional unit of the mind/brain – our current theoretical framework has been updated to include neuro-glial interactions. In recent years, there is a debate as to how the astroglial network modulates neuronal activity, influencing cognitive, affective and behavioral processes. The hypothesis of modulation by means of gliotransmitter release by astrocytes, activating a synchronous neuronal assembly was not confirmed 'in vivo´. Other transmitters have been proposed for this modulatory function, such as the cholinergic and purinergic ones. Another possibility is the "Hidro-Ionic Wave": a continuous energy exchange mechanism that traverses the neuro-glial arrangement. Inside astrocytes, it has the form of a "calcium wave"; in the extracellular medium, it changes to a potassium current that changes the pattern of organization of the aqueous gel, which interacts with the neuron membrane and modulates the pattern of neuronal activation.

b) The placebo effect according to double sided approach to the mind-body relation

Jonas Gonçalves Coelho.
(School of Architecture, Arts, and Communication – Univ Estadual Paulista (UNESP), *campus* Bauru, SP.)

My aim in the present paper is to interpret the placebo effect according to the "double sided approach" of the mind-body relation. I am therefore accepting the challenge made by the researchers Donald D. Price, Damien G. Finniss & Fabrizio Benedetti in the paper "A comprehensive review of the placebo effect: recent advances and current thought": "Powerful placebo effects reflect mind-brain-body relationships, and there is a need to philosophically resolve explanations of these relationships without resorting to eliminative materialism or forms of dualism that completely divide the mind from the body" (p. 586). The quotation indicates that the authors have a non-reductive physicalist view of the mind-brain-body relation, according to which neither the mind should be eliminated, nor should it be separated from the brain-body. This means that the mind, the body and the relation between the two have a fundamental role in the placebo effect, a thesis that the mentioned neuroscientists intend to prove, transferring to the philosophers the task of solving the mind-brain-body relation. To deal with the problem of the mind-brain-body relation, following the lead of the placebo effect, I will start by presenting some definitions of the placebo effect, attempting to explicate the terms in which one establishes the distinction and relation between mental (psychological) processes and cerebral/bodily (biological) processes. I will then try to show how to interpret the placebo effect form the two inseparable and irreducible sides of the mind-brain relation, i.e. “mind as brain” and “brain as mind”.

c) Non-identical versions of the mind-body identity thesis

Osvaldo Pessoa Jr.
(Department of Philosophy – FFLCH – University of São Paulo)

The presentation will begin by arguing that the mind-body identity thesis is essential to any reductive physicalist view. But a little reflection indicates that there are at least as many versions of the identity thesis as there are different monist solutions to the mind-body problem. After exploring early defenses of the view, it will be stressed that the identity thesis of U.T. Place (1956) in fact privileges the scientific description of the brain, instead of phenomenal consciousness, and that this version of materialism carries over to Smart (1959). This is clearer in Feyerabend’s (1963) version of identity theory, which eliminates mental concepts altogether. On the other hand, radical idealism also identifies mind and body, but considers that everything is mental. An intermediary version of the identity thesis was presented by Fechner (1860) and Th. Nagel (2002), following Spinoza in proposing a monist view of reality of which mind and matter are two different aspects or perspectives. But returning to reductive physicalism, one may also adopt the identity thesis while privileging the phenomenal subjective quality of consciousness (described as sense data, raw feels or qualia). This results in what might be called “qualitative physicalism” (or “colored-brain thesis”), proposed by Case (1888) and suggested by Boring’s (1933) formulation of the identity thesis, and which will be further explored.

Round table 9

Cognitive Neuroscience of Art: Dialog among Human, Biological and Exact Sciences

Ronald Ranvaud (USP/ICB – coordinator)
Mirella Gualtieri (USP/IP)
Maira Monteiro Fróes (UFRJ)
Patrícia Vanzella (UnB & UFABC)

a) Artistic Experience, Expression and the Brain

Mirella Gualtieri.
(Institute of Psychology - University of São Paulo)

We are now at an interesting time in the exploration of the relationships between neuroscience and art. Let us considerer three major factors on which art is constructed: inspiration, creativity and aesthetics. From a neural point of view, inspiration is a mental experience relying on the integration of subcortical (motivation/reward, emotions) and frontal cortical areas of the brain. As an experience integrated by goal-directed behavior, inspiration can be closely related to creativity, which can come spontaneously or as a result of deliberate action. Deliberate creativity could be summarized, according to Damasio (1994), as emotional evaluation of a set of cognitive processes and its neural substrate initiates with prefrontal cortical activity, whereas the spontaneous creative processes seem to arise from temporal cortex activity. At the core of creativity, the intimate linkage between highly variable cognitive and affective features of the brain often leads to situations where the artist's work reflects a form of knowledge and insight about the world that precede scientific exploration of the same phenomena. For instance, the kinetic art of Tinguely long preceded the discovery of the cortical visual motion area (V5), but the artist already knew that color and shape did not matter when motion is the means of communication. Many artists understood how to manipulate shading to emphasize edge by creating illusory enhancements that the vision science community understands to be Mach Bands, discovered by the physicist Ernst Mach and documented physiologically only many years later. Aesthetic-related brain areas, mainly the anterior insula and prefrontal cortex, are active in response to classical beauty and are also activated when people watch elite, dynamic athletic performance, or manifestations of forces of nature, or even when presented with elegant arguments or theoretical concepts, which may be experienced as examples of loftiness or the sublime. It has been shown that the brain structures activated during experiences of beauty and of the sublime are different. The implications and importance of such neuroscientific findings regarding the arts are both wide-ranging and profound. For example, it is now possible to evaluate, from a neuroscientific perspective, the diversity of the impact of art on different individuals. For that matter, the role of experience upon the brain has also been shown to have an impact on the aesthetic experience. The judgment of consonant or dissonant pairs of tones according to the Pythagoras' ratio rules was remarkably different among musicians and non-musicians, with the level of brain BOLD response being proportional to the magnitude of the Pythagorean ratio in the musically trained but not in the untrained subjects.

b) An Artsci Science

Maira Monteiro Fróes
(Federal University of Rio de Janeiro, Centro de Ciências Matemáticas e Natureza, UFRJ).

Would aesthetical immersion drive cognitive handling in science? This question has been systematically addressed through controlled scientific experimentation in my laboratory. In a partnership with artists, my lab has intentionally developed tools for a non-conventional aesthetical contextualization of scientific material and conjectural objects. In one of the experimental investigative fronts, distinct groups of undergraduate students from the university's schools of fine arts and life sciences (Department of Phonoaudiology) were invited to answer the Aesthesis quest, a Web questionnaire we have specially conceived. Aesthesis was designed to evaluate primary aesthetic, emotional-affective and cognitive aspects of perception developed in response to conventional and non-conventional referential anatomical images. These subjective qualifiers represent foundational aspects of human perception, as aesthetics, emotion, abstraction and analytical thought. Our results confirm our expectation that non-conventional contextualization of the anatomical object, provided by contemporary art treatment, alters aesthetical, emotional and cognitive markers of perceptual assessment. Notably, they favour our more speculative hypothesis that cognitive resources for abstraction and abstract thought itself are positively correlated with the contextualization of the scientific object by contemporary art. Our results also point to involvement of positive emotion and judgments of beauty, suggesting that, together with gains in abstraction, these might represent interrelated, indissociable aspects of a scientific objectivity impregnated by the aesthetical experience.

c) Emotion in Music from a neuroscientific viewpoint
Patrícia Vanzella (University of Brasília and Federal ABC University).

Musical behavior is a primordial and universal human characteristic. Among the most ancient artefacts encountered in archeological excavations are musical instruments, and there is no evidence of some civilization that does not engage in some type of musical activity. It is undeniable that music evokes and modulates emotions, promotes social cohesion and synchronizes both movements and states of mind. Several experimental techniques (EEG, NIRS, galvanic skin respose etc) allow to measure reliably behavioral, cognitive and neurophysiological changes associated with music. From a neuroscientific point of view the challenge is threefold: to identify the varied neural mechanisms whereby music engenders such resposes, to identify which of the physical parameters of the sound wave are important, and to understand how these physical parameters participate in the above neural mechanisms.

d) Cognition, Music, Plastic Arts and Literature

Ronald Ranvaud
(Institute of Biomedical Sciences, University of São Paulo)

Among the most fundamental functions of the nervous system is generating predictions as to what will happen next. This is possible by constantly monitoring the environment and relying on prior experience. Good predictions permit preparing timely and adequate motor responses as circumstances evolve. Generating predictions is an automatic process which runs continuously, even though awareness of its operation is generally lacking. Of course, it is also possible to generate predictions voluntarily, focussing attention and reasoning on the challenge being faced at any moment, but, thankfully, under normal conditions it is not necessary to exert such effort. Generating predictions has great adaptive value, permitting proactive rather than merely reactive behavior. Generating expectations is also an essential part of cognition, as can be realized considering that the etimology of the word cognition remits to knowledge, or knowing, and further considering what knowing something means. For example, what knowing a person mean? Rather than just having information as what the name of the person is, and their address, telephone number and so on, knowing someone really means having a good idea of what the person will do under different circumstances, i.e. predicting, albeit with some limitations, their behavior. Several theories of Artistic Cognition also are based of the idea of generating expectations. According to this approach, the charm of music would result from the alternations of moments described in musical theory manuals as moments of relaxation (expectations confirmed) and moments of tension (expectations negated). These concepts can also be applied to the plastic arts and literature, and they thus form a solid basis for the neurophysiological study of artistic behaviors.

Round table 10

Some historical and evolutionary perspectives on mind, brain, and cognition

Hamilton Haddad Junior (IB-USP) (coordinator)
Maria Inês Nogueira (ICB-USP)

a) Evolution, niche construction and human cognition

Hamilton Haddad Junior
(Instituto de Biociências, Universidade de São Paulo)

The purpose of this talk is to examine some recent approaches of human mind and cognition beyond the biological processes, pushing also the boundaries of traditional computational approaches arising from the artificial intelligence. The main idea is to analyze theories that reinforce the role of niche construction on human cognition and try to conceive the mind as essentially dependent on an environmental scaffolding process. Many non-human animals modify theirs immediate environment, shaping it to improve fitness; these organisms in part adapt to their niche and partly build their own niche. This process of 'niche construction' (Laland *et al*., 2000) has been postulated as an important factor in evolution. It is suggested that over the evolutionary process of human species, a scaffolding process in the cognitive domain occurred similar to that niche construction. Human ancestors epistemically modified their environments, which were inherited by subsequent generations. The cognitive abilities of these new generations depend on, and were transformed by, these new environmental resources – these resources were built, modified and preserved precisely because they improve cognitive capacities (Sterelny, 2012). This dialectical process, in which agents modify their epistemic environment which retroact over the agents, is assumed to be the cornerstone of evolution and the current mechanisms of the human mind.

b) History of the morphofunctional comphreension of the brain and its relation to cognition

Maria Inês Nogueira
(Laboratory of Neuroscience, Anatomy Department, Institute of Biomedical Sciences, University of São Paulo)

Under this heading are addressed, historically, some concepts, ideas, actions and techniques that influenced our current knowledge on the brain. Which is understood as part of the encephalon, an organized tissue composed by two basic cell types: neurons and glia, but with great variety of form function and distribution. The encephalon is the rostral part of the nervous system present in vertebrates protected by a cartilage or bone box (skull). It is comprised by the brainstem that supports the brain (tele- and diencephalon) and the cerebellum (little brain). However, the focus of this historical approach lies in the human primate, Homo sapiens, however keeping in mind the warning that evolution is not linear, and that the brain did not evolve just by putting new more complex structures over the less ones, and in that man occupies the top of the list. In revisiting the history of science, we seek to understand the importance attributed to the head, brain and heart as to its relevance to sustain life, thinking, feelings, actions and reactions. Where the ancient civilizations of the old and new world found the site of reason and emotions? Is it possible that only the brain is reponsible for them? Which is the substrate to monism, dualism, localizationism, holism. Along the way, there is a search to identify how has the understanding of the organization and brain functions evolved and what were the competing factors for both: the main searchers, concepts and technologies relevant to the current understanding, but still incomplete, of the brain and the nervous system. How did we get to neuroscience (neural plasticity, neural communication, somatic markers) and what is its relationship to cognition. Are Artificial Inteligence models a true representation of the brain and mind relation, as some use to say like hard- and software?

Round table 11

Cognition in Peirce's Semiotic

Vinicius Romanini (USP/ECA – coordinator)
Ivo A. Ibri (PUC/SP)
João Queiroz (UFJF)

a) Everything Speaks – The Pragmatic Signs of Semiotics

Ivo A. Ibri
(Center for Pragmatism Studies – PUC/SP; Charles S. Peirce Society)

Peirce is well known as the father of Semiotics and classical Pragmatism. Nevertheless, the studies that deepened the intimate relationship between both theories still are few, which I suppose to be very essential to a fairer consideration of the systemic constitution of Peircean philosophy. One way to do such a task would be a serious study of the ontological realism as adopted by Peirce, one main axis of such system. However, such a way has been misunderstood, or even disregarded on its importance, by many scholars and, as a consequence, it is not infrequent to see nominalistic interpretations of those theories impeding the realistic connection between them. Another visible way to establish the relationship between Semiotics and classical Pragmatism is to consider what I have called categorial symmetry, a concept built throughout the passage from Peirce's phenomenology to his ontology. Such symmetry will provide an extension of the notion of language to Nature and, by doing so, enable us to consider that everything speaks. In other words, pragmatic signs are meaningful as a true saying of the natural and human inner worlds, allowing an ample concept of interpretant signs through the observation of the conduct of every being in the universe.

b) Distributed creativity in Peirce's cognitive semiotics

João Queiroz
(Iconicity Research Group; Instituto de Artes e Design/UFJF)

Charles S. Peirce can be considered an important precursor of situated mind and distributed cognition thesis. But differently from the anti-cartesianism defended by some embodied-situated cognitive scientists, which is predominantly anti-representationalist, for Peirce, mind is semiosis (sign-action) in a dialogical -- hence communicational -- materially embodied form, and cognition is the development of available semiotic artifacts. It takes the form of development of artifacts, such as writing tools, instruments of observation, notational systems, languages, and so forth. My aim here is to explore some connections between Peirce's semiotic theory of mind and the conception of distributed creativity through the notions of iconicity and semiotic niche construction, taking advantage of examples in dance and poetry improvisation. According to this approach, creativity is a property of cognitive artifact manipulation and niche construction. More specifically, creativity is distributed as opportunities for evolution in semiotic niches.

c) The Solenoid of Semiosis as a general model for cognition

Vinicius Romanini
(PPGCOM, University of São Paulo, USP)

Early in his studies, Peirce considers cognition as a particular case of representation in conscious minds and, following his ubiquitous triadic divisions in firstness, secondness and thirdness, defines its basic elements as feelings, efforts and notions. While Peirce maintains this basic structure throughout his career, his late theory of cognition broadens as he becomes an extreme realist. The sign is then defined as a “cognizable” that allows for information not only in actual but also in possible minds. Cognition is not a psychological faculty of individual minds, Peirce claims, but a logical process than can be explained by the general laws of mind that govern the development of life and even the grow of complexity in physical systems. We will present here a model, called the Solenoid of Semiosis, that analyses the action of sings in its minute logical elements and relations. I will also apply it to an example of cognition often quoted by Peirce: the information conveyed by a weathercock. Our hypothesis is that the Solenoid of Semiosis can function as a general model for cognition.

Round table 12

Logic, consequence operators, and information

Hércules de Araújo Feitosa (UNESP - FC – Bauru)
Itala M. Loffredo D'Ottaviano (CLE-Unicamp) (coordinator)
Marcos Antonio Alves (Unesp-Marília)

a) Consequence operators and consequence relations

Hércules de Araújo Feitosa
(UNESP - FC – Bauru)

At the beginning of 20th century several different logics appeared from the logic until considered the Logic. From that time we have named the Logic introduced by Greeks, with particular contribution of Aristotle, so a construction from classical world, by Classical Logic, and the other logics distinct from Classical Logic we have named non-classical logics. In 1930, Alfred Tarski tried to explicit the common aspects of all these logics. For that, he defended that the fundamental aspect of any logic is on its deductive context. Thus, the central notion is the deduction, derivation or consequence. Tarski defined the consequence operator of Tarski, a function that puts emphasis on the fundamental aspect of consequence. In a complementary way, many logic textbooks usually consider the consequence as a relation that associates or links a set of information with conclusive information. Relation is a more general concept than a function. This notion puts the inference in evidence, from which we obtain a conclusion from a collection of premises. We observe several different definitions of consequence relation in the logical environment. In this paper, we present some of these formulations and collate these definitions. Our contribution to these analyses is to show that even though there is equivalence between some of them, a given principle is stronger than another one that occurs in another definition. This way, we observe the independence of some principles and try to expose with clarity and simplicity these basic notions of consequence. We do that in the context of universal logic, without using artificial languages, but only using set theoretical tools. In this case, we do not use the operators of negations, conjunction, disjunction and other logical operators. We only work with operators and relations that preserve the essential characteristics of a Tarski logic. Nowadays, many new logics are proposed and even the general aspects of these operators and relations are not enough to involve them. These more general notions must be investigated in the context of universal logics in future researches.

b) A quantitative-informational approach to logical consequence

Itala M. Loffredo D'Ottaviano
(Unicamp, Philosophy Department, Centre for Logic, Epistemology and the History of Science – CLE, University of Campinas, Campinas, Brazil)

In this work, we propose a definition of logical consequence based on the relation between the quantity of information present in a particular set of formulae and a particular formula. As a starting point, we use Shannon's quantitative notion of information, founded on the concepts of logarithmic function and probability value. We first consider some of the basic elements of an axiomatic probability theory, and then construct a probabilistic semantics for languages of classical propositional logic. We define the quantity of information for the formulae of these languages and introduce the concept of informational logical consequence, identifying some important results, among them: certain arguments that have traditionally been considered valid, such as *modus ponens*, are not valid from the informational perspective; the logic underlying informational logical consequence is not classical, and is at the least paraconsistent *sensu lato*; informational logical consequence is not a Tarskian logical consequence.

c) Implication and information: a quantitative-informational analysis to material implication

Marcos Antonio Alves
(UNESP, Philosophy Department, State University of São Paulo, Marília/SP, Brazil)

We show that the usual material implication does not capture the notion of information as developed in Mathematical Theory of Communication by thinkers like Shannon. Initially, we define this quantitative notion of information, and then we introduce a probabilistic semantics for the language of classical propositional logic. After that, we define the probabilistic and informational values of formulae of such language, emphasizing the implication. We present some examples where the informational value of usual material implication does not capture the quantitative notion of information. Finally, we introduce a definition of probabilistic implication, whose definition of informational value is suitable for the quantitative notion of information.

PAPERS AND POSTERS

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Application of Support Vector Machines for Adulteration Detection of Bovine Milk

Wesley Becari, Gabriel Durante, Henrique Estanislau Maldonado Peres, Francisco Javier Ramirez-Fernandez
Department of Electronic System Engineering
Polytechnic School of the University of São Paulo
São Paulo, Brazil
wesley@lme.usp.br, gbdurante@gmail.com, hperes@lme.usp.br, jramirez@lme.usp.br

***Abstract*—Milk is one of the main brazilian food production sectors, among grain and meat sectors, with a total production of 35.50 billion liters in 2014. However, quality control does not attend the demand of the sector production growth, which facilitates fraud. Furthermore, current analyses checking adulteration in milk are primarily through analytical methods, performed in laboratory environment [1]. Thus, milk analysis and classification is an important way to prevent frauds. This work proposes a detection methodology of bovine milk adulteration applying Support Vector Machines (SVM) classifiers. SVM are a set of supervised learning methods used for classification, regression, recognition and prediction [2]. Through SVM it is possible to obtain higher classification accuracy and robust models [3] [4]. Three samples of cow milk were analyzed: raw milk, UHT (Ultra High Temperature) brand Ninho and UHT brand Paulista. These samples were diluted with different proportions of usual milk adulterants such as water, hydrogen peroxide, sodium hydroxide and formaldehyde. Then, the samples were characterized by measurements of its electric impedance, pH, temperature, and by the Time Domain Reflectometry (TDR) technique. Classification was performed with a 5-fold validation set, each fold with approximately 59 data obtained from the sensors. Linear and non-linear SVMs were trained with different kernels. The best results were obtained with a simple linear SVM that allowed qualifying milk samples as "unadulterated" or "adulterated". The overall percentage of correct answers (overall accuracy) was 94.9%. Therefore, the proposed methodology is useful for classifying milk, enabling the possibilities of local and real-time monitoring systems for fraud detection in milk composition.**

Keywords—Support Vector Machines; Electrical Impedance; Time Domain Reflectometry; Bovine milk analysis

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ANALYSIS OF SAMPLE ENTROPY DURING A RESTING-STATE EEG RECORDING IN ALZHEIMER'S DISEASE

Vinícius Godoi Fernandes
Center for Mathematics Computation and Cognition
Universidade Federal do ABC, UFABC
São Bernardo do Campo, Brazil
viniciusfernandes_17@hotmail.com

Lucas Remoaldo Trambaiolli
Center for Mathematics Computation and Cognition
Universidade Federal do ABC, UFABC
São Bernardo do Campo, Brazil
lucasrtb@yahoo.com.br

João Ricardo Sato
Center for Mathematics Computation and Cognition
Universidade Federal do ABC, UFABC
São Bernardo do Campo, Brazil
joao.sato@ufabc.edu.br

Renato Anghinah
Department of Neurology
University of São Paulo Medical School
FMUSP
São Paulo, Brazil
anghinah@usp.br

André Ricardo Oliveira da Fonseca
Center for Mathematics Computation and Cognition
Universidade Federal do ABC, UFABC
São Bernardo do Campo, Brazil
andre.fonseca@ufabc.edu.br

Abstract

Objective: Our study aimed to analyze the electroencephalogram (EEG) at rest in subjects with probable Alzheimer's disease (AD) to test the hypothesis that regularity is higher in these subjects than in age-matched controls. Method: We recorded EEG from 34 subjects, 22 with probable AD, and 12 normal elderly. We applied spectral analysis to test whether the data present a typical activity signature (reported in literature) and then we correlated the results with sample entropy. Results: Spectral analysis was able to detect differences between the control subjects and Alzheimer's subjects; there was a decrease in the spectral power of high frequencies and an increase in slow frequencies throughout the cortex, a finding which is characteristic of the phenomenon known as waves' slowdown. By comparing the sample entropy taken from both AD subjects and healthy adults, we observed more regularity in the EEG signal from the Alzheimer's group at rest. Conclusions: The sample entropy results complemented the findings obtained using spectral analysis, an increased regularity may also be caused by the slowdown phenomenon, due to the death of cholinergic neurons. Nonlinear analysis of EEG might provide valuable information contributing to a wider view on brain dynamics in AD, which are not observable using conventional methodologies.

Key words: Alzheimer; Spectral Analysis; Sample Entropy.

I. INTRODUCTION

Alzheimer's disease (AD) is a neurodegenerative disorder characterized by progressive cognitive impairment including memory loss. The disease is unusual in people under 50 years old, but is the most common cause of dementia in subjects over the age of 65 [13]. Its diagnosis can be difficult because symptoms may be confused with that often occur in aging, such as decreased cognitive performance. Therefore, life expectancy after the clinical diagnosis was 5 to 8 years [8]. So, the accurate and premature diagnosis is a relevant and salient point as life expectancy continues to increase.

Currently, the definitive diagnosis of Alzheimer's can be obtained only through necropsy, where one can observe histopathology findings such as protein beta-amyloid plates and neurofibrillary lesions [18]. However, a differential diagnosis can be made using clinical history, neuropsychological and imaging exams and analysis of cerebrospinal fluid [14].

A few drugs are worth mentioning due its effect on EEG, such as Donepezil - a cholinesterase inhibitor that is used to reduce cognitive impairments in mild-to-moderate AD – has shown to be associated with slower deterioration of electroencephalographic activity in AD in the resting state [3] and during cognitive tasks [11].

One reason for implementing EEG in an Alzheimer's study is the ability to observe changes in the power spectrum. These findings are an anatomical and functional reflection of the impairment caused by the disease's progression [24]. Quantitative EEG (qEEG) is a computational and topographical exam which deals with EEG tracing in a functional fashion. Its operates by temporal and frequency analysis of the EEG signal and has potential to be an excellent tool in AD studies because it is a simple, noninvasive and inexpensive method with excellent temporal resolution [36].

Regarding analysis of the EEG signal through different methods, the most common finding is the slowing of the EEG signal, which is commonly characterized by an initial increase in the presence of theta and delta waves and decrease in beta waves, followed by a decrease in alpha waves. Over the course of AD delta waves also increase [1,12,14,19,20]. Other studies have demonstrated the correlation of EEG slowdown with the atrophy degree [8] and disease severity [23] for decades.

The prediction of AD subjects based on EEG spectral analysis can reach an accuracy of 80% [10]. Some authors aim to infer whether the EEG signal can discriminate subjects with AD and normal elderly or subjects with MCI that may develop AD [30]. Others even try to discriminate AD from other diseases, such as Parkinson's disease, vascular dementia [2] and various form of fronto-temporal dementia, where the EEG power spectrum differs from AD in that there is a decrease in higher frequencies in the spectrum. On the other hand, given the highly nonlinear nature of neural interaction, the application of nonlinear methods is of great interest to EEG [20]. While EEG signal allows a temporal visualization of the cortical processes, changes that occur in the cerebral cortex itself may be measurable using changes in the EEG entropy, such analysis can be taken as a measure of the extent to which limitations imposed by DA reduced the number of states available in the cortex and it's based on potential differences between two pair of electrodes [31].

A deterministic nonlinear system can show dependence under initial conditions, implying that system different states may have been arbitrarily close at the beginning and become distant from each other over time. This behavior is known as deterministic chaos. Such complex and irregular behavior of a system shows similarities to a stochastic system. The brain has such a great number of correlated variables that it is impossible to measure them directly. How can we analyze this multidimensional dynamic measuring only a few variables? Reference [35] showed that if we measure one of these variables with sufficient accuracy for a long period of time, it is possible to reconstruct the underlying structural dynamics of the whole system from the behavior of this single variable. Based on this theorem, we can extract information related to underlying cortical dynamics by analyzing a group of trajectories (i.e. the attractor) reconstructed from time series (in this case, EEG). This procedure is related to the referred inverse problem. The geometric and dynamics properties of the trajectories in phase space are quantified by nonlinear measures [19,35]. That being said, nonlinear dynamic analysis can provide information about the progress of the disease that cannot be obtained by conventional analysis [1]. Lower complexity of the signal is the most common finding.

In this context, [1] applied two measures, approximate entropy (ApEn) and auto mutual information (AMI), to differentiate groups of normal elderly from probable AD subjects. These measures may infer regularities in the EEG signal, for example, a more pronounced decrease was seen in occipital regions, with significant results presented by some electrodes in the parietal and temporal lobes [1]. Previously he used spectral entropy (SpecEn) and sample entropy (SampEn) to test the hypothesis that the resting-state EEG in subjects with AD is more regular than the EEG in healthy subjects. In fact, they found smaller SampEn values at electrodes P3, P4, O1 and O2, a similar finding to those observed using other measures. Other studies such as [31,5] also used entropy measures in other EEG contexts, as SpecEn in the evaluation of states of consciousness while subjects underwent anesthesia and SampEn in the context of semantic information processing when subjects were confronted with false information, respectively.

In this study we evaluated the EEG power spectrum as a functional marker in AD and correlated the results with those obtained in the entropy analysis. Then we compared sample entropy between normal subjects and subjects with diagnosed as probable AD in order to show the feasibility of these measures as a biomarker for early prediction of AD.

II. MATERIAL AND METHODS

A. *Subjects*.

The dataset used in this study consists of EEG recordings from subjects with and without AD (controls). Two volunteers' samples were selected: the first group (G1) was composed of 22 probable AD individuals, 5 men and 17 women. The second group (G2) was composed of 12 healthy subjects, 4 men and 8 women. Participants were well-matched with regards to age, with control individuals, and probable AD having mean ages of 71.9 years (SD 7.7 years), and 68.7 years (SD 6.7 years). The mini mental state examination (MMSE) scored a mean of 15.9 for probable AD and 27.1 for control subjects. AD diagnosis was made according to the NINCDS - ADRDA, classified as mild to moderate, according to DSM V. The subjects had no history of diabetes mellitus, nephropathy, thyroidopathies, alcoholism, liver disease, lung disease or vitamin B12 deficiency, to avoid comorbid disorders related to cognitive impairment.

B. *Data Acquisition and Processing*

Project's experimental model was approved and authorized by the Coordinator of Ethics in Research of the Faculty of Medicine, USP (CEP-USP), and all subjects signed the informed consent form (Statement of Consent). These documents are listed under the jurisdiction of the USP Reference Center for Cognitive Disorders (CEREDIC), as a means of maintaining the confidentiality of subjects' personal data. EEG recordings were obtained with a Braintech 3.0 hardware (EMSA "Equipamentos Médicos"), with 32 channels, an A/D converter of 12 bits and a sampling rate of 200 Hz. The placement of scalp electrodes (Fp1 , Fp2 , Fz , F3 , F4 , F7 , F8 , C3 , C4 , Cz , Pz , P3 , P4 , T3 , T4 , T5 , T6 , O1 , O2 , Oz) followed the 10-20 international system, and we used one electrode connected to the earlobe as a reference, as recommended by the Brazilian Society of Clinical Neurophysiology and the American EEG Society [27]. During the examination, the recordings were obtained from awake and relaxed individuals, with closed eyes. Then the images were evaluated by an experienced technician in order to eliminate excerpts with artifacts (such as electrical interference, which can be originated from movements of the wires, bad contact, and eye movements). From the excerpts free of artifacts different segments of the signal were selected from all electrodes, each one divided in time intervals of 8 seconds, designated in the literature as "epochs ".

The digitized EEG signals containing epochs were submitted to a digital low-pass filter with cutoff frequency at 60 Hz. The filter used was the type II-R elliptical filter with a zero at the frequency of 60 Hz, which completely eliminates interference from the power grid. Frequency analysis was performed using Fast Fourier Transform.

C. *Entropy Analysis*

The usefulness of the information entropy estimators as a measure of cortical function are related to the fact that as cortical atrophy occurs due to death of cholinergic neurons, there is a decrease in the logarithm of the number of possible micro-states. Therefore, we can see entropy as the logarithm of the number of ways in which micro-states can rearrange still produce the same macro-state. In the context of the cerebral cortex, synaptic events cause the propagation of electrical charges along the scalp. Assuming that the processing of cortical information is linked to the distribution and transfer of electric charges, the EEG entropy is measuring cortical pyramidal neurons electrical activity [15,31].

1) *Sample Entropy*

To understand a dynamical non-linear system such as the brain, we use nonlinear time series analysis in a inverse problem approach, starting with the system output (in this case the EEG signal) and seeking to return to the state space, via obtaining its attractors and learning their properties.

Attractor state space reconstruction takes place via one or more time series observations from which we obtain a sequence of vectors in a *m*-dimensional space using a time lag parameter τ. If the system has an attractor, and *m* is sufficiently high, the series of reconstructed vectors will constitute an "equivalent attractor" with the same dynamic properties (dimension, Lyapunov spectrum, entropy) as the real attractor, as stated by Takens embedding theorem, obtaining valuable information about the dynamics of the system.

Usually the optimum embedding dimension *m* is determined from the concept of "false neighbors" (attractor points that are close within a *m* embedding dimension, but distant when *m* + 1) and the optimum time lag τ is related to the minimum of the original time series autocorrelation function or mutual information. Reference [35] suggests choosing the τ value that captures the smallest details of interest in the series, and the *m* value whose embedding window captures the biggest phenomenon of interest [5,34,35]. Those approaches consider *m* and τ as independent variables. We decided to use Gautama Mandic Hulle method based on the Kozachenko - Leonenko (KL) [5,116], which takes in consideration *m* and τ correlation as possible. The results were $m = 2$ and $\tau = 5$.

The sample entropy or *SampEn*, created by Richman and Moorman [29], is a modification of the approximate entropy or *ApEn* aiming for lower bias [28]. It is the negative natural logarithm of the conditional probability that two sequences that are similar for *m* points remain similar at the next point, where self-matches are not included in calculating the probability.It is the ideal method for neural signals that generate short and noisy series. For each artifact-free time series $X = X_1, \dots X_n$ it rebuilds its phase space:

$$\vec{x} = \left\{ \vec{x_i} = (x_i, x_i + \tau, \dots, x_i + (m-1)\tau) \right\}$$

with $i = 1, \dots, n - (m-1)\tau$. Based on a tolerance ε (set as 0.25 in our study), for all $\vec{x_i}, \vec{x_j} \in \vec{x}$ we define the $\vec{x_i}$ recurrence set as:

$$R_i = \left\{ \vec{x_j} : \left| \vec{x_i} - \vec{x_j} \right| < \varepsilon \right\}, i \neq j,$$

and the recurrence probability of $\vec{x_i}$ as:

$$P_i = \frac{\#R_i}{n - (m-1)\tau},$$

where # is the cardinality operator. The average recurrence probability for the *m-embedding reconstructed space* is $\overline{P_m} = \langle P \rangle$. Performing the same computation for the successive embedding dimension we define sample entropy as:

$$SampEn(m, \tau, \varepsilon) = -\ln \frac{\overline{P_{m+1}}}{\overline{P_m}}$$

The averaged sample entropy over trials for each interval was compared between conditions using permutation between paired t-tests. Low sample entropy indicates greater self-similarities in time series [1,5].

D. Statistical Analysis

For each channel, the *t*-test was applied to assess statistical mean differences between values of spectral analysis and sample entropy for subjects with probable AD and control subjects. The significance level was set at 5%. In addition, we applied the false discovery rate method (FDR) for multiple tests correction. For showing overlaps between the linear and non-linear a linear regression was conducted, as before, the significance level was set at 5% [6].

III. RESULTS

Table 1 shows the results of spectral analysis (log spectrum). When the relationship between the mean values of the subjects with AD were higher than the controls, the symbol (+) was used. Otherwise, the symbol (-) was employed. Those with a significant difference between groups ($p < 0.05$) were highlighted with the symbol (*). As can be seen, the alpha, beta and gamma bands showed significant results in most channels, regarding slow frequencies, that just happened in theta in the F3 channel.

Meanwhile, Table 2 summarizes the values found for sample entropy (log spectrum) of each group and each channel. As in Table 1, the relationship between the mean values of the groups are represented by the symbols (+) and (-), with significant values highlighted by the symbol (*). As can be seen, Sample entropy found seven channels (T5, Fp1, P3, T6, P4, Fz, Pz) where the means were significantly different. These results suggest that EEG activity of probable AD subjects is less complex than in normal brain in the frontal and parietal regions.

Table 1 - Relationship between the mean values of AD patients and controls for each spectral band and each channel. (+) represents AD values higher than controls, (-) AD values lower than controls and (*) the significant difference between groups (p <0.05).

	Channels																			
Band	*F7*	*T3*	*T5*	*Fp1*	*F3*	*C3*	*P3*	*O1*	*F8*	*T4*	*T6*	*Fp2*	*F4*	*C4*	*P4*	*O2*	*Fz*	*Cz*	*Pz*	*Oz*
Delta	+	-	-	+	+	+	-	+	+	-	+	+	+	+	+	+	-	+	-	+
Theta	+	+	-	+	+*	+	-	+	+	+	+	+	+	+	+	+	-	+	+	-
Alpha	-*	-*	-*	-*	-	-*	-*	-	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*
Beta	-	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*
Gamma	-	-	-*	-*	-	-*	-*	-	-*	-*	-*	-*	-*	+*	-*	-*	-*	-*	-*	-*

Table 2 – Values found for sample entropy of each group and each channel presented with mean±SD. Relationship column uses (+) to AD values higher than controls, (-) AD values lower than controls and (*) the significant difference between groups (p <0.05).

Channels	*Control subjects*	*AD patients*	*Relation*
F7	2.18 ± 0.22	2.17 ± 0.19	-
T3	2.27 ± 0.08	2.18 ± 0.22	-
T5	2.32 ± 0.06	2.14 ± 0.15	-*
Fp1	2.31 ± 0.17	2.13 ± 0.22	-*
F3	2.29 ± 0.12	2.22 ± 0.16	-
C3	2.31 ± 0.07	2.25 ± 0.15	-
P3	2.31 ± 0.05	2.17 ± 0.17	-*
O1	2.23 ± 0.12	2.15 ± 0.17	-
F8	2.17 ± 0.23	2.11 ± 0.22	-
T4	2.27 ± 0.17	2.21 ± 0.16	-
T6	2.25 ± 0.09	2.11 ± 0.20	-*
Fp2	2.32 ± 0.17	2.17 ± 0.23	-
F4	2.29 ± 0.11	2.21 ± 0.15	-
C4	2.31 ± 0.07	2.22 ± 0.15	-
P4	2.30 ± 0.06	2.18 ± 0.16	-*
O2	2.23 ± 0.12	2.14 ± 0.21	-
Fz	2.21 ± 0.37	1.82 ± 0.51	-*
Cz	2.31 ± 0.09	2.22 ± 0.18	-
Pz	2.32 ± 0.06	2.20 ± 0.19	-*
Oz	2.11 ± 0.36	1.83 ± 0.49	-

As another viewing of significance, distribution of significance values for these measures among the scalp can be seen in Figure 1. This one presents the topographical maps with the scalp distribution of t-values for the five spectral bands (a-e) and sample entropy (f).

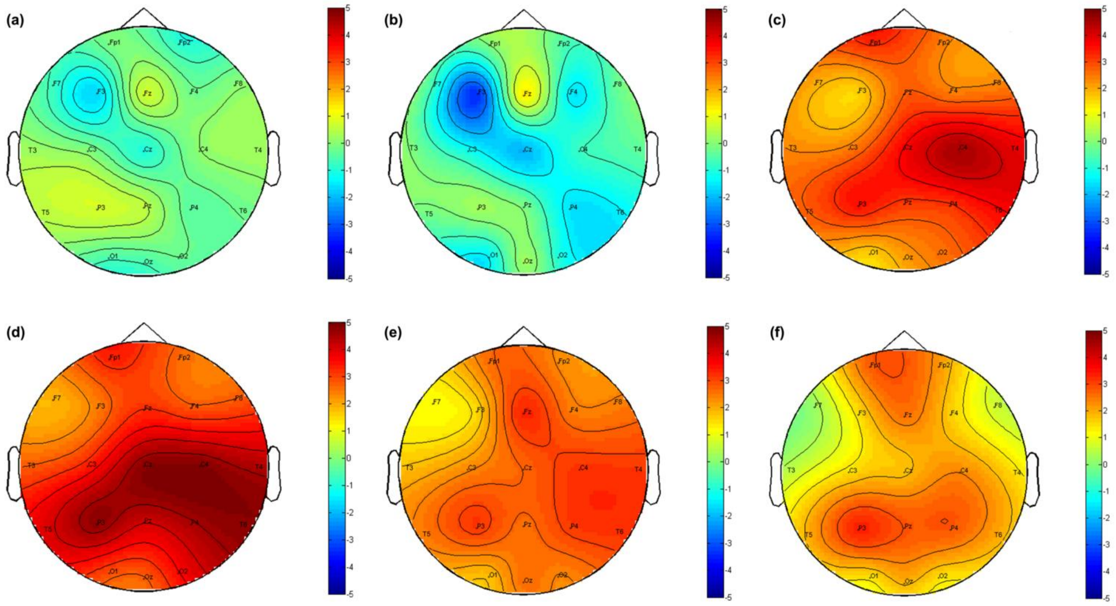

Fig. 1 - Scalp distribution of t-values (controls vs Alzheimer's disease subjects) for delta (a), theta (b), alpha (c), beta (d), gamma (e) bands power (spectral analysis) and the sample entropy (f).

Last, but not least, table 3 presents a linear regression between sample entropy and spectral analysis. As can be seen, there were eleven channels where a correlation between these measures was found.

Table 3 – Linear regression between sample entropy and spectral analysis for each channel. (+) represents a contribution of spectral analysis to predict sample entropy ($p < 0.05$).

Channels																			
F7	*T3*	*T5*	*Fp1*	*F3*	*C3*	*P3*	*O1*	*F8*	*T4*	*T6*	*Fp2*	*F4*	*C4*	*P4*	*O2*	*Fz*	*Cz*	*Pz*	*Oz*
+	+	+	-	+	-	-	-	-	-	-	+	+	+	+	+	+	-	-	+

IV. DISCUSSION

The spectral analysis measure showed the slowdown phenomena, which can be observed as the spectral power decrease of alpha, beta and gamma frequencies, with increased power of delta and theta. Even after applying the FDR correction, we still had significant differences in the cortex, especially in the alpha, beta and gamma frequencies. We noted significant differences in the parietal, frontal and temporal regions. Our findings show similarities to those reported by [2]: maximum spectral power of alpha along the cortex, mainly in occipital regions in healthy subjects, while in Alzheimer's subjects, alpha and beta were diffuse, they could be observed in central, parietal and anterior regions, which might vary according to the severity of the disease [2]. Yet regarding the disease progression, [10] observed a change in spectral power about thirty months after the probable diagnosis, with increasing in theta and delta frequencies and a decrease in alpha frequencies.

It has been suggested that the slowdown phenomenon has a close relationship with the integrity of the cholinergic system and cortico-cortical connections [2,4,14,30].

Despite these findings, it must be noted that a correlation between cognitive decline and symptoms may be biased due to differences in the algorithms used and individual differences, bearing in mind that the brain has plasticity and even healthy elderly individuals may show changes in the power of a given frequency over time.

Besides spectral analysis, we implemented sample entropy in order to assess EEG complexity through the signal regularity, from the operating variable observation; we infer the theoretical variable, i.e., the cognition decline through pathology. Sample entropy depicts the dynamics of the signal complexity in the time domain, considering the activation of the cortical micro-states. We believe that studies involving complexity may provide a better understanding of the relatively unexplored issue of the brain dynamics underlying Alzheimer's, enabling a better understanding of the disease through a connection with the neural substrates associated with its progression.

The sample entropy is an embedding entropy where a non- linear signal is reconstructed, this procedure provides information about the variation of the EEG signal over time, by comparing the signal with a time-lagged version of itself in a phase space [1,17]. We found significant results in nine channels, showing lower means in the Alzheimer's group compared to the control group, a result which is probably related to the limitations in the number of possible microstates of cortical activation and acquiescence following AD onset [1,31]. From these results we infer greater regularity in Alzheimer's and greater complexity in normal subjects.

When examining the alleged causes of this drop in complexity in individuals with AD in our findings, we adopted the hypothesis that there would be an overall decrease in neuronal interaction because of the death of cholinergic neurons, resulting in anatomo-functional decoupling. This would lead to a more simplistic and predictable neuronal firing pattern. In other words, our results indicate that a reduction in complexity is related to a reduced non-linear firing pattern, and that, on a behavioral level, should be associated with the cognitive decline commonly observed in AD [20]. Furthermore, there is a possible correlation between this drop in complexity and the slowdown phenomenon observed in the spectral analysis, given that the low frequencies are more regular [1,14].

The anatomical complexity of the brain varies due to AD, therefore a simpler cortical surface can result in smaller SampEn. Based on a similar idea, [21] investigated AD-related atrophy focused on the integrity of structures such as gyri and sulci, cortical thickness and compression degree. From this study we conclude this atrophy may lead to a loss in EEG complexity, which supports the biological hypothesis which associates the death of cholinergic neurons. However, it is important to note that atrophy may present itself in different ways, once there is a decrease in the degree of brain compaction, which can be observed presented in the complexity of the gyri and sulci, we can expect lower entropy, however, atrophy also can lead to a deepened sulci, which would result in a more complex anatomical configuration in some cases [21].

We conclude that the increased regularity in the case of SampEn in AD, may be subject to variations due to factors such as brain reserve capacity and compensation mechanisms, which is in agreement with the cholinergic death hypothesis while the main cause of complexity signal variability, as well as studies to explain different results between authors who have worked with the same measure. It is important to emphasize other causes for differences, such as the severity among subjects, the reference electrode influence (for methodological differences employing EEG), plasticity phenomena, among other methodological differences - which may ultimately preclude direct comparison between different techniques [22,34].

Among the limitations of our study we would like to emphasize the inability to detect impairment precisely in subcortical structures through the EEG, one limiting factor is a possible correlation with the level of regularity and the signal's spectral distribution and lesions in specific regions reported by certain authors [7,12,37]. Despite this spatial limitation, we believe that there is the possibility of obtaining an early diagnosis of Alzheimer's disease in a cross-sectional study and preferably correlated with other techniques, but due to the kind of approach of our study, even observing which cortical regions were affected, this was not possible. Another limitation we must point is the small number of participants.

Above all, before considering the use of EEG techniques for the purpose of differential diagnosis, it is necessary to bear in mind that although AD is progressive, which could paint the EEG as a good indicator of the disease severity before the onset of cognitive changes, the potential for recovery or adaptation varies greatly between acute onset with progressive development diseases, therefore, studies with the AD will not always allow direct implications for studies in other conditions and any conclusions should be made cautiously [7,34,37].

From our results we can infer that there are differences in corticocortical connectivity and the synchronization of neural rhythmic oscillations at several frequencies observed in pathological aging compared to the physiological state. We conclude that the discrimination between these states emerge at the group level, with possible applications at individual level. The possibility of combining the use of EEG biomarkers and imaging techniques allows a promising prognostic for risk groups, because it is an evaluation of low cost, non-invasive and widely available. Early identification of a patient with mild cognitive impairment may facilitate pharmacological intervention contributing to mitigation of the progression of the disease [25].

In conclusion, although it is tempting to point to a specific characteristic neural signature judging by the difference in average power and regularity between groups and say that it will turn into Alzheimer, one must remember that there are other dementias, such as vascular disease showing similar findings hence it is necessary to follow probable AD's subjects through longitudinal studies and in conjunction with techniques such as MRI and CT scans, because the EEG alone just infers that there was a change in the neural substrate associated with AD [26,32].

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Logical and Philosophical Foundations of Partial Belief Models

André Bazzoni
University of California, Berkeley
University of Sao Paulo
Email: andrebazzoni@gmail.com

***Abstract*—This paper is an attempt to put forward a new kind of partial model for representing belief states. I first introduce some philosophical motivations for working with partial models. Then, I present the standard (total) model proposed by Hintikka, and the partial models studied by Humberstone and Holliday. I then show how to reduce Hintikka's semantics in order to obtain a partial model which, however, differs from Humberstone's and Holliday's. I finally discuss the nature of such differences, and provide motivations for using the former rather than the latter.**

I. Introduction

In recent years, the recourse to partial models in modal logics has attracted an increasing interest among logicians, in spite of the fact that the idea dates back at least to the work of Humberstone in 1981—Barwise and Perry's [1] concept of *situation* is also close to the idea of a partial model—, without much development in the meantime (given the fabulous flourishing of modal logics in general, 24 years certainly represent some fragment of eternity). More recently, a volume of contributions edited by Doherty [3] was dedicated to the topic, while Cresswell [2] revived Humberstone's ideas in a partial framework for intuitionistic logic, and Holliday [6] finally adapted them to the epistemic/doxastic cases and also proved metalogic theorems for a number of related systems. Partial models have thus so to speak an aborted germination in the history of modal logics, but even though there certainly remains much to be done, the interest in this kind of models is seemingly being revived.

This paper follows the main insight of those previous works, namely that the notions of knowledge and belief can be more intuitively captured by using partial instead of total states, or possible worlds. This is typically achieved by letting the valuation function of a model be partial, thus extending the mathematical possibilities offered by the standard Kripke model.

The intuitive idea in the case of belief is simple enough: we say that some agent a knows/believes that φ in w *iff* φ is true at the knowledge/belief state of a with respect to w, where 'the knowledge/belief state of a with respect to w' is construed as a partial world. In order to achieve both partiality and single valuation, we will have to give up compositionality, though. The reason is that disjunction cannot be given a compositional semantics when it comes to partial worlds. However, it will be argued that compositionality is a reasonable semantic desideratum only insofar as total worlds are concerned, and in fact, the present account *is* compositional in the total case. Just as Holliday argued that partial valuation is intuitive in the cases of knowledge and belief, it will be argued in the same vein that non-compositionality is also intuitive in those cases.

I shall first present Hintikka's total model, and Humberstone–Holliday's partial model for belief. It will be argued that the partiality feature introduced by the latter constitutes a fundamental step towards an adequate semantics for belief.

Then starting from Hintikka's system, I will first show how the semantic clauses for knowledge and belief can be straightforwardly reduced to valuations in single worlds, instead of the universal quantification over worlds introduced by the standard approach. In order to construct a model on top of that, though, we shall have to consider some adjustments. In particular, we will need to allow valuation to operate on any formula of the language. The next step will be to give truth conditions with respect to the new model, respecting our working desideratum of having truth conditions at single worlds, without any quantification over worlds, which is a common feature of the two approaches introduced earlier. I shall finally address the motivations, problems and advantages of using the proposed partial model to formalize knowledge and belief.

II. Formal and conceptual motivations

Often in science, new important insights are brought to light from purely mathematical generalizations of previously existing formal theories. To cite but one canonical example, the mathematical apparatus behind general relativity comes from a generalization of Euclidean geometry, also known as Riemannian geometry. Of course, virtually anything is formally conceivable, but only a tiny share of all the sundry possibilities will eventually reveal fruitful to the investigation of scientific and philosophical questions.

The purpose of this paper is to consider a formal variation of the standard approach to the semantics of modal logics, i.e., the so-called possible-world semantics, and to provide it with formal and conceptual motivations for profitable future work.

Possible-world semantics exploits the powerful mathematical possibilities offered by the model-theoretic treatment of logical semantics. However, when it comes to the full realization of such possibilities, possible-world semantics remains underdeveloped in the following respect.

Since the pioneering work of Hintikka [4], a number of systems of epistemic logic have been proposed, most of them exhibiting high degrees of technical sophistication. On the other hand, all (roughly) of them seem to retain the fundamental conceptual bases of Hintikka's semantics for the notions of knowledge and belief. In particular, they all seem to rely on Hintikka's idea that those notions are to be understood on a par with the alethic 'box' (for the operator symbol $\Box$) modality from standard modal logics. In particular, the semantic clauses for knowledge and belief both involve (universal) quantification over a certain set of possible worlds governed by specific accessibility relations on worlds. According to this picture, it is crucial to possible worlds that they are total, in the sense that they provide a maximally consistent description of the relevant state of affairs, i.e., given a world w, we have either $p \in w$ or $\neg p \in w$ for any atomic proposition p of the underlying (in this case propositional) language. This 'totalistic' nature of worlds derives formally from the fact that the valuation function of the (Kripke-like) models interpreting the languages is itself total. However, we know that total functions are special cases of partial functions. That is to say, the standard models for modal logics exclude the mathematical possibilities offered by partial rather than total valuation functions.

A crucial common point of Humberstone's, Cresswell's and Holliday's approaches is that their semantics resolve the atomic indeterminacy on complex formulas through various formal techniques (Cresswell works with valuations at sets of worlds, whereas Humberstone and Holliday introduce a refinement relation on worlds in such a way that indeterminacy at some world w is eventually resolved at other worlds refining w). As we shall see, this may be viewed as a shift of the quantificational clause from the knowledge/belief operator, to disjunction. Indeed, the standard approach to epistemic logic due to Hintikka [4], in the tradition of Kripke semantics, treats knowledge and belief in terms of universal quantification over certain possible worlds. In Humberstone et al.'s approach, this quantificational element is placed on the clause for disjunction. We shall see that an underlying reason for this movement is to keep a unified and compositional truth definition at both total and partial worlds.

This paper follows a different track in that latter regard. While agreeing with Holliday in considering partial models for knowledge and belief more intuitive than the standard Kripke models, we shall further follow the idea that it is also more intuitive to consider valuation at single worlds in general, not only for belief statements, but also for disjunction.

Since knowledge and belief feature similar semantic behaviors on both the traditional and the present accounts, let us concentrate on belief throughout the discussion.

III. Possible-world semantics for belief

We work with a *doxastic propositional language* $\mathcal{L}_B$ equipped with a set $S = \{p, q, r, \dots\}$ of *atomic propositions*, and a finite set $I = \{a, b, c, \dots\}$ of *agents*. The set Φ of well-formed formulas of $\mathcal{L}_B$ is the smallest set generated by the following grammar:

$$p \mid \neg\varphi \mid \varphi \vee \psi \mid B_a\varphi$$

where $p \in S$ and $a \in I$. We use the usual abbreviations for conjunction, implication and equivalence.

The intended meaning of $B_a p$ is that "agent a believes that p". According to Hintikka's idea, $B_a\varphi$ is to be interpreted, with respect to some world, say the actual world ω, as saying that φ is true in *every* possible world compatible (or consistent) with what a believes in ω. The accessibility relation is thus a *compatibility* relation, and is relative to each agent.

Definition 1. *A* model *for $\mathcal{L}_B$ is a tuple $\mathcal{M} = \langle W, \{R_i\}_{i \in I}, V\rangle$, where W is a non-empty set of* possible worlds*, $R_i \subseteq W^2$ is an* accessibility relation *on W for each $i \in I$, and V is a (total)* valuation function *from $W \times S$ to $\{0, 1\}$.*

A model for $\mathcal{L}_B$ is a structure that interprets the non-logical symbols of $\mathcal{L}_B$. In particular, as we can see directly from the definition of $\mathcal{M}$, this means that the counterpart of an agent in a model is a compatibility relation: with each $i \in I$ is associated a compatibility relation R_i in $\mathcal{M}$.

Truth in $\mathcal{M}$ is defined relative to some world $w \in W$.

Definition 2. *A* pointed model *is a pair $(\mathcal{M}, w)$ consisting of a model $\mathcal{M} = \langle W, \{R_i\}, V\rangle$ and a world $w \in W$. The* satisfaction *relation $\vDash$ between a pointed model and a formula of $\mathcal{L}_B$ is defined inductively as follows:*

$\mathcal{M}, w \vDash p$	iff	$V(w, p) = 1$
$\mathcal{M}, w \vDash \neg\varphi$	iff	$\mathcal{M}, w \nvDash \varphi$
$\mathcal{M}, w \vDash \varphi \vee \psi$	iff	$\mathcal{M}, w \vDash \varphi$ or $\mathcal{M}, w \vDash \psi$
$\mathcal{M}, w \vDash B_a\varphi$	iff	for all $v \in W$, if $wR_a v$ then $\mathcal{M}, v \vDash \varphi$

IV. Possibility semantics for belief

Humberstone [7] devised a semantic model having possibilities in the place of possible worlds. There is more than one feature that distinguishes his model from the classic Kripke (or relational) models, but such features have a common source, namely the partiality of the valuation function V of the model. This means that his valuation function is not defined at all pairs (w, p) of a possibility w (rather than a possible world) and an atomic proposition p.

Humberstone does not deal with the specific modalities of knowledge and belief, but Holliday [6] adapted it to such cases, thus it is Holliday's formalization that will be at stake in the sequel.

Definition 3. *A* possibility model *for $\mathcal{L}_B$ is a tuple $\mathcal{M}_p = \langle W, \geqslant, \{f_i\}_{i \in I}, V\rangle$, where W is a non-empty set; $f_i : W \to W$ is a function; $V : W \times S \to \{0, 1\}$ is a* partial *valuation function; and $\geqslant$ is a weak partial order on W, such that the following conditions hold:*

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- (persistence) *If* $V(w,p)$ *is defined and* $v \geqslant w$*, then* $V(v,p) = V(w,p)$*;*
- (refinability) *If* $V(w,p)$ *is not defined, then there are* $u, v \geqslant w$*, such that* $V(u,p) = 0$ *and* $V(v,p) = 1$*;*
- (f-persistence) *If* $v \geqslant w$*, then* $f_i(v) \geqslant f_i(w)$*;*
- (f-refinability) *If* $v \geqslant f_i(w)$*, then there is* $w' \geqslant w$*, such that for all* $w'' \geqslant w'$*, there is* $v' \geqslant v$*, such that* $v' \geqslant f_i(w')$

The function of an $f_a(w)$ is to play the role of Hintikka's expression 'what a believes in w'. As Holliday puts it, "[a]t any possibility X, $f_a(X)$ represents the world as agent a believes/knows it to be." The idea is that we are now in a position to evaluate $B_a\varphi$ with respect to w directly at the possibility (i.e., partial world) $f_a(w)$, rather than at some totality of possible worlds as in Hintikka's model. Thus compare the truth definition of $B_a\varphi$ in $\mathcal{M}_p$ with the one proposed by Hintikka for $\mathcal{M}$.

Definition 4. *Given a possibility model* $\mathcal{M}_p = \langle W, \geqslant, \{f_i\}_{i \in I}, V\rangle$*, the satisfaction relation* $\vDash$ *between a pointed model of* $\mathcal{M}_p$ *and a formula of* $\mathcal{L}_B$ *is defined inductively as follows:*

$\mathcal{M}_p, w \vDash p$	iff	$V(w,p) = 1$
$\mathcal{M}_p, w \vDash \neg\varphi$	iff	for all $v \geqslant w, \mathcal{M}_p, v \nvDash \varphi$
$\mathcal{M}_p, w \vDash \varphi \wedge \psi$	iff	$\mathcal{M}_p, w \vDash \varphi$ and $\mathcal{M}_p, w \vDash \psi$
$\mathcal{M}_p, w \vDash B_a\varphi$	iff	$\mathcal{M}_p, f_a(w) \vDash \varphi$

Where Hintikka's clause for belief involves universal quantification over a certain set of possible worlds, Humberstone–Holliday's semantics evaluates belief directly at a single world, namely $f_a(w)$. Indeed, this seems much more intuitive than Hintikka's suggestion: when expressing my belief that the earth is round, I do not feel like I am considering all possible worlds compatible with what I believe about our actual world, to eventually conclude that 'the earth is round' holds in all of those worlds. It seems even that such a cognitive operation is an impossible task. I take this move of placing the evaluation of a belief sentence at the world representing the beliefs of the relevant agent not only as an important improvement on the standard view, but also as a definitive one—belief sentences *must* be interpreted along the lines of Humberstone–Holliday's proposal.

If this is correct, the immediate consequence is that we cannot do epistemic/doxastic logic without partiality. To state this point crudely, $B_a\varphi$ must be evaluated at the single state describing a's beliefs, and this single state cannot be total in general—it could be so only if a had beliefs about every proposition in S. Even if we postulated S to be finite, its cardinality should be considerably restricted. At any rate, none of such conditions appear to be realistic as a model of actual doxastic situations.

Now it seems puzzling at first blush to learn that partial worlds are so essential and at the same time have been so marginal throughout the history of epistemic/doxastic logic. It seems puzzling, indeed, to read that a believes that φ means that φ is true in all worlds compatible with a's belief state, and not simply that a is true in a's belief state. Why such a hopeless tour of the vast compatible universe?

The reason is that partiality breaks down monotonicity. We shall come back to this crucial point, but for the time being let us consider Definition 4 again. We have seen that the belief clause is no longer stated in terms of universal quantification. However, such a quantification seems to have somehow moved to the *negation* clause. What happened?

The answer is directly related to the relation $\geqslant$ in the possibility model $\mathcal{M}_p$ (cf. Definition 3). Indeed, the unique kind of relation in $\mathcal{M}$ was the compatibility relation, and its role is played in $\mathcal{M}_p$ by the functions f_i: while agents were understood as compatibility relations in $\mathcal{M}$, they are viewed as partial worlds in $\mathcal{M}_p$; but nothing in $\mathcal{M}$ seems to correspond to $\geqslant$. And as one can appreciate, this relation only appears in the semantic clause for negation in Definition 4.

V. Reducing Hintikka's system

In this section we shall see how we can reduce by set intersection the set of all compatible worlds with respect to some agent, to a single set. The idea is simply to, given some agent a and some world w, take the intersection of all possible worlds compatible with what a believes in w.

We proceed in three brief steps. We first recall that the standard way of understanding an element $w \in W$ (I henceforth drop reference to a particular model whenever convenient) is as being itself a set: the set of all atomic propositions p such that $\mathcal{M}, w \vDash p$. That is to say, w is the set of all atomic propositions that are true in w. Secondly, we define the set of all possible worlds compatible with what a believes in w, and finally we take the intersection of all sets belonging to that set.

Definition 5. *For each* $a \in I$ *and* $w \in W$*, call* $\mathcal{R}_a(w) = \{v \in W : wR_av\}$ *the* compatibility space of a with respect to w*. We next define* the belief state of a in w *as the following set:*

$$\mathcal{B}_a(w) = \bigcap_{v \in \mathcal{R}_a(w)} v$$

Why have we called $\mathcal{B}_a(w)$ a belief state? The reason is that $\mathcal{B}_a(w)$ is the formal notation for the expression 'what a believes to be true in w'. Indeed, $\mathcal{B}_a(w)$ is by construction the intersection of all worlds compatible with what a believes in w, therefore a proposition belongs to $\mathcal{B}_a(w)$ if and only if it belongs to what a believes in w.[1]

However, from such a perspective on possible worlds, $\mathcal{B}_a(w)$ fails to characterize a belief state. To see why, consider the formula $\varphi := B_a(p \vee q)$ of $\mathcal{L}_B$. Suppose φ is true in w. This means that a believes φ in w, or in other words, that φ belongs to the belief state of a. The problem is that φ need *not* be in $\mathcal{B}_a(w)$, for a may believe that p or q is true without believing that either p is true or q is true—provided also that a believes neither $\neg p$ nor $\neg q$.

[1] It follows from classic axiomatic set theory that $\mathcal{B}_a(w)$ is a set and is unique, assuming that $v \in W$ is a set.

For example, I may believe that 'Mary or Sally is the winner' without having any belief about which of them is the winner; actually, I believe neither of the following: 'Mary is the winner', 'Sally is the winner', 'Mary is not the winner', 'Sally is not the winner'. In short, I have no beliefs at all about the atomic propositions of φ, yet I do have a belief about φ. Curiously, Hintikka's expression 'what a believes in w' does not capture a's belief state in w.

The point is thus that $\mathcal{B}_a(w)$ does not fully capture the notion of a belief state, because w is a set of atomic propositions, but $\mathcal{B}_a(w)$ is not generated from atomic propositions. One way out of this issue is to postulate a possible world not as a set of atomic propositions, but more generally as a set of propositions *simpliciter*. In this way, $\mathcal{B}_a(w)$ does seem to represent the belief state of a with respect to w, and it then immediately follows from the definitions that:

$$\mathcal{M}, w \vDash B_a\varphi \quad \text{iff} \quad \varphi \in \mathcal{B}_a(w)$$

This suggests that $\mathcal{B}_a(w)$ might itself be viewed as a possible world, namely the possible world describing how a understands w.

Definition 6. *For each $a \in I$ and $w \in W$, we call $w_a(w) := \mathcal{B}_a(w)$ the* possible doxastic world of a in w.

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Notice that agents are no longer ... relations, since these latter have ... doxastic worlds. In other words, agents are now construed as belief states with respect to certain ('ordinary' or doxastic) worlds. The model must then be modified accordingly.

Definition 7. *A* partial doxastic model *for $\mathcal{L}_B$ is a tuple $\mathcal{M}_B = \langle W, W_I, V_B \rangle$, where W is a non-empty set of possible worlds, $W_I \subset W$ is a set of possible doxastic worlds, and $V_B : W \times \Phi \to \{0, 1\}$ is a partial valuation function.*

Notice that V_B has Φ, not S in its domain, and that it is a partial function. This encodes the two distinguishing features of possible doxastic world as compared to the possible worlds described by the standard models. First, they are sets of propositions, atomic or not. Second, they are partial, not total. Of course, the ordinary total worlds are preserved in partial models, but now they are special cases of the more general mathematical picture.

There is a problem with the first point, though. Specifically, when we try to extend the definition of truth in $\mathcal{M}$ to $\mathcal{M}_B$, we immediately realize that the clause for disjunction would have to be split in two, the old one for total worlds and a new one for partial worlds. This reflects another issue at stake here, namely compositionality.

Definition 8. *Given a partial doxastic model $\mathcal{M}_B = \langle W, W_I, V_B \rangle$, the satisfaction relation $\vDash$ between a pointed model of $\mathcal{M}_B$ and a formula of $\mathcal{L}_B$ is defined inductively as follows (we write $W_{\setminus I}$ as short for $W \setminus W_I$):*

$$\begin{array}{lll}
\mathcal{M}_B, w \vDash p & \text{iff} & V_B(w, p) = 1 \\
\mathcal{M}_B, w \vDash \neg\varphi & \text{iff} & \mathcal{M}_B, v \nvDash \varphi \\
\mathcal{M}_B, w \vDash \varphi \vee \psi & \text{iff} & \begin{cases} w \in W_{\setminus I} : \mathcal{M}_B, w \vDash \varphi \text{ or } \mathcal{M}_B, w \vDash \psi \\ w \in W_I : V_B(w, \varphi \vee \psi) = 1 \end{cases} \\
\mathcal{M}_B, w \vDash B_a\varphi & \text{iff} & \mathcal{M}_B, w_a(w) \vDash \varphi
\end{array}$$

where $\nvDash$ is the dissatisfaction relation *(or* falsehood*), which is also given inductively:*

$$\begin{array}{lll}
\mathcal{M}_B, w \nvDash p & \text{iff} & V(w, p) = 0 \\
\mathcal{M}_B, w \nvDash \neg\varphi & \text{iff} & \mathcal{M}_B, v \vDash \varphi \\
\mathcal{M}_B, w \nvDash \varphi \vee \psi & \text{iff} & \mathcal{M}_B, w \nvDash \varphi \text{ and } \mathcal{M}_B, w \nvDash \psi \\
\mathcal{M}_B, w \nvDash B_a\varphi & \text{iff} & \mathcal{M}_B, w_a(w) \nvDash \varphi
\end{array}$$

Again, conjunction, implication and equivalence are abbreviated as usual. We see that there is no quantification over worlds involved any longer in the semantic clauses above. The price we pay is that disjunction must be defined by cases, and compositionality fails. But notice that nothing is new as regards the standard total worlds—disjunction behaves classically in their case. It is really the need for partiality and single valuation that introduced a new 'semantic case'. As we have seen, however, this is what we wanted in order to stay closer to what really seems to happen with real-life agents. To put it in fancy terms, the worlds are left untouched, and ... by the limits of agents' minds. ... we need a separate clause for negation. This is desirable to capture the fact that negation is actually contradictory negation also in the case of doxastic worlds. To illustrate what is going on, let us consider again the English sentence 'Mary is the winner', and some agent, say Bill. Bill may very well have no beliefs at all about whether Mary is the winner, so the sentence may be undefined in Bill's doxastic world. However, if Bill does believe that Mary is (or is *not*) the winner, he must also believe that it is false that Mary is not (or *is*) the winner, thus if the semantic value of 'Mary is the winner' is defined in Bill's doxastic world, so must be 'Mary is *not* the winner'. Therefore, it seems that negation is contradictory negation in doxastic worlds.

We see from Definition 8 that, contrary to the positive case, the falsehood clause for disjunction *is* compositional. The reverse would happen for conjunction if it would be explicitly given in the language. The intuition is clear: if Bill believes that it is false that Mary or Sally is the winner, then Bill believes that Mary is not the winner, and that Sally is not the winner.

Notice also that even though partiality introduces a gap between truth and falsity, such a gap is not of the same nature as the one created by three-valued semantics (e.g. in intuitionistic logics), precisely because negation is contradictory. As a consequence, double negation and De Morgan's Laws also hold.

To close our discussion, a further point concerning axiomatization. A number of completeness problems have been proved for different systems of classic epistemic/doxastic logic, and Holliday also provided some for Humberstone's. On the other hand, the proofs benefit from the method of extending partial to total worlds. This is clear in both Hintikka's and Humberstone's ideas of quantifying over possible worlds or possibilities. Indeed, it seems that one way of understanding this systematic recourse to partiality resolution could be that it is already designed to prepare the ground for further axiomatizations and proofs of meta-theorems.

The semantics proposed above has an outline that does suggest incompleteness. However, I shall not discuss axiomatization here, e.g. whether we could devise techniques for proving completeness for some variations of certain axiomatizations, and the like. This is mainly because I see no obvious reason why we should require complete axiomatizations of doxastic reasoning. Should one *force* complete systems on naturally incomplete ones? If incompleteness does in fact follow, it should be viewed as a 'local' phenomenon, in the sense explained above in connection with compositionality. Moreover, Hintikka [5, ch. 1] himself claimed that the descriptive (i.e. expressive) function of logic is more basic than its deductive function. In line with Hintikka's observation, and without going into questions of order of importance, it does seem to me that the descriptive function should at least be the *guide* for formalization. It is this latter point that I found lacking in the main existing approaches to the semantics of knowledge and belief representations.

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VI. Conclusion

The present paper offered reasons for treating belief states according to two basic ideas. First, belief states are partial. Second, belief statements and disjunction are to be both assessed at single points of valuation. As we have seen, the first point may be viewed as a reduction of the standard semantics for belief due to Hintikka, which rests on total models, following the usual practice among modal logicians. The second point presents an alternative to existing partial models for belief such as the one proposed by Holliday after Humberstone's work, which treats disjunction in terms of quantification over possible worlds—thus shifting quantification from belief statements as in Hintikka's case, to disjunction statements. According to this alternative view, both belief and disjunction statements are evaluated at single possible worlds.

Partiality was attained by allowing the valuation function of our models to be partial, as in the cases of Humberstone and Holliday. Singularity (with respect to valuation) was achieved by letting the domain of the partial valuation function span the totality of the underlying language, and not only its atomic sentences. A troubling consequence of this latter step is that compositionality ceases to hold. However, as we have seen, compositionality only fails with respect to the fragment of the language dealing with belief, which does seem realistic as a representation of how belief states typically operate—specifically, in the case of 'disjunctive belief'.

A number of formal developments are open to future research, such as questions related to axiomatization, completeness, and complexity. This paper had only the much more modest goal of setting the philosophical and logical foundations for a so to speak 'single-partial' model for belief representation.

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Analysis of skills and competencies of logical reasoning in a logic puzzle in traditional and in digital environment

Lucy Mari Tabuti, Ricardo Luis de Azevedo da Rocha, Ricardo Nakamura
Escola Politécnica
Universidade de São Paulo (USP)
São Paulo, Brazil
lucymari@gmail.com, rlarocha@usp.br, ricardo.nakamura@poli.usp.br

Abstract— *The progress of technology and its access to a large number of people, especially in mobile devices, make digital puzzles and games a very popular tool, also in academic environment. Although, for digital puzzles – mainly logic ones – to have acceptable quality in education, they must be developed in a way that skills and competencies of traditional puzzles are kept in the digital environment. This article presents a study of skills and competencies of logical reasoning in a logic puzzle both in traditional and in digital environments. The study shows that most of the skills and competencies of logical reasoning when developed in traditional environment are preserved in digital environment.*

Keywords—skills; competencies; logic reasoning; logical games; puzzles, cognitive science.

I. Introduction

The progress in information and communication technology makes easier to children, teenagers and adults to use different digital applications in mobile devices. Regardless of the knowledge area they will be immersed, their logic and cognitive development can be qualified by digital puzzles and logic games [17].

The traditional logic puzzles and games, besides being the oldest kind of games, challenge the gamer by presenting problems involving reasoning and patience. Kuperschmid e Hildebrand [4] share the vision that puzzles and logic games challenge mind much more than reflex, by encouraging mind in solving problems, both thoughts as patience, in addition to being fun.

Ramos [21] understands that the developing a pedagogical work with games, especially puzzles and logic games, helps to exercise and develop cognitive aspects in students, making them playful and pleasant. The students' cognitive, affective and social aspects are also improved by the puzzles and logic games, which enables the development of imagination, imitation and rule.

For Ramos [21], puzzles and games that are logically challenging, drive to problems that make gamers think, raise hypotheses, try, plan, test, solve calculations, which contribute to the development of logical reasoning, planning, visual perception and attention.

As these high school students were born in the Internet generation, Fraiman [7] says that these young people grew up in a different mind model, synapses formed in a different way comparing to the analogue generation, born before the Internet.

For Freire [8], nobody ignores everything. Nobody knows everything. Everybody knows something. Everybody ignores something. That is why we always learn. Nevertheless, these students from the Internet generation need to be connected to the digital world to learn.

It's important to seek a pedagogical educational model focused on students from the current generation. Fraiman [7] says that the transference of knowledge methods used in our schools need to be quickly changed to a digital version, (…), it is only then we can set up an efficient communication protocol to them, to obtain success in learning.

Nonetheless, Ott and Pozzi [19] comprehend that it is important to get a deep study in the development of logical digital puzzles and games in order to maintain the creativity of children and teenagers when used for the educational purpose. In the same way, researches such as those from Mäyrä, Holopainen e Jakobsson [15] that show that digital puzzles and games have evolved, might be used.

Fraiman [7] and Sato [23] suggest that the logical digital puzzles and games are the virtual tool to optimize work and time for students and teachers from the current generation, when used in the teaching-learning process.

In this sense, the motivation of current students have easy access to the internet and mobile devices, we have developed a learning study of logical reasoning in both the physical and digital environments.

This article shows a study of skills and competencies of logical reasoning in a logical puzzle call Magic Cube shown in Fig. 1, in the traditional and virtual environments, to understand whether all the features in the traditional environment are preserved in the virtual environment.

We are considering the use of Magic Cube puzzle in the traditional and virtual environments to train students in the skills and competencies of logical reasoning.

In section II, we present some related work. In section III, some cognitive science concepts, competencies and skills of logical reasoning, and magic cube are described. The methodology applied in this research was described in section IV, showing the research subjects profile, how the research was made, and the script of the study. In section V we present the results in transposition, environment, and traditional and digital interaction. In section VI, we present the results discussion and in section VII some conclusions and future works.

The purpose is to get answers for these questions:

- How the traditional puzzles are used for children, teenagers and adults education to generate benefits in learning?
- How are the criteria been applied to measure if the characteristics given by the traditional logical puzzles are preserved when are used in the digital puzzles? And
- What are the difficulties in the development process of digital puzzles to preserve the original characteristics of the traditional form of the puzzles?

Hence, we developed researches on a group of students to understand how logical reasoning skills and competencies are developed in a logical puzzle called Magic Cube, both in traditional and the digital environments. As a result, it could be seen that most of the logical reasoning skills and competencies are preserved in both environments.

II. Related Works

Researches has been taking traditional or digital logical game development such as one from Tonéis [3], who studied the development from a digital game to math and logical reasoning teaching which provided a better way of learning to students. In this work, logical puzzles, besides involving the logical reasoning, it can also be used to the development of math concepts.

As well as this research, Ramakers, Luyten and Schoening [16] also proposed a learning system based on digital puzzle, but for people who use deformation principles from 3D puzzle in mobile devices.

Researches from Garcia, Abed, Tufi and Ramos [10], related to the application in cognitive skills of magic cube, show a methodology, applied to a curricular and pedagogical program to the development of social, emotional, and ethical cognitive skills by reasoning puzzles, with an emphasis in the relevance of learning and on the role of the teacher-mediator.

Part of the magic cube research in the digital environment can mention Dantas et al. [5], who proposed a methodology where digital puzzles were used in the skills development to solve problems.

In the same line of reasoning about magic cube in digital environment, Ramos [21] showed some electronic cognitive puzzles and its contributions to the learning process in high school from an exploratory research and systematic remark, based on behavior category which presented changes related to attention, the capacity to solve problems, and social behavior.

Tabuti and Nakamura [24] showed a systematic review to study the current methodologies in the development of digital logical games and puzzles qualified to teaching. They considered 31 researches on digital games and puzzles, most of them logical reasoning based.

III. FOUNDATION

To make this research, it required a study of the cognitive science, the skills and competencies of logical reasoning related to the cognitive science and logical puzzles, the relevance of cognitive puzzles and games for children, teenagers and adults learning, and the magic cube as a logical puzzles used to reasoning development.

A. Cognitive Science

The work of Lepre and Aragon [13] is related to the theory of relevance learning of David Ausubel [27], which approach the cognitive learning, with two necessary conditions to a remarkable learning: the student disposal to a remarkable learning and without memorizing and a potential significant content, with relevant material.

However, for Lima Junior [14], the learning relevance can be related to technology by the deep digital innovation process, as data processing development of computational machines in fixed or mobile devices, and the spreading of telematics networks.

The purpose of Lima Junior [14] is to connect to some kind of tripod formed by technology, communication, and cognitive science, the comprehension of flow information and their impact in a media ecosystem formation.

In the research of Ramos [21], the relevance in the games and puzzles for child's development is presented as essential to the childish and teenager cognitive development.

In this research, Ramos [21] presents electronic games as a new model of cognitive activity and their contribution in the learning process, and says the electronic cognitive games and puzzles are involved by a content, structure and mechanic activity, which benefit the cognitive skills exercise, and make essential to the good performance in the digital puzzles and games.

Magic cubes, as those other logical puzzles, are potentially relevant materials to a significant learning, and when they get into digital puzzles with all skills and competencies, they might get important tools in the significant learning process because they can be used in fixed or mobile devices and be spread by telematics networks.

Primit et al. [20] present cognitive skills and competencies that measure reasoning and knowledge by the interdisciplinarity and the problem-solving context. These skills and competencies can be analyzed and applied to study the magic cubes and logical puzzles to a significant learning in digital innovation.

B. Competencies and skills of logical reasoning

For Fraiman [6], comprehend the learning capacity of students might be useful for the daily challenge of teaching, then, it is important to think out of box and encourage students to improve themselves in knowledge, the best they can.

Nery's [18] researches indicate that digital puzzles and games provide children and teenagers development. Some elements of development might motivate logical and mathematical skills, strategy plan and overcoming obstacles, focus and creativity, social skills development, accepting frustration and rules, physical activity, and existential feeling.

Some logical reasoning skills and competencies and capability to develop strategies to solve any problem in any area of the knowledge help students to organize themselves in the social and academic activities.

The skills and competencies of logical reasoning considered for the analysis of the digital and traditional logical puzzles and games were noticed in Brazil [1] in the Parâmetros Curriculares Nacionais (PCN), a Brazilian curriculum parameters, and used by Garcia, Abed e Ponte [9], Garcia, Abed, Soares e Ramos [10] e Sales [22] as showed in Table 1.

With the development of the competency of analyses, students might be capable to improve skills and solve complex problems separating in simpler problems, in easier problems and the skills to recompose all the results to solve the complex problem.

With the development of the competency of synthesis, students might be capable to improve skills of join problems information and data of different issues; skills to identify the weaknesses of theses issues to resolve the problem; the skills to identify the lack of necessary information to solve the problem; the skill to prioritize and order all the information to get a sequence of the development until resolve the problem.

With the development of the competency of inference, students might be capable to develop skills to discover new patterns in a range of information: and the skills to input them to new ones preserving the earlier pattern structure.

These competencies and skills of logical reasoning were used in the digital and traditional logical puzzle of Magic Cube.

C. Magic Cube

In 1974, Professor Erno Rubik from Hungary developed a logical puzzle well known today by Magic Cube or Rubik's Cube (Fig. 1). The magic cube was created by Rubik to explain the relationship of spaces for his students. The magic cube became the most sold logic toy in the world because it is implicated in challenging problems and logical intelligence, simple and complex, stable and dynamic, order and chaos [12].

For Kiss [12], Rubik's cube became famous because it is easy to understand, easy to know the end result without instruction, although it is necessary the algorithm to resolve in most cases, and it is ever the most frustration and addictive invention been created.

For Araújo, Santos Junior, Santana and Castro [2], magic cube is a puzzle that requires logical reasoning to be resolved and it might be used as a teaching resource in an efficient educational tool because of its casual feature.

Zorzal, Oliveira, Silva, Cardoso, Kirner and Lamounier Junior [26] understand that logical puzzle, besides been used for having fun, might develop the personal cognitive view, and that they connect the magic cube with one of logical puzzle that can cooperate in the children, teenagers and adults cognitive development.

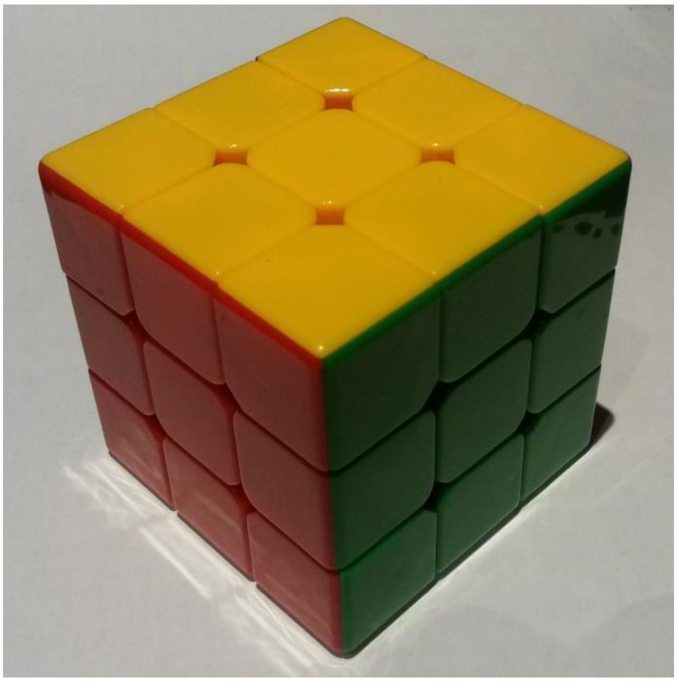

Fig. 1. Magic Cube

IV. METHODOLOGY

Nowadays, some of Brazilian basic education and universities employ, with greater or lesser intensity, digital logical puzzles and logical games to stimulating the learning of students [28]. In this context, this research defines students from technological graduation and post graduation degree.

The methodology research used is the exploratory research, because it gives more knowledge related to the issue. Exploratory research from bibliographic research and from case studies might cover bibliographical survey and the interview of people involved in the problem process to be researched [11].

The case study methodology identifies the relevant questions like how and why the questions for the research from contemporary events, without scene control of all the events involved by researcher [25].

The bibliographic research was defined by analyzing the documents and the case studies through observation, questions and interviews taken for problem deepens purposes.

To answer the research questions, we considered in the qualitative and quantitative data analysis the following students' issues:

- Understanding the questions;
- Defining forms questions which theorize the problem of the research;
- Outline the field strategies;
- Observing the process in the scene of the research;

- Knowing the hypothetical questions that might be made in the research;
- Ordering and organizing the material and notes made in the research;
- Transferring knowledge gotten from the field to theory;
- Interpreting information properly;
- Making comprehensive texts, seen in context and a research providing a picture of the reality; and
- Assuring validity criteria and reliability.

The data were analyzed by quantitative and qualitative manner, from form filled in by people with objective and subjective questions.

The objective questions might be analyzed on a 7-point scale, ranging from "completely disagree" to "completely agree" in 20 questions created to the research.

The subjective questions were created to investigate what were the favorite environment and/or the best environment to develop the magic cube, and to see the advantages and disadvantages gotten from people in the research, in traditional and digital environment during research. Research instrument can be seen in Appendix A.

The research data are presented in data tables and contextualization.

A. People who participated in the research

To guarantee the necessary and deep research results, the research sample consisted of two groups, 14 students each, to perform the exploratory research of skills and competencies preservation study used in traditional and digital logical reasoning puzzles, composed by university students from technology courses.

All university students that participated in this research were at full age and they are/were graduated or post graduate students.

About genre, in this research, the male sex predominated with 86.5% against female sex with 13.5%.

B. How the research was made

The methodology applied presume the following steps and their resources:

- Cataloging the state of the art through bibliographic review in the logical puzzles, digital puzzles, criterion for the assessment in the logical puzzles characteristics, skills and competencies of logical reasoning and cognitive science, to ratify and rectify the problem in this research;
- Definition of the unit case and the number of cases to study (like the problem itself, to ratify and rectify the purpose in the study from samples);
- Create a research protocol from the bibliographic reference and the questionnaire used and the interview applied;
- Collect data about competencies, strategy and skills analyzes in the digital logical puzzles, based on techniques of documents, questions, interviews and observing analysis;
- Perform qualitative analysis of collected data to structure a preserving skills and competencies study of logical reasoning in a magic cube from identified elements in the earlier steps; and
- Definition of fundamentals marks and criteria to measure the efficacy in the methodology applied in the research.

C. Script of the study

The script used in the study was defined as:

- Give instructions to do the task in the magic cube and the risks involved in the study;
- Each individual person must receive the same magic cube. When initiated by the digital puzzle, the traditional magic cube was delivered after digital puzzle finished. When initiated by the traditional puzzle, it was delivered in the beginning;
- Explanation of magic cube and the basic concepts of magic cube;
- Explanation of the first layer solution algorithm of the magic cube;
- Resolve the traditional magic cube and check how long it took to be done;
- Install the application of 3x3x3 magic cube for smartphone;
- Resolve the magic cube in the application installed in the smartphone;
- Resolve the magic cube by using the computer desktop mouse;
- Resolve the magic cube by using the computer desktop keyboard;
- Fill in the questionnaire on this research.

V. RESULTS

The Research Ethics Committee of the University Hospital, of the University of São Paulo (CEP-HU/USP) has approved this research and delivered the consolidated number 1.114.876 in 06/19/2015.

After the research finished, the data of the research was put in a results table to be analyzed. We employed ANOVA two factor to measure statistically significant correlation and to analyze the application effect of the traditional and digital environment variables and in the transposition of traditional to the digital environment and the digital to the traditional environment.

After analyzing ANOVA results, we made a Turkey test graphic to analyze the different causes in ANOVA analyses.

In Table I there are the summaries of the skills in each competency analyzed in this study.

TABLE I. COMPETENCIES AND SKILLS

competencies	skills	skills descriptions
analysis	**H1**	Skill to solve a complex problem separating in smaller part with immediate solution
	H2	Skill to recompose de results of the research to solve the complex problem
synthesis	**H3**	Skill to put together the data and information of a problem of different issues
	H4	Skill to evaluate the weaknesses of the information to solve the problem
	H5	Skill to describe the lack of information to solve the problem
	H6	Skill to prioritize the information to solve the problem
	H7	Skill to order the information and obtain a sequence of development to solve the problem
inference	**H8**	Skill to discover pattern format in a range of information
	H9	Skill to use again some information and add newer ones to put in the existing pattern structure
	H10	Skill to use again some information and add newer ones to put in a group to preserve the existing pattern structure

Table II shows the p-value of competencies and skills of logical reasoning analyzed in the result study of the magic cube, considering the environment (traditional and digital), transposition (traditional/digital and digital/traditional) and interaction (environment and transposition).

TABLE II. P-VALUE OF THE COMPETENCIES AND SKILLS

competency	skill	Environment (Tra/Dig) p-valor	Transposition (T/D e D/T) p-value	Interaction envir/transp p-value
analysis	**H1**	0.091	0.044	0.732
	H2	0.028	0.214	0.214
synthesis	**H3**	0.205	0.855	0.205
	H4	0.322	0.016	0.322
	H5	0.009	0.048	0.738
	H6	0.215	0.000	0.215
	H7	0.003	0.000	0.393
inference	**H8**	0.006	0.010	0.566
	H9	0.000	0.040	0.433
	H10	0.047	0.160	1.000

Table III shows the preferred environment or the best environment used to resolve the digital and traditional magic cube.

TABLE III. ENVIRONMENT USED PREFERENCE

	Environment	
	Traditional	***Digital***
preference	100%	0%
best	89%	11%

A. *Transposition*

Based on Table II results, Fig. 2. shows the average of the transposition in the use of the magic cube in the Traditional to Digital environment comparing to Digital to Traditional environment on a scale of zero to seven points.

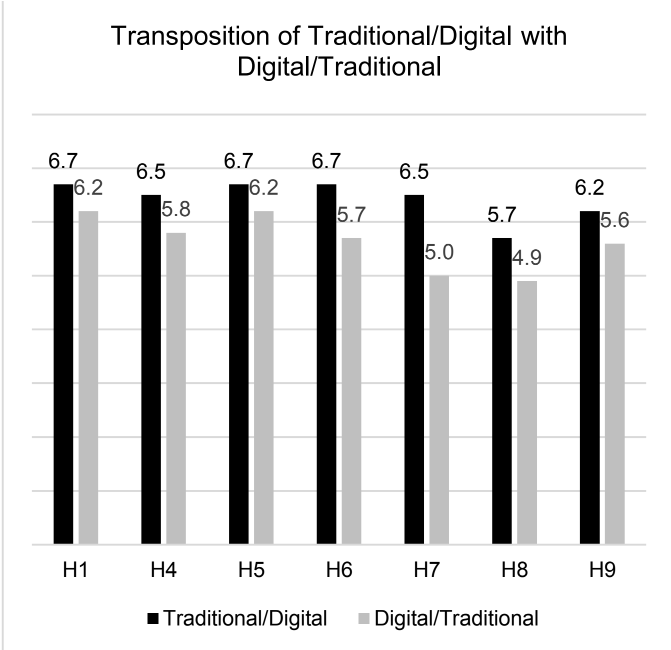

Fig. 2. Average of transposition Traditional/Digital and Digital/Traditional

Analyzing the results shown in the Table II, to the value $p <= 0.05$, related to the transposition Traditional to Digital and Digital to Traditional, observe that:

- For a P value equal to 0.044, considering the graphic from Tukey test, checked that the skill H1 to solve a complex problem separating in smaller part with immediate solution, in the analyses competency developed to resolve the magic cube, was the most used when beginning by traditional environment first. It was 6.7 points average in the traditional to digital against 6.2 points average in the digital to traditional;
- For a P value equal to 0.016, considering the graphic from Tukey test, checked that the skill H4 to evaluate the weaknesses of the information to solve the problem, in the synthesis competency developed to resolve the magic cube, was the most used when beginning by traditional environment. It was 6.5 points average in the traditional

to digital against 5.8 points average in the digital to traditional;

- For a P value equal to 0.048, considering the graphic from Tukey test, checked that the skill H5 to describe the lack of information to solve the problem, in the synthesis competency developed to resolve the magic cube, was the most used when beginning by traditional environment. It was 6.7 points average in the traditional to digital against 6.25 points average in the digital to traditional;
- For a P value approximately equal to 0.000, considering the graphic from Tukey test, checked that the skill H6 to prioritize the information to solve the problem, in the synthesis competency developed to resolve the magic cube, was the most used when beginning by traditional environment. It was 6.7 points average in the traditional to digital against 5.7 points average in the digital to traditional;
- For a P value approximately equal to 0.000, considering the graphic from Tukey test, the skill H7 to order the information and obtain a sequence of development to solve the problem, in the synthesis competency developed to resolve the magic cube, was the most used when beginning by traditional environment. It was 6.3 points average in the traditional to digital against 5.0 points average in the digital to traditional;
- For a P value equal to 0.010, considering the graphic from Tukey test, checked that the skill H8 to discover a pattern format in a range of information, in the competencies of inference developed to resolve the magic cube, was the most used when beginning by traditional environment. It was 5.7 points average in the traditional to digital against 4.9 points average in the digital to traditional;
- For a P value equal to 0.040, considering the graphic from Tukey test, checked that the skill H9 to use some information and add newer ones to put in the existing structure, in the competencies of inference developed to resolve the magic cube, was the most used when beginning by traditional environment. It was 6.15 points average in the traditional to digital against 5.6 points average in the digital to traditional.

B. *Environment*

Based on the results shown in the Table II, Fig. 3. shows the average using the logical reasoning skills in the use of magic cube in the traditional environment and digital environment.

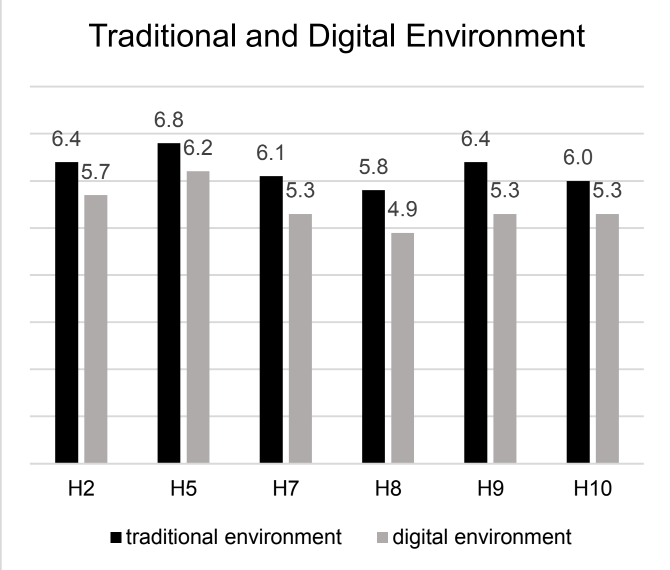

Fig. 3. Average in the of skills in the traditional and digital environment

Analyzing the results shown in the Table II, to the value p <= 0.05, related to the Traditional environment and Digital environment, observe that:

- For a P value equal to 0.028, considering the graphic from Tukey test, checked that the skill H2 to recompose de results of the research to solve the complex problem, in the competencies of analysis developed to resolve the magic cube, the traditional environment was more used than digital environment. It was 6.4 points average in the traditional against 5.7 points average in the digital;
- For a P value equal to 0.009, considering the graphic from Tukey test checked that the skill H5 to describe the lack of information to solve the problem, in the competencies of synthesis developed to resolve the magic cube; the traditional environment was more used than digital environment. It was 6.8 points average in the traditional against 5.2 points average in the digital;
- For a P value equal to 0.003, considering the graphic from Tukey test checked that the skill H7 to order the information and obtain a sequence of development to solve the problem, in the competencies of synthesis developed to resolve the magic cube; the traditional environment was more used than digital environment. It was 6.1 points average in the traditional against 5.25 points average in the digital;
- For a P value equal to 0.006, considering the graphic from Tukey test, checked that the skill H8 to discover a pattern format in a range of information, in the competencies of inference developed to resolve the magic cube, the traditional environment was more used than digital environment. It was 5.8 points average in the traditional against 4.9 points average in the digital;
- For a P value equal to 0.000, considering the graphic from Tukey test, checked that the skill H9 to use some information and add newer ones to put in the existing

pattern structure, in the competencies of inference developed to resolve the magic cube, the traditional environment was more used than digital environment. It was 6.4 points average in the traditional against 5.3 points average in the digital;

- For a P value equal to 0.047, considering the graphic from Tukey test, checked that the skill H10 to use some information and add newer ones to put in a group to preserve the existing pattern structure, in the competencies of inference developed to resolve the magic cube, the traditional environment was more used than digital environment. It was 6.0 points average in the traditional against 5.3 points average in the digital.

C. Traditional and Digital Interaction

Analyzing the results shown in Table II related to the Traditional and Digital Interaction and transposition of the Traditional to Digital environment and of the Digital to Traditional environment, there is no p-value less or equal than 0.05 to generate significant difference analysis.

D. Quantitative Results

Analyzing the qualitative results from the qualitative questions applied in this study, observe that:

- 100% of all the answers indicate that it is easier to resolve the magic cube in traditional logical puzzle than the digital logical puzzle, because it is easier to face all the sides of the magic cube, better control of the logical puzzle because it is easy to handle, to not make mistake in the logical puzzle handling, to be useful with intuitive turn with usability, familiar environment to use, better to memorize all the movements, better control of the movements, apply a necessary speed to handle the magic cube, preview of the current state of the puzzle is better;

- The advantage to resolve the logical puzzle in traditional environment is related to the view of all the sides of the magic cube, in the easiest view of all pieces, it is easy to handle movements, easy visualization to rotate magic cube, the movement is precise and hope as expected, the movement is faster, control of logical puzzle on hand, it is fast to return in a wrong face and it is not necessary to adequate interface command because it is real;

- 56% of all answers indicate that there is no advantage resolving the logical puzzle in a digital environment but there are some as playing anywhere from a mobile device, play by shortcuts, back a wrong move, to not take traditional puzzle wherever you go, automatic shuffling, it is not necessary to buy a traditional logical puzzle and easy to restart;

- 66% of all answers indicate that there is no disadvantage resolving the logical puzzle in a traditional environment but there are some such as the rotation crashes depend on the magic cube quality, sometimes it gets confused movement, it can be broken, there is no automatic shuffling;

- 100% of all answers indicate that there are some disadvantages resolving the logical puzzle in a digital environment, most of them are related to the impossibility to face all the sides of the magic cube, the unexpected command made, the complex movement, the complex view of the digital puzzle, the difficulties using the keyboard, the uncomfortable color view, the logical puzzle in a digital environment is not intuitive, magic cube gets static, it is necessary to manipulate the interface first and after resolve the problem, the interface it not easy to use, it is necessary to have a device, software or internet to play;

- Some bad point of view, suggestion and ideas were introduced, all of them from the logical puzzle in a digital environment. Such as an intuitive and useful keyboard, possibility to see three faces for the magic cube all time, visualize all the six sides in the same time, the possibility to back a wrong move, the possibility to insert arrows to indicate the movement do be done, use bottoms with arrows, use easiest key in the keyboard, command subtitle and a visual feedback.

VI. RESULTS DISCUSSIONS

Based on the profile of all the individual person that took part on of the research, the physical structure for both groups and the results in the section V, can be said that:

- For skill H1 to solve a complex problem separating in smaller part with immediate solution, in the analyses competency developed to resolve the magic cube, although it was most used when beginning by traditional environment if compared with resolved in a traditional environment first, in 92.5% of cases that resolve in a digital environment first also used skill H1;

- For skill H2 to recompose de results of the research to solve the complex problem, in the competency of analysis, more used in the traditional environment than the digital, comparing to them whose resolved in the traditional environment, 89.1% of the cases from the digital environment also used the skill H2;

- For the skill H4 to evaluate the weaknesses of the information to solve the problem, in the competency of synthesis, developed to resolve the magic cube, although it was most used when beginning by traditional environment if compared with resolved in a traditional environment first, in 89.2% of cases that resolve in a digital environment first also used skill H4;

- For skill H5 to describe the lack of information to solve the problem, in the synthesis competency developed to resolve the magic cube, although it was most used when beginning by traditional environment if compared with resolved in a traditional environment first, in 93.3% of cases that resolve in a digital environment first also used skill H5. And, more used in the traditional environment than the digital, comparing to them whose resolved in the traditional environment, 91.2% of the cases from the digital environment also used the skill H5;

- For skill H6 to prioritize the information to solve the problem, in the synthesis competency developed to resolve the magic cube, more used in the traditional environment than the digital, comparing to them whose resolved in the traditional environment, 85.1% of the cases from the digital environment also used the skill H6;

- For skill H7 to order the information and obtain a sequence of development to solve the problem, in the synthesis competency developed to resolve the magic cube, although it was most used when beginning by traditional environment if compared with resolved in a traditional environment first, in 79.4% of cases that resolve in a digital environment first also used skill H7. And, more used in the traditional environment than the digital, comparing to them whose resolved in the traditional environment, 81.1% of the cases from the digital environment also used the skill H7;
- For skill H8 to discover a pattern format in a range of information, in the competencies of inference developed to resolve the magic cube, although it was most used when beginning by traditional environment if compared with resolved in a traditional environment first, in 86.0% of cases that resolve in a digital environment first also used skill H8. And, more used in the traditional environment than the digital, comparing to them whose resolved in the traditional environment, 84.5% of the cases from the digital environment also used the skill H8;
- For skill H9 to use some information and add newer ones to put in the existing structure, in the competencies of inference developed to resolve the magic cube, although it was most used when beginning by traditional environment if compared with resolved in a traditional environment first, in 91.1% of cases that resolve in a digital environment first also used skill H9. And, more used in the traditional environment than the digital, comparing to them whose resolved in the traditional environment, 82.8% of the cases from the digital environment also used the skill H9;
- For skill H10, more used in the traditional environment than the digital, comparing to them whose resolved in the traditional environment, 88.3% of the cases from the digital environment also used the skill H10.

VII. Conclusions and Future Works

From the discussion of the research results, it can be said that H1, H4, H5, H6, H7, H8 e H9 competencies and skills, related to the transposition of Traditional to Digital and Digital to Traditional was preserved in 88% of the cases.

Besides, it can be seen that H2, H5, H7, H8, H9 e H10 competencies and skills related to Traditional and Digital environment were preserved in 75% of the cases.

Based in results shown in the Table III, Fig. 4 shows that 100% of all individual person preferred to resolve the Traditional magic cube and 89% believed it is the best choice.

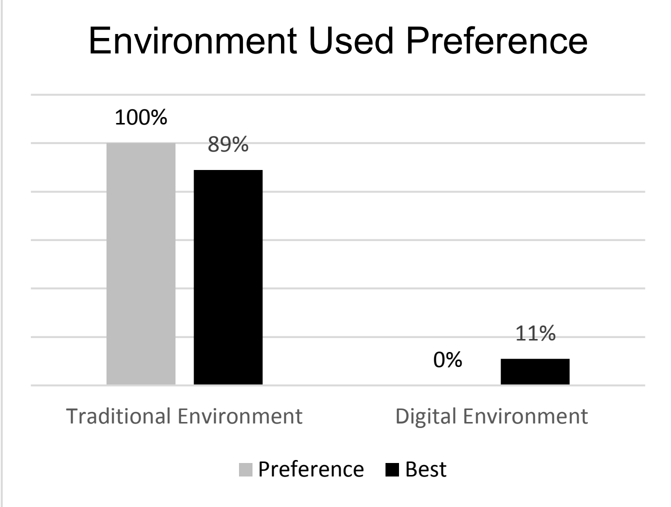

Fig. 4. Environment ussed preference

The qualitative results indicate that it is easier resolving the traditional magic cube because it is easier to view all the faces, it is easy to handle and the intuitive logical reasoning use.

To resolve the magic cube, advantages and disadvantages indicate that traditional environment is preferred than the digital.

For all the competencies and skills studied resolving the magic cube, it was preserved in 78% in the traditional environment and 70% in the digital.

To continue this study, logical puzzles like seen in Fig. 5 and other logical puzzles and logical games can be analyzed when resolving in the traditional and digital environment, to analyze the competencies and skills preserved in the logical reasoning evolved such as board puzzles and games, math and logical reasoning puzzles and games, strategy games, puzzle and others.

Fig. 5. Logical games

We are considering the use these all puzzles in the traditional and virtual environments to train students in the skills and competencies of logical reasoning.

Besides, the development and analyze of logical games and logical puzzles in the digital environment using virtual reality can be considered.

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APÊNDICE A

Modelo de Questionário – Experimento I

Perfil do sujeito de pesquisa:

Idade: ____ anos Sexo: ( ) Masculino ( ) Feminino

Email: ____

Ano Escolar:

( ) Ensino Fundamental II

( ) Ensino Médio

( ) Graduação

( ) Pós-Graduação

Tempos desenvolvidos pelo sujeito de pesquisa:

Qual o tempo de resolução do jogo de lógica no meio físico?

Qual o tempo de resolução do jogo de lógica no aplicativo do *tablet*?

Qual o tempo de resolução do jogo de lógica no aplicativo do *smartphone*?

Qual o tempo de resolução do jogo de lógica no *site* com auxílio do *mouse*?

Qual o tempo de resolução do jogo de lógica no *site* com o auxílio do teclado?

Questões: Escala com 7 pontos, variando de "Discordo plenamente" a "Concordo plenamente":

1 – Para resolver o jogo de lógica físico, dividiu-se o problema maior em subproblemas menores.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

2 – Para resolver o jogo de lógica físico, reuniu as soluções dos subproblemas menores numa solução para o problema maior.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

3 – Para resolver o jogo de lógica físico, utilizou-se de conhecimentos prévios.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

4 – Para resolver o jogo de lógica físico, as informações coletadas foram suficientes.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

5 – Para resolver o jogo de lógica físico, todas as informações coletadas foram utilizadas.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

6 – Para resolver o jogo de lógica físico, foi capaz de entender a importância de cada informação coletada.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

7 – Para resolver o jogo de lógica físico, foi capaz de pensar numa sequência adequada.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

8 – Para resolver o jogo de lógica físico, foi capaz de pensar em um ou mais padrões para um conjunto de informações.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

9 – Para resolver o jogo de lógica físico, foi capaz de executar o(s) padrão(ões).

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

10 – Para resolver o jogo de lógica físico, manteve a mesma estrutura de padrões.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

11 – Para resolver o jogo de lógica digital, dividiu-se o problema maior em subproblemas menores.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

12 – Para resolver o jogo de lógica digital, reuniu as soluções dos subproblemas menores numa solução para o problema maior.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

13 – Para resolver o jogo de lógica digital, utilizou-se de conhecimentos

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

14 – Para resolver o jogo de lógica digital, as informações coletadas foram suficientes.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

15 – Para resolver o jogo de lógica digital, todas as informações coletadas foram utilizadas.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

16 – Para resolver o jogo de lógica digital, foi capaz de entender a importância de cada informação coletada.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

17 – Para resolver o jogo de lógica digital, foi capaz de pensar numa sequência adequada.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

18 – Para resolver o jogo de lógica digital, foi capaz de pensar em um ou mais padrões para um conjunto de informações.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

19 – Para resolver o jogo de lógica digital, foi capaz de executar o(s) padrão(ões).

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

20 – Para resolver o jogo de lógica digital, manteve a mesma estrutura de padrões.

Discordo plenamente ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 Concordo plenamente

Questões Dissertativas:

21 – É mais fácil resolver o jogo de lógica no meio físico ou no digital? Por quê?

22 – Quais as vantagens em resolver o jogo de lógica no meio físico?

23 – Quais as vantagens em resolver o jogo de lógica no meio digital?

24 – Quais as desvantagens em resolver o jogo de lógica no meio físico?

25 – Quais as desvantagens em resolver o jogo de lógica no meio digital?

26 – Críticas, sugestões e ideias. Pode-se colocar o número de cada questão e realizar comentários separadamente.

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Presuppositions about the role of consciousness in the Agent Causation conception of agents and the problem of the Disappearing Agent

Beatriz Sorrentino Marques
PhD student at Dept. of Philosophy - USP
São Paulo, Brazil
biasorrentino@usp.br

***Abstract*—Well-known Agent Causation theories rely on a certain conception of agency that leads to the expectation that agents play a role in the production of their action, a conscious role. According to this conception of agents, the requirement about consciousness is the ground for these theories to pose the objection of the Disappearing Agent to the Causal Theory of Action. I will argue that, in a similar way, Daniel Wegner [12], [13] defends the idea that consciousness is a defining mark of agency. However, Wegner is not an Agent Causationist; in this sense, he is viewed here as posing a modern version of the view that consciousness is a requirement for agency, and of the view that without consciousness playing a part in the production of action the role of the agent would be lacking in this production.**

I will argue that the objection of the Disappearing Agent raised by Agent Causation theories [2], [9], [10] also equates lack of consciousness with lack of agential role in the production of action. This will show that the issue is grounded on a specific conception of what an agent is, and what her role in producing actions should be. In this sense, the elements that ground the Disappearing Agent objection resemble Wegner's view. I, however, defend the claim that this conception of agency should be revised, as well as the problem of the Disappearing Agent, because if we accept Wegner's arguments, human agents cannot fulfill the requirements in question.

***Keywords*—consciousness; control; agent**

I. INTRODUCTION

The lack of consciousness during the production of some actions—such as automatisms—leads Wegner to claim that conscious mental states are not part of this production [12]. And the lack of a role for consciousness in the production of action is the reason why Wegner claims that we are not agents and that we do not cause what we do [12], which can be related to the concern made explicit in the problem of the Disappearing Agent (DA). The DA is an objection that has been advance by Agent Causation (AC) to the Causal Theory of Action's (CTA) account of actions: CTA is accused of not accounting for the agent's role in the production of her action, since according to this theory mental states causally produce her action [2], [7] (p. 110–11), [10], [11].

On the same note, Wegner claims that there are no agents because he holds a conception of agency that involves conscious origination of action; let's call this the Illusory Agent (IA) view.

Though Wegner argues that actions are not actually consciously originated by the agent, he seems to think that if we were to be considered agents, then consciousness would have to originate our actions, which is analogous to AC's concern about the agent playing a role in the production of her action (p. 341-42). I will argue that for the agent to *play a role* in the production of her action involves the requirement that she must have conscious control over her action. This shows that the issue of the DA springs from a specific conception of what an agent would be and what her role should be in the production of actions under this conception.

Though posed differently, Wegner's IA shares similarities to the traditional DA problem. I will argue that the problem is related the conception of agents as being associated with her consciousness and with *regulative control* (see section II). It is possible to pose the traditional problem in a way that shows how conscious participation in the production of action is crucial to the theories that raise this objection. I will argue that consciousness is seen as relevant for the production of actions in representative AC views [8], [10], because it plays the important role of insuring a kind of control over actions that is held dear by this theory: regulative control.

If Wegner is correct when he claims that consciousness does not play a relevant role in originating (or controlling) our actions [12], then these cannot be requirements for human agency; unless we are willing to claim that we are not agents; nevertheless, we then would have to ask what in fact would agents be and what sort of entity would fit the criteria for it. So, instead of concluding something as contradictory to our daily experience, like Wegner does when he claims that we are not agents, it may be best to accept that the conception of agents advanced by AC, and which Wegner seems to endorse, is a mistaken conception, lest we risk throwing the baby out with the bathwater. Therefore, AC and IA set the bar too high for agency. Our conception of *human* agents cannot have requirements that human beings cannot fulfill; therefore, the concept of human agents cannot involve

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conscious origination, or control, over the production of our actions. This conception of agents must be revised, and once it is revised the problem of the DA does not arise.

II. Regulative Control and Consciousness

In AC theories, if the agent does not cause her action in the special sense of causing[1] according to which the theory supposes agents produce their actions, the agent is not considered as having played a relevant role in the production of her action [2], [8]. And it is implied by Wegner's view that only actions caused by the conscious will (which he claims to be an illusion) would allow us to be agents. Roughly, CTA claims that intentional actions are caused (not necessarily in a deterministic way) and are, at least in part, causally explained by mental states[2] [4], [5], [6]. This is why it is said that CTA makes the agent disappear from the production of action, because it does not propose that the agent herself plays a role in producing action; instead, it suggests that her mental states would causally contribute to the production of her action.

Furthermore, AC requires that the agent have a sort of control that would guarantee that she could have acted otherwise than she did, and this control would guarantee her involvement in the action [2], [8]; [10]. Even theorists who do not endorse AC, but are concerned about the DA seem to endorse this requirement [11]. This is what John Martin Fischer [3] has called *regulative control* and it depends on the agent's conscious supervision over her actions. If the agent cannot control her action it is claimed that she has no role in its production [8], [10].

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This may cast doubts on wh[illegible] this requirement of agential role. [illegible]ce, when an agent brakes before she even notices that a cat ran into the street—let's suppose that it all happened so fast that she could not have prevented herself from doing so—because of her training as a driver that has automatized that she shall brake at the vaguest sign of any creature running into the road. Her action is faster than her conscious processing of the perceptual information. So, even if she has an unhealthy hatred for cats and would have preferred running it over, she would have braked before she could have noticed that it was a cat.

According to the versions of AC being discussed [2], [8], [10], in the story, the driver would need to have been able to *not* brake by consciously vetoing her braking action, so that she could be considered having played a role in it. This story makes apparent that regulative control is required by AC in order for the agent to have a role in the production of her action.[3] It also must be clear that this kind of control is not required by CTA because the mental states that play a causal role in it are already the agent's; though the theory may require control of another kind[4] in order to attribute responsibility to the agent for her action.

Without regulative control some AC would consider the action unfree, as if the action was produced by external forces that were not the agent's. One example is Timothy O'Connor's [8] theory. O'Connor does not accept that an agent may be ignorant of her intention [8]:

> What of the limiting case—total conscious ignorance of one's intention in acting? Here, I think, the agency theorist must say—what is independently plausible—that one does not act *freely*. I, at any rate, am unable to conceive an agent's directly controlling his own activity without any awareness of what is motivating him (p. 88).

In O'Connor's theory, in order to control one's own activity, one must be conscious of some of the mental states that motivate the agent to act. So if there was lack of consciousness of these motives involved in the agent causing her action it would result in lack of control. The assumption that freedom is tied to *conscious* production of action is a key reason to why AC theories consider actions in which the agent was not conscious of producing (which results in not having regulative control) as lacking a role for the agent in it; because lack of freedom[5] in acting is associated to something other than the agent producing the action, since she did not have [illegible] the problem of the agent not [illegible] the production of her action.

But perhaps not all human actions can be produced with the same amount of control. Some actions fall short of the criteria to be classified as *full-blooded* actions of the agent, as Velleman [11] classifies actions in which the agent it said to *participate*. We know that many times we act automatically, or are influenced by external factors, like when a drunk college student stumbles towards his house stepping all over his neighbor's garden flowers, even while trying to avoid them. In this case, the alcohol ingested played a relevant role in the agent's lack of balance/control. So, in the debate about the agent's role in the production of action, actions that do qualify as full-blooded are considered as having a distinctive characteristic.

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[1] In general, some kind of substance causation.

[2] Theories, though, may vary in the details. Some may take beliefs and desires as playing the major causal role in action production, while others may take motivations, intentions, and other causal contributors, as well as planning [1] to be relevant.

[3] We may suppose, nonetheless, that Wegner would not see any reason to claim that the conscious experience of control that we have over our actions is not an illusion as well. After all, he does not attribute any role to conscious mental states in the production of action.

[4] Some supporters of CTA believe that guidance control is important for the agent to be responsible for her action. For an agent to have guidance control over an action requires that the mechanisms that issue in the action must respond to reasons of the agent to some extent [3].

[5] Under the conception of Free Will that requires that the agent must have been able to do otherwise.

[6] To Chisholm [2], the problem with reducing statements about an action done by an agent to an event-causal account is not just reducing the AC into statements in which events play the causal role. The problem is doing so without losing the meaning, that the agent did A, and still accounting for the fact that the agent could have done otherwise. According to Chisholm, the reduction must be done in a way that it will leave open the possibility that the agent could do otherwise, thus granting her control over her action. The right sort of control, regulative control, is what will keep the agent from disappearing in the case of a successful reduction.

This is clear in Velleman's discussion of the DA. Even if he does not endorse AC, Velleman [11] does not believe that an explanation of actions that involves only motives and intentions causing action can account for the distinctive characteristic of a full-blooded action [11]:

> When my desires and beliefs engendered an intention to sever the friendship, and when that intention triggered my nasty tone, they were exercising the same causal powers that they exercise in ordinary cases, and yet they were doing so without any contribution from me. Hence what constitutes my contribution, in other cases, cannot be that these attitudes are manifesting their ordinary causal powers. (p. 465)

Velleman believes that: (1) since there can be actions that are caused by motives and intentions in the *normal* way (mental states causally producing the action) that the agent does not identify herself with; (2) while she identifies with other actions produced in the same way; (3) the agent's *role* in her action is not due simply to motives and intentions causally contributing to the production of the action, even if the causation goes in the normal way. The agent must add something to her motivational influence in order to identify with her action.

According to Velleman, the distinction that makes actions full-blooded, which we will take here to mean actions in which the agent is said to play a role in their production, is that the agent's desire to act in accordance with reasons plays a role in it. This desire would contribute to her motivations in tipping the balance in favor of the reason that provides the strongest reason to act, and allegedly it would amount to the agent exercising control over what she does. The desire would perform the agent's *function* in producing action and it would turn the agent's *thought* (conscious thought) to her motives [11]. Therefore, she would act full-bloodedly when this desire turns the agent's thought to her motives for acting, because the desire actually would, functionally, play the agent's role. In this view, we may conclude that it is the agent's conscious thought that plays her role functionally.

Hence, the agent having a role in the production of the action, and being able to alter it seems to be what is considered missing in the CTA account of action that allegedly issue in the problem of the DA. This is the consensus between Velleman's and AC's account of the problem. And this seems to involve the belief that the agent must have some kind of direct control over her action, not only to originate it, but also to change it if she pleases.[7] This would involve being conscious of this production (or at least potentially conscious).

Chisholm's [2] concern is whether agent causation could be reduced to event causation in a way that action would not lose its meaning in the midst of statements about events as causes, but in which the agent would have no originating role. In order to be successful, Chisholm holds that this kind of reduction would have to leave open that the agent could have done otherwise, so that she would have control over her action [2].

Steward [10] is also concerned with the agent having meaningful control over her action in order for the action to be attributed to the agent (as will be seen in the next section). In this sense, the relevant control that Steward is concerned with would be the kind that would allow the agent to choose to execute or not her actions.

This is why regulative control over one's actions is viewed as necessary, along with the supposition that the agent must be conscious, or at least aware that she is producing her action in order for her to be considered to have a role in producing it. And, this goes along with Wegner's conclusion that if actions are causally produced by unconscious activities, then there is no agency.

III. Agents and Their Role in Action Production

AC raise the DA objection to CTA's account of actions by claiming that the agent doesn't play any role in it; therefore such explanation of action production cannot account for actions produced by a human agent. However, this is an odd statement. It is curious to claim that the agent has no role in producing her action if it is causally produced by the agent's mental states. This strangeness is salient exactly because, according to CTA, the action is caused by her mental states. I have argued that the objection springs from AC's expectation that action production would involve a conscious role for the agent and, consequently, her having regulative control over her action, which CTA does not grant.

Moreover, if the agent is said to not play a role in CTA's account, it must be clear what we are considering the agent and her role in action. If it is claimed that the agent must play a role in producing her action, then her role is something different from her mental states causally contributing to this production. What could this role be? This becomes a question about the ontological status of what is being called the *agent*. It is necessary to understand what the conception of an agent might be in this objection, and what would be her role in producing the action.

Therefore, the disagreement about what counts as an action of the agent and what makes her disappear is due to a more fundamental disagreement between AC and CTA; i.e., a disagreement about what is considered an agent. Because of the concern for control, the AC theory associates agents to the conscious states of human beings, thus pushing her apart from her activities that are not under conscious governance. At the same time it seems that this conception assumes that consciousness would play the role of a supervising system that coordinates and directs the agent's actions, as Steward suggests [10]:

> What makes it right, it seems to me, to attribute the movements to *me*—what makes them voluntary movings by me rather than, say, reflex responses over

[7] Helen Steward seems to believe this [10].

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which I have no meaningful control—is that the relevant systems are ultimately subordinated to personal-level, conscious ones in a well-integrated hierarchy whose purpose generally is to ensure that they function overall to serve my conscious aims, although of course it may happen on individual occasions that there is no point or purpose to a given individual output from such a system. The subordination has many aspects. I can choose at any time to make the workings of the relevant subordinate systems the focus of conscious will. (p. 51)

In order to do so the agent must be integrated with her body in a way that she plays an irreducible role in the organism's motor activity [10], which should involve the capacity for top-down determination of her movement, above the processes going on inside the organism that eventuate in the movement of the body [10]. The top-down determination proposed by Steward would presumably be a centralized system that consciously determines the movements performed, in the sense that the agent may consciously interfere on her action production, which amounts to having the sort of control that AC treasures in agency.

In this sense, AC relies on a centralized conscious system for producing actions, while CTA could involve a more distributed one, where different mental states causally contribute to produce the action. For instance, in Steward's AC theory [10], the agent cannot be reduced to parts of herself:

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> It will not by itself suppl[illegible]er to the question how agency is possible. An answer to *that* question will require also an understanding of what could lead us to want to say that an *organism* rather than merely some part of one, or some process within one, has brought something about, and of how the causality thereby effected (the causality that is agency) relates to the causality involved in the sub-personal processes that make it possible. (p. 12)

According to this view, agents are direct contributors to the mechanisms of action, therefore crucial contributors to making the action happen [10]:

> In their case, we seem faced with a kind of agency that belongs in a deeper way to the entity concerned such that the entity is no longer merely the thing that *houses* the relevant mechanisms of movement production, but is thought of as itself a crucial contributor to those mechanisms. The crucial determinant, for me, of whether a creature truly can be said genuinely to be a self-mover has to do with whether there is any irreducible role to be played in the explanation of that organism's motor activity by a certain kind of *integration* which I believe is part and parcel of the functioning of most animals of a certain degree of complexity, a type of integration which I shall be attempting to characterize towards the end of this book. (p. 17)

In this view, the agent must play an irreducible role in the production of action. What distinguishes these entities that *have* bodies from other entities is that they have minds, and to move the body *at will* would involve having goals and a subjective point of view of the world [10]:

> Entities with a mind, it is tempting to say—and indeed, in a sense I think the question which entities have minds and which have bodies ought properly to be regarded as the very same question […] involves at least the applicability of the rudimentary psychological ideas of a goal, an attempt and a subjective point of view on the world. (p. 18)

Steward equates the agent with a personal-level conscious system that supervises her action production processes and keeps them in track with her conscious aims, in a way that the agent could turn her conscious supervision to anyone of those whenever she pleases or finds necessary. It is being under this kind of agential control that allows the agent to play a role in producing her action. Even if the movement is not consciously done it must be a part of the system under potential[8] conscious supervision in order for the agent to have a role in it; since the action producing systems are subordinate to a conscious hierarchy that coordinates that actions are done [illegible]e agent.

[illegible]ows, or not, the relevant sub-personal systems to go into operation in the first place" (p. 52) [10]. In this sense, the agent has the movement under her control, and she could consciously interfere in it at any moment she pleases. The personal-level system allows or prevents the operation of sub-personal ones. Thus, in this theory, consciousness seems to play a big part in guaranteeing that the agent plays a role in the production of her action, because it aims at guaranteeing agential control over the action. The agent's movements are not under her control in the sense that she consciously and directly originates each movement, but in the sense that she could directly and consciously change the course of her movements.

Are we supposed to consider that whenever a bodily movement falls out of this scope of control the agent should not be considered to have played a role in its production? However, some movements are not under conscious supervision, like muscle reflexes, automatic action, heart beat or peristaltic movements. If we are to follow Steward's criteria, reflexes and automatic actions would not be considered actions attributable to the agent.

It is, nonetheless, an odd claim that automatic actions are not attributable to the agent. For instance, let's picture a middle school boy, Sam, who has become accustomed to a distasteful "prank" that his classmates like to play whenever

[8] This system does not always intervene in the action production, nor does it originate all actions. Rather its supervisor role is to intervene when considered necessary, thus exerting potential control over all of the agent's actions.

juice is served in a cup at lunch hour. The children will try to hit his cup at the bottom, to make the cup turn and the drink spill on him. Sam knows he must not be distracted while having a cup in his hands; he even devised a plan. Whenever one of his classmates approaches him while he is holding his cup of juice, Sam gets ready and throws the content of the cup on his attacker as soon as the other child moves her hand towards him. After a while Sam becomes so well trained in his technique that the movement is automatized, if anyone moves their hand towards Sam's cup he acts immediately. His training has come to a point that, if he wished to abort the action, for instance, because the Principal was approaching, he might throw the juice before he can stop himself from doing so. Sam's classmates no longer bother him when he is having lunch, and he is pleased.

On Steward's account, however, Sam could not be considered to play a relevant causal role in the production of this action of his, because he would lack the conscious control considered important in her theory, even though this was an action that Sam trained himself to be able to perform very quickly and precisely, and it seems to be in conformity with his wishes and plans (whether we consider his action praiseworthy is a different issue). Since he has worked hard to automatize his movements, it would seem odd to consider that he does not play enough of a role in its production just because he may lack the ability to modify it while it is in the process of being produced and executed. After all, the situation triggers a fast response, as Sam has planned that it should.

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Steward's conception of the control necessary in action in order to guarantee that the agent plays a role in it seems to leave out actions that, even if the agent lacks regulative control over, seems too much of a result of her own training to be lacking a role of hers. It is too rooted in her values, desires, and plans to be considered lacking her role.

This indicates that the conception of what an agent is shapes which actions can be attributed to the agent and according to which criteria. This is why AC theories cannot accept CTA's explanation of action, because the latter theory presents actions under a different conception of agents that does not require the same kind of control, which relies on consciousness playing a supervisor's part. Thus, it has different criteria for what the agent's role would be in producing action.

In AC's conception, the agent's role in an action requires conscious supervision of the production of the action, even if only potentially. And Wegner seems to hold a similar conception of the role of agents. In his view, if there were agents, then agents would be the sort of entity whose experience of *consciously* causing actions would not be an illusion; i.e., consciousness would in fact originate actions. This is the reason why Wegner denies that we are agents, because he claims that the conscious experience of causing our actions does not correlate to how our actions are really produced; we would only have the *illusion* that it occurs in this manner.[9]

These are similar views in the sense that conscious participation in action is considered important to agency. On the other hand, Wegner does not have a problem with the fact that CTA's explanation of action involves mental states of the agent, not the agent herself, playing a causal role in producing action (in opposition to AC's DA objection). Wegner, like Velleman, does not have a problem with explanations of actions which involve event-causation, but Wegner conceives of agents as an entity that consciously wills her actions.

According to Wegner, only in this way the agent could play a role in producing her action; thus, in Wegner's theory, the conscious will would play the role of the agent to fulfill the expectation that we cause our actions. However, Wegner does not believe that we are agents that can play this causal role in producing our actions. These would just be illusions. And he denies that we are agents exactly because he argues that human agents do not have this conscious origination role.

So Wegner is not concerned with control in the sense that AC is. Nevertheless both theories are concerned with consciousness in action production. This is clear when Wegner claims that we only have the illusion of causing what we do, because he believes that the experience of the conscious will causing action does not correspond to the real cause of action. So, according to Wegner, if we don't really consciously cause our actions, then we don't cause what we do; therefore, we are not agents. In this conception, Wegner must say that there are no agents, nor agency, since he defends the claim that consciousness plays no role in producing action. The problem is that he raises the bar for agency too high, to a point that the criteria are unreachable in his own theory. However, we have more reasons to think that this conception of agency is mistaken than to think that human beings are not agents and never cause what they do, because if we do not fulfill the criteria for agency, then I don't know what kind of entity does. If we wish to claim that people act, then we must be agents.

AC theorists object to CTA by claiming that it makes the agent disappear for this same reason. The conception of what an agent is in this theory sets the bar higher than what CTA would claim that an agent is, since AC seems to require regulative control in order for the agent to play a role in the production of her action, and consequently a conscious role for the agent is required for this kind of control. So consciousness would have to play a role in this production. Nonetheless, the role AC expects the agent to play in action explanations is unrealistic because, as Wegner's theory points out, consciousness may not have such a prominent role of governance as AC claims.[10] In this view, the agent would have

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[9] According to Wegner consciousness is not on top of what we do. Conscious processing is quite slow compared to unconscious processing, and it is absent from most our fast reaction actions, as well as actions done automatically or under hypnoses.

[10] Since Wegner claims that the real causes of action are unconscious processes inaccessible to consciousness.

to be an entity separate from her physiological action mechanisms, but that would have the conscious power to produce or supervise her actions.

It is also interesting to point out, that AC can be understood as doing exactly what it believes to be the source of CTA's issues: it is reducing the agent's role. This is a reduction in the sense that it reduces the agent, or agential control, to consciousness of the production of action.

The AC conception of agency, that considers the agent an entity that causes her actions and has regulative control over it, is a mistaken conception. It is from this unrealistic conception that the problem of the DA springs. The agent only disappears when AC looks at CTA accounts because she is conceived in a way that should be revised, which relies on an unattainable conscious control.

IV. BRIEF OBJECTION

It could be objected that CTA makes the agent disappear independently of whether conscious or unconscious states are said to causally produce the action, therefore conscious interference would not actually be the issue behind the DA problem. A CTA explanation in which the action is caused by conscious mental states still has no role for the agent in it, according to this objection.

In fact, CTA does not attribute the role of the agent's control over her action to consciousness. This is the reason why it does not matter if the mental states involved in the production of action are conscious or not, it would still lack the regulative control dear to AC [illegible] DA would apply all the same, be[illegible] will only be considered to have [illegible] the production of action if they have regulative control over it. However, the problem is whether agents can really have this kind of regulative control.

It has been argued above that the requirement of regulative control is part of a conceptual context in which the agent is seen as consciously governing her actions, in a centralized way. Even if CTA explanations involve conscious mental states in its explanation of action, it would still not involved regulative control, nor centralization. However, what is being put into question here is exactly AC's conception of agents that requires this sort of control.

If it is agreed that this explanation of actions, involving conscious control in action production, is too high a requirement, to the point that it leaves out actions that have become habits, or automatic actions, then we may rather accept that AC's conception of agents sets the bar too high for anyone to be an agent. Therefore, the conception of agents as entities that play a conscious role in actions needs to be revised.

V. CONCLUSION

The discussion presented here contributes to make clear how AC and Wegner conceive of agents. Even though Wegner's theory does not agree that conscious regulative control of action has an important role in the production of action, as AC requirement, Wegner does seem to share AC's conception that if there are agents, consciousness must be involved in the production of their actions. I have argued that consciousness, as required by Wegner and AC's conception of agents, may be too high a bar for agency, which means that this conception should be revised.

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Brain-Body-Life

Towards a panpsychist theory of embodied cognition

Charles Borges
FFCH-Department of Philosophy, PhD Candidate
PUCRS
Porto Alegre, Brazil
charlesdittgen@gmail.com

Abstract—This paper develops a Panpsychist theory of embodied cognition. As a monist theory, its aim is to present a non-reductive Materialist ontology of mind as an alternative to Dualist conceptions of mind and cognition (Substance Dualism and Propriety Dualism) regarding the mind-body and the mind-mind problems.

Keywords—materialism; panpsychism; embodied cognition; Develpmental Systems Theory;

I. Overcoming the Dualist Framework

Dualism is a pervading world-view taking place not only in philosophy but in some trends in neurosciences as well. Its widespread chorus is well known: there are two distinct substances (thought and extension) and one of them is a kind of model for the other. In this way it demands from us a choice between reality and ideality. If the objectivity of reality comes first, then thought (or consciousness) takes its place *ex post facto.* From this point of view, consciousness, as a kind of "effect", it *represents* the "real world out there." By contrast if consciousness comes first the "real world" is not so real being, in fact, a sort of "projection" of our consciousness to the extent that it depends on *a unified subject* who makes it "real."

I am well aware of the limits of the schema I am presenting here. For sure, it is a sort of reductionism. Philosophical positions are richer than the picture depicted above. We will rarely be presented to a philosophy that is one hundred percent "Idealist" for example. Nevertheless this reductionist view tells us something. It seems to me that any theory assuming as its point of departure one of these "sides" winds up claiming, roughly speaking, the *precedence* of one side and therefore succumbing to dualism.

Thus when our inquiry is about the self ("where and how does it comes from?" "What is it to be 'conscious?" and so on), the mind and its relation to the body, and the role played by this body; temptations of reductionism are very strong. The main temptation is the drawing of a distinctive line between "the real" and "our consciousness" assuming the later as a kind of "symbolic processor machine." It doesn't matter if you are realist or anti-realist, what really matters here is your starting point assuming a dualist vision and seeing "the world" and "the self" as distinct realities.

But – you may ask – what is wrong with this view? Its main failure consists in presupposing either the materiality of the body (and with it a mechanic brain: "the brain that provides us with information") or the cognitive (disembodied) self as a ground for cognition [24], conceiving of the cognition as a sort of hesitancy between these two "poles." What is at stake therefore is the question (and the quest) of a "ground" for cognition. A ground which is neither the materiality of the brain, nor the "essence" of a mind but in fact, the emergence of both of them. There is cognition only where there is a body *with* the world, and this body *with* the world *is* a perceived consciousness (and a possibility of reflection).

That is my starting point: cognition is in the movement of an embodied matter. Consciousness and perception (including self-perception) are bound to affects of the body in action – with its volume and mobility –, inhabiting, or better, *with* an environment. Consciousness emerges with the capabilities of bodies, with their availability to affecting and being affected. It is, therefore, from this point of departure that I want to link two research programs whose main concern is to put an end to all kinds of dualism.

Damásio's somatic marker hypothesis will be my first target. In sketching his theory, I intend to argue that his point of view, despite being a relevant turning point in the neurosciences, still tends to rely on a realistic framework informed by the assumption of a neo-Darwinist theory of adaptation. In a nutshell: in Damásio's view affects and the somatic marker are tools developed by the organism in order to ensure the survival of the species and to solve problems imposed by a given environment. They are the outcome of the pressure exerted by a milieu.

Conceived in this way the somatic marker hypothesis runs the risk of falling prey to the very same dualism that it originally intended to criticize. In assuming a ground – "the real world" – from where emotions, feelings and rationality take place this theory is prone to be a victim of misinterpretations. Affects, therefore, lose their ontological position and become useful tools to ensure our survival and our adaptation to that "hostile milieu out there." Thus the real danger is the possibility of a sort of re-edition of dualisms: we live under pressure, we need to adapt ourselves in order to win that run imposed by the milieu we were parachuted in - emotions, feelings and rationality are our tools.

You may notice that I am not making a statement of any "Damásio's error!" I am well aware that Damásio's theory takes in its account the complexity inherent to the relations between the organism and its milieu and that, even when he says things like "Nature gifted us with equipments to survive in a hostile environment" and so on, he is using a metaphor in order to make his theory more palatable. Nevertheless, there is a real possibility of misinterpretation here: neo-Darwinism is lurking around and has to be dissipated.

What I would like to advance as a hypothesis – and that is my second target – is that in order to be immune to any kind of philosophical dualism the theory of affects developed by Damásio has to be read from the lenses of a post-Darwinist framework. To fulfill this task I will use some advances made by Developmental Systems Theory (DST). This theory sees the organism and its milieu as a co-evolution and as an emergent system composed by the movement from the part to the whole and vice versa. From this point of view, then, living systems are complexes of various elements affecting and being mutually affected assembling an *open system*. Therefore, "the reality" is in itself emerging from inside (*causa sui*), what leads us to a theory of individuation and to the contemporary Dynamic Systems and its new concept of emergence [8].

My first step consists of presenting the theory of homeostasis as developed by Damásio. As we will see that theory is the basis for his latter arguments about emotions, feelings, *conatus,* and somatic markers. My main aim will be trying to disentangle the homeostasis from any residual dualism what implies, above all, overcoming the adaptationist framework. Then, I will develop a theory of homeostasis as emergent causality, which will enable the somatic marker to be seen as an environmental auto-regulatory procedure composed of elements, relation between elements and singularities (as a process of individuation). As a conclusion, I will claim that Damasian theory of affects is compatible not only with DST theory, but with Deleuzean approach to *difference* [and with contemporary Emergentism], since these three views are based on the immanent causality resonating with Spinoza. The most provocative aspect of my conclusion remains in its explicit advocacy of a Panpsychist theory [linked to Emergentism] as a way to approach the "hard problem of consciousness" inherent to our discussion. As we know the so-called *hard problem* is, in a nutshell, the problem of *subjectivity* [consciousness "feeling", "perceiving" or even "explaining" itself] or, in technical terms:

[…] Is the problem of explaining why any physical state is conscious rather than non-conscious. It is the problem of explaining why there is "something it is like" for a subject in conscious experience, why conscious mental states "light up" and directly appear to the subject. The usual methods of science involve explanation of functional, dynamical, and structural properties—explanation of what a thing does, how it changes over time, and how it is put together. But even after we have explained the functional, dynamical, and structural properties of the conscious mind, we can still meaningfully ask the question, Why is it conscious? This suggests that an explanation of consciousness will have to go beyond the usual methods of science. Consciousness therefore presents a hard problem for science, or perhaps it marks the limits of what science can explain. Explaining why consciousness occurs at all can be contrasted with so-called "easy problems" of consciousness: the problems of explaining the function, dynamics, and structure of consciousness. These features can be explained using the usual methods of science. But that leaves the question of why there is something it is like for the subject when these functions, dynamics, and structures are present. This is the hard problem [25].

Thus the *hard problem* is more an ontological problem than an epistemological one. Its question is not "what" but "how", "why", "where" is there consciousness? These are questions about the *ground* of action, perception and cognition.

II. Brain-Body: Homeostasis as the Basis of Emotions and Feelings

Let us start with the theory of homeostasis as defined by Damásio.

All living organisms from the humble amoeba to the human are born with devices designed to solve automatically, no proper reasoning required, the basic problems of life. Those problems are: finding sources of energy, incorporating and transforming energy; maintaining a chemical balance of the interior compatible with the life process; maintaining the organism's structure by repairing its wear and tear; and fending off external agents of disease and physical injury. The single word homeostasis is convenient shorthand for the ensemble of regulations and the resulting state of regulated life [5].

In Damásio's view homeostasis is the basis for the development of consciousness. Our self or our capacity of reflection is a sort of complexification of the basic mechanism of emotions (even the paramecium has an "emotional" behavior of metabolic regulation). "Complexification" is composed by feelings (affects) and rationality (practical rationality and abstraction). Therefore, there is no abstraction or "mind" without a body. There is no "gap": mind and body are one and the same expression of *conatus* (homeostasis).

It is from this unitary structure (from metabolic regulation to emotions, feelings, decision-make skills) that the somatic marker hypothesis comes from:

[S]omatic markers are a special instance of feelings generated from secondary emotions. Those emotions and feelings have been connected, by learning, to predicted future outcomes of certain scenarios. When a negative somatic marker is juxtaposed to a particular future outcome the combination functions as an alarm bell. When a positive somatic marker is juxtaposed instead, it becomes a beacon of incentive. [6]

Here is the main problem that I am trying to avoid: if the somatic marker and consciousness emerge after metabolic regulations, emotions and feelings, their emergence is a response to an environment: consciousness (the self) is a sophisticated response to that hostile milieu. Then we fall prey to Neo-Darwinism (reality comes first, then an organism and then a consciousness inside this organism).

Let us therefore take a look on the main features of Neo-Darwinism. Its point of departure is three main Darwinian theses, which can be summarized as following [24]:

- Evolution occurs as gradual modification of organisms by descent; that is, there is reproduction with heredity.
- This hereditary material constantly undergoes diversification (mutation, recombination).
- There is a central mechanism to explain how these modifications occur: the mechanism of natural selection. This mechanism operates by picking the designs (phenotypes) that cope with the current environment most efficiently.

This vision can be dubbed as adaptationism and arises from the so-called modern synthesis that consists of a synthesis between Darwinian ideas and the rising knowledge in cellular and population genetics of 1930's (as a consequence of Lineu's and Haldane's works). As highlighted by Varela, Thompson and Rosch [24], the so called modern synthesis "established the basic view that modifications occur by small changes in organismic traits specified by heritable units, the genes," these changes are the outcome of a process of adaptation in time. In other words, they are the product of a makeup of an animal population over generations as response to an environmental change. From this view we can derive the concept of adaptation [24]:

The most intuitive sense of adaptation is that it is some form of design or construction that matches optimally (or at least very well) some physical situation. For example, the fins of fishes are well suited for an aquatic environment.

This concept is tied to another one, namely, fitness: in order to adapt themselves to environmental changes, organisms have to try and find heritable strategies or "sets of interrelated genes that will be more or less capable of contributing to differential reproduction" [therefore] "when a gene changes so as to improve in this task, it improves its fitness" [24]. The success of an organism is measured by two factors: its abundance and its persistence in time (reproductive permanence over time). The environment is conceived of as a "field of forces" exerting selective pressure while the organism is judged according to its fitness or performance. Natural selection is the main factor in organic evolution. The consequence is well known: the strongest and the smartest will survive.

Adaptationist programs tend to focus on the surviving organism and its success or failure in surviving in an environment. The environment, in turn, is assumed as it was given beforehand, as it were the cause of organisms (each organism "fits" itself within a milieu). Thus the environment works as the "judgment of the organism" or a transcendent instance introducing a new kind of Dualism.

The temptation of reading the theory of homeostasis and the somatic marker hypothesis through the lenses of Dualism is a strong one. Then, we have to raise the question: by following this hint wouldn't we be reading Damásio as a sort of Cartesian metaphysics? Wouldn't it be outrageous for someone that wrote a book named "Descartes' Error" to commit the same dualistic "error" found in Descartes?

Let us be full-fledged Spinozists and assert: everything in this world is an expression of at least two attributes, thought and extension. Let us take a step back (being at least biological Panpsyquists) and say that organisms, at their metabolic, emotional, sensorial, sentimental and rational registries are simultaneously thought and extension and that species and their parts co-emerge with (and not within) an environment, as dynamical systems composing a space/time of relations.

Let us, therefore, think of evolution as natural drift raising the bar of existence, instead of being an adaption to a hostile and pre-given environment. As Varela, Thompson and Rosch say, let us switch from a prescriptive logic to a proscriptive one, "from the idea that what is not allowed is forbidden to the idea that what is not forbidden is allowed." [24].

Here we are far from a vision based on a gap between on one hand, phenotype elements and genotype ones and, on the other hand, an ordering form applying itself over a chaotic matter. Organisms are not the development of a blueprint or a genetic program (in-formation) imposed over a formless matter. Genes are not the new designers who use "us" as "vehicles" of perpetuation. Genotype and phenotype are co-emergent factors among other factors (physical, chemical, energetic) at various levels of interaction. We can, obviously, select one or more of these levels of interaction as a method of analyzing and even describing patterns of evolution, nevertheless the main point is that the emergence of organisms is a process, a bricolage (to use a metaphor from Varela, Thompson and Rosch [24]) where a dose of randomness has to be admitted.

So what about "randomness?" What I mean by term "randomness?" To answer that question let me get back to the issue of form and matter as remarked by Susan Oyama. Instead of seeing a gap between form and matter, Oyama sees form emerging from successive interactions:

Form emerges in successive interactions. Far from being imposed on matter by some agent, it is a function of the reactivity of matter at many hierarchical levels, and of the responsiveness of those interactions to each other. Because mutual selectivity, reactivity, and constraint take place only in actual processes, it is these that orchestrate the activity of different portions of the DNA, that make genetic and environmental influences interdependent as genes and gene products are environment to each other, as extraorganismic environment is made internal by psychological or bio-chemical assimilation, as internal state is externalized through products and behavior that select and organize the surrounding world. If biological plans, constraints, and controls have a serious meaning, it is only in such mobile, contingent phenotypic processes, not in a preformed macro- molecular code specifying the species type, of which type the individual is but a token [13].

These successive connections occur in a differential space of interaction guided by randomness. This is not to say that there is chaos everywhere, but rather say that there are dynamic interactions (differential elements) working all the time in the process of formation of species, an organism and so on.

We have to reserve a space (not a rigid structure) of interaction where multiple elements provide the emergence of forms of life (modes of existence). These forms of life depend not only on multiple elements but on the relation among those elements as well. Any change in one of those elements is a potential cause of emergence of new relations forming new organizations. So, if there is an "emotional paramecium", an organism capable of selecting its interactions, it goes in this way because of a momentary stability of relations. This is the true significance of the term *conatus*. In many levels, sets of relations tend no only to remain on their existence; rather they enhance their existence as a co-emerging assembly. Brain-body is, therefore, a system that emerges in and with its own *conatus*.

III. WHAT IS IT LIKE "TO BE"?

The main remark from my reading of Damásio may be expressed as following: this system, which I will name a "brain-body system", should not be seen as a sort of device for adapting ourselves to the caprices of "Nature". Systems must be seen as an expression of nature, as a "degree of consciousness" whose main characteristic is their openness in time (as we will see below, an irreversible time). In a nutshell, they should be seen as an open system where momentary closures take place.

This view leads us to two paths. First: we have a soft concept of consciousness. What defines consciousness therefore is not the sophisticated level of self-reflection, but these two capacities of forming an assemblage and having a context-based purpose (a kind of "blind intentionality"), or an ability to take part in interactions driven by symbolic behavior where the symbolic is not founded on icons and indexes, but rather constitute with them a relational system [10]. Thus, consciousness is in matter. As matter, it is what defines an interior, an exterior and a boundary. Consciousness is of the order of intensity, a degree. Second: consciousness is a difference in kind as a contraction and retention of time (duration). Each kind of consciousness has its capacity of contraction-retention. Each kind of consciousness inhabits a different contraction-retention of time.

Consciousness is, firs of all, an organization of matter and then an organism. But what therefore is an "organism?" Here I would like to bring to the fore two registries highlighted by Deleuze and Guattari in A Thousand Plateaus: The molecular and the molar. As Brian Massumi summarizes them, molecularity and molarity can be seem as following:

Molecular and molar do not correspond to "small" and "large," "part" and "whole," "organ" and "organism," "individual" and "society." There are molarities of every magnitude […]. The distinction is not one of scale, but of mode of composition: it is qualitative, not quantitative. In a molecular population (mass) there are only local connections between discrete particles. In the case of molar populations (superindividual or person) locally connected discrete particles have become correlated at a distance. […] Molarity implies the creation or prior existence of a well-defined boundary enabling the population of particles to be grasped as a whole […] a supple individual lies between the molecular and the molar, in time and in mode of composition [12].

Molarity is a stop or selection, a categorization as the outcome of a process of individuation (the reference here is Simondon) interacting with molecularity. That outcome is a singularity expressing the "habit" of a set of relations as "homeostasis." The key here is *evolution not as an adaptation but as creativity*. Creative evolution dispenses with ontological dualisms seeing the natural world as composed of processes of assemblage involving organic and inorganic matter. Therefore, consciousness can be defined as a perspective of matter, as point of view striving to extend itself in time. This is a sort of Panpsyquism.

Despite his past dualistic commitments, Chalmers seems to have recently advanced an argument sympathetic with Panpsychism where he describes these two levels of interaction as "microexperience" and "macroexperience" (mirroring "microphysical" and "macrophysical") and interpreting them as a "Russellian monism" or a "broad physicalism" appealing to "quiddities":

An initial question is whether physical properties are restricted to the properties invoked by physical theory (space, time, mass, charge, and so on), perhaps along with those properties grounded in them. These are the properties that Stoljar calls the t-physical properties (for theory-physical) and that Strawson (2006) calls 'physics-al' properties. It is most common to restrict physical properties in this sense, but one can also invoke expanded senses of the term, such as my notion of a broadly physical property, or Stoljar's notion of an o-physical property, or Strawson's notion of a physical property which appears to subsume all natural properties. Given such an expanded sense, then even if quiddities are not t-physical properties, they may count as physical in the expanded sense. The resulting position might be seen as expansionary Russellian physicalism, with (proto)phenomenal properties counting as physical properties in an expanded sense [3].

Chalmers is well aware of the fact that this "expansionary physicalism" has some explanatory limits – for example: this sort of "panpsychism" (or its variation, the "protopanpsychism") cannot escape from the problem of causation, falling prey either to eliminativism/materialism (microphysical causation) or to dualism ("quiditties" as a new instance).

I would like to suggest a way to complement Chalmers appealing to intensity (or duration) as a characteristic of physical processes in time. One may even say that these intensive traits are tantamount to "quiddities" as they cannot be explained by mechanics alone, but rather depend on concepts taken from chaos theory.

From this point of view, intensive processes are intrinsic in any extensive instantiation. Intensive traits can be seen as "loops" or "images" formed with(in) the chaos of matter in movement. Life becomes an infinite and indefinite process of creation, of assemblage and selections of "lines of development." Human consciousness – with its specificities – emerges with one of these lines of development being at the same time a difference in degree and in kind aiming its auto-transcendence. In this way we move from homeostasis as fitness to homeostasis as *conatus* and expansion, aggregation, creation. It is only from chaos that patterns of expansion/aggregation/creation become possible, even when we are talking about consciousness, or brain activities. As Skanda and Freeman remind us:

It was once generally assumed that chaos was undesirable, that it occurred in brains subject to pathological malfunction, and that 'normal' physiological functioning resulted from dynamic processes that could be modeled as periodic. Our data suggest the opposite view: deterministic chaos is essential to normal brain functioning at many levels of activity. What we previously dismissed as "noise" in the system, something to be eliminated with filters when recording, something that the brain seemed to be fighting an impossible battle with in information processing, now appears to be the behaviorally relevant signal [20].

Therefore we have an intensive process keeping up with an extensive one. The conjoining of both of them could be dubbed as "blind intentionality" accompanying any material assemblage and life processes ("even the paramecium…"): an organization emerging and depending on chaos (more on chaos theory in a forthcoming paper).

At this point we need to bring to the fore two important remarks: 1. One needs not distinguishing organism and environment anymore. Intensive processes go all the way down. 2. "Consciousness," as "blind intentionality" (the analogy of teleology), is in life; consciousness is the outcome of an intensive/extensive process; consciousness is a matter of degree. If we cut out an "individual realm" from a "milieu" this operation is done only for didactical purposes since they are a complex and inter-relational processes.

But I didn't face the problem of the "difference in kind" yet. As I said above consciousness is a difference in kind. Saying that, I meant that we have different qualitative manifestations of that phenomenon. Now I can say: from this qualitative perspective consciousness is a "blind intentionality process" going on inseparable from "attentionality." What does it mean? It means that in elementary forms of consciousness intention and attention are indiscernible, they are one and the same expression/function, there is no *de jure* separation between them, they are pure corporeal action. Still, some kinds of consciousness have in the "availability to attentionality" their remarkable characteristic. In other words, they have as their remarkable achievement the complex processes of separation between habit and memory. Our consciousness is surely one in which these complex processes take place.

So the key concept here is "Attentionality." This is a concept took from Prinz's AIR theory as a way to show "[…] how do mental processes become consciousness?":

"AIR" stands for Attended Intermediate-level Representation. Conscious states are AIRs. [T]he basic idea is that, when we attend, there is a change in the way intermediate-level representations are processed. That change is what makes the difference between these representations being conscious and not [16].

First we have to highlight the change in the concept of consciousness when we pass from non-complexes to a complex form of experience. Some paragraphs above I was talking about consciousness as a "blind intentionality" (a Panpsychist concept of consciousness). Now "consciousness" is the propriety of having phenomenal qualities. That is, we moved from a broad concept to a narrow one, but Panpsyquism underlies the "attentional" process and the transition from a "nonconscious perception" (attention) to conscious perception and reflection as well. What once was a single structure now is complexified. Attention is the way by which we become conscious:

By consciousness I mean to refer to the property of having phenomenal qualities. Mental states are conscious if they feel like something, or, in Nagel's (1994) phrase, if there is something it is like to have them. Attention can be defined without reference to phenomenal qualities, as says Prinz:

I treat "attention" as a natural kind term. It is not something that has an essence that can be discovered by conceptual analysis. Pre-theoretically, we grasp the concept of attention by appeal to a range of different activities and phenomena. A couple of those have already been mentioned. There is the phenomenon of pop-out, when a stimulus seems to stand out from things around it. Pop-out is passive, but attention can also be effortful. There is the phenomenon of search, as when you are looking for a specific object in a complex scene. Attention can also involve monitoring, as when we retain perceptual contact with something; tracking, as when we watch an object moving through space; or vigilance, as when we remain alert and responsive to anything that might come before our senses. Attention sometimes involves selection, as when we focus in on a feature of an object. But it can also be diffuse, as when we survey our surroundings. Meditation can put one in a state of being hyper-attentive without attending to any specific thing. Put differently, attention can be thought of as a process that, in principle, could be applied to everything in the visual field at once, even if, in practice, it is usually selective [16].

Attention is directly linked to working memory viewed as a "short term storage capacity […] that allows for executive control" [16]. More specifically:

The simplest explanation for this relationship is an identify claim: attention can be identified with the processes that allow information to be encoded in working memory. When a stimulus is attended, it becomes available to working memory, and if it is unattended, it is unavailable [16].

Therefore, according to Prinz "consciousness arises when and only when intermediate-level representations undergo changes that allow them to become available to working memory", and this makes the AIR Theory worth being approached from an ontological point of view. AIR Theory shows us how retention is important as a difference in kind or a transition from a "blind intentionality" (or pure corporeal perception) to an "attentional-intentionality" [16].

This attentional availability [16] is perhaps what is behind Bergson's distinction between habit-memory, as a build-in mechanism "set in motion as a whole by an initial impulse" or a "close system of automatic movements" and image-memory, a memory that records events of our daily life and turn them up representations, as a sense of a whole past [2]. Our consciousness, as the convergence of habit and representation, is a sort of complexification both cultural and naturally informed.

The attention process is not only "natural" informed; it is culturally informed as well. We track an alien bug on our living room's wall in twilight's shadows. But we do not track in the same way flies or mosquitoes flying in the same room: this occurs because we share part of our *umwelt* [23], with these flies and mosquitoes, we have the same "coupled attitudes," we are part of a relational system, we are used to each other. Nevertheless, the point is that all of them (the alien bug, the fly and the mosquito) are available to be tracked, they are occurring in our habitual memory or in our corporeal action (and reaction) and a small change can make us turn from a "dispositional" mood to an attentional one and vice-versa (1. a zoom in on the fly standing on the coffee spoon, rubbing her head is sufficient to evoke conscious perception and memories triggering the representation of a fly as a fly; 2. the perception that the "alien bug" was in fact a leaf being moved by an air stream is sufficient to shut down the attentional process and put it in the background) .

Now this availability is possible only because each action and each perception is followed by a virtual image-memory. At the same time, this image-memory is naturally/culturally informed. As a species we select some images that eventually become imagination, dreams and concepts. These dreams and concepts are part of our cultural (you cannot dream about a cat, a tree, the Lernean Hydra, Caesar crossing the Rubicon, a fork, a clock, before these images have been selected by you) and natural lives (the assimilation of, the aggregation of, the fusion and the combination with other forms of life). The "alien" bug is an alien just because we have never experienced it or dreamed about it, i.e., it is not part of our image-memory.

And here we have our turn towards Panpsychism. Bergson's thesis is set up in the domain of the embodied action. From heterogeneous agitations – that in fact are matter in itself – a (self)-image appears as a body or a perspective inhabiting matter. Thus that body forms a habit and an image of its past. Action, perception and conceptualization are part of a process of selection of images in matter – a process that consists of creating a homogeneous space (extensional, discrete space) from a heterogeneous time-matter (intensive, durational time). Bergson presents us with a complex theory regarding the passage from intensive matter to an extensive conceptualization of matter and then to an intuition of the intensive matter again. His thesis can be formalized as following [2]:

1. $M = Ht$
2. $Hm \leftrightarrow Ht$
3. $Hm \leftrightarrow P$
4. $P[Hm + Ht] \rightarrow M$

Where: 1. M (matter) is (Ht) heterogeneous flux or a continuum of undifferentiated and intensive flux of light; 2. Ht (heterogeneous flux) is the condition for Hm (homogeneous space) to exist; 3. If there is Hm (homogeneous space), there is P (perspectives) as well. They are intrinsically tied to the extent that it is only from the extension (discrete space) that we can postulate fixed points, trajectories, velocities, terms, objective and subjective points of view (perspective is a delay between action and reaction); 4. P (perspective) = M (matter) as Hm (homogeneous space) is impossible without an underlying Ht (heterogeneous flux).

Here we face some difficulties in premises 1 and 2 and in the conclusion yielded by them. These difficulties seem to be a variation of the "Russellian monism" as presented by Chalmers: aren't we saying that everything is matter [$M= Ht \leftrightarrow Hm$]? Is not our conclusion a tautological one [$M=M$]? If that is not the case, aren't we advocating a sort of epiphenomenalism [$Ht \leftrightarrow Hm$]?

In order to give an answer to these questions three points must be highlighted. 1. The Bergsonian model works with a differential conception of matter. It cannot be reduced to a corpuscular theory of matter to the extent that time and irreversibility are inherent components of the natural world (for a explanation of irreversibility and entropy see [13] and [7]. Therefore his conception of matter is an intensive one. Moreover, his concept of matter is one where images (singularities) are inherent, what brings us to self-organizing cycles of Dynamic Systems Theory [7]. Then instead of looking for a parallel propriety besides or mirroring the extension we assume that matter is first of all intension and that extension is not the default but a "loop-moment", or said in another way the stability emerges from a far-from-equilibrium stage of a system; 2. From this perspective there is no problem in assuming everything as being matter because there is no ontological commitment to dualism. If any dualism occurs, it occurs only as a consequence of P (perspective). The main point however is that behind P (perspective) there are intensive processes in time; 3. It seems to be better therefore not to talk of "epiphenomenalism" since consciousness (as pure perception) is in matter all the way down. Consciousness is immanent in matter to the extent that it expresses a statistical "preference."

As remarked above, our consciousness is a sort of complexification as we act selecting, registering, recording and storing images (I could say that "lower" kinds of consciousness, for example, work selecting/registering only). The attentional process shows us in detail how this ongoing consciousness works. If, as says Prinz, attention is the gate keeper of working memory then we are "double subjects." We are the zombies. I would rather say that there is a legion in us. The subject is a legion. Thus there are uncountable working machines of perception and interaction underneath what is being stored in the working memory. The gatekeeper works as a principle of selection as it "gives voice" to some of that subjects while muting others. In a nutshell: consciousness (in its narrow sense) is part of a huge emergent relational system.

From this perspective, homeostasis (embodied regulation) is tied to habit-memory while the somatic marker (a triggering process) is tied to image-memory. Complementing them there is an attentional-intentional process occurring in time. Roughly speaking, consciousness is its own selected evolutionary environment.

IV. Conclusions

In way of conclusion I may remark that Damásio must be read as an evolutionary-immanentist, i.e., no residual dualism is to be found in Damásio's theory.

If, on the one hand, I maintain that Damásio's evolutionary theory is not a dualist one, on the other hand, his naturalism cannot be read as sort of mechanism, eliminativism or even epiphenomenalist dualism just because his homeostasis and somatic marker theories rely on the contemporary concepts developed by Dynamic Systems Theory.

Finally, I think that his theory of emotions could be connected to visions expressed by the natural drift hypothesis of a DST theory and Panpsychist theories as well. I have tried to use some theoretical constructions from Deleuze (complemented by Bergson and Prinz) to show how embodied cognition (affects and emotions) is directly linked to DST. On the same stroke, I have tried to show some inevitable connections with Panpsychism. With regard to the latter, I would say – following Chalmers [3] – that it is still a theory in need of further theoretical development and empirical evidence.

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Integration of Fuzzy C-Means Clustering and Fast Level Set for Aerial RGB Image Segmentation

Zhengmao Ye, Habib Mohamadian, Hang Yin
College of Engineering
Southern University
Baton Rouge, LA70813, USA
zhengmao_ye@subr.edu

Yongmao Ye
Supervisor of Broadcasting Department
Liaoning TV Station
Shenyang, 110000, China
yeyongmao@hotmail.com

Abstract— The fuzzy level set method is proposed for aerial object recognition with respect to three RGB color components independently. Seeing that the convergence rate and robustness of the fuzzy level set are both sensitive to initialization, fuzzy C-Means clustering is employed for pixel classification in spatial initialization and parameter configuration. The fast level set model is then introduced to deploy active contours and formulate dynamic boundaries. This approach has been implemented on multiple sets of aerial RGB images such as sparse-distributed and dense-distributed ones. Based on the numerical simulation, rapid and distinct recognition of targeting objects in several typical cases are observed for each primary color representation, with the presence of inherent intensity inhomogeneity among aerial images. Both qualitative and quantitative analyses on the fuzzy level set segmentation outcomes have been presented.

***Keywords* — Fuzzy C-Means Clustering, Fast Level Set Model, RGB True Color Image, Image Segmentation**

I. INTRODUCTION

Thresholding and clustering are two traditional techniques for region segmentation and contour classification of digital images. Thresholding is a straightforward but natural way to differentiate between bright and dark regions by generating binary patterns out of the grayscale images. Cluster analysis is more complex, focusing on a set of objects to be classified so that the greater similarity occurs within the same cluster while the less similarity occurs in separate clusters. With the need of variational boundaries of moving targets in aerial imagery, the multi-dimensional nonlinear level set function could be introduced to cover both space and time information. The level set refers to a real valued function of a set of multiple real variables that takes on a specified constant value. A level surface is formulated with a set of three real valued roots of the equation. A level hypersurface can also be formulated with a set of more than three real valued roots. On the other hand, level set segmentation is highly sensitive to the parametric initialization. Both initialization and optimal adjustment of control parameters are crucial to performance of level set segmentation. In this case, fuzzy C-Means clustering can be applied to identify the initial surface or contour, where spatial and intensity information is counted into a performance index to be well defined. The iterative C-Means clustering is an unsupervised learning approach which groups the data into a set of hard clusters, while fuzzy C-Means clustering assists in generating a set of soft clusters for automatic initialization and image partition. In the meanwhile, the control parameters are also estimated beforehand along with further dynamic level set evolution and segmentation with variational boundaries and active contours in regard to space and time. Fuzzy C-partition has a wide variety of clustering and thresholding applications on data interpretation. To speed up the convergence rate, the evolution inspired global optimization techniques have been employed such as the Genetic Algorithms, Particle Swarm Optimization, Ant Colony Optimization [1-9]. In some cases, a convergence theorem is introduced to generate a biased fuzzy C-Means algorithm with a focal point, which exhibits better scale in data space and less sensitivity to initialization [10]. At the same time, approaches shown above increase computation complexity significantly.

An alternative approach of less computational expense is the level set method which has been implemented as well. The fuzzy C-Means clustering with a level set model is deployed in an effort to localize the nonideal iris images accurately without over-segmentation and reinitialization. Using spatial fuzzy clustering and evolutionary feature extraction, it incorporates the spatial information into the level set based curve evolution approach so as to regularize the level set propagation locally. It also combines both the sign and magnitude features to improve texture classification performance [11]. Performance of the level set segmentation is subject to appropriate initialization and optimal configuration of controlling parameters. Thus fuzzy clustering is applied for initialization whose spatial information is important to approximate medical image boundaries of interest and controlling parameters. The fuzzy level set presented is based on the Hamilton-Jacobi function, which will suppress boundary leakage and alleviate manual intervention [12]. Watershed transform is also testified for initial partition together with fuzzy C-Means clustering to produce an initial contour. It avoids leaking at the boundary during the curve propagation of level sets. The efficiency and accuracy of this algorithm is demonstrated by the experiments on MR images, which shows a considerable improvement in the evolution of the level set function [13]. The fast two-cycle model provides the fastest level set image segmentation. However, it is still highly dependent on initialization. The spatial kernel fuzzy C-Means clustering is applied to produce an initial contour, such that enhancement on accuracy, convergence and robustness are achieved on segmentation of both synthetic and real images [14]. A combination of the level set model with fuzzy clustering and Lattice Boltzmann method is also proposed for medical image segmentation which is independent to the initial contour. It shows good segmentation performance of speed, effectiveness, accuracy, robustness and efficiency on medical and real world images [15].

Due to atmospheric dispersion and high speed motion trail effects, on the other hand, aerial images tend to be blurry and inhomogeneous which enlarges the difficulty of segmentation. Therefore integration of fuzzy C-Means clustering and fuzzy level set has been proposed on segmentation of aerial images. To enhance the accuracy, robustness and efficiency in object recognition, instead of grayscale images that are typically used in medical image segmentation, segmentation based on RGB true color components is made to ensure the quality of aerial image segmentation. Several sets of experiments on sparse and dense distributed images are conducted with convincing results.

II. GENERALIZED FUZZY C-MEANS CLUSTERING

In fuzzy C-Means clustering, a fuzzy membership function is defined as the degree of membership μ_{mn} of the nth object to the mth cluster, such that each object belongs to multiple clusters with certain degrees of fuzziness. It reflects the fact that region boundaries among diverse neighboring clusters are seldom distinct in practice. A fuzzy partition matrix indicates the degree of belonging on to what extent an image pixel can be counted as a member of different image clusters. The geometric center and scope of each cluster will be computed adaptively to minimize the objective function in fuzzy C-Means clustering. The pixels along the boundary between clusters have lower degrees of belonging than the ones close to cluster centers. Some typical fuzzy membership functions are Triangular, Trapezoidal, Sigmoidal, Gaussian, and Bell Shape functions, among which the Gaussian fuzzy membership function is widely applied. The sum of degrees of belonging for any individual pixel in all C clusters is equal to one, as shown in (1).

$$\sum_{i=1}^{C}\mu_{ij}(x)=1;\ \mu_{ij}(x)\in[0,1];\ i=\{1,2,\cdots,C\};\ j=\{1,2,\cdots,N\} \quad (1)$$

where $x=\{x_1, x_2, \ldots, x_N\}$ represents a finite collection of N data points to be classified into C fuzzy clusters. μ_{ij} refers to the fuzzy membership function; C refers to the total number of clusters; N refers to the total number of data points or image pixels to be clustered.

The problem is formulated as partition of N-dimensional image pixel dataset into C fuzzy subsets by minimizing an objective function (2).

$$\begin{aligned}\min\{F(U,X,C)\} &= \min\{K\sum_{i=1}^{C}\sum_{j=1}^{N}\mu_{ij}^{m}\|x_j - c_i\|^2 - S(U)\} \\ &= \min\{K\sum_{i=1}^{C}\sum_{j=1}^{N}\mu_{ij}^{m}\|x_j - c_i\|^2 + \sum_{i=1}^{C}\sum_{j=1}^{N}\mu_{ij}\log_2(\mu_{ij})\}\end{aligned} \quad (2)$$

where the cluster centers (c_i) are computed as the normalized quantities weighted by the fuzzy membership functions.

$$c_i=\sum_{j=1}^{N}(\mu_{ij}^{m}x_j)/\sum_{j=1}^{N}(\mu_{ij}^{m}) \quad (3)$$

The total number of clusters is predefined and $C=\{c_i\}$ represents a vector of cluster centers. K is a factor to normalize the magnitude levels of two terms. $U=\{\mu_{ij}\}$ represents a fuzzy partition matrix whose any row sum is equal to unity. μ_{ij} is the fuzzy membership of a pixel x_i in a cluster j. $X=\{x_i\}$ represents the data matrix, where x_i is the jth element of the data matrix. The fuzziness index m ($1\leq m<\infty$) serves as a weighting exponent which is applied to control fuzziness of clustering based image segmentation. $\|.\|^2$ represents the L_2 norm.

An individual fuzzy membership function μ_{ij} illustrates the degree of belonging. It is defined as the ratio of single cluster distance measure over the sum of all distance measures from C clusters to the particular image pixel.

$$\mu_{ij}=\frac{\|x_j - c_i\|^{-(\frac{2}{m-1})}}{\sum_{i=1}^{C}\|x_j - c_i\|^{-(\frac{2}{m-1})}} \quad (4)$$

A feasible objective function is defined as (2) to optimize fuzzy C-Means clustering. Its first term covers the spatial neighborhood information such as the intensity, brightness, texture and position in the feature space to formulate the region based segmentation for pixel clustering. Its second term involves a definition of the discrete entropy for a digital image which is associated with boundary and contour information. Physical meaning of the entropy defers that boundaries among separate clusters of digital images mostly occur between any two sets of image pixels with the largest dissimilarities in the intensity or any other features. Thus the corresponding fuzzy entropy can also be defined as (5) which incorporates the second term of (2).

$$S(U) = -\sum_{i=1}^{C}\sum_{j=1}^{N}\mu_{ij}\log_2(\mu_{ij}) \quad (5)$$

The fuzzy entropy actually loosely depicts the uncertainty on information. Whenever two sets of image pixels exhibit most significant variations in the intensity or brightness, the marginal fuzzy entropy is equal to a maxima (e.g. at border). Whenever the same intensity or brightness occurs across all neighboring pixels, the fuzzy entropy drops to the minima of zero. Therefore, combination of fuzzy spatial information and vague boundary information is made in definition (2). For 8-bit grayscale images, there are 256 intensity levels. For RGB true color 24-bit images, three channels (Red, Green, Blue) can be processed separately so that each color still has 256 intensity levels. The goal is to minimize the fuzzy distance norm and maximize the fuzzy entropy at the same time. By iterative computing, global minimization is gradually reached when the pixels around centers are assigned with larger degrees of fuzzy memberships and the pixels far away from centers are assigned with smaller degrees. In this case, initialization for the level set model is formulated.

III. FAST LEVEL SET APPROACH

A level set model generates dynamic variational boundaries to represent topological changes of either a level surface or a hypersurface. The active contour is represented by a zero level set function which provides an implicit representation of the interface. A typical level set function is formulated as the Signed Distance Function (SDF) to the surface. Regarding the applications on image segmentation, the initial contour is produced by fuzzy C-Means clustering. Via fuzzy C-Means clustering, the fuzzy boundary between each pair of clustered sub-images has been weighted, which is applied to define an edge indicator function based on the gradient information. The implicit evolution of the active contours is approximated by tracking the zero level set driven by the level set partial differential equation. Implicit representation of active contours leads to automatic tracking of topological changes in terms of interfaces and shapes. To evolve the surface towards outer boundaries, both external and internal forces are defined.

For 2D image segmentation, a level set function represents a closed surface which evolves along with time being defined as Φ(x, y, t). It follows a time dependent PDE function (6).

$$\frac{\partial\Phi}{\partial t}+F|\nabla\Phi|=0 \qquad (6)$$

where $\Phi(x, y, t)|_{t=0} = \Phi_0(x, y)$. Rather than using an arbitrary starting contour or lengthy initialization process without spatial information, fuzzy C-Means clustering helps for the contour initiation. Evolution of the active contours can be formulated as the zero level set Γ(t), so that Φ(x, y, t)=0 whenever (x, y) is located at Γ(t). The contour evolution is then driven by the level set equation (6). |∇Φ| defines the gradient operation at the normal direction. F represents the total force function which covers internal and external forces. The internal force stems from topological geometry and the external force results from the gradient operation and artificial momentum.

The edge indicator g is formulated to regulate and terminate the level set evolution around the optimal solution as (7):

$$g=\frac{1}{1+|\nabla(G_\sigma * I)|^2} \qquad (7)$$

where gradient operation is applied to the convolution of the Gaussian kernel with a 2D image I. For each clustered sub-image (I_1, I_2, I_3,...), the fuzzy boundary can be computed as well such that a composite weighted function serves as the updating edge indicator. In this case, the level set model is now simplified as (8).

$$\frac{\partial\Phi}{\partial t}=g|\nabla\Phi|\,[\mathrm{div}\,(\frac{\nabla\Phi}{|\nabla\Phi|})+\nu] \qquad (8)$$

where the divergence of a normalized term ∇Φ/|∇Φ| indicates the mean curvature and ν indicates the balloon force.

To solve the level set equation, numerical techniques can be used to track interfaces and contours. The Fast Level Set method can be presented to substitute the explicit solution for the implicit solution. A finite difference approach is introduced to obtain an explicit computation solution of the curvature. Thus the fast level set approach has been applied where the controlling factors μ, λ, ν are defined as three constants, reflecting penalty, topological conservation and balloon force information, respectively. (8) is now replaced by (9) and (10):

$$\frac{\partial\Phi}{\partial t}=\mu\alpha(\Phi)+\beta(g,\Phi) \qquad (9)$$

$$\frac{\partial\Phi}{\partial t}=\mu[\Delta\Phi-\mathrm{div}\,(\frac{\nabla\Phi}{|\nabla\Phi|})]+\lambda\delta(\Phi)\mathrm{div}\,(g\frac{\nabla\Phi}{|\nabla\Phi|})+\nu g\delta(\Phi) \qquad (10)$$

where

$$\alpha(\Phi)=\Delta\Phi-\mathrm{div}\,(\frac{\nabla\Phi}{|\nabla\Phi|}) \qquad (11)$$

$$\beta(g,\Phi)=\lambda\delta(\Phi)\mathrm{div}\,(g\frac{\nabla\Phi}{|\nabla\Phi|})+\nu g\delta(\Phi) \qquad (12)$$

The first term μα(Φ) in (9) is the penalty term which is to penalize any deviation of Φ from the Signed Distance Function upon evolution. The second term β(g, Φ) of (9) covers the gradient information which is also dependent on the Dirac function δ(Φ). In (12), the role of the gradient operation is to drive a zero level set towards the variational boundaries while the role of the balloon force is to either push or pull the dynamic interface towards the objects of interest. The Dirac function can be defined as an adjustable threshold (13) which is equal to zero when x is outside of [-ε, ε].

$$\delta_\varepsilon(x)=\frac{1}{2\varepsilon}[1+\cos(\frac{\pi x}{\varepsilon})] \qquad (13)$$

where ε is a regulating factor of the Dirac function. Given a step size τ, an iterative evolution of Φ can be formulated as:

$$\Phi^{k+1}(x,y)=\Phi^k(x,y)+\tau[\mu\alpha(\Phi^k)+\beta(g,\Phi^k)] \qquad (14)$$

Here the initial contour is processed with fuzzy C-Means clustering. The level set model is simply defined as the Signed Distance Function whose dynamic interface evolves towards optimal boundary adaptively for image segmentation.

IV. Segmentation of RGB Aerial Images

Even though numerous image segmentation applications using level set methods are made on the medical images in grayscale representation, an aerial image is seldom taken into account because it is sensitively affected by the atmospheric dispersion and motion effects. For RGB true color images, however, the corresponding 8-bit grayscale representation can barely cover complete and authentic information. True color specifies the color system with pixels on display screen using a 24-bit value. It allows the maximal possibility of up to 2^{24} colors. An 8-bit grayscale representation can be regarded as a single channel out of the multichannel color images. The bit-depth of the true color is 24-bit which is formulated by three independent RGB light beams (red, green, and blue). Each light beam representation has its own bit-depth of 8 bit with up to 256 possible colors. In the true color system, three colors represent the primary spectral components in the Cartesian coordinate system. Each of the three could have an arbitrary intensity, from fully off to fully on in the color mixture. In this case, every primary intensity component could be computed and analyzed independently before the composite mixture is made. In the true color subspace, each color can be mapped into a cube uniquely in which the RGB values are located at three corners; black lies at the origin and white lies at the corner opposite to the origin. The rest three colors (cyan, magenta, yellow) are located at other three corners. RGB images consist of three independent stacked channels for every primary color components. Inside the color cube, the lowest value refers to the color of black and the highest value refers to the color of white. The greyscale occurs along with the leading diagonal that connects black and white corners. Every mixing color acts as a vector on or inside the cube directed from the origin. Arbitrary mixture combination of red, green and blue will generate a wide variety of true colors. The projection of the RGB true color intensity components onto the leading diagonal gives rise to the grayscale image. The intensity component is the composite color image from three primary image planes. Unlike the grayscale images, the level set segmentation on true color images is seldom conducted, so integration of the fuzzy C-Means clustering and fast level set is proposed for aerial image segmentation via true color representation. At the same time, true color images are superior to grayscale ones which are capable of showing the dynamic boundaries from multiple points of view. Hence RGB aerial images are selected instead of grayscale images. Each primary component of red, green and blue could be treated similar to the grayscale image of 8 bits, whose intensity level ranges from 0 to 255. Thus image segmentation via technology integration of fuzzy C-Means clustering and fast level set can be made for aerial images represented by 3 primary colors individually. Obviously it will enhance the quality of image segmentation significantly with greater accuracy in a much broader scope.

V. Case Studies of Fuzzy Segmentation

For segmentation based on integration of fuzzy C-Means clustering and fast level set approach, the merits of two will be combined. Now feasibility and effectiveness must be verified by diverse types of aerial images to be selected. Without loss of generality, four types of source RGB aerial images are chosen including the sparse-distributed aerial images, dense-distributed aerial images, typical landscape aerial images and typical skyline aerial images. Since grayscale representation can act as a single channel of multichannel color images, three independent channels for red, green and blue can also be processed for image segmentation in a similar way. The role of technology integration of fuzzy C-Means clustering and fast level set approach being proposed is subject to testing on each of three true primary color components of aerial images. Numerical simulation results on all four diverse cases of aerial image selections are obtained successfully. For comparison purposes, each source RGB aerial image is placed together with three segmented images based on red, blue and green components, so that the level set contours can be clearly demonstrated in all three cases across different sets of numerical simulations.

A. Segmentation of Sparse-Distributed Aerial Images

In Figs. 1-2, segmentation of two sparse-distributed aerial images is made in terms of red, blue and green primary components. Fig. 1 contains single major target of airplane, while Fig. 2 contains multiple major targets of small islands and island chains. The distinct level set contours have been observed from each case despite the presence of intensity inhomogeneity. It is clear to see the effects from atmospheric dispersion and motion. On the other hand, minor differences exist among the level set contours being captured with respect to three primary components. It depicts the fact that level set segmentation on an exclusive grayscale representation of the source image will lead to reduction in feature usage, which can never fully indicate the actual contour information. RGB true color segmentation can suppress the boundary leakage which provides much more details and produces better visual appeal than grayscale segmentation.

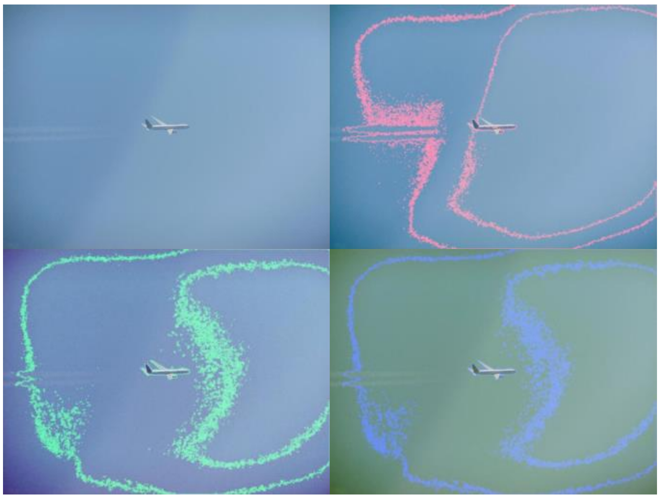

Fig. 1. Segmentation of Sparse-Distributed Aerial Image A

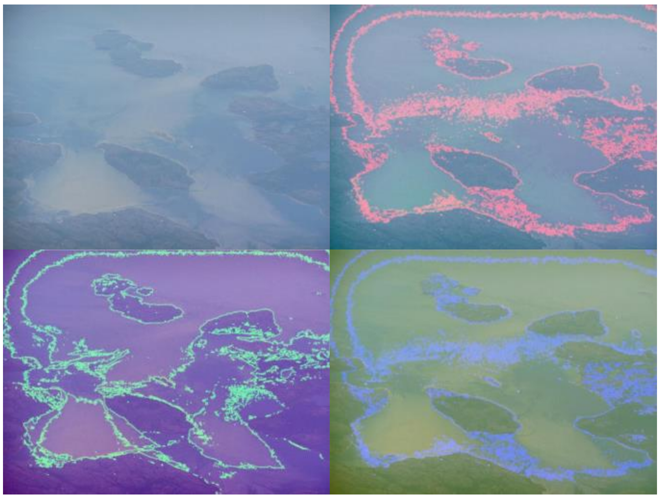

Fig. 2. Segmentation of Sparse-Distributed Aerial Image B

B. Segmentation of Dense-Distributed Aerial Images

In Figs. 3-4, segmentation of two dense-distributed aerial images is made in terms of red, blue and green primary components. Fig. 3 shows a bird eye view of New York City and Fig. 4 shows a bird eye view of Moscow City. Both images are composed of hundreds of useful objects. For two dense-distributed aerial images, once again, distinct level set contours have been observed at both cases in spite of the presence of intensity inhomogeneity. At the same time, minor differences still occur among the level set contours captured from three primary color channels. It strengthens the conclusion that level set segmentation on an exclusive corresponding grayscale representation of a source image can only indicate the incomplete contour information. RGB true color segmentation still suppresses boundary leakage, which gives rise to much more details and produces better visual appeal than grayscale segmentation.

Fig. 3. Segmentation of Dense-Distributed Aerial Image A

Fig. 4. Segmentation of Dense-Distributed Aerial Image B

C. Segmentation of Landscape Aerial Image

In Fig. 5, segmentation of the landscape aerial image of Melbourne is made in terms of red, blue and green primary color channels. Similar to Fig. 1 and Fig. 2, it contains single major target of a palace. However, the majority portion of the digital image is covered by green trees and lawns, which increases the difficulty in identifying those small paths and trails. Using the same approach, distinct level set contours can be captured and recognized once again with the presence of intensity inhomogeneity. Dissimilarities still exist among level set contours detected from three color components. An individual corresponding grayscale representation of the source image is far from enough to cover all necessary actual contour information giving rise to reduction in feature usage. Therefore, RGB true color level set segmentation provides more detail information in separate three cases, which is necessary to substitute classical level set segmentation in grayscale. In the meanwhile, the contour of the major object turns out to be sharper than the grayscale counterpart.

Fig. 5. Segmentation of Landscape Aerial Image

D. Segmentation of Skyline Aerial Images

In Fig. 6, segmentation of the skyline aerial image of Tokyo is made in terms of red, blue and green primary components. Similar to Fig. 3 and Fig. 4, it contains numerous major objects illustrated as the combination of landscape and architecture. Based on three primary colors, distinct level set contours are recognized in three cases regardless of inhomogeneity. Mismatches still can be easily located among level set contours stem from 3 color channels due to the boundary leakage. Segmentation on an exclusive grayscale representation of the source image is incomplete to identify actual contour feature. True color segmentation is a more suitable option that provides the complete feature information with better visual appeal than grayscale segmentation.

Fig. 6. Segmentation of Skyline Aerial Image

Via comparison of active contours generated based on three primary color component by integration of fuzzy C-Means clustering and fast level set method, minor differences can be observed throughout diverse types of source images. As a result, it manifests the necessity of replacing the typical grayscale segmentation by RGB true color segmentation. It also validates that integration of fuzzy C-Means clustering and fast level set method serves as a powerful approach for broad applications on aerial image segmentation.

VI. Quantitative Comparisons

Case studies are conducted above for qualitative analysis, which infers that the fuzzy level set segmentation outcomes could hardly be represented fully by grayscale segmentation exclusively. At the same time, quantitative analysis is also needed to confirm the results. To avoid redundancy of various metrics defined in quantitative comparisons, only two simple metrics of homogeneity and dissimilarity are proposed in the context. In Fig. 7, the level set contours based on the grayscale representation and 3 primary color channels are shown, where the result of grayscale fuzzy level set segmentation in the 1st case is chosen as an example so as to compare with outcomes from those three independent color channels. Its fuzzy level set contour differs from any of three other outcomes.

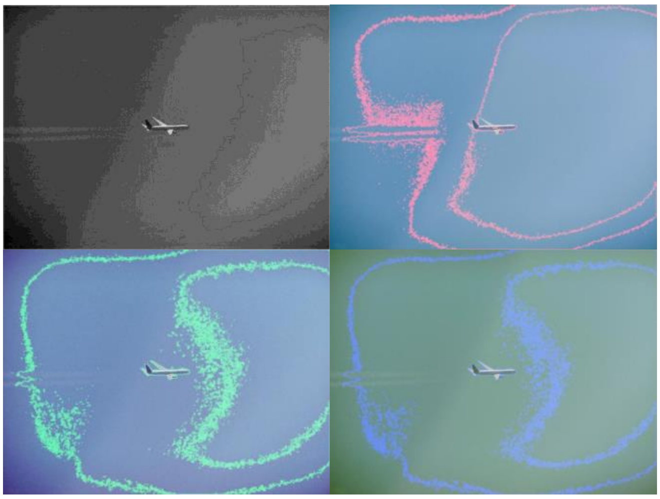

Fig. 7. Comparison of Fuzzy Level Set Segmentation Results

Homogeneity is a metric that depicts local variations in the grayscale image or each of three channels of RGB images. It associates inversely to the image contrast which shows both similarities and differences among objects and background within exactly the same scope of regions. Higher values of homogeneity measures indicate less structural variations and lower values indicate more structural variations. Larger values are corresponding to higher homogeneity and smaller values are corresponding to lower homogeneity. It is formulated as (15) whose results are listed in Table I.

$$\text{Homogeneity}=\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}\frac{1}{1+(i-j)^2}g(i,j) \qquad (15)$$

where M and N are the total numbers of pixels in the single row and column of a digital image, g(i, j) is the intensity level of the image co-occurrence matrix at the coordinates i and j, for a digital image of the size M by N.

Table I. Comparison of Homogeneity

Fuzzy Level Set Segmentation	Gray Scale	Red Channel	Green Channel	Blue Channel
Homogeneity	0.9868	0.9864	0.9425	0.9917

Even though four results based on the grayscale, red, green and blue color components are at the same magnitude level, the corresponding data are quite different, where the grayscale outcome lies between the highest and lowest homogeneity values among 3 color channels. The grayscale outcome is far from enough to describe information in all three channels.

Dissimilarity is another metric for the local distance representation which is associated with the distribution of the image co-occurrence matrix g(i, j). It is simply expressed as (16) whose results are listed in Table II.

$$\text{DisSim}=\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}g(i,j)\,|i-j| \qquad (16)$$

where M and N are again the total numbers of pixels in the single row and column of a digital image, g(i, j) is the intensity level of the image co-occurrence matrix at the coordinates i and j, for a digital image of the size M by N.

Table II. Comparison of Dissimilarity

Fuzzy Level Set Segmentation	Gray Scale	Red Channel	Green Channel	Blue Channel
Dissimilarity	0.0324	0.0273	0.1166	0.0166

In Table II, the dissimilarity value computed in terms of the grayscale representation is significantly different from three other values stem from the 3 primary color channels. However, it is once again located between the highest and lowest dissimilarity values among 3 color channels. In order to fully manifest global contour information, outcomes from all three primary color channels are crucial.

VI. Conclusion

Integration of fuzzy C-Means clustering and fuzzy level set has been presented for segmentation of aerial images. The objective of fuzzy C-Means clustering is to partition a finite collection of data into C fuzzy clusters by minimizing the performance index, so that the initial contour can be reached for further fast level set segmentation. The selection of performance index incorporates both the local intensity information and spatial information, which also covers the notion of fuzzy entropy. True color image segmentation is used to substitute the grayscale segmentation typically used in medical image processing for the concern of dispersed and inhomogeneous aerial images, where each of three RGB color components has been processed independently. Based on experimental outcomes on sparse and dense distributed aerial images as well as the typical landscape aerial image and skyline aerial image, convincing performance with robustness has been observed in a fast convergence rate. In addition, fuzzy level set segmentation with respect to exclusively grayscale representation of the true color image leads to reduction in contour information. In addition, quantitative comparisons on a basis of homogeneity and dissimilarity are also made which validate the qualitative analysis results. The RGB true color segmentation provides much more authentic details with better visual appeal than the grayscale segmentation.

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Repetition Probability Modulates Repetition Suppression without Perceptual Awareness

Leonardo S. Barbosa
Laboratoire de Sciences Cognitives et Psycholinguistique,
École Normale Supérieure - PSL
ENS, PSL, ED3C
Paris, France.

Sid Kouider
Laboratoire de Sciences Cognitives et Psycholinguistique,
École Normale Supérieure - PSL
ENS, PSL, EHESS, CNRS
Paris, France

Abstract— **Neural activity induced by a visual stimulus is usually reduced when it is repeated. This phenomenon, termed repetition suppression (RS), is classically held to stem from neuronal adaptation either as a consequence of bottom-up adaptations (Grill-Spector et al., 2006; Gotts et al. 2012). More recently, however, RS has been argued to derive from top-down mechanisms of predictive coding, reflecting a comparison between the expected and actual sensory evidence conveyed by the stimulus (Rao & Ballard 1999; Friston 2005). Congruent with this view, RS has been shown to increase with the probability of encountering a repeated stimulus (Summerfield et al., 2008; Todorovic et. al, 2011). Nevertheless, this assumption has been challenged by a surge of recent studies arguing that this modulation of RS is restricted to a certain class of prior expectations (Kovacs et al., 2013; Larson & Smith, 2012), casting doubt as to which extent top-down mechanisms are necessary to explain RS, otherwise saying, questioning the automaticity in forming and applying prior information to sensory evidence. Here, to address this issue, we used a subliminal priming paradigm combined with EEG recordings (Henson et al., 2008). Moreover, we varied the probability of repetition between experimental blocks in order to address whether unconscious RS can be modulated by the predictive context (i.e. repetition probability). Our results show that invisible stimuli evoke RS at early stages of EEG in electrodes close to perceptual regions. Crucially, RS was present only when a repetition was expected, and vanished when an alternation was expected, independently of consciously perceiving the prime. We argue that this provides evidence for automatic, unconscious influence of probabilistic context in RS, affecting early perceptual components.**

Keywords—Repetition Suppression; EEG; Awareness; Predictive Coding.

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A modelagem multiagente como metodologia de estudos dos fenômenos sociais

Denis James Pereira
Faculdade Interdisciplinar em Humanidades
Universidade Federal dos Vales do Jequitinhonha e Mucuri
Diamantina, Brasil
pereira.denisjames@outlook.com

Leonardo Lana de Carvalho
Faculdade Interdisciplinar em Humanidades
Universidade Federal dos Vales do Jequitinhonha e Mucuri
Diamantina, Brasil
lanadecarvalholeonardo@gmail.com

***Resumo* — A divisão moderna das ciências em várias áreas do conhecimento (como, por exemplo, em ciências humanas e sociais, ciências exatas e ciências biológicas) têm origem nas discussões filosóficas desde o período da Grécia Antiga. No momento de retomada dos estudos deste período grego, mais precisamente durante o renascimento, especificou-se, além dos conceitos de ciência, a metodologia e a especialização de algumas abordagens do conhecimento. O objetivo deste trabalho é o de delinear os conceitos centrais da influência nas ciências humanas pela teoria da enação com o suporte da modelagem computacional baseada em multiagente. Neste sentido, não se trata de propor modelagem e simulação de um fenômeno social específico mas de discutir as mudanças nas bases epistemológicas em ciências humanas trazidas pelos conceitos enativos e multiagente. Wilhem Dilthey (1833-1911), pioneiro na fundamentação das Ciências Humanas, propõe e conceitualiza a chamada ciências do espírito. Para Dilthey, fazia-se necessário distinguir as ciências da natureza, aquela em que seus objetos são exteriores ao ser humano, das ciências do espírito, onde os objetos de estudos são internos e possuem uma relação entre os seres humanos [1]. Nas Ciências Humanas e Sociais contemporâneas, diversos pesquisadores brasileiros se apoiam nesta conceitualização, considerando como extremamente divergente os estudos das ciências da natureza e os estudos das ciências humanas e sociais. O antropólogo Roberto da Matta por exemplo, diferencia as ciências da natureza das ciências sociais a partir de um ponto de vista, por ele elucidado, da complexidade. Suas considerações apresentam que, dentre outros, a simplicidade é característica das ciências naturais, contrapondo-se então a complexidade das ciências humanas e sociais [2]. Opondo-se a esta análise que caracterizamos como herança da tradição dualista, apontamos, no âmbito da abordagem Enativa das Ciências Cognitivas, uma nova síntese natural percorrendo a biologia, as ciências humanas e sociais. Trata-se primordialmente de um campo de estudos transdisciplinar, pois a teoria da enação rompe com a divisão espírito *versus* natureza; simples *versus* complexo. Isto ocorre através de conceitos-chave como o de autopoieses. Humberto Maturana e Francisco Varela (1946-2001) caracterizam a autopoieses e outros conceitos como acoplamento estrutural, deriva natural, cognição corpórea, inaugurando assim esta perspectiva [3] [4]. A organização autopoiética é a definição que unifica o que pode ou não ser definido como formas de vida. Para Maturana e Varela um ser vivo possui uma organização que lhe permite produzir continuamente a si mesmo, definido assim a autopoiese. A autoprodução das formas de vida se realizam acopladas estruturalmente ao ambiente, mantendo interação recorrente com o meio externo e com outros seres autopoiéticos, esta interação recorrente o levará a possibilidade de modificar sua própria estrutura. Formas de vida são encontradas em diferentes níveis, pois pode-se encontrar níveis diferentes de autopoiese. Uma célula é um ser autopoiético e está em acoplamento estrutural com outras células e seu entorno, assim como um órgão de um ser vivo também é um ser autopoiético e está em acoplamento estrutural com outros órgãos do ser vivo. Os indivíduos de uma sociedade que são seres autopoiéticos e que estão em acoplamento estrutural com outros indivíduos são caracterizados nesta abordagem como um sistema autopoiético de terceira ordem. Estas definições podem ser aplicadas a diversas áreas do conhecimento, tornando-se portanto um paradigma teórico [5]. Estudos contemporâneos das Ciências Cognitivas têm utilizado da abordagem enativa para a demonstração computacional de fenômenos sociais. Um importante marco do uso de modelagem computacional para demonstração de fenômenos sociais é o Modelo de Segregação Racial de Schelling, demonstrado em 1969. Destaca-se também as contribuições que foram dadas por autores como Nigel Gilbert, Jacques Ferber e Robert Axtell, apresentando novas possibilidades para o estudo de fenômenos sociais a partir do desenvolvimento da Modelagem Multiagente em Ciências Humanas e Sociais [6]. Esta modelagem se torna portanto uma importante ferramenta de estudos, mas destacamos aqui que tal modelagem aponta um importante marco epistemológico, direcionando a possibilidade teórica e metodológica das ciências humanas sob uma perspectiva enativa, indicando ainda não haver ruptura metodológica no domínio das ciências, tal como pregado por Dilthey.**

Palavras-chave — ciências humanas, enativismo, autopoiese, modelagem multi-agente.

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Ethanol Fuel Analysis Using Artificial Neural Networks

Daniel B. R. Rodrigues, Wesley Becari, Alexandre L. Neto, Péricles F. N. de Oliveira, William E. da Silva, Henrique E. M. Peres
Department of Electronic System Engineering
Polytechnic School of the University of São Paulo
São Paulo, Brazil
drodrigues@usp.br, wesley@lme.usp.br, hperes@lme.usp.br

***Abstract*— Brazil is a country with a high production of automotive fuel, producing almost 29 billion liters of ethanol in 2014. However, the illegal adulteration of automotive fuel can cause numerous problems: there is the pollution resulting from irregular fuel (burning of adulterated products results in more dangerous pollution); there are health issues (methanol used to adulterate ethanol can cause death in sufficiently large doses) [1]; there are mechanical problems (adulterated fuel conduces to reduced engine lifetime); and also economic issues (tax evasion and unfair competition are consequences of adulteration with cheaper and illegal substances). Besides, usual ways of fuel analysis require relatively complex laboratory methodologies and equipment [2]. Hence, this work proposes a classification methodology of ethanol fuel using an Artificial Neural Network (ANN) algorithm embedded in a microcontroller, using the data from four sensors, and testing it with water-adulterated ethanol. For analysis, the ANN utilizes a Multilayer Perceptron (MLP) model trained with backpropagation for qualifying ethanol based on four different sensing methods: time-domain reflectometry (TDR), conductivity measurement, infrared absorbance (based on spectroscopy studies) [3] [4], and density measurements (obtained from a pressure sensor). In contrast to the current fuel qualification methods using chemical-analytical techniques, in this work we use a unique set of electrical sensors for the analysis, contributing to the portability of the system proposed. Sixteen samples of ethanol adulterated with various proportions of water were prepared. Nine of them were used for training the ANN (to classify samples between "approved" or "reproved"), while the other ones were used for validation of the system.**

The results have shown that the system was able to detect a variation of 2 % (volume/volume %) of water in the ethanol samples. Therefore, the proposed methodology can classify ethanol fuel adulteration and can be useful for *in situ* ethanol fuel qualification.

***Keywords*–Ethanol Fuel, Artificial Neural Network, Time-Domain Reflectometry.**

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Information and Complexity in the Study of Cognition

Mariana Vitti Rodrigues
Department of Science Education
University of Copenhagen
Copenhagen, Denmark
mariana.rodrigues@ind.ku.dk

Claus Emmeche
Department of Science Education
University of Copenhagen
Copenhagen, Denmark
cemmeche@ind.ku.dk

Abstract: The objective of this work is to analyze the relationship between information and cognition, from the perspective of the Theory of Complex Systems. The central research question is: "What is the role of information in abductive reasoning?". Our approach will be to analyze the concept of information and abduction focusing on its semiotic aspects, as defined by Charles S. Peirce (1839-1914). Three hypotheses will guide the work: **H1** Information about objects indicates their characteristics or predicates; **H2** The unveiling of information in the context of problem solving is the "fuel" of abductive reasoning and, in turn, of the process of cognition; **H3** Complex object requires the study of its multiple layers. We can understand the complexity of the studied object through the concepts of information, abductive reasoning and styles of reasoning in the perspective of the Theory of Complex Systems. Inspiring by the Peircean definition of sign as "a medium for the communication of a form" (EP2, p. 477), we understand that the informational process is completed when the communication of the form of objects to a possible receiver, via sign, is consolidated. By indicating the properties of objects and their spatial and temporal locations, the *Informational Sign* specifies the object properties that conveys the available form of it to a possible receiver. Information can thus be understood as a semiotic process of indication of forms provided by the object to a possible receiver. In this context, we understand provisionally that information fulfills two roles in the process of hypotheses-making, or abductive reasoning: **(1)** Information contributes to the perception of objects and facts that do not fit into the current set of beliefs, here understood as stable habits that guide action; **(2)** Information operates as an indicator of possible hypotheses, enabling the unveiling of relevant characteristics and properties of the studied objects. To aid our understanding about the role of information in abductive reasoning we provide an example about the discovery of a new class of protozoan, named, *Bodo designis* (2005, KOCH, & EKELUND). The initial question that triggered the abductive reasoning was: "Whether the forms of *Bodo designis* from contrasting environments are conspecific, i.e. largelly genetically identical, or whether they merely share the external morphology is presently not known" (p.97). The authors stated that "[i]t is puzzling that many flagellates found in highly contrasting environments apparently can be assigned to the same morpho species" (*ibid.*, p. 98). To solve this problem, the authors tried to constrain the possible properties of the studied object through a morphological, physiological and phylogenetic analysis of *Bodo designis* strains collected at nine different geographic origin. At the beginning, they authors knew that these different strains shared the same morphological aspects, but it was not enough to claim that the strains pertain to the same kind of species. Through these three different analyses, the authors discovered that *Bodo designis* should be considered as a group of organisms. Although they share the same morphological aspects, they differ in relation to phylogenetic and physiological properties. In this context, they highlight that "[i]f our phylogenetic trees provide a realistic picture of

the relationship, then it is not meaningful to consider *B. designis* as a species, but rather, *B designis* should be conceived as a group of organisms which shares a common external morphology". (2005, KOCH, & EKELUND, p. 107). According to our understanding, the hypothesis of a new group of protozoan which share morphological aspects but neither physiological nor phylogenetic was possible from the unveiling of information of the properties available in the studied strains. In this context, this discovery allowed an increase in the depth of the concept "Bodo designis", which contributed to the grow of knowledge about this group of protozoans through the restriction of possible properties attributed to it. In short, we intend to analyze in this work the role of information in the development of abductive reasoning, which we hypothesize can shed lights upon the process of cognition.

Key-words: Information, Abduction, Cognition, Complex Systems.

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TRADERS' DECISION-MAKING PROCESSES: RESULTS FROM AN INVESTMENT SIMULATION MONITORED WITH AN EEG

Roberto Ivo da Rocha Lima Filho
Federal University of Rio de Janeiro – Industrial Engineering Department; University of São Paulo – Medical School
Rio de Janeiro, Brazil
roberto.ivo@poli.ufrj.br

Armando Freitas Rocha
ENSCER
São Paulo, Brazil

Eduardo Massad
University of São Paulo – Medical School
São Paulo, Brazil

***Abstract*— The objective of this article is to identify, with the aid of an electroencephalogram (EEG), whether traders use different areas of the brain (and therefore different levels of neuronal activity) in their decision-making process when it comes to making a financial investment. A sample of forty (40) experienced traders was used, divided equally into 50% male and 50% female. Some findings through brain mapping indicate that these operators in the financial market tend to make decisions using an associative based rule process (anchored to historical or intuitive data); rather than any form of analytical based rule, as the classical financial literature on this issue suggests. From an economic standpoint, this work is distinct from the classical theories of Finance - Efficient Markets Theory and Modern Portfolio Theory - to the extent that it not only employs assumptions of behavioural finance, but also encompasses studies of neurocognitive processes.**

Keywords*— *Neuroeconomics, Rationality, EEG, Cognitive Science

I. INTRODUCTION

The objective of this article is to identify, with the aid of an electroencephalogram (EEG), whether traders use different areas of the brain (and therefore different levels of neuronal activity) in their decision-making process when it comes to making a financial investment.

From an economic standpoint, this work is distinct from the classical theories of Finance - Efficient Markets Theory and Modern Portfolio Theory - to the extent that it not only employs assumptions based on behavioral finance, but also encompasses studies of neurocognitive processes. The aim of this contribution is to strengthen the methodological link between neuroscience and economics / finance by using an EEG (electroencephalogram).

It is widely accepted that within neuroscience people use prices as anchors, as observed in some seminal work by Miller (1956), Parducci (1965), which suggests that this is no difference within the financial market. In behavioral finance, anchoring is seen as a behavioral bias, since it uses a number to draw up an estimate, even when there is no logical connection or even a relationship. In other words, there is a heuristic process to formulate any kind of judgment, as already envisaged in the work of Tversky & Kahneman (1981).

The evaluation of the acceptance of a certain decision - financial or not - is strongly linked to a risk-benefit analysis calculated by these agents, underpinned by the neuropsychological aspects related to the emotional space of a decision (ED).

From the experimental point of view, functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) have been recently used to study the brain activity correlated with this type of decision-making process.

According to scientific experiments, such as the one conducted by ET AL McClure (2004), ET AL Plassman (2008) and Dayan (2008), Rocha and al (2010), a wide network of neural circuits is involved in assessments of risks, benefits, conflicts, intentionality, etc. (this weighting is closely related to serotonin in the event of risks, and dopamine in the case of benefits). Understanding the functionality of such systems is of fundamental importance in understanding the dynamics of the financial market, i.e. to record the perception of each individual in relation to general market sentiment, which can lead to hysteria (a bear market) or euphoria (a bull market). It is reasonable to suggest that there is a reliability factor in the market itself.

It is known, however, that the risk-benefit scenario generates a conflict in the decision-making process. In the event of a change in an individual's perceptions, the distance between these variables - risk & benefit - will also alter, to the point of not making any decision at all.

So if, for instance, the conflict associated with the financial negotiation of the action exceeds the average conflict existing in the market, then the market humor tends towards that of a "vendor" (a seller or bearish), as the final price will be influenced by the buyer (and for "buyer" the word "bullish" can also be used). Thus, the moves of individuals can be anticipated through a determined time anchor based on market sentiment.

II. Neuro Basis of The Decision-Making Process

A. Neural Evidence

In the literature on neuroscience, the contribution made by some areas of the brain related to the cognitive processes of an individual is mainly determined by the regions of the parietal, frontal and hippocampal cortex, reflecting the spatial representation, memory and the generation of action in space. Miller; Cohen (2001) proposed an integrative theory of prefrontal cortex, based on the original work of Fuster (1987) and Goldman - Rakic (1988). The authors asserted that cognitive control stems from the active maintenance of patterns of activity in the prefrontal cortex that represent goals and the means of achieving them. They also provided signs of bias to other brain structures, the net effect of which is to guide the flow of activity along neural pathways that establish the appropriate links between inputs, the internal mapping of states of mind, and the skills needed to perform a given task. In essence, the two theorized that the prefrontal cortex is capable of guiding the inputs and connections, thus permitting the cognitive control of actions.

Importantly, controlled behavior also involves a time variable. Relevant information for decision making should be anticipated and kept in mind for a certain time, in what is called short-term or working memory. Moreover, one can also say that these processes are limited in capacity and, therefore, must also be properly selected. In the sensory realm, the latter fact is known as attention.

Shimamura (2000), with his dynamic filtering theory, describes the prefrontal cortex acting as a high-level gating system, where there is a filtering mechanism that enhances goal-directed activations and inhibits irrelevant activations. This filtering mechanism enables executive control at various levels of processing, including the selection, maintenance, updating, and forwarding of these activations. It has also been used to explain emotional regulation.

From an anatomical point of view, the prefrontal cortex is connected with the sensory systems via the dorsal and ventrolateral parts of the cortex. They are related with the sensory element more than the neocortex orbitofrontal cortex. The information received from the sensory areas comes from the occipital, temporal and parietal cortices.

According to Passingham, 1993, and as cited by Squire et al. 2003, it is suggested that the basal ganglia - dopaminergic ventral tegmental area of the midbrain – constitute the most important driver of the reward signals, and thus influences the prefrontal cortex.

Important to the somatic marker hypothesis (SMH), Damasio (1991) suggests that the orbital prefrontal cortex is responsible for the appointment of persons, objects, and situations with an "affective significance." This fact is achieved by virtue of the association between past memories and these markers help the individual to make a decision. This dynamic is then called the "somatic marker".

When there are complex or even conflicting choices, it is not possible only to use cognitive processes, as they can suffer from overloads, resulting in the inability to reach a satisfactory result. In these cases, somatic markers may help in decision making, as they are associations between stimuli that induce an associated reward affective / physiological state. It is conjectured that somatic markers are stored in the brain in the ventromedial prefrontal cortex (vmPFC; subsection of the orbital prefrontal cortex) region. These combinations of markers may occur again during decision-making, and can influence our cognitive process. The entirety of this state directs or influences a certain decision as to how to act through the brain stem and the striatum (unconsciously), or by manifesting (consciously) with high cortical cognitive processing. Damasio proposes that somatic markers direct attention to the most advantageous options, thus simplifying the decision-making process. This hypothesis was inspired by the economic theory in which the model of human decision making is devoid of emotions, involving the assumption of full rationality - with full knowledge and information obtained from the environment - of individuals and their "reaction functions", which are expressed in a mathematical form, thus generating optimal decisions. In contrast to this idealization, the somatic marker hypothesis proposes that emotions play a critical role in the ability to make quick, rational decisions in complex and uncertain situations.

In the same line of thought as Damasio (1991), Steven Sloman produced another interpretation of dual processing theory in 1996. He divides them into logical groups of information based on their statistical regularity. In other words, this organization is nothing more than in direct proportion to the similarity with past experiences, still relying on the similarity and temporal relations to determine the reasoning rather than an underlying mechanical structure.

The other process of reasoning, in the opinion of Sloman (1996), was based on the fact that reason works on a type of logical structure to reach conclusions different to those in the associative system. He also believed that the system of rules based on reason always had control over the associative system, although the former does not completely suppress the latter.

Kahneman (2003) provided additional interpretation, differentiating the two types of processing, calling them intuition and reasoning. The first system, intuition, or System 1, is similar to associative thinking, and had a fast and automatic feature, usually with strong emotional ties involved in the reasoning process. The author goes even further, stating that this kind of reasoning is strongly based on habits formed in the past (anchored in past experiences), and that is very difficult to change or even manipulate. The second system, i.e., reasoning or system 2, works at a slower speed and is much more volatile, being subject to conscious judgments and attitudes.

System 2 is relatively recent in evolutionary terms specific to humans. As mentioned earlier, it is also known as the rule-based system; or rational analytical system, and is the general area held in the short-term memory system. Because of this, it has a limited capacity and is slower than system 1, which is correlated with general intelligence. This system allows the advent of hypothetical thinking, which is not allowed by system 1, and that is also distinct to humans.

Dual reasoning (or dual processing) postulates, therefore, that there are two systems at work in a mind or brain. The current theory is that there are two separate and distinct cognitive systems underlying thinking and reasoning, and that these different systems have been developed through human evolution. These systems are often referred to as being either implicit or explicit; however, some theorists, such as Goel et al. (2000), prefer to emphasize the functional side; that is, the differences between the two systems, and not the factor of consciousness, and therefore relate to systems simply as system 1 and system 2.

Goel et al. (2000) and Goel and Dolan (2003) produced neuropsychological evidence for the dual processing of human reasoning, using magnetic resonance imaging (fMRI) in their respective studies. The authors found that anatomically distinct parts of the brain were responsible for the two different types of reasoning; proving that the reasoning based on content activated the left temporal hemisphere, while considering the formal problem, abstract reasoning activated the parietal system. They concluded that different types of reasoning activate the semantic content of the two different systems in the brain.

They also found that different mental processes were competing for control of the response to problems presented to volunteers. The prefrontal cortex was instrumental in detecting and resolving conflicts, which are characteristics of the system 2 area, already typically associated with that same system. The ventral medial prefrontal (vmPFC) cortex, and medial orbitofrontal, known to be associated with more intuitive responses, or heuristic system area 1, is in competition with the prefrontal cortex.

The activation of the vmPFC is associated with suppressing the success of emotional responses to negative emotional signal. Patients with lesions in the vmPFC show defects both in emotional response and in the regulation of emotion, as shown in a study by Koenigs et al. (2007). The emotions of the patients in this study were closely associated with moral values, as well as maladjustment in terms of tolerance, anger, and frustration; in certain circumstances. We also emphasize that lesions in this area show personality changes, such as lack of empathy, irresponsibility and poor decision making, as described by Motzkin et al. (2011).

The right half of the ventromedial prefrontal cortex was associated with the regulation of the interaction between cognition and empathy (empathic responses). Hedonic responses (pleasure) were also associations made with the level of activity in the orbitofrontal cortex by Morten Kringelbach, in his work meeting "Pleasures of the Brain" in 2009. This finding contributes to others associated with the prefrontal ventromedial cortex when it comes to judging preference, for example. There is the idea that the ventromedial prefrontal cortex is important for the reactivation of associations, and the component related to past emotional events (Kringelbach, 2009).

Individuals' expectations can easily be manipulated by changing the anchor of past prices. This result is now a stylized fact in the area of neurosciences, and exploring it will provide a new slant to the events that took place in the financial market crises.

Neuroeconomics shows that human decisions are made based on a weighting between the impulse for immediate gain or its maximization in the future. And consequently, rationality plays an important role in this system, because each time that lag is also taken into consideration, with the appropriate expected discount rate, whereas impulsive preference is indicative of disproportionate gains in the short term.

B. Investment Simulation

The objective of this research protocol is to describe the format of the experiment for the present work, which counted on the help of the Marketing Research recruitment firm, A + Recruitment.

A total of eighty volunteers, equally divided into two samples were recruited - undergraduate students between the second and penultimate semesters (before graduation), as well as financial market professionals working in the area of treasury, brokerage or asset management trading desks, also called traders or brokers. To facilitate the criteria, the latter was called a group of "traders". Moreover, a pre-requirement was to have at least one year of experience in the relevant area.

For both, the incentive was offered at R$100.00 (one hundred Brazilian Reais) for undergraduate students, while for traders, this figure was R$180.00 (one hundred and eighty Brazilian Reais) at the end of each experiment.

The experiment included 40 traders, both subdivided into 20 men and 20 women to have a viable and reliable comparison of recruited groups.

Volunteers participated in a simulation of investments in the Sao Paulo Stock Exchange - BM&FBovespa - while their brain wave activity was recorded by an electroencephalogram (EEG). The total simulation time lasted 50 minutes, also subdivided into 25-minute intervals, primarily related to a bull market (bullish in financial jargon), and then a bearish market (also identified as bearish).

Thus, the purpose of this study was to characterize patterns of brain activity associated with the decision to buy, sell or hold a stock comprised of two experimental portfolios (called A - B and market High - Low), and to correlate these patterns of brain activities.

Volunteers encountered on the computer a portfolio of pre-selected shares, with an initial amount of two hundred (200) at prices first disclosed by the system.

In each "Trading Day", the volunteer had to take a number of decisions for each portfolio (approximately 25 minutes for both portfolios), which could be to: - buy (C), sell (V), or leave unchanged.

Market prices evolved either as in a buyer's market (bullish market), or a seller's (bearish market). Prices relied on the trajectory of past trading sessions and online news was also disclosed at the time. These were then provided to try to identify the type of market in which trading was being made, to negotiate voluntary actions.

The simulation was terminated when it reached 25 minutes for each portfolio, or if the volunteer reached the next screen "END".

C. *The registration of EEG*

EEG was run by a program named *Icelera*, where brain waves were read by 20 electrodes with amplitudes resolution of 100µV, while the impedance was 10 kOhms with a low-pass filter of 50 Hz, and a sampling rate of 256 Hz with 10 bits of resolution. The great advantage of this technique is the fact that it is portable and noninvasive, without the need to go to a specific hospital or laboratory. Two networked computers were used for the EEG (electroencephalogram) recording, while the subject performed a specific cognitive activity, which in this case was a simulation of trading. The solution and time required to make the decision was duly recorded for later analysis.

Thus, the decision and the individual time required that led to this decision were recorded for each event. Every decision regarding all volunteers, was stored in the performance database. Other important socioeconomic data (such as gender, age, work experience, position) for each protocol were also recorded in this performance database.

Correlation coefficients - $r_{i,j}$ - for the activity recorded from each electrode (i) in relation to the other 19 electrodes (ej) were also calculated for each event (EVE) in the cognitive activity of volunteers. Entropy - $h(r_i)$ - of the 19 correlations, $r_{i,j}$, was calculated for each electrode "i", and associated with each event of a given cognitive activity recorded for volunteers was based on the following formulas:

$$h(r_{i,j}) = -r_{i,j}\log_2 r_{i,j} - (1-r_{i,j})\log_2(1-r_{i,j}) \quad (1)$$

$$h(\bar{r}_i) = -\bar{r}_i\log_2 \bar{r}_i - (1-\bar{r}_i)\log_2(1-\bar{r}_i) \; onde \; \bar{r}_i = \sum_{j=1}^{20} r_{i,j}/20 \quad (2)$$

$$h(r_{i,j}) = \sum_{j=1}^{20} h(r_{i,j}) - h(\bar{r}_i) \quad (3)$$

The above formula - see Rocha (2009) - reflects the Shannon entropy, which quantifies the expected information contained in a message value. It provides an absolute limit on the best possible encoding, assuming that communication can be represented as a sequence of independent and identically distributed random variables.

The average uncertainty and the average operator shall be obtained by the following formula:

$$\langle u \rangle = \sum_{i=1}^{n} p(x_i)u_i = -\sum_{i=1}^{n} p(x_i)\log_b p(x_i) \quad (4)$$

The definition of entropy h (x) is used. In the case where b equals two (2), the equation of expected measures of the bits that need to specify the result of a random number in an experiment.

The Factor Analysis (FA) of base Entropy will then be used to build up the mapping Factors (MFs) that show how the entropy regression $h(r_i)$ covariates with all electrodes in a given cognitive task. In general, three factors explain more than 55% of covariation $h(r_i)$, restricting the dimensionality of the variables, therefore facilitating the outcome analysis, and as according to Rocha 2009. The FA identifies three different patterns of brain activity that explain, in general, good covariance " $h(r_i)$" and can also be associated with three different types of neural circuits in the making of a particular decision (Rocha et al, 2010; Rocha, 2013):

(A) The P1 pattern is proposed to reveal the activity of attached neural circuitry for recognizing the solutions of possible problems, and they also evaluate their risks, and of course, the benefits involved in decision making;

(B) The P3 pattern is proposed to reveal the activity of neural circuits responsible for the calculation and adjustment of action, justice and willingness to take into account the results calculated by P1 neural networks;

(C) The P2 pattern is proposed to reveal the activity of executive neural systems and charge to trigger the whole process of decision making. With this, one selects the action to be implemented taking into account the information provided by the P1 and P3 neural networks.

Thus, it will analyze all the decisions made by all volunteers to extract the brain dynamics in each conflict of risks and benefits, given a previously chosen event.

As previously mentioned, FA identifies three different patterns of brain activity - P1, P2 and P3 – with values totalling over 55% of the covariance of h (i) - and the values below this cut off are represented by the blank colour in the map, while 100% are the colour red - where P1 reflects the solutions of possible problems vis-à-vis their associated benefits, and of course, risks involved in decision making. P3 already implements the action glimpsed in P1 and, finally, the P2 pattern reveals executive neural systems, and triggers the whole process of decision making, as an anticipation effect - Rocha (2013). With this, you select the action to be implemented taking into account the information provided by P1 and P3 neural networks.

According Preuschoff et al (2008, pg.77): "(...) neurons in parts of the brain respond immediately (with minimal delay) to changes in expected reward and with short delay (about 1 to 2 seconds), to risk, the measured by payoff variance." One can thus assume that there is a neuronal dynamics at the time of decision making, during which time the overall situation is assessed, and then the scope and brain finally decide on doing the deed. Resuming the work of Pavlov via Fiorillo; Tobler; Schulz (2003) using the conditional stimulus, after a certain time, a decision is made.

Knutson et al (2003) also showed this fact, using magnetic resonance imaging in the nucleus accumbens in four-second intervals between stimulus and reward. This is consistent with the idea that dopamine neurons fire more when the expected reward increases. Similarly, activation significantly increases the reward point in time in which it is advertised. This anticipation effect is raised by Rocha (2013). However, Preuschoff et al (2008) also draws attention to the fact that observing the short-term response at the moment of realized risk, i.e., when the stimulus is switched off and the outcome (reward / no reward) is revealed. One would not have expected this because both rewarded and unrewarded trials are averaged. In other words, the average prediction error should be zero. Yet VTA neurons react positively on average to the realization of risk. It could be assumed that this is because of a fundamental asymmetry: neurons can reduce their firing rate (in response to an absence of reward) only to zero; they can increase their firing rate (in response to reward delivery) to a much higher extent - at least in principle.

In other words, risk may trigger a different type of neuronal circuitry. The author argues that in the context of decision making, the theory that assigns a positive role to emotions is the SMH (Bechara, Damasio, 2005). Recent research suggests that decision-making occurs in the activation of the amygdala, insula, and orbitofrontal cortex, playing a crucial role in emotional context.

However, financial risks are too recent to have had an impact on the human brain. While the brain may have been optimized to assess environmental risks, the latter is known to be very different from financial risks. For example, environmental risks usually do not have a leptokurtic distribution and independence generally found in financial data. Errors are bound to arise when assessing financial risk to the brain, which end up invoking processes intended to evaluate environmental risks. Thus, one should assume that the brain areas when assessing the financial risks are different from those encountered when evaluating a reward or expectation of reward. (Preuschoff et al, 2008).

In the case of this work it highlights the result with buying, selling or holding of investment strategy (after visual stimuli as a graphic and newspaper articles to guide their decisions) was only revealed at the end of each move (be it positive or negative). The ultimate goal of each volunteer was to maximize their portfolios.

Recalling that in this experiment, the sample was divided into between 40 undergraduate students and 40 professionals from the financial market, subdivided into 20 men and 20 women in each situation. The balance of the sample was taken as 16 decisions in each market - separated into high and low markets - for the first sample (undergraduate), while the second (traders) made 22 decisions.

The results of the factor analysis are presented below the brain maps, with the respective factors being presented in order of magnitude (in parentheses), with the ">" sign, at a significance level above 55%.

D. Brain mapping technique with EEG

Most ancient techniques to map the brain are based on a measurement of the electric field or the magnetic field induced by the ionic currents generated by neurons involved in brain processing. They are the electroencephalogram (or EEG) and magneto EEG (or MEG). The latest technique to make this type of measurement is supported by analysis of a brain's magnetic field, by varying the movement of water molecules that are stimulated by strong and short disruptions of the brain's magnetic field. This technique can provide both a static image of the anatomy of the brain, called magnetic resonance imaging (or MRI), or information on the transitional changes of blood flow to the activated brain areas, called functional MRI (or fMRI) . The latter is used to disclose possible brain injury and the objective of the fMRI is therefore to identify the brain areas that are activated during a specific brain processing activity.

To analyze the abovementioned disorders, medical scientists rely on very sensitive machinery with sensors to measure the dipoles reversed and displaced from their original positions. Special experiments then need to be done in bays, where patients (or volunteers) are placed, to avoid any strong motor drive.

Statistical analysis of the data on the dipole offset provides precise spatial information about many sets of neurons activated in both cortical and sub-cortical areas during a specific processing. However, because the measurements are about the transient influx of blood, fMRI has a very low temporal resolution. Statistical analysis requires at least two seconds of data sampling to provide reliable information on the activated cortical or subcortical areas.

Moreover, the electrical activity (electric field temporal variation) is recorded by a set of electrodes, two of them in the headset. In other words, the electroencephalogram (EEG) is a weighted sum of the electric currents (2s sources - two seconds) generated by sets of neurons that are activated in different cortical areas.

Rocha et al (Foz et al, 2002; Rocha, Massad Jr. and Pereira, 2004; Rocha et al, 2005; Arruda, Rocha and Rocha, 2008; Rocha et al, 2010) developed a methodology for mapping the brain activity recorded from the electroencephalogram (EEG) that allows the study of the decision-making process both in simulated conditions as real.

The analysis of the EEG epochs is associated with specific moments of the cognitive task under study, and allows its characterization by FA (FA) through major patterns of the brain activity underlying finding a solution for the task at hand.

Rocha et al. (2006) used this technique to study the brain activity associated with the choice of buying products with different degrees of risk assessment, and showed that the emotional valence associated with each product correlates positively with brain activity recorded by frontal and parietal electrodes. These authors showed that the evaluation of satisfaction with an aesthetic dermatological treatment correlates with the activity of neural circuits that evaluate beauty both in personnel and social contexts.

Massad (2009) studied the brain activity during decision-making in veterinary diagnostic. The EEG was recorded while volunteers read clinical history data associated with an RX examined and decided on the diagnosis. The brain mapping identified a brain circuitry associated with the analysis of visual information and executive control tasks, with a pattern of activity similar to the 3 phases of the process. In addition, the FA has allowed the identification of two other patterns of brain activity, one of them associated the process of integration of clinical and radiological data, and the other with the diagnostic decision-making process.

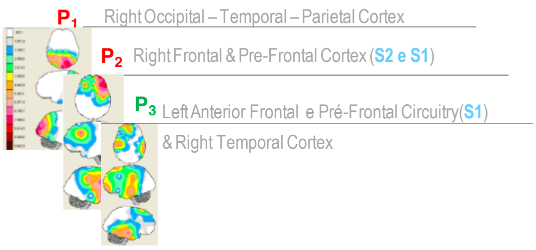
III. MAIN FINDINGS:

In the case of professional financial market trading desks, noting that traders are also called or "operators or brokers", the first pattern (P1) brain mapping identified occipital - temporal-parietal areas - Oz > T5> O2> P3> Pz> P4. The group of traders initiate moves with the right side of the brain's hemisphere dominating first impressions, leading to negative feelings (possibly uncertainty).

And the third pattern (P3) was mainly the frontal area - Fp2> F8> F4> F3> C4 - indicating that the analysis and monitoring of the scenarios was made by distinct neuronal circuits. However, in the latter (P3), although with less intensity, the left hemisphere is emphasized, culminating in a possibly positive emotion in relation to moves made. There is a possible drive system 1 related to the prefrontal and ventromedial orbito-frontal areas.

The revelation of the results was confirmed and possibly also suggests an instinctive mental accounting (heuristic) by participants at bullish market.

The final decision (P2) was on account of the reward system, since the right frontal cortex and anterior prefrontal region were activated - Fp2> F8> F4> F3> C4 - with bolder / aggressive investment attempts.



P1	P2	P3
Oz(0.82) | T5(0.77) | O2(0.72) | P3(0.63) | Pz(0.63) | P4(0.60)	Fp2(0.86) | F8(0.79) | F4(0.76) | F3(0.76) | C4(0.67)	T4(0.70) | T6(0.66) | T3(0.66) | Fp1(0.65) | Fz(0.58) | C3(0.57)

(*) The magnitude of factors higher than 0.55 is shown in brackets.

Figure 1 – Traders' Brain Mapping in Bullish Market

Increased use of neural circuits in buy vs. sale orders may again be due to higher refusal of the latter.

Table 1 – Number of Orders

Orders	Buy	Sell
Accepted	272	119
Denied	142	271

Despite the homogeneity of the group, i.e., all volunteers worked in different trading areas, such as brokerage desk, financial or asset management and hedge funds. This can be seen in chart below.

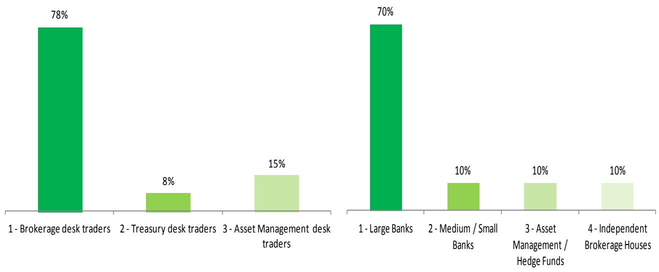


Figure 2 – Sample Characteristics

The frontal and prefrontal circuit is, according to Rocha (2013), responsible for "associative based reasoning" type rules (or rules based on intuition), as has been observed in studies by Goel ET AL (2000).

The group proved to make more heterogeneous decisions with standard deviation of R$33,595, and 42 with negative values. It is also worth mentioning that the average decision time of this group was at 49.2 seconds. This may also suggest a temporal discount compared to the expectation of reward, as advocated by Muller and Cohen (2001), since the activation of the final decision-making process occurred in the region of the frontal cortex and right prefrontal region.

Although speed is an indication of system domain 1 (heuristic bias), it should be emphasized that the decision was made in system 2 (cognitive control), showing that safety and emotional control were involved at some stage.

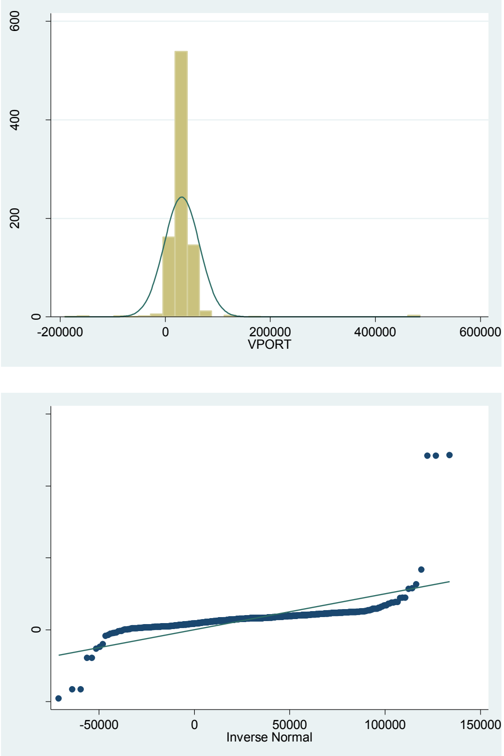


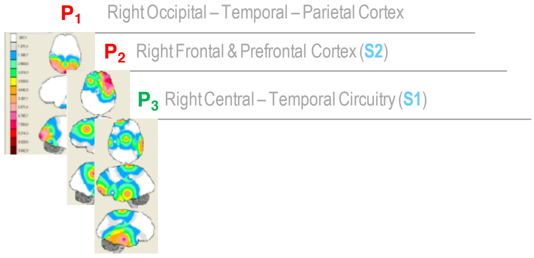
Figure 3 – Histogram and Normality Tests from Traders' Decision in Bullish Market

In adverse market, noting that this is also called bearish, the group of traders showed activation in the temporal-parietal areas - occipital (Oz> T5> P4> P3> O2> O1) and the third pattern, especially in the temporal region - T4> Fp1> T3> T6> Cz.

However, the final decision (P2) showed marked activation of the frontal and right prefrontal regions - Fp2> F8> F4> F3> C4 - suggesting a lateralization of the decision-making process.

In a down trending market, which is often unpredictable, there was a brain circuit activation of the occipital - temporal and parietal lobes in the case of the first pattern (P1), which supports the fact that the activation occurs in different neuronal circuits, when compared to other patterns.

The second pattern (P2), as it was more intense, was dominated by system 2 of cognitive control on the right side, possibly striving to implement the best strategy for certain games in order to maximize portfolio value. P3 is already related to system 1, or intuitive moves, because uncertainty prevails in a bearish market, and it is not known beforehand whether the outcome was positive or negative. In addition, the area on the right side (negative emotion) of the brain indicates some kind of dissonance regarding the moves made.



P1	P2	P3
Oz(0.86) | T5(0.77) | P4(0.63) | P3(0.63) | O2(0.60) | O1(0.56)	Fp2(0.85) | F8(0.77) | F4(0.75) | F3(0.73) | C4(0.72)	T4(0.75) | Fp1(0.71) | T3(0.65) | T6(0.59) | Cz(0.57)

(*)The magnitude of factors higher than 0.55 is shown in brackets.

Figure 4 – Traders' Brain Mapping in Bearish Market

However, losses were more significant in the down market, according to the histogram and QQ plot. There were thirteen volunteers, recruited from among the forty, which ended with portfolio simulation values in a negative quadrant.

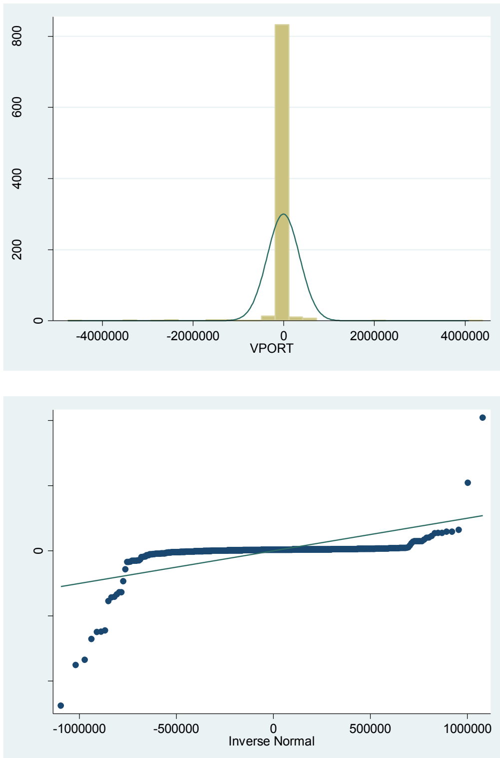


Figure 3 – Histogram and Normality Tests from Traders' Decision in Bearish Market

It is important to identify, in general, that in high and low markets, the circuits triggered by different trading strategies by the participants in the simulation also diverged; possibly indicating a greater involvement a rule of associative type or "instance-based" versus of the rule of reason (cognitive control), that is, following some experience anchored in the past, as advocated by Rocha (2013) and Sloman (1996).

This is true even in terms of decision times and the intensity of neuronal circuits, as in the case of sales that took longer to make the biggest decisions (making sure that this was the time to take profits), as advocated by the modern theory of finances.

IV. CONCLUSION

The advantage of this new methodology in terms of neuroeconomics is the fact that besides being non-invasive, it can determine in which areas of the brain the cognitive activity took place, and show how relevant this was for the decision.

Recalling Daniel Kahneman, he stresses that: "Economic analysis is more congenial to wants and preferences than hedonic experiences, and the current meaning of utility in economics and decision research is a positivistic version of wantability: utility is a theoretical construct inferred from observed choices".

This new approach will help not only add coherence to the theory itself, but also provides an important implication related to the attempt to draw a more realistic hypothesis under our neurobiological rules.

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What can a drone operators' PTSD tell us about embodied and extended mind?

Mgr. Marek Vanzura
Department of Philosophy
Faculty of Arts, Masaryk University
Brno, Czech Republic
342586@mail.muni.cz

Abstract*—For a long time, academics are discussing ethical aspects of use of unmanned aerial vehicles, also known as "drones" in the warfare, especially the notion of remote killing. However, out of sight is another highly important perspective concerning drones, which is interesting mainly for philosophy of mind and cognitive science. It is the impact of drone use on their very pilots or operators. So far drone operations are not completely autonomous and at least all the important decisions are still made by human operators; in many cases, these men and women control unmanned vehicles almost all the time. So the perspective of what impact have drone operations on their remote pilots is still waiting for its analysis. Luckily, in recent years there emerged first studies, which promise a huge potential for important and interesting research.*

The starting points for philosophical exploration of this topic are studies on existence of Post-Traumatic Stress Disorder (PTSD) among drone operators. The very existence of this issue among people, who are physically distant from war-zones, is disturbing and so far not sufficiently explained. I am offering a potential explanation. I propose to think about this topic in framework of the extended mind theory. If we use this explanatory framework on drone operators' PTSD problems, we get not only quite satisfying look on what causes this problem with mental health of remote pilots, but we also get a lot of epistemologically relevant consequences.

According to the extended mind theory, the PTSD among drone operators is caused by the fact that their minds (and also cognition and even emotions, as I propose) are embodied and extended not only into their biological bodies, but also into external non-biological artifacts, such as ground control station and the remote drone itself. Because of that, their mind is physically exposed to stressful conditions of war-zones and thus, drone operators experience everything almost the same way as pilots sitting in the manned airplanes. Cognitive processes and emotions are embodied and extended as well. This concept explains, why there is a PTSD present among people, who are sitting in safe and air-conditioned cubicles, while all discomfort connected to war is on the other side of the globe.

If we accept this view, we will face serious epistemological, as well as ethical consequences. Drones are a picture perfect example of teleoperations, so we can find here a whole group of epistemological (in this case telepistemological) problems concerning acting and acquiring information in distance. First difficulties spring from the skeptical view that we could be deceived. It would be, for example, possible that situations presented via monitors at ground control station are computer-generated simulations that do not mirror reality in any sense, which drone operators do not know. In this case, it would mean that PTSD among operators is caused by non-existent situations, or at least by situations existing in very different and strange ontological sense. In other words, this would mean that mind, cognition and emotions are embodied and extended into computer simulations and potentially into something that does not exist. It seems that it is sufficient as a drone operator to think that I am causally active in a sequence of operations to embody and extend a mind into computer simulation.

Ethical perspective on this situation is as follows. If we consider mind as embodied and extended into external artifacts and relationship between internal biological components and external non-biological components as reciprocal and causally active, then it would be possible to change ground control station's interface in a way that it would, for example, make every situation funny, insignificant or so. In this case, the perception of drone operators would change dramatically and the PTSD problem would eventually disappear. The mental health of these men and women would be again all right, but drones' engagement in war would be completely changed.

To summarize, the fact that there is a PTSD among drone operators, who do not face any real discomfort connected to war, raises question why is it that. I propose to look at this problem through lens of the extended mind theory, which will offer us useful explanatory tool to grasp this topic. If we then think more deeply about epistemological problems of this notion, it will offer us, on the one hand, important questions for ontology, philosophy of mind and cognitive science, and on the other hand, another major ethical consequences.

Keywords—drones; post-traumatic stress disorder; extended mind

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The relation between James and Damasio

The body loop of emotions and feelings

Luiz Augusto Rosa
Dept. of Philosophy
São Paulo State University (UNESP)
Marilia, Brazil
luiz.augusto.rosa@outlook.com

***Abstract*—William James [1] argue that contrary to the natural way of looking at emotions as triggering bodily changes, "the bodily changes follow directly the PERCEPTION of the exciting fact and our feeling of the same changes as they occur IS the emotion" (pp. 189-190). So, according to James, when we see a predator we do not feel fear before we run, we feel fear *as* we run. Antonio Damasio [2] argues that even agreeing largely with James' theory of emotion, he disagrees about one point: James fuses emotion and feeling. For Damasio feeling and emotion are not the same thing, feeling is the conscious experience of an unconscious emotion. Thus what James defines as emotion is in fact feeling. Besides this problem, Damasio see other difficulties in James approach of emotion. One of them is that James restricts the cognitive aspect of emotion to the perception of the stimulus and bodily activity, different from nowadays view, according to which the stimulus goes through stages of evaluation, filtering and channeling in the brain, even unconsciously, that is, James' vision that the perception of the stimulus directly triggers the body activity is no longer supported. However, his idea of the mechanism of emotions and feelings is very much the same as Damasio's theory on the body loop. For Damasio, emotional feelings are composed by both the particular state body during an emotion and the change of cognitive states with the use of mental scripts. And the emotional feelings are processed by areas responsible for creating the images, such as the brainstem and cortex. In the cerebral cortex the area that stands out in the processing of feelings is the insular cortex. This area is responsible for processing the feeling of disgust, for example, important for survival, as well as being associated with visceral functions (representation of the viscera), and, together with the somatosensory cortex, is also responsible for the production of body maps. Thus, Damasio shows the importance of brain areas responsible for processing signals arising from the body in the study of emotions and feelings. Therefore, both Damasio and James point out the importance of the body in the biological studies of the emotions and feelings.**

***Keywords*—Damasio; Emotion; James.**

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A Model for Facial Emotion Inference Based on Planar Dynamic Emotional Surfaces

Ruivo, J. P. P.
Escola Politécnica
Universidade de São Paulo
São Paulo, Brazil
joao.ruivo@usp.br

Negreiros, T.
Escola Politécnica
Universidade de São Paulo
São Paulo, Brazil
tupa.negreiros@gmail.com

Barretto, M. R. P.
Escola Politécnica
Universidade de São Paulo
São Paulo, Brazil
marcos.barretto@poli.usp.br

Tinen, B.
Escola Politécnica
Universidade de São Paulo
São Paulo, Brazil
tinen.bruno@gmail.com

Abstract—**Emotions have direct influence on the human life and are of great importance in relationships and in the way interactions between individuals develop. Because of this, they are also important for the development of human-machine interfaces that aim to maintain a natural and friendly interaction with its users. In the development of social robots, which this work aims for, a suitable interpretation of the emotional state of the person interacting with the social robot is indispensable. The focus of this paper is the development of a mathematical model for recognizing emotional facial expressions in a sequence of frames. Firstly, a face tracker algorithm is used to find and keep track of faces in images; then the found faces are fed into the model developed in this work, which consists of an instantaneous emotional expression classifier, a Kalman filter and a dynamic classifier that gives the final output of the model.**

Keywords—face, emotion, Kalman, surface

I. Preface

Emotions influence the human behavior and the way individuals interact and relate to other members of society. They permeate one's daily life and determine how people react to the various situations they encounter in their routines.

Studies indicate that people with impairments to express or recognize feelings end up having great difficulty keeping even casual relationships [6]. Emotions also help the body prepare for specific external events. For example, the fear people may experience when they see a large object coming fastly towards them stimulates blood circulation in their legs, allowing them to act promptly and respond trying to avoid the object.

Computer interfaces that can understand the emotional state of its users can communicate more naturally compared to interfaces without this capability. Affective computing comes to deal with the integration of the concept of emotion in the computational area [23].

Emotions are characterized by signs in voice, speech and body movements, which are recognized regardless of culture, possibly being a legacy of human evolution and not a result of personal experiences of the individual [10]. Particularly in the face, the most obvious signs are presented in the regions of the mouth, eyes and eyebrows. Ekman and Friesen showed evidence for the hypothesis of universality of emotional facial expressions in intercultural studies with illiterate populations of Papua New Guinea and investigated the influence of the cultural phenomena [10].

Works from Ekman [5] [9] propose the existence of six major universal emotions: joy, sadness, surprise, fear, anger and disgust. An emotional display can either be classified as belonging to one category, such as joy, or more than one category, forming composite emotions, such as the mixture of fear and angry, or joy and surprise.

This study aims to identify five basic emotional states: Happiness, Sadness, Anger and Fear, plus the Neutral state, which could be understood as the absence of emotions. The model proposed in this work does not try to describe short-lived or rapidly changing emotions (micro expressions, in the works of Ekman), but focuses on trying to detect lasting emotional states people may be subject to. The dynamic model for emotion recognition presented in this work is a novel model based on the work of [12].

II. Bibliographic Review

There are three main approaches to emotions classification: discrete model, dimensional model and the approach based on evaluation mechanisms [32].

The discrete model arranges emotions in categories, like the basic emotions of Ekman. Categorization of emotions is an intuitive and practical way to identify them, even if a large number of classes is necessary in order to classify all of the known affective states. Many of the works developed in the area utilizes this approach [31] [32] [13] [24].

The dimensional model seeks to describe the emotions by means of some criteria or dimensions. Two key dimensions are valence and arousal [24] [14]. Valence transmits how the person feels under the influence of a certain emotion, and can assume continuous values ranging from extreme sadness, for negative valence, to extreme happiness, for positive valence. Arousal is associated to the possibility of an individual to take or to perform an action under influence of an emotion, and can assume continuous values ranging from an extremely passive attitude, for negative arousal, to an extremely active attitude, for positive arousal. Some authors [26] suggest other dimensions for the model, such as dominance. Dominance is related to the control somenone has over a situation while under the influence of an emotion, and can assume continuous values ranging from total lack of control to total control of the situation. The dimensional model avoids the need for an extensive list of categories. Emotions are identified depending on its position on the model's axes. However, because of the limited number of dimensions this approach deals with, the projection of an emotion to the model's axes could cause loss of information [32].

The evaluation approach classifies emotional displays based on a set of assessments of the event that caused such display. For a given emotion, it is evaluated how relevant it is the event that elicited the emotion, what are its implications, the individual's ability to deal with these implications, and what is the significance of that event for the society the individual inhabits [27]. This approach is less simple and intuitive when compared to the others, as it requires a detailed analysis of the situations that elicited the emotions.

Pantic [21] suggests automatic recognition of facial emotion expressions to be done in three main steps: face detection, extraction of relevant features of the face and emotion classification

Face detection is a crucial step in the recognition of expressed emotions, and comprises of locating faces in still images or image sequences. In several works, such images are obtained under conditions that helps face detection algorithms, like the capture of the face in frontal orientation, without occlusions, and under uniform lighting conditions. However, in real situations, these conditions rarely can be reproduced, which makes the problem more challenging. Consequently, an ideal method of facial detection should deal with problems such as the different scales and orientations the human face may take, besides having to consider possible partial occlusions of the face and changes in the lighting conditions.

Extraction of face relevant characteristics has the purpose of generating a feature vector to be used for the emotion identification. It seeks to describe the face through certain categorical or numerical information that should contribute to the recognition of the emotional state of the analyzed person. These characteristics may be based on features of the human face such as eyebrows, nose and mouth, or may be based on mathematical models. These models, in turn, may follow an analytical approach, in which the face is represented by a set of points or patterns of interest that contain specific regions of the face; or they may follow a holistic approach, in which the face is seen as a unit, with its particular shape and texture. Hybrid approaches also exist, in which features of the two above-mentioned approaches are combined. Different scales and orientations of the face, as well as partial occlusion and noise, hamper the execution of this step.

The extracted features vector should then be used to estimate the expressed emotion via a classification algorithm. In this step, any of the approaches presented for emotion classification may be used; however, much of the work done in the area uses the discrete approach [8]. The classification of the facial emotion expressions is done by machine learning algorithms trained with the feature vectors extracted from the samples of one or more training databases. Examples of these algorithms are Support Vector Machines (SVMs), Decision Trees and Neural Networks (NNs).

The present work introduces a fourth step to the process proposed by [21] and includes the usage of a continuous emotional classifier model, following the line of work of [13] and [28]. This step was introduced so that the model would be able to detect long-lasting emotional states rather than instantaneous emotional displays; also, it should help with the minimization of the influences of natural noises, like laugh and speech, that deform the face and difficult the determination of someone's facial emotion expression.

Figure 1 presents a flow diagram of the steps aforementioned.

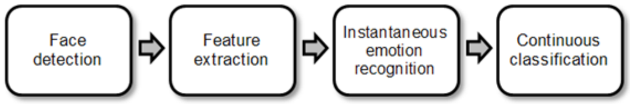

Fig. 1: Flow diagram for the proposed model.

One way to describe one's facial emotion expression is to use the Facial Actions Coding System (FACS) [7]. This system defines 44 Action Units (AU), each one representing the facial movements caused by muscle activity in a specific region of the face. Studies show that a particular subset of 15 of these AUs have greater relevance in the communication between humans [29].

FACS can be understood as an abstraction layer of the underlying facial muscle activity. Through the identification of the level of activity of the relevant AUs, one can infer the related muscles' activities and the corresponding facial expression. FACS defines, for example, involuntary and sincere expression of happiness as the activation of AUs numbers 6 and 12, that is, the lifting of the cheeks and the lateral and vertical extent of the lips, respectively. A forced (faked) expression shows only activation of AU 12 instead. This differentiation is possible because AU 12, which is the contraction of the zygomatic major muscle, is voluntary, while AU 6, contraction of the orbicularis oculi muscle, occurs involuntarily.

Furthermore, FACS brings into consideration the duration and intensity of AUs. Spontaneous muscle activations are in the range 250ms to 5 seconds, depending on the AU [11]. Rules for determining the intensity of each AU are also determined on FACS, for example, as the degree of elevation of the corner of the lips to the AU 12 or the wrinkle density over the nose for AU 44.

As noted in [13] [16], two different categories of properties could be extracted from faces: geometric properties and appearance properties.

Methods based on geometric properties look for characteristic regions of the face, such as eye contour, representing the shape and geometry of the features to be studied. For the extraction of data in video, one approach is the optical flow, as in [3], with tracking of characteristic points. Another approach are three-dimensional methods [17], which were developed along with the development of three-dimensional videos. In the solution presented in [15], the Active Shape Model [2] and a Kalman filter were used to locate specific areas such as mouth and eyes in each frame of a video.

Appearance-based methods, however, search for changes in texture, such as wrinkles on the face. These methods can be used to describe the whole face or specific regions of interest [4] [29].

Following Figure 1, the next step, emotion classification, can be based on neural networks (NN), support vector machines (SVM) or hidden Markov chains (HMM) [13] [17] [17] [30], among other algorithms [29] [15].

It should also be noted that the humans' emotions detection system is not perfect, and emotions are not always interpreted correctly [21]. Donato [3] shows that people who had no training were able to correctly identify emotions in about 80% of a set of photos, but trained people, such as those passing throught FACS training, have a hit rate of about 90%. For Russell [25], however, a number of studies show that the rate of recognition by individuals varies according to the experimental conditions, ranging from about 55% to about 95%; also, negative emotions, such as anger and sadness, have a significantly lower accuracy recognition rate than positive ones.

The instantaneous emotion recognition model presented in this work is based on the work of Loconsole et al. [18]. In the referred work, an emotion classifier (namely, a random forest) based on geometric facial features is trained and used to differentiate images of faces expressing five emotional states: Joy, Sorrow, Surprise, Fear, Disgust and Anger. The authors analyze the accuracy their model achieved with and without calibration with neutral faces and considering different quantities of learned facial expressions. Also, they compare the accuracy of their model with that of other authors' models, and conclude their model achieved higher accuracy for the experiments made.

III. Methodology

This section briefly introduces the methods and techniques used to implement each of the steps shown in the diagram of Figure 1.

A. Face Detection

In this step, the Chehra Face Tracker is used [1]. This tracker detects and keeps track of faces in input images. It can be classified as a discriminative tracker, as it uses facial landmarks and discriminative functions to describe the current state of the face of a person, rather than a generative tracker, which would seek parameters that would maximize the probability of the deformable model to reconstruct a given face [1].

The Chehra Face Tracker uses an incremental parallel cascade of linear regressions to train the model, which has a better performance on face tracking in videos when compared to both the parallel cascade of linear regressions and the sequential cascade of linear regressions, showing better adaptation over time and robustness to environment changes on the face [1].

The tracker is capable of handling new training samples without having to retrain the model from scratch. It can also automatically tailor the model to the subject being tracked and to the imaging conditions, hence becoming person-specific over time [1].

B. Feature Extraction

Once the face tracker is able to fit the face model on one of the found faces in the image, one can proceed to extract features of interest from it.

The process of choosing what features to extract is not trivial, as the chosen feature set should be one that describes the studied concepts (in this case, the five facial emotion expressions: Happiness, Sadness, Anger and Fear, plus the Neutral state), so the trained classifier may have a better chance of learning how to properly differentiate amongst samples of these concepts. Loconsole [18] presents a feature set which is intended to differentiating among facial displays of Ekman's six basic emotions. This set comprises of two kinds of features: linear features and eccentricity features. While the linear features are determined by calculating the normalized linear distances between two given landmarks outputted by the face tracking model, the eccentricity features are given by the eccentricity measures of ellipses fitted over groups of three facial landmarks.

In the present work, Loconsole feature set is adopted with some new features added to it. The added features were chosen based on facial cues Ekman found to be of relevance in the process of facial emotion recognition [5]. The complete set of features adopted is described in Table I (refer to Figure 2 for the landmark's labels referenced in the table).

Table I: Extracted feature set

Name	Measure	By
F1	$\overline{UEBl_{m7y}UEl_{m3y}}/DEN$	[18]
F2	$\overline{U_{m1y}SN_y}/DEN$	[18]
F3	$\overline{D_{m2y}SN_y}/DEN$	[18]
F4	$\overline{EBlr_{Mx}EBrl_{Mx}}/DEN$	Us
F5	$\overline{A_{My}D_{m2y}}/DEN$	Us
F6	$\overline{B_{My}D_{m2y}}/DEN$	Us
F7	$\overline{A_{My}U_{m1y}}/DEN$	Us
F8	$\overline{B_{My}U_{m1y}}/DEN$	Us
F9	$\overline{EBlr_{My}Elr_{My}}/DEN$	Us
F10	$\overline{EBrl_{My}Erç_{My}}/DEN$	Us
F11	$\angle(A_m, D_{m2}, B_m)$	Us
F12	$\angle(A_M, U_{m1}, B_M)$	Us
F14	$\angle(EBll_M, EBl_{aux}, EBlr_M)$	Us
F13	$\angle(EBrr_M, EBr_{aux}, EBrl_M)$	Us
F15	$\angle(EBllm_m, EBlr_M, EBl_{aux})$	Us
F16	$\angle(EBrr_M, EBrl_M, EBr_{aux})$	Us
F17	$Ecc(A_M, B_M, D_{m2})$	[18]
F18	$Ecc(A_M, B_M, D_{m2})$	[18]
F19	$Ecc(Ell_M, Elr_M, UEl_{m3})$	[18]
F20	$Ecc(Ell_M, Err_M, DEl_{m4})$	[18]
F21	$Ecc(Erl_M, Err_M, UEr_{mr})$	[18]
F22	$Ecc(Erl_M, Err_M, UEr_{m6})$	[18]
F23	$Ecc(EBll_M, EBlr_M, UEBl_{m7})$	[18]
F24	$Ecc(EBrl_M, EBrr_M, UEBr_{m8})$	[18]

In Table I, $\overline{(P_1P_2)}$ represents the linear distance between points P_1 and P_2, and the indices x and y are used to represent the horizontal and vertical points' coordinates, respectively. The notation $\angle(P_1, P_2, P_3)$ represents the internal angle between points P_1, P_2 and P_3, in radians. Finally, $Ecc(P_1, P_2, P_3)$ represents the eccentricity of an ellipse fitted over the points P_1, P_2 and P_3. The measure of eccentricity of an ellipse is given by the formula below (refer to Figure 3).

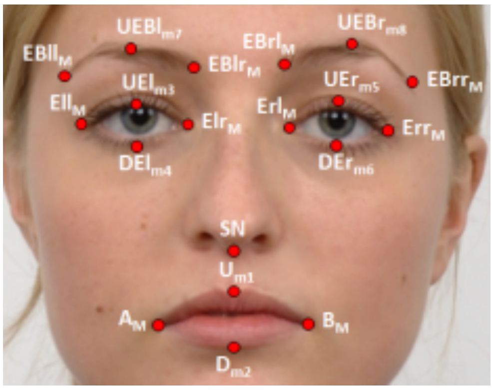

Fig. 2: The facial landmarks considered for the feature extraction process (taken from [18]).

$$Ecc(P_1, P_2, P_3) = \sqrt{\frac{\left(\frac{P_{1x} - P_{3x}}{2}\right)^2 + \left(\frac{P_{1y} - P_{2y}}{1}\right)^2}{\left(\frac{P_{1x} - P_{3x}}{2}\right)^2}} \tag{1}$$

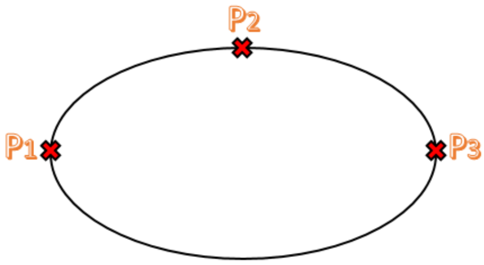

Fig. 3: An ellipse and the necessary points to the calculation of its eccentricity.

Feature F4 is a measure of the horizontal distance between the inner points of the eyebrows. This distance should be smaller in angry faces (which usually present the inner points of the eyebrows closer together) and bigger in surprised faces (which usually present the inner points of the eyebrows farther apart), for example.

Features F5 and F6 are measures of the vertical distances between the leftmost and the rightmost points of the mouth and the bottommost point of the mouth, respectively. These features should be helpful in differentiating facial expressions that present open mouths (like an angry expression, with exposed teeth) and closed mouths (like in a neutral expression). Also, they should be helpful in detecting if the analysed face is currently speaking or not.

Features F7 and F8 are similar to F5 and F6, but measure the vertical distances between the leftmost and the rightmost points of the mouth and the topmost point of the mouth. They have the same purpose features F5 and F6 have.

Features F9 and F10 are measures of the vertical distance between the inner points of the eyebrows and the inner points of the eyes. These features should help to differentiate facial expressions that present the inner corners of the eyebrows lifted (like in a surprised expression) from facial expressions that present the inner corners of the eyebrows lowered (like in an angered expression).

Feature F11 is the measure of the inner angle formed by the leftmost and rightmost points of the mouth with the bottommost point of the mouth. Feature F12 is the measure of the inner angle formed by the leftmost and the rightmost points of the mouth with the topmost point of the mouth. Together, they should be helpful in describing if the mouth is closed of opened, similarly to the features F5 to F8.

Features F13 and F14 are the measures of the inner angles formed by the corner of the eyebrows with the central point of each eyebrow. They should be helpful in describing if the eyebrows are arched (like in a surprised facial expression) or flat (like in an angered expression).

Features F15 and F16 are the measures of the inner angles formed by the outter corner and center points of the eyebrows with the inner corners of the eyebrows. They have the same purpose of the features F13 and F14.

Some of the points used to calculate the features aren't directly output by the face tracker algorithm adopted in this work, and must be calculated before the features can be computed. These points are: UEl_{m3}, UEr_{m5}, EBl_{aux} and EBr_{aux}. The Equations 2, 3, 4 and 5 describe how each of these points are obtained. EBl_{aux} and EBr_{aux} are not facial landmarks, but auxiliar points used in conjunction with the landmarks to calculate some of the chosen features.

$$UEl_{m3} = \left(\frac{Ell_{Mx} + Elr_{Mx}}{2}, \frac{Ell_{My} + Elr_{My}}{2}\right) \tag{2}$$

$$UEr_{m5} = \left(\frac{Erl_{Mx} + Err_{Mx}}{2}, \frac{Erl_{My} + Err_{My}}{2}\right) \tag{3}$$

$$\begin{aligned} UEr_{m5} = (&Elr_{Mx} - Erl_{Mx} + EBlr_{Mx}, \\ &Elr_{My} - Erl_{My} + EBlr_{My}) \end{aligned} \tag{4}$$

$$\begin{aligned} UEr_{m5} = (&Erl_{Mx} - Elr_{Mx} + EBrl_{Mx}, \\ &Erl_{My} - Elr_{My} + EBrl_{My}) \end{aligned} \tag{5}$$

C. Databases

Once the feature set is chosen, the next step is to choose one or more databases to extract these features from. These databases should contain samples of all of the concepts the machine learning algorithm is expected to learn.

In the present work, both Cohn-Kanade Plus[19] and MMI Facial Expression [22] Databases are used to train the instantaneous facial emotion classifier model.

The Cohn-Kanade Plus (or CK+) Database comprises of 486 sets of pictures from 97 posers. Each set contains a sequence of pictures depicting a person acting the onset of a particular target emotion and each sequence is labeled as a sample of that particular represented target emotion. All of the sets start with a neutral expression and evolve into a particular target emotion expression.

The CK+ Database contains, but is not limited to, sequences of all of the studied basic emotions, that is: Happiness, Sadness, Anger and Fear; but doesn't contain sets labeled as Neutral. For the purpose of this work, for each selected set, the first picture of the sequence is taken as a Neutral sample and the last picture of the sequence is taken as a sample of the sequence's target emotion. To avoid one emotion being predominant over the others in the training set, which could degrade the quality of the training process, the limit of samples for each target emotion is set to be the number of samples available for the scarcer target emotion. After the features are extracted from the chosen sets, 129 samples are generated by this process.

The MMI Facial Expression Database comprises of over 2900 videos and images of 75 posers. Only part of these videos are labeled as samples of basic emotion, so just a subset of the database is effectively utilized in this work. The selected videos show humans acting a full emotional cycle of a particular target emotion, that is, all of the three phases of the emotional display are represented: onset, apex and offset. All of the selected videos start with a Neutral face expression, which progresses to a target emotion expression and then regresses back to the Neutral display.

Similarly to the CK+ Database, the MMI Facial Expression Database contains, but is not limited to, videos of all of the studied basic emotions, but doesn't contain samples of Neutral displays. Since the videos aren't labeled at a frame-level and considering there is no preliminary indication of which of the frames represent the emotion's apex, one must first manually annotate the frames' target emotions before they can extract the features from them.

That said, all of the 74 videos chosen from this database were annotated in the following manner: the authors would watch the videos and pinpoint four instants of interest. The first instant (referred to as t_1 from here forth) represents the start of the emotional onset in the video; the second instant (t_2) represents the emotional onset's ending and the beginning of the apex; the third instant (t_3) represents the apex's ending and the beginning of the emotional offset; finally, the fourth instant (t_4) represents the emotional offset's ending.

With these instants annotated, a frame-level categorization of the videos is created: the frames before t_1 and after t_4 (inclusive) are classified as Neutral samples; the frames between t_2 and t_3 (inclusive) are classified as that video's target emotion samples; finally, the frames between t_1 and t_2 and t_3 and t_4 are classified partially as Neutral samples and partially as that video's target emotion samples.

However, not all of the generated samples were used to train the classifier. The first and the last frames of each video were chosen to compose the Neutral set of the database; also, windows of size $n = 10frames$ were built around the center of the apex region (that is, around the middle frame between t_2 and t_3) in each video, and all of the frames within these windows were taken as samples of that video's target emotion. The value of n was chosen empirically, and aimed to stablish a balance between the quantity of Neutral samples and the quantity of the other four emotions' samples. Also, care was taken so the created windows would never exceed their boundaries, that is, a window would never start at an instant before t_2 nor would it end after t_3.

After the features are extracted from the chosen pictures, 809 samples are generated by the described process.

It's worth saying both of the adopted databases contain videos and images of faces in profile and in other non-frontal orientations. However, different head orientations may cause the selected features to vary considerably for samples of the same target emotion. This could hamper the classifier's learning process and, for that reason, only videos and images containing emotional displays in frontal-oriented faces are used to train the classifier.

Finally, one should take note that all the sample images contained in these databases were acted, and not naturally elicited.

D. Instantaneous Facial Emotion Recognizer

The instantaneous facial emotion recognizer is a machine learning algorithm trained over the training set extracted through the previously described procedure.

The Random Forest learning algorithm is adopted in this work, as it was shown to have good accuracy on the work of Loconsole [18] when compared to other algorithms. The learner's accuracy and other statistics of interest are presented further in Section IV

The information fed into the dynamic classifier, however, is not simply the category output by the instantaneous classifier for a given sample, but rather, a measure of confidence that the classifier has for that sample to belong to each of the considered classes. The confidence measure used was the normalization of the number of votes each class received by the weak learners. Suppose, as an example, that a particular sample is classified by a random forest containing 100 random trees, and that 70 trees vote for the sample to belong to the Happiness class and the rest of the trees vote for it to belong to the Neutral class; in that case, the confidence measure for the sample to belong to the Happiness class would be 70%, the confidence measure for the sample to belong to the Neutral class would be 30% and the confidence measure for the sample to belong to the other classes would be 0. So, given a sample S_1, the output of the instantaneous classifier that is fed into the dynamic model is a vector of the form $V_1 = (Pr_{1n}, Pr_{1h}, Pr_{1s}, Pr_{1a}, Pr_{1f})$, where $Pr_{1n}, Pr_{1h}, Pr_{1s}, Pr_{1a}$ and Pr_{1f} are the confidence levels for S_1 to belong to the Neutral, Happiness, Sadness, Anger and Fear categories, respectively.

E. Kalman Filter

After the instaneous facial emotion classifier is properly trained, its outputs can be fed into the dynamic classifier, which will output the model's final prediction for the samples. However, aiming to eliminate high frequency noises, these outputs are firstly processed by a Kalman filter before they are inserted into the dynamic model. This section describes this filter and highlights the advantages of its usage.

As a natural consequence of the use of video frames to analyze the facial features of a person, different sources of noise can affect the classification algorithm.

It is assumed that the emotions are represented by the data initially fed in the training phase, which are gathered under controlled conditions; thus, effects such as face deformation resulting from speech, light source variations and unexpected face motions should be minimized. Furthermore, the objective of the model is to enhance the presentation of the slow and continuous emotions in spite of the instantaneous ones, sp a low pass filter should be used.

Kalman filtering is the solution proposed to this model, being a filter that has a good performance on linear systems with zero mean Gaussian noise on both the model and in the process of data acquisition. The empirical evidence presented in [13] supports this choice.

Being x_s the state variable of a linear system and y, the output of the filter for a single emotion, the filtered signal related to one of the emotions being analyzed, 6 and 7 describe the Kalman filter.

$$\dot{x_s} = x_s \tag{6}$$

$$\dot{F_a} = y = \frac{Kx_s}{\tau} \tag{7}$$

In the above equations, K is the filter's gain and τ is the time constant. There are two steps for the filtering, the first being the prediction step and the second the update step. The update is only run when new information from the sensors – in this case the output of the instantaneous emotion analyzer – is available. If the delay between data acquisitions is higher than the delay between filter steps calculations there will be some steps in which only the prediction steps will be run.

The prediction step is described by 8 and 9, where $x_{s,t}$ is the current state $x_{s,t-1}$ is the previous state, w is the noise covariance, p the covariance of the state variable on the t state. Note that the update step always assumes that the state variable has not changed, only the covariance of the system.

$$x_{s,t} = x_{s,t-1} \tag{8}$$

$$p = p + w/\tau^2 \tag{9}$$

The update step is described by equations 10, 11 and 12, where m is the residual covariance, v is the covariance of the observation noise and r_t and y_t are the filter input and output at instant t. This input corresponds to the output of the instantaneous emotion classifier. The state variable now has its value updated and, consequently, the output of the Kalman filter has its value proportionally changed.

$$m = \frac{\frac{pK}{\tau}}{p\left(\frac{K}{\tau}\right)^2 + v} \tag{10}$$

$$x_{s,t} = x_{s,t} + m(r_t - y_t) \tag{11}$$

$$p = (1 - \frac{mk}{\tau})p \tag{12}$$

Note that these equations describe the filtering process for a single class (that is, the filtering of outputs of a particular emotion). The full model is represented by applying these equations for each emotion separately.

However, neither w nor v are known, and have to be estimated by an optimization algorithm, which is described in Section III-G.

F. Dynamic Model

After the instantaneous output is filtered, it is ready to be fed into the dynamic model.

The dynamic model proposed here does not aim to describe rapid emotional variations a person may be subject to, but rather, it tries to describe more lasting emotional states. Suppose, for illustration purposes, that you are talking to a dear friend of yours that you haven't seen for a while. One may expect the overall conversation to elicit a pleasant emotion. However, during this conversarion, you happen to see a person throwing trash in the street; it infuriates you for a while, but you rapidly get back to talking to your friend and forgets the sight that angered you. If pictures of your face were fed into the proposed model during this entire event, one should expect the model to detect the overall pleasant emotion of the conversation (that is, if it was pleasant enough so that your facial expression indicated so); however, your temporary enragement should not modify the output of the model.

The dynamic model is based on the work of [13], and utilizes the concept of Dynamic Emotional Surfaces (DESs).

As name indicates, DESs are surfaces that aim to describe the dynamics of transitions between different emotional states. In this work, a planar surface is adopted, and it is partitioned in four quadrants, one for each of the considered basic emotions: Happiness, Sadness, Anger and Surprise. Centered in the intersection of the four areas, there is the Neutral area, which represents the absence of emotions. Figure 4 illustrates the model's DES.

Located on the $+45°$ and $-45°$ diagonals of this plane, there are four Emotional Attractors (EAs), one for each of the considered non-Neutral emotions, and each located in its corresponding quadrant. Refer to Figure 4. The Happiness, Fear, Sadness and Anger attractors are located on the points $PA_{Happiness}$, PA_{Fear}, $PA_{Sadness}$ and PA_{Anger}, respectively, and the Neutral attractor is located on the point $PA_{Neutral}$.

Let to slide upon the plane, there are Emotional Particles (EPs), one for each analyzed subject. The location of a particle in a given instant indicates the model's output emotion for that instant, according to the equation below, where $P = (P_x, P_y)$ is an EP's position and $f(P)$ is the model's output in the considered instant.

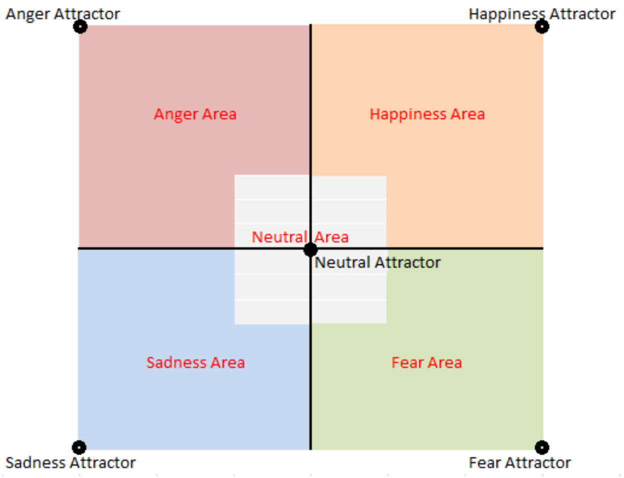

Fig. 4: A representation of the planar DES used in this work.

$$f(P) = \begin{cases} \text{Happiness}, & \text{if } P_x > K_{nr} \text{ and } P_y > K_{nr} \\ \text{Sadness}, & \text{if } P_x < -K_{nr} \text{ and } P_y < -K_{nr} \\ \text{Anger}, & \text{if } P_x < -K_{nr} \text{ and } P_y > K_{nr} \\ \text{Fear}, & \text{if } P_x > K_{nr} \text{ and } P_y < -K_{nr} \end{cases} \tag{13}$$

In the equation 13, K_{nr} is a constant that determines the width and height of the Neutral area.

The EAs are responsible for pulling EPs towards them. The stronger the confidence level the Kalman filter outputs for a given emotion, the stronger the pull velocity for that emotion's attractor will be. If at the instant $\bar{t}$ Kalman filter outputs a confidence level of $Pr_E(\bar{t})$ for emotion E, then E's attractor velocity, $VA_E(\bar{t})$, is given by Equation 14.

$$VA_E(\bar{t}) = K_{avm} Pr_E(\bar{t}) \tag{14}$$

The parameter K_{avm} is the attractors velocity modulator parameter, which value, like the Kalman filter parameters w and v, is also found via an optimization algorithm.

The dynamics for EPs are described by equations 15 and 16, where $P(t)$ and $V(t)$ are particles' position and velocity, $Pr_E(t)$ is the confidence measure for emotion E and $VA_E(t)$ is the attractor's E pull velocity, all at instant t.

$$P(t) = P(t-1) + V(t) \tag{15}$$

$$V(t) = \begin{cases} VA_{Neutral}, & \text{if } max(Pr_E(t)) = Pr_{Neutral}(t) \\ \sum_{E=\bar{e}} VA_E, & \text{if not} \end{cases} \tag{16}$$

where $\bar{e}$ is the subset $\{Happiness, Sadness, Anger, Fear\}$. Also, the position of the particle is never let to exceed the rectangle delimited by the four non-Neutral EAs.

The noise smoothing introduced by the Kalman filter and the intrinsic inertia presented by the proposed model make so that natural facial noises - like the mouth movements caused by laughter or speech - should have its influence on the predictions diminished, when in comparison to the instantaneous classifier.

G. Parameters Optimization

As the previous sections explained, some of the model parameters can't be known *a priori*, and are better defined via an optimization process. These parameters are: Kalman filter's noise covariance (w), Kalman filter's covariance of the observation noise(v) and DES's attractors velocity modulator (K_{avm}).

The optimization process here adopted is based on the simulated annealing algorithm, and can be described by the pseudo-code presented below.

```
// Initializations:
T_0 = 200°C;
T_room = 20°C;
T_curr = T_0;
p_curr = randomizeParameters();
p_la = p_curr;
p_sol = p_c;
e_0 = +∞;
e_curr = e_0;
e_la = e_0;
e_sol = e_0;
dr = 0.99995;
// Iterations:
while (T_curr > T_room) do
    e_c = calculateEnergy(p_curr, dataset);
    if (e_curr < e_la) then
        Pr_acc = 1;
    else
        Pr_acc = e^((e_la − e_curr)/T_curr);
    end
    if (Rnd(0,1) > Pr_acc) then
        p_la = p_curr;
        e_la = e_curr;
        if (e_la > e_sol) then
            p_sol = p_la;
            e_sol = e_la;
        else
            p_curr = p_la;
        end
    end
    p_curr = moveAround(T_curr);
    T_curr = T_curr × dr;
end
```

In the above pseudo-code, T_0, T_{room} and T_{curr} are the initial, room and current temperatures of the optimizer, in that order; $p_c urr$, p_{la} and p_{sol} are the current iteration's parameters, the last accepted solution's parameters and the final solution parameters, respectivelty; e_0, e_{curr}, e_{la} and e_{sol} are the initial energy, the current iteration's energy, the last accepted solution's energy and the final solution's energy, in that order; dr is the temperature decay rate and Pr_{acc} is the probability that a solution will be accepted by the algorithm.

Note that an iteration's energy, e_{curr} is obtained by the function $calculateEnergy(p_{curr}, dataset)$, which considers both the current value of the parameters being optimized and a dataset chosen for the optimization. The MMI Facial Emotion Database's previously selected 74 videos were used to extract the energy measure; however, this time they were considered in their full-length. The adopted energy measure is the number of frames the model misclassified in the iteration.

A proposed solution is always accepted if it causes the system's energy to decrease in comparison to the last accepted solution's energy. However, even if a solution causes the energy to increase, it has a chance of being accepted that is proportional to the iteration's current temperature and inversely proportional to the energy increase it causes. This measure helps the optimizer to avoid getting stuck in local minima.

If a solution is accepted, its parameters and energy are stored to serve as comparison data for the next iteration. However, a solution is only stored as a final solution if its energy is smaller than the last accepted final solution.

At the end of every iteration, the parameters are varied through the function $moveAround(T_{curr})$, which takes into consideration the iteration's temperature - the higher the temperature, the more the parameters are allowed to variate -, and the optimizer temperature is made to decay by a constant rate dr.

IV. Tests and Results

This section presents the results of the tests realized on the model. These tests are presented separately for the instantaneous facial emotion classifier, for the parameters optimization algorithm and for the dynamic facial emotion classifier.

A. Tests on the Instantaneous Facial Emotion Classifier

Tests were made to measure the quality of the instantaneous classifier. Since a poorly trained classifier may compromise the overall performance of the model, the quality of its outputs should be analyzed with caution.

The random forest learning algorithm discards the need for procedures like cross-validation, bootstrap or separate test sets for estimating the classifier's accuracy. During the training of each of the weak learners (that is, of each tree of the forest), an out-of-bag set (or "oob set", containing roughly 1/3 of the complete training set) is created for that learner. The oob set is used to validate the accuracy of that particular tree. After all the trees have finished training, the following procedure is used to calculate an estimation of the accuracy of the learner for samples stranger to the training set:

1) Each sample contained in the complete training set is considered separately;
2) All trees that contain a particular sample in their oob sets are used to classify that sample, and a vote counting is used to decide to what class it belongs to. The procedure is repeated for all samples of the complete training set;
3) The random forest's accuracy is given by the number of samples of the set classified correctly divided by the number of samples classified incorrectly by that process....

Through the described procedure, an accuracy estimate of approximately 90% was obtained.

The analysis of the learner's confusion matrix allows one to observe how its predictions are distributed amongst the different classes. Table II presents the confusion matrix for the trained random forest.

Table II: The confusion matrix for the trained random forest

	Neutral	Anger	Fear	Happiness	Sadness
Neu.	201	5	4	8	20
Ang.	0	168	1	0	5
Fea.	0	0	168	0	1
Hap.	0	0	2	189	0
Sad.	0	1	0	0	113

One can notice that the Neutral class is the one with more misclassified samples, even if considering relative numbers. Also, more than half of the misclassified Neutral samples are categorized as Sadness samples, which suggests that the boundaries between these two classes is the less obvious for the classifier, at least on the considered dataset.

B. Tests on the Parameters Optimization Algorithm

Tests were made with values of K_{nr} (which determines the height and width of the neutral area of the plane) varying from 1 to 5, with unitary increments. Also, for all the tests, the attractors were positioned on the points $PA_{Happiness} = (10, 10)$, $PA_{Fear} = (10, -10)$, $PA_{Sadness} = (-10, -10)$, $PA_{Anger} = (-10, 10)$ and $PA_{Neutral} = (0, 0)$. Figure 5 shows the model's accuracy history for the best optimization achieved - that is, for the optimization that reached the lowest energy on the used dataset.

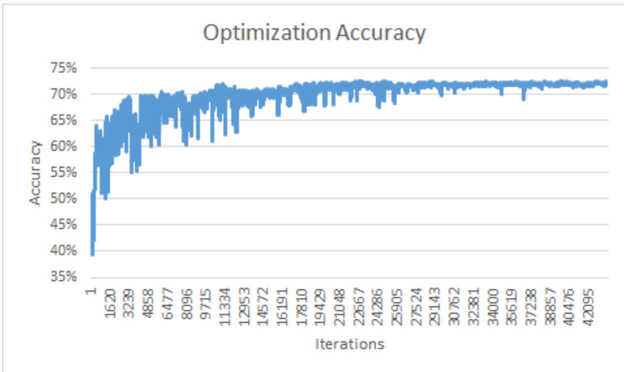

Fig. 5: The accuracy curve for the best optimization case.

It's possible to see an overall increase of the optimization accuracy as the iterations progress; also, the accuracy curve seems to converge to a value of about 72% by the end of the process. The accuracy achieved with the instantaneous model for the same dataset is of 64%. This fact suggests that the use of the dynamic model was beneficial even for a dataset with videos that don't contain too many facial noises caused by factors like laughter or speech.
The best accuracy was reached for a value 1 of K_{nr}.

C. Tests on the Dynamic Facial Emotion Classifier

To test the developed dynamic classifier, a test was run on the video "S43_an_2" of the eNTERFACE'05 Database [20], the same analyzed in the work of [13].

This video depicts the face of an angered person as she irritatedly proclaims a certain sentence. The presence of facial noises in the video is relevant for the experiment, as it allows for the analysis of how well the dynamic model is able to deal with such noises. Also, this is the first experiment that utilizes a video entirely stranger to the datasets used for training the instantaneous classifier and for the optimization process.

Because the video ”S43_an_2” is simply classified as an Anger video, and since there is no information about whether any other emotional displays are considered to be present in it, all of its frames were considered as Anger samples and fed into the model.

Figures 6 and 7 present the dynamic model output and the instantaneous classifier output for each frame of the video, respectively. The accuracy achieved with the dynamic model was of 89%, while the accuracy achieved with the instantaneous classifier was of 64%. This result suggests that the dynamic model successfuly dealt with a considerable portion of the facial noises presented in the video. Note that not only the dynamic model achieved a higher accuracy on the video, but its outputs seem to be more reliable. With exception of the last frame, all frames in the video were classified as Anger or Neutral frames by the dynamic model, and there are less variations between different emotional states; the classifications attributed by the instantaneous model, however, flicker more rapidly and between a larger number of emotional states. One could argue that the result achieved by the dynamic model is more useful than the one achieved by the instantaneous classifier if it was to be used to control an automated system like a social robot - maybe the social robot wouldn't be able to react as well to a flickering input as it would react to a more stable one.

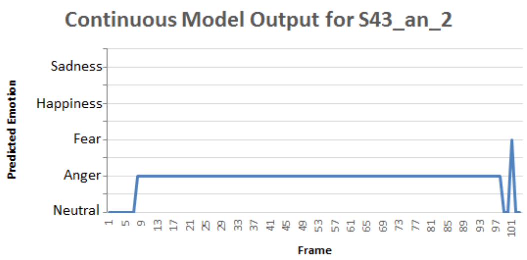

Fig. 6: The output of the continuous model for the video ”$S43\_an\_2$”.

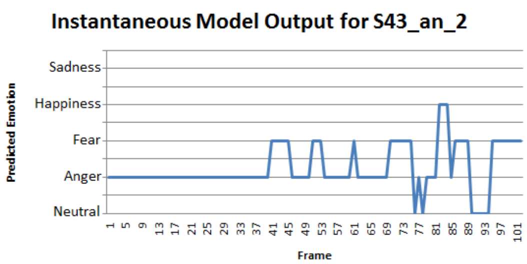

Fig. 7: The output of the instantaneous classifier for the video ”$S43\_an\_2$”.

Finally, Figure 8 presents the trajectory on which the EP traveled throughout the video. Note that the particle rapidly progresses to the Anger area, where it remains until the latter parts of the video, regressing back to the neutral area and then to the Fear area by the end of the video. The transition to the Fear area is probably due to the considerably large number of Fear predictions outputted by the instantaneous classifier in the latter parts of the video.

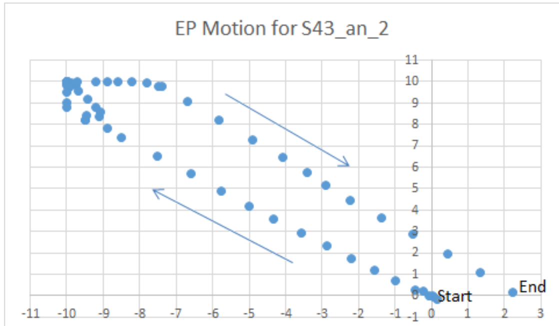

Fig. 8: Motion of the EP throughout the video ”$S43\_an\_2$”.

V. Conclusions

In the present work, an innovative dynamic emotion recognition model was presented. This model comprises of the conjugation of a machine learning algorithm, a Kalman filter and an original dynamic model that aims to describe durable emotional states and to minimize facial noises like deformations caused by laughter and speech. A simulated annealing algorithm was utilized to optimize the model's parameters.

The model has shown good performance when compared to the instantaneous emotion classifier trained in the present work: while the former achieved an accuracy rate of 72% over the chosen dataset, the latter presented an accuracy rate of just 64%, on the same dataset.

When tests on a sample stranger to the datasets utilized to train the instantaneous classifier and to optimize the model's parameters, the dynamic model once again outmatched the instantaneous model: not only it achieved a higher accuracy rate (89% against 64%), but it also provided a much more stable output.

As target objectives for future works, the following tasks are proposed:

1) Execute more tests on the dynamic model, in order to better analyze its accuracy and the way it describes the progression of emotional expressions in faces;
2) Utilize larger datasets to train the instantaneous model and to optimize the dynamic model;
3) Utilize datasets that contain faces deformed by natural facial noises, like laugther or speech, for the training and optimization of the model;
4) Study possible changes the proposed planar DES may need to better describe the way emotions manifest themselves in human faces;
5) Increase the number of considered emotions and study how the DES should be changed to accommodate this change.

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Gain Control at the First Visual Synapse

Kae Leopoldo[1], Diego Decleva[2], Maarten Kamermans[3] & Christina Joselevitch[1,2]
[1]Department of Experimental Psychology / [2]Department of Neuroscience and Behavior
Institute of Psychology, Universidade de São Paulo, São Paulo, Brazil
[3]Retinal Signal Processing, The Netherlands Institute for Neuroscience, Amsterdam, The Netherlands
christina@usp.br

Abstract

The visual scene changes nearly 50 billion-fold in ambient light intensity throughout the day [1], and yet the visual system is able to adapt to these changes. This is achieved by photoreceptors with distinct absolute sensitivities, the rods and cones [2], as well by post-receptoral mechanisms that process the information conveyed by these neurons [3-5]. As we advance through the retinal layers, both convergence and signal amplification increases [6]. This, added to the fact that the rod pathway has more input connections to second-order neurons than the cone pathway, led to the widely accepted idea that a large convergence helps increase retinal sensitivity. However, the link between convergence and sensitivity is not straightforward. While a large convergence potentially leads to greater sensitivity by increasing the probability of photon absorption within the receptive field of the second-order neuron, a bipolar cell (BC) needs to produce dendrites with both synaptic and non-synaptic channels to contact rods. Together, this increased membrane conductance could potentially lead to a smaller influence of each photoreceptor onto the second-order neuron, as stated by Kirchhoff's current law [7]. Thus, the aim of this work was to investigate how the convergence between rods and their post-synaptic partner, the bipolar cell, affects the integration of rod signals. To reach this aim, we used the NEURON simulation environment to create a mathematical model of a rod-driven bipolar cell, based on a previous model of a teleost mixed-input bipolar cell [11;12]. Distribution and density of synaptic- and non-synaptic conductances were added according to literature data. Because the gain of the rod:BC synapse is partly determined by the resting membrane potential of the post-synaptic neuron (V_{rest}), we investigated the effect of rod:BC convergence on V_{rest}. Our simulations show that a change in rod:BC convergence alone has no net effect on V_{rest}. This happens because in order to increase the number of synaptic contacts, one needs to add more thin dendrites to the post-synaptic neuron. Since these dendrites contain both glutamate-gated channels, which have a reversal potential (E_{rev}) around 0mV, and passive conductances with E_{rev} around -80 mV, the balance between these two conductance densities remains the same. V_{rest} changes significantly, though, when the length of the primary dendrites, which contain only passive conductances, vary with rod:BC convergence. This is the case in the growing fish retina: as the retina stretches out with growth, the membrane surface area of all second-order neurons increases significantly [13;14], and so does rod:BC convergence [15;16]. In the mammalian retina, there is no increase in rod:BC convergence with growth, because neurogenesis after birth is very limited. The retina – and retinal neurons – grow therefore mainly by stretch in mammals [17]. When we simulated this situation by increasing only the size of the BC dendritic tree while keeping rod:BC convergence constant, we found that V_{rest} became proportionally more negative for larger dendritic lengths. Together, our results suggest that the size of the dendritic tree plays an important role on setting V_{rest}, thereby significantly altering the gain of the rod:BC synapse. On the other hand, rod:BC convergence by itself does not have great influence on V_{rest}. The consequences of this arrangement will be discussed.

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Phineas Gage and ADHA. Some related aspects.

Ana Paula de Carvalho Gomes
Adaptative Systems and Intelligent Computing Lab
Sao Paulo State University - UNESP
Bauru-SP, Brazil
asyslab@gmail.com

João Fernando Marar
Adaptative Systems and Intelligent Computing Lab
Sao Paulo State University - UNESP
Bauru-SP, Brazil
fermarar@fc.unesp.br

***Abstract*—Attention-Deficit/Hyperactivity Disorder (ADHD) is a cognitive dysfunction indicating functional deficits in attention, impulsivity, control and reward processing. This study compares a famous case in the history of neuroscience and actual research results on ADHD. Phineas Gage's injury ravaged parts of ventromedial prefrontal cortex in both hemispheres and revealed important personality changes. He became impatient, impulsive, losing his capacity to choose better things for his life.**

Recent studies using functional magnetic resonance imaging support the hypothesis that in ADHD patients executive deficits are accompanied by early dysfunctions, especially in frontal brain areas. Therefore this study reveals similarities of some symptoms with the same cortical areas involved in both cases. Despite this approach seems reductionist, we can reflect on important aspects of cognition.

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Face-to-face interaction and the minimal enchronic unit

Cacilda Vilela
Faculty of Philosophy, Language and Literature, and Human Science (FFLCH)
University of São Paulo
São Paulo, Brazil
cacilda@upgames.com.br

***Abstract*— We propose a new unit of practice for face-to-face interaction, called the minimal enchronic unit (MEU). Based on concepts from Conversation Analysis, Nonverbal Communication and Gestures Studies and the Enfield's notion of enchronicity, we qualitatively analyze semi-spontaneous face-to-face interaction. We observe that, collaboratively and in a jointly commitment, participants have a practice, inside the current-speaker's turn, that allows them to deal with possible moves that could compromise the projectable trajectory of the interaction in progress. Working at the micro level of interaction, MEU allows a better understanding of language-in-use, such as how higher levels of sequence organization can be produced in order to achieve the preferred social-agreement pact.**

***Keywords*— cognition; multimodality; gesture; conversation**

I. Introduction

When we interact, we interpret each other´s behaviors. Liking it or not, what we say and gesturally display next will be interpreted as a response, at some level, to what was just said and displayed. Any time we engage in social interaction, our actions are of real consequence to the social relationship currently being exercised. Therefore, understanding this social process of actions and responses is fundamental to our comprehension of human behavior and the use of language.

In this paper, we propose a framework – the minimal enchronic unit (MEU) - that describes a practice about how participants´ behavior can contribute to the progression of face-to-face interaction. At the micro level of face-to-face interaction, this practice deals with different semiotic dimensions. It concerns the participants' behaviors that can help understand how higher-level sequence structures are produced during an interaction. In our research, we follow the cognition approach that understanding human cognition as a process that orients human actions and thoughts in the present, taking under consideration events and actions happened in the past and being future-oriented (e.g. [1]). MEU presents a listeners' behavior that occupies a backward-looking move as a response to what has just happened, and a forward-looking move as something that elicits a response next at a specific point of the speaker's turn.

We claim that MEU can be a universal practice for social interaction, which helps not only a better understanding of how language-in-use works, but also how artificial agents can interact with humans in a more natural way. We adopt a holistic perspective for language analysis, since we consider language as a complex, dynamic, adaptive and multimodal system that is social-, cultural-, and historically situated. We based our proposal in some concepts from the fields of Conversation Analysis (CA) and Gestural Studies (e.g. Nonverbal Communication; Gesture Studies) and some notions presented by N. J. Enfield [2]. MEU is based on the concept of Enfield's enchronic frame[2], which considers language in the move-by-move flow of interaction.

Although CA and Gesture Studies fields have given some of the theoretical support for our investigation on face-to-face interaction, these areas are limited in some ways. CA deals only with speech, focusing in the speaker who has the floor at the moment. Gesture Studies claim to treat language differently, taking under consideration the multimodality of language, but, in general, this field also focuses on the current-speaker. Nevertheless Gesture Studies treat language as a multimodal system, just few studies from this area really consider the joint work of speaker and listener for the progress of face-to-face interaction. Our purpose is different. So, in order to explore how interlocutors construct their moves in social interactions, we should not ask what speech does or what gesture does or what role the environment plays when meaning is made. We should ask more general questions. We should ask what participants' resources are through which an interpreter can ascribe understanding to that behavior; how different types of simultaneous signs can have meaning; how the participants' assessment of a move they manage can achieve signification and so on. Only with a holistic perspective, analysts will have a chance to rethink the primacy of language in meaning making. As we have considered the holistic approach of language and the collaborative joint work of participants, we have been able to observe the regularity of MEU in the sequence construction of face-to-face interaction, understanding how language-in-use works and how are the recurrent practices that can be observed.

II. Theoretical Background

Although conversation is considered a minor form of face-to-face interaction and difficult to analyze because of its lack of structure, we follow the understanding from CA that claims conversation is the most fundamental and common form that language takes. CA observed that conversation presents sequences organizations and regularities that can be observed in other forms of face-to-face interaction (e.g. business meetings; interviews; teacher-student interaction), although the sequence organization can differ.

CA methodological ideal is that we should not describe interactional data in terms of the inner states of the individuals involved (e.g. acting nervous). We should rather describe such inner states in terms of the public behavior that might be taken as signs of them (e.g. delaying the onset of the turn, nevertheless claiming it by beginning to talk with *uhm*). For conversation analysts, our access to other people is exclusively through observable speech and bodily signs. It is only through these signs that we can make inferences and attributions about things such as beliefs, desires, intentions, and the capacities of participants to anticipate others' behaviors. In interaction, we apply our cognitive skills to anticipate and project actions that others will apply their cognitive skills in interpreting our behavior-managing others (e.g.[3],[4]). By cognition, we do not mean only inner states and processes but a set of dynamic relations that are as public as they are private. We are only able to come to MEU by analyzing semi-spontaneous face-to-face conversations in a multimodality approach, taking under consideration not inner states of participants, but their observable behaviors and what these behaviors produce in the progress of the interaction.

The perspective about interaction that emerged from CA takes the idea that participants in social interaction engage in practical reasoning both to produce their own talk and to understand the talk of others [5]. Research from CA show that conversation can be analyzed into parts and that these parts consist of definable practices of speaking which have systematic effects and form orderly sequences of action in interaction [6],[7]. This order is the product of persistent orientation by the participants to a set of structures or norms. The norms that organize social interaction do not determine conduct, but rather provide a framework through which conduct becomes intelligible and can be evaluated [5],[8]. Participants in interaction can be seen following a rule, deviating from it, attempting but failing to follow it, or simply violating it. Thus, "[t]he orderliness of interaction then is an endogenous product that is achieved by participants in interaction in each and every one of its local instantiations through the application of regular practices of reasoning" [9, p.95-96]. One example of practice structures that orderly organize social interactions is the organization of turn-taking. This system has not been studied across a wide range of languages, but the findings so far suggest it is universal. Sacks, Schegloff and Jefferson[10] define the system as having a turn constructional component (TCU) that defines the linguistic units out of which a possible turn can be constructed. By extension, TCU also allows participants in interaction to anticipate the possible/probable extent and shape of any actual unit and thus to project or predict its completion. The projectable point of possible completion of a TCU is the possible transition relevance place (TRP), i.e., the point in the TCU at which listeners can potentially take the floor and become the next speaker. For instance, if a participant says - *Are we going to the game?* - this utterance coincides with a TCU[1]. Listener can project the possible completion of this TCU at the moment speaker utters *gam* from *game*, taking also under consideration the raising pitch of interrogative sentences. This *gam* coincides with what CA calls TRP, i.e., a possible place for listener to become the next speaker. Sacks, Schegloff and Jefferson[10] even suggest that this constant projective monitoring of current-speakers' turn construction gives people a motivation for listening, above and beyond any interest in what a speaker is actually saying. Critics about the limitation of TCU as linguistic units were made since the first proposal of Sacks, Schegloff and Jefferson. Today, researchers accept that a TCU can be done by verbal (words, phrases or sentences), prosodic and/or kinesic elements [11]. MEU accepts the notion of turn system since it is a practice that occurs inside one's turn. MEU allows speaker to produce and organize his/her speech and rephrase it whenever it becomes necessary. As MEU deals with multiple semiotic dimensions at the micro level of a face-to-face interaction and adopts a multimodal approach, considering the collaborative and joint commitment of participants, it goes further about the understandings of how a turn can be produced the way it is.

Enfield and Sidnell[9] highlight an important and widely underappreciated point concerning turn-taking system: it operates independently of whatever social actions are being accomplished in and through the talk it organizes. Whether people are requesting, inviting, questioning, answering, agreeing, disagreeing, complaining, excusing, insulting and so on, they do it in turns constructed and distributed through the turn-taking system. All of it supports the idea that the turn-taking system is a part of the infrastructure that operates in an independent form that goal-directs the social behavior people are eliciting in their context-situated usage of language. We claim the same status to MEU.

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Another important notion from CA that we accept in order to propose MEU is the concept of preference structure and the agreement pact. As Clark[12] points out, humans lead their actions by social pacts, made by all of us, all the time. The most desirable pact is the social agreement pact. It does not mean that people will agree all the time one another, but they will search an alignment in terms of behavior; they will merge, on some level, with other individual in a course of action in order to achieve the agreement pact. For instance, as Sacks[13] observes, during an interaction, people will primarily search for agreement in their utterances and not in agreeing one another. Sacks[14] notices that the preference for agreement implies contiguity between turns. Pomerantz[15] discovers some ways in which an utterance can set up a preference structure that constrains the ways in which another person can respond [16]. For example, when a person issues an invitation, the linguistic structure of the response will be different depending on whether it is an acceptance or a rejection. In the case of accepting, which we can regard as the socially preferred, cooperative response to an invitation, the response normally comes without delay. By contrast, in the case of declining, which we can regard as the relatively non-cooperative, socially marked response to an invitation, the response has a set of formal properties that are not observed in the acceptance, such

[1] In this case, a TCU coincides with the production of a turn, but speakers often produce turns composed by more than one TCU.

as delay, prefacing with discourse markers like *well*, markers of disfluency or hesitation, and the provision of accounts or reasons for the declination. The features of preference structure have two important properties. Firstly, preference structure is explained in terms of inherently social interactional factors such as the degree to which an utterance constitutes a cooperative action, as opposed to an action that resists the trajectory the other person has projected on. Secondly, it is defined in terms of specific positions in conversational sequence, such as initiating actions versus responsive actions. Thus, we can summarize that the preference structure is a reflex of the social agreement pact, which is a constant and essential part of social life, and is implicit in every move any individual does in social life. MEU is an example of a practice that evinces the participants' behavior in the jointly searching for the agreement pact.

MEU is based on the concept of Enfield's enchronic frame[2], which considers language in the move-by-move flow of interaction. Enfield explains that his choice for introduce a new term *enchrony* instead of using the concepts and terms such as sequence, adjacency, nextness, contiguity, and progressivity has two different reasons. One reason is that he considers that the existing terms denote something narrower than he wants. A second reason is to situate the idea within a broader interdisciplinary set for the analysis of human communication. As MEU deals with concepts from different fields, we adopt the proposed term.

Enfields[2] details that an enchronic perspective on human communication focuses on sequences of interlocking or interdependent communicative moves that are taken to be co-relevant, and causal-conditionally related. Enchrony implies "types of causal process that tend to operate at a certain temporal grain-conversational time-defining a frame that an analyst of communication may adopt" ([2], p.29). In an enchronic frame, an action is distributed in a collaborative sequence of moves, being launched by one agent and ascribed by another. Enfield summarizes that enchrony is "forward-feeding temporal, causal-conditional trajectory of relevance relations" ([2], p. 28). MEU incorporates this dynamical semiotic process of move and oriented response, since it occupies a backward-looking status as a response to what has just happened, and a forward-looking status as something that elicits a response next at a specific point (TRP) of a TCU during the speaker's turn.

As we talk about moves, practices and actions, it is important to establish the distinctions we make of them. In Goffman's[17] terminology, moves are units of directed and mutually attended social action. In Enfield's terms[2], move is a recognizable unit of communicative behavior constituting a single advancement in an interactional sequence, resulting from making some relevant social action recognizable. It is both a response to a prior move and a prior to a responsive move. Enfield[2] considers that moves are always composite utterances constructed from multiple semiotic resources in concert. Enfield explains that multiple semiotic dimensions can vary independently within a single modality. For instance, speech is not a single semiotic dimension. Pitch and segmental phonetics are both part of a single audible stream, but each can be varied independently of the other. A single word can be interpreted in different ways depending on the pitch used when someone pronounces it. Enfield continues with the example of hand gesture. Hand gestures are definable in terms of a large set of independently variable features such as speed, acceleration, placement and movement, considering three spatial dimensions. Also facial actions are definable in terms of different movements of eyebrow, eyelid, nose movements, mouth gestures, and jar movements. Meaningful semiotic dimensions can independently vary from one another within a single communicative move, so the analysis of communicative move needs to acknowledge fine semiotic distinctions. According to Enfield[2], this can be done by iconic-indexical devices such as spatial cohesion and temporal alignment. The challenge for an interpreter faced with a composite communicative move is to ascribe some relevance to each constituent sign in order to make sense of it. For instance, Enfield[2] gives the example that, as we assume a relation of relevance between co-occurring speech and gesture, the speech constrains our interpretation of the gesture, because maximally contiguous events are most likely to be interpreted as causal-conditionally related.

Concerning actions and practices, we adopt the notion that social action is what a person is doing to or with another person by means of an interactional move. Social action constitutes an ascribable move in an interactional sequence. Action ascription is always provisional, adequate rather than consummate. For instance, we know it was a complaint because it was treated as one by our interlocutor. For us, practice differ from action. Practice are tools for carrying out actions, specifically by [illegible] actions being done. In other words, practice is a conventional form of behavior, with a specifiable meaning, that is general and recurrent enough to be identified across contexts. Because the same words and signs can be used to formulate other kinds of actions in different contexts, we see that practices are not inflexibly fused to their action effects. For instance, as Enfield[2] exemplifies, a requesting can be done through the use of different practices, including interrogative utterances (*Could you pass that knife?*), imperative utterances (*Pass me that knife*), and declarative statement of relevance *(I need a knife*).We add the gestural move of pointing to the knife. This practice of pointing will effectively become an action for requesting a knife when the interlocutor produces the responsive move of delivering the knife to the requester. As Enfield[2] summarizes, actions emphasize ends; practices are means to those ends. Part of the problem of analyzing action in interaction is that there is no one-to-one mapping between practices and actions. The relationship between "practices of conduct" and "the actions they engender," says Schegloff, "will rarely be a simple and straightforward link between a simply formulated practice and a single, vernacularly nameable action." ([18], p. 98)

Other fields we take notions from are Nonverbal Communication and Gesture Studies. From the field of Nonverbal Communication, we work with its repertoire of gestural actions such as facial actions, bodily orientation, distancing between participants and so on. This repertoire can be divided into two categories: one that can be associated to

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positivity (e.g. Duchenne smiles[2], nods; frontal bodily orientation; close distance between participants; facial expressions of emotions like happiness and surprise) and one that can be associated to negativity (e.g. non-Duchenne smiles, headshakes, long distance between participants, facial expressions of emotions like sadness, fear, disgust and anger). Differently from Nonverbal Communication that deals only with gestural actions without considering their relations to speech, Gesture Studies works with co-speech gestural actions. From this field, we adopt the perspective of speech and gestural actions as a single and unified process (e.g.[19],[20],[21],[22]), accepting that gestural actions can add, complement, substitute, illustrate, emphasize or deny what is proposed by speech.

Taking under consideration these theoretical background, considering the holistic approach of language, and accepting the collaborative joint work of participants during a face-to-face interaction give us the possibility to propose MEU.

III. Method

A. *Participants*

Nineteen participants from São Paulo (SP), n=10, Juiz de Fora (MG), n=2, and Recife (PE), n=7 - cities from different states in Brazil - took part in this research. All participants were native Brazilian-Portuguese speakers. Twelve were male and seven were female. Their ages were from 15 to 58. They had different occupations. The females were one high-school student, two psychology college students, one music college student, one linguistics teacher, one English teacher, and one psychologist. The males were one [illegible] college student, six music college students, three linguistics teachers, one computational engineer, and one electric-electronic engineer.

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B. *Materials*

The nineteen participants produced twenty semi-spontaneous dialogues. The majority of the research set-up included two chairs (without armrests) placed opposite each other at a comfortable conversational distance. Just one interaction was held while the participants were walking.

Eight conversations (seven participants) took place at the researcher's house. The participants were left alone for approximately 30 minutes. The dyads choose their own topic of conversation. Each participant of the dyads was video recorded with two cameras: one camera for close-up and one camera for medium shot. Family members (husband-wife, father-daughter, father-son, mother-daughter, mother-son, brother-sister, sister-sister) performed seven of these interactions. One was an interaction among friends.

Five conversations (four participants) took place in The Multimedia Studio (EMM) at University of São Paulo. These dyads also choose their own topic of conversation. These interactions were recorded with five cameras. Each participant of the dyads was filmed in close-up and in a frontal medium shot. One camera recorded both participants in a lateral long shot. Although the researcher was not present during the interaction, two camera operators were at the room. All participants were friends.

Six interactions (seven participants) took place at a room at the Music College of the Federal University of Pernambuco. Each participant of the dyads was filmed with a camera in a frontal medium shot. One camera recorded both participants in a lateral long shot. In four of these interactions, there was a camera operator at the room, although the researcher was not present. In the remaining two, the participants were left alone. In these six interactions, the participants were asked to talk about two artistic movements specific from Pernambuco – the Armorial Movement and the Manguebeat Movement. All participants in these interactions were friends.

One interaction was held at the house of a professor from University of São Paulo. The participants were filmed while they walking around a room. They were asked to propose a decoration for the room. The participants did not know each other. Two people holding cameras followed the movements of the participants.

C. *Ethics Documents*

The participants were informed of the use of video cameras at the point of recruitment and we sought orally their permission for being video recorded. Before videotaping the participants, we explained that the purpose of our research is, [illegible] communication in face-to-face interaction. We did not mention anything related to gestural actions. After the recording, we asked participants and the responsible person, in the case of the minor, to sign a consent form with their permission to use the collected data for academic purposes.

D. *Data Analysis*

Using ELAN[3], the respective speech of each participant in every dyadic interaction was transcribed based on the notion of intonational unit (e.g.[23],[24]). Based on controlled vocabularies proposed by LLIC[4], schemes for head movement, facial actions (eyebrow, eyelid, and mouth), shoulder movement, body torque and manual gesture were continuously coded for both participants of the dialogue.

Paying particular attention to contexts of disagreement, we are able to observe how non-verbal as well as vocal listener's disagreement are firstly displayed during the current-speaker's turn. We notice that this kind of listener's behavior promotes an opportunity for current-speaker to rephrase his/her speech in order to search for the agreement-preferred response.

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[2] Duchenne smiles are considered the genuine and sincere smiles and they engage the muscles around the mouth and eyes. Non-Duchenne smiles are the smiles considered to be false and attitudinal smiles such ironic or sarcastic smiles and miserable smiles. Differently from Duchenne smiles, non-Duchenne smiles engage only the muscles around the mouth (e.g. [30],[31]).

[3] ELAN (*Eudico Linguistic Annotator*) is a freeware professional tool for the creation of complex annotations on video and audio resources from Max Planck Institute of Nijmegen, The Netherlands.

[4] Laboratório de Linguagem, Interação e Cognição - LLIC (Language, Interaction and Cognition Laboratory) is under the supervision of Prof. Evani de Carvalho Viotti and Prof. Leland Emerson McCleary, both professors at Faculty of Philosophy, Language and Literature, and Human Science (FFLCH) at University of São Paulo.

We also notice that the listener's disagreement display is produced at a specific point (the TRP) comprised in the current-speaker´s utterance (the TCU) that has elicited the listener's disagreement. Taking this kind of regularities as parameters, we investigate if listener also displays the same behavior on contexts of agreement. We observe the same regularities. Listener also produce a non-verbal and/or a vocal agreement-display in possible TRPs. From these observations, we extrapolate a general practice and are able to propose the minimal enchronic unit (MEU).

IV. The Minimal Enchronic Unit (MEU)

Like any animal communication, human interaction involves ritualized patterns of behavior that bring predictable effects on others in the social world. This conception of social interaction brings a dynamic relation between a communicative action and the response it elicits. A response is a communicative action itself, engendering, in response, a further communicative action in turn. Thus, following some notions of CA and of Enfield's enchronic frame, a fundamental claim on this paper is that any sequence of communicative action and subsequent response is a unit, not a conjunct. This is because one action cannot be defined without the other. They are part of the same and unique process. When people are interacting, they are interpreting each other's signals, gestures, and signs. Liking it or not, what one says or does next can be interpreted as a response to what was just said or done. Taking under consideration these concepts and a multimodal approach of language, we propose a practice for face-to-face interaction, a minimal enchronic unit (MEU) that can help explaining how people behave when they interact. The hypothesis is that this practice can be a universal behavior for the use of language at the micro level of face-to-face interaction, even when basic styles of human interaction seem to differ radically across groups.

Certain features characterize the basic form of MEU:

1) There are two moves. Each move is realized by different interlocutors (the current-speaker and the listener);

2) These two moves are produced during the current-speaker's turn;

3) The two moves are relatively ordered. They are differentiated into first move (FM) and second move (SM). FM is a move, which initiates some exchange, produced by the current-speaker and SM is a move produced by the listener, which is responsive to the move of the prior speaker's behavior.

4) None of the moves is rigid or invariant. The moves of MEU can be defined by their flexibility. As Enfield[2] proposes, flexibility is the degree to which one can freely determine the elements of a course of behavior and its results, in multiple senses: the physical carrying out of the behavior, the planning and design of the behavior, the placing of the behavior in an appropriate context, the anticipation of likely effects of the behavior. We observe that FMs can take a form of speech and/or bodily actions. As talk, FM is a flux of speech, such as an intonation unit, or a TCU; i.e., a flux of speech that brings a possible complete idea. SMs can be vocal and/or bodily actions. Differently from FMs that bring a possible complete idea in the form of speech and/or bodily action, SMs, as vocal moves, can be a vocalized sound that has little or no referential meaning but still verbalizes the listener's attitude. For instance, in Brazilian-Portuguese and other languages (e.g. English), *uh-huh* and *hmm* or *uhm-uhm* and *humm* serve the roles of continuers or assessments and disagreement. As bodily actions, SMs can be produced with different bodily movements that show the attitudinal listener's behavior (e.g. smiles and nods as bodily moviments associated with agreement; headshakes and furrowed eyebrows as bodily moviments associated with disagreement).

5) The two moves are contiguously placed. In the organization of face-to-face interaction, one of the most relevant features is the relationship of adjacency or "nextness" [25]. The relationship of adjacency inside the current-speaker's turn is central to the ways in which face-to-face interaction is organized and understood. Listener's SM can be inspected by the current-speaker in order to find out how it reaffirms or favors the understanding-so-far of what has preceded it. But also, it can be inspected to verify if the current-speaker should modify his/her next move in order to make a reconfiguration of that understanding. The basic practice of MEU is: given a recognizable production of current-speaker's FM, the listener should display his move (SM) at the specific point of the possible completion of the TCU in progress.

6) Three groups of actions are possible as SMs:

a) Listener´s Agreement: Listeners agree with the TCU in progress and display their agreement. These actions can be in the form of:

a.1) vocalized sounds with a positive connotation (e.g. *uh-huh; hmm*);

a.2) bodily actions considered associated with positivity such as nods, Duchenne smiles; or

a.3) a composition of vocalized sounds and bodily actions.

b) Listener´s Disagreement: Listeners disagree with the TCU in progress and display their disagreement. These actions can be in the form of:

a.1) vocalized sounds with a negative connotation (e.g *uhm-uhm; hum*);

a.2)bodily actions considered associated with negativity such as headshakes (e.g. [26],[27]), furrowed eyebrows (e.g.[28]), wrinkled nose (e.g.[29]), non-Duchenne smiles (e.g.[30],[31]), tightened lips (e.g.[32]); or

a.3) a composition of vocalized sounds and bodily actions.

c) Listener´s Neutral Display: Listeners do not display any reaction at all. Listeners keep silence and make no bodily movement that the current-speaker can interpret as a communicative action. We believe listeners use the "stand-by" behavior in order to wait for current-speakers' next move. This new current-speaker´s move can provide more information for listeners to take some conclusion and stance themselves in relation to the subject.

7) The moves follows the relevance rules. In any domain of social action, to act ordinary is, by definition, to attract no special attention to that way of acting. When actions run in accordance with the expectation of a community, people do not notice anything. As Enfield[2] exemplifies: John is a plumber and by dressing in overalls while at work, he chooses the default, unmarked course of action. It is not only practical, but it is expected. He will not be held accountable or even commented on for doing it (if he works wearing a dress, things can probably be different). When we follow a default course of action in this way, we are, in one sense, not doing anything special. Nevertheless, we are still doing something. It takes work to achieve the appearance of ordinariness ([33],[13]). Even when our way of behaving fails to draw any attention because it conforms closely to the norm, we are always doing something by choosing just that kind of behavior. Thus, as Sacks[13] remarks, the more general preferred action is an unnoticeable, unmarked action, since it is the expected action. In MEU, preferred SMs are th[illegible] relation to FM. Metaphorically, th[illegible] associated with the green traffic li[illegible]ers´ absent moves (both vocal and bodily) can be considered a display of some possible problem on the way. They can be associated with the yellow traffic light. SMs as displays of disagreement response to the prior FM are understood as dispreferred responses; noticeable, marked moves, and they can be associated with the red traffic light. Then, what relevance rules do is to set the initial terms for conduct and interpretation of the next moments that will follow their invocation. They do not define those next moments and what will possibly occur in them. However, it is by reference to a FM that what follows is selected, done, and understood. The FM casts a web of meaning and interpretation that informs the surrounding moves and actions; and

8) The two moves operate in prospective dynamics. FM projects a prospective trajectory of the current-speaker's turn. SM thereby sets not only a retrospective understanding of the prior move, but also some of the terms by which a possible next turn will be delivered. For example, SM is composed of a vocalized *uhm-uhm*, delivered with a headshake and a tightened lip. This composite of different semiotic dimensions displays the listener's disagreement. If current-speaker does not make any action to try to acquire listener's agreement, it is most probable that the listener's next move will be the production of his/her disagreement when he/she takes the floor.

In the Figure 1, we can visualize how MEU works.

Figure 1

Fig. 1. A schematic view of MEU

In summary, the central features of MEU bring the notion that moves are not just produced in a flat string of actions in conversation, but rather are related to each other in specific [illegible]uch inter-move relations is the [illegible]oves (FMs) and responsive moves (SMs) and the next actions that they will elicit.

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V. Discussion

We are social animals who spend much of our daily lives interacting to one another, in both ordinary conversation and other specialized settings such as business meetings, interviews, classrooms, courtrooms etc. Unfortunately, most researchers investigating language do not considered the social aspect of language. They usually focus on the speaker´s actions. Listeners are relegated to secondary status. MEU is a proposition that tries to contribute to change this bias of language research.

MEU considers that a unit of interaction is a communicative action from one interlocutor that elicits a response from another and that these two moves belong to the same process. CA also has this notion of unit sequence in the organization of interaction, but conversation analysts deal with speech, concentrating only on the individual who is the speaker at the moment. As they do not consider listener's behavior and participants' bodily action in their analysis at the moment of current-speaker production, they could not see the role of these activities in the progression of interaction. In general, even the field of Gesture Studies have given relatively little attention to the role of listener's bodily actions. With its emphasis on manual gestures, it has also focused primarily on the speaker role in interactional exchanges. MEU does not neglect the role of listener's bodily action for the progression of the interaction.

MEU considers language as a complex, dynamic, adaptive and multimodal system that is social-, cultural-, and historically situated. MEU describes a practice for interaction that allows analysts to see participants' behaviors in a holistic way. As O'Connell and colleagues say, "[a]t any time in a conversation, all the time belongs to all the interlocutors" ([11], p. 350). We add that the joint time belongs to all participants' in any type of interaction, not only in a conversation.

One can ask about the relevance of MEU since CA has already proposed the notion of adjacent pairs [25]. Although MEU and adjacent pairs have much in common, there are some differences. Firstly, adjacent pairs consider only the speech production; MEU accepts language in its multimodality, considering the use of language in a holistic way. Secondly, adjacent pairs are composed by actions (e.g. question-answer; greeting-greeting; invitation-acceptance/refusal) while MEU is composed by moves that will potentially lead to certain type of actions. Thirdly, adjacent pairs consider the production of different turns, at least two turns, from different participants; MEU is a practice produced during the current-speaker turn that gives the opportunity to current-speaker to rephrase his/her moves in order to search for the preferred-agreement response. Fourthly, adjacent pairs are not found in some sort of sequence organizations as storytelling (e.g.[34]) and other telling sequences (e.g.[35]) or teacher-student interaction in classrooms (e.g.[36]); MEU is also productive in these types of sequences. For instance, the speaker can monitor the listener's behavior in order to see if his/her story telling is been well assimilated or believed. Being sensible to listener's SM, current-speaker can change the w[illegible]y in order to be more effective in his/he[illegible] the story telling.

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One may claim that MEU is no different of backchannel or actions that lead to repairs. Although similarities can be pointed out, there is a remarkable difference. MEU is produced at a specific point during the current-speaker's turn. The listener displays his/her agreement or disagreement at a possible end of current turn, at a possible end of a complete idea (the TRP of the TCU) that has elicited the listener's attitudinal move. MEU deals with the projectable trajectory of the interaction. Differently, backchannel and repairs are behaviors that deal with local problems that, in general, do not compromise the projectable trajectory. For instance, in relation to backchannel, research on listener feedback has recognized its importance in developing and maintaining common ground, as seen for example in speaker cuing for feedback (e.g.[37]) and the effect of feedback on speaker production (e.g.[38]). Nevertheless, there is still little understanding of the ways in which non-verbal moves might constitute an ongoing substantive contribution to dialogue. MEU is an attempt to contribute to that understanding.

As same moves can have different meanings, for instance, when the listener produces a headshake or a nod, one can ask how we can recognize MEU and what is the difference that MEU has in comparison to repairs or backchannel. Take the example of the movement of the head - a nod - made by the listener. This move can have at least two kinds of interpretation: a type of SM (the agreement display) or a backchannel, showing the listener is paying attention and given to speaker the green light to proceed with his/her speech. The difference between one interpretation and the other concerns the moment the listener produces this move. We observe that while MEU is produced at specific points (TRPs) of the flux of current-speaker's speech, backchannel are produced at different points. In a TCU or intonational unit with a complete idea, the nod, to be interpreted as a SM, must occur at the current-speaker's TRP; while the nod, as backchannel, can occur at different points of current-speaker's talk. This is the difference concerning the practice, but there also is a difference about the function of MEU and backchannel. MEU is an attitudinal practice that involves a projectable trajectory of face-to-face interaction while backchannel is a practice that listeners promote to display for speakers that they are paying attention in what is going on in the interaction.

The same consideration can be made with the difference between MEU and repairs. While MEU displaying disagreement can be used to regulate the projectable trajectory of the interaction, repairs are a system of practice (e.g.[39]) used to deal with troubles that can arise in speaking, hearing and understanding (e.g.[12],[7],[25],[40]). Take the example of the movement of eyebrow. A furrowed eyebrow can be interpreted as a signal that the listener is disagreeing with something the current-speaker has just said in the TCU in progress or as a signal that constitutes a source of trouble (e.g. the listener does not understand a specific word). As a MEU signal, the furrowed eyebrow must be produced at the TRP. As a signal of trouble, listener might display it near the point where the trouble has occurred. In repairs, we do not have a [illegible]y of the interaction, but a local, [illegible]

Thus, inquirers can persist about how one can interpret a move as having a function of backchannel/repair or having a function as MEU, since the same bodily action can function as one another. We have already claimed that there is a difference at the specific point in the current-speaker's FM at which the listener´s bodily action will be produced. But, if there is someone who claims that this difference is not enough, we also notice a difference in the quality of the movement. When the bodily action assumes the function of SM in MEU, the movement is more intense. Combining the features – point of production (TRPs or other places), quality of the movement (intensity), and function (interference in the projectable trajectory or local adjustments) – analysts are able to differentiate MEU from backchannel or repairs.

Understanding these differences not only can contribute to the comprehension of the practices individuals use whenever they interact one another, but also it can help artificial agents to be more effective in interacting with humans. Although research in the area of Artificial Intelligence is starting to take under consideration some aspects of the prosodic and gestural actions, we observe that artificial agents are far away to "behave" accordingly to what is expected and desired for them, i.e., interact with human in a more natural way. MEU can be a tool for artificial agent programmers in order to understand the apparent semantically unrelated talks that can accepted as answers. For humans, it is commonplace to accept *It's raining* or *Isn't it raining?* as a refusal of the invitation

Are we going to the game? If researchers analyze face-to-face interactions in a multimodal approach and try to build their artificial agents with the ability to understand MEU, perhaps, these artificial agents can understand why apparent semantically unrelated talk is possibly connected. For example, consider that an artificial agent produces a FM invitation – *are we going to the game?* Then, the listener produces, at the TRP (milliseconds after the agent's production of *ga* from *game*) of this TCU, an irritated or disgusted face. Noticing this listener's SM as a signal of possible refusal that will probably come next as soon as the listener gets the floor, the artificial agent can have the chance to reformulate its invitation and avoid the *It is raining* refusal.

In summary, in this article, we propose a new sequence construction of practices for talk-in-interaction. We call this practice the minimal enchronic unit of interaction (MEU). The importance of MEU is to show how our actions in interaction are organized at the micro level of sequence organization and how we have to consider language as a multimodal system if we want to understand how language-in-use works in a social environment. Although further research must be done in order to verify if this pattern of MEU can be shared across cultures and languages, we believe MEU can be a universal practice, since all human interactions are undertaken in order to fulfill purposes. Interactions are intrinsically characterized by their shared finality involving shared means. Interlocutors in choosing the appropriate means both holistically and from moment to moment achieve this finality. The shared means are not simply speaking and listening, [illegible] sense as interlocutors participate [illegible] going on in face-to-face interac[illegible]t is going on in interaction cannot be appropriately investigated without taking a holistic perspective, considering account, gestural, kinesic, prosodic, temporal, semantic, and syntactic factors. MEU is a contribution to understanding all these factors at the micro level of face-to-face interaction. MEU is a contribution to understanding how its moves are building blocks for higher-level sequential structures that allow participants to search the preferred-agreement social pacts in a more effective way.

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A Qualitative-Spatial Account for the Brazilian Portuguese Preposition "*em*"

Edilson Rodrigues
Universidade Federal do ABC
Santo André - SP
Email: edilson.rodrigues@ufabc.edu.br

Paulo E. Santos
Centro Universitário FEI
São Bernardo do Campo - SP
Email: psantos@fei.edu.br

Marcos Lopes
Universidade de São Paulo
São Paulo - SP
Email: marcoslopes@usp.br

***Abstract*—This paper presents a formal definition for some applications of the Portuguese preposition *em* (usually translated as "in") as used in Brazil. Our goal is to establish a mathematical model using Qualitative Spatial Reasoning formalisms and an extension of supervaluation semantics.**

I. Introduction

Spatial Representation and Reasoning are essential skills for humans to communicate (and infer) knowledge about objects in space. One way of sharing spatial information is by the use of prepositions to describe the relations between entities in an environment. Usually we refer to relations between objects using non-numerical expressions, for example "the cup is on the table" or "the chair is in the room", rather than in numerical terms. This calls for the use of qualitative relations to represent and formally define spatial terms.

Qualitative Spatial Reasoning (QSR) [1] is a research area in Artificial Intelligence whose aim is to formalise space in terms of elementary entities and primitive relations. In terms os spatial prepositions we highlight the work described in [2] as a reference on the use of space prepositions in English. QSR formalisations of linguistic terms are developed mostly for the English language. To the best of our knowledge, there are no researches related to the formalisation of Portuguese spatial terms. This work uses the Region Connection Calculus formalism [3], along with supervaluation semantics [4], to represent the spatial preposition *em* (*in*) as used in Brazilian Portuguese. This preposition has a number of (potentially inconsistent) meanings. It is used, for instance, to say that *"a note is at the fridge door"* (*"a mensagem está* **na** *porta da geladeira"*), or that "*the chicken is in the fridge*" (*"o frango está* **na** *geladeira*"), or that "*the penguin is on the fridge*" (*"o pinguim está* **na** *geladeira*")[1].

Given the fact that the preposition "*em*" is polysemic, our method is to analyse scenarios and describe them unequivocally, using supervaluation semantics to model them. In a nutshell, supervaluation semantics provide the tools for assigning distinct classical interpretations (called *precisifications*) to a given language creating multiple (potentially inconsistent) versions of it. In this work we model the various precisifications by means of qualitative relations defined within qualitative spatial reasoning formalisms.

This work is a first step towards the development of a formal general theory for spatial terms that could be further tested in order to verify the extend of which it is capable of modelling the human conceptualisation of space and, also, to serve as a bridge for a seamless communication between humans and machines.

In the examples given in this paper we use the notation "**in**" to represent a loose translation of the Portuguese preposition "*em*" to English. For brevity the formalisation presented here does not distinguish between objects and their occupancy regions.

A. Literature overview

The ability to locate objects in the world is one of the most basic skills required for any living organism [2]. Similarly, being able to describe where objects are located using simple locative descriptions are considered basic skills for any speaker of a language [5]. Spatial expressions are present in our daily life and occur in a wide range of contexts: object location, scene representation, understanding concepts of placing things. The unequivocal formalisation of spatial expressions, however, is certainly a hard and (for now) an unachieved task. For example, according to Bowerman [6], spatial prepositions are among the most difficult terms to acquire in the study of a second language. This happens due to the fact that languages differ in the way they map linguistic terms for spatial terms. Despite this fact, natural languages encode only a limited number of spatial relations between objects and these have to cover all possibilities. This relates directly to the polysemy issue, which is one of the most difficult problems in formal semantics [7].

Polysemy refers to the set of distinct but related interpretations that a word can have. Spatial prepositions are good examples of polysemic terms [8]. Prepositions are also part of a set of expressions, which together act as an organising structure for other conceptual materials [9], [10]. In cognitive linguistics, spatial expressions have been considered as the primary structuring tools for other areas, hence the extensive use of spatial metaphors [11]. Besides that, from a semantic point of view, spatial prepositions are related in some way to scene description and, therefore, to measurable characteristics

[1]The last example refers to the common habit in Brazil to place a penguin statuette on top of the fridge, which was originated by the 1950's ads for Kelvinator's fridges.

of the world [12]. Therefore, it should be possible to provide precise semantic definitions of spatial prepositions, since the parameters defining their meanings seems to be grounded on the world itself.

There are many approaches that attempt to capture the meaning of lexical terms only by means of other lexical terms. However, Harnad [13] noted that such approaches do not deal with the problem of how the meanings of terms are grounded to the world. In the present work, the meaning of a preposition will be established according to the perception of the environment, and this will be accomplished using notions from the field of Qualitative Spatial Reasoning (QSR), specially from the formalism called Region Connection Calculus [3] described in the next section.

II. Region Connection Calculus

Region Connection Calculus (RCC) [3] is a QSR formalism described in [14] as a tool that integrates spatial reasoning into artificial intelligence systems. RCC is a first-order theory based on the primitive relation *connection*, denoted by C, which is a symmetric and reflexive binary relation. From this relation a set of mereotopological relations can be defined as shown in Figure 1.

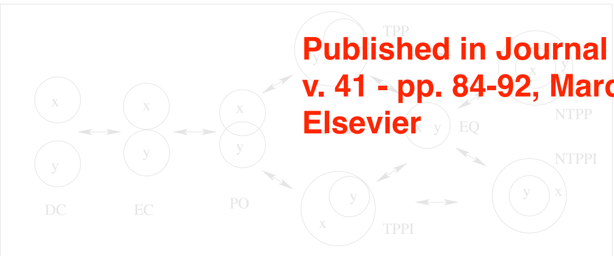

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Fig. 1. The RCC8 relations [14]

Figure 1 shows a conceptual neighbourhood diagram for the RCC relations, where two regions, a and b, are initially disconnected ($DC(a,b)$). Then they touch at the edge, i.e., they become externally connected ($EC(a,b)$). In the sequence they partially overlap ($PO(a,b)$). From PO three possibilities unfold: either a is equal to B: $EQ(a,b)$, or a is a tangential proper part of b, $TPP(a,b)$, or a is an inverse tangential proper part of b, $TPP^{-1}(a,b)$. Finally, there are the relations $NTPP(a,b)$ and $NTPP^{-1}(a,b)$ which are similar to the previous ones, but this time there are no tangential regions.

The relations shown in Figure 1 are especially important because they form an exhaustive and pairwise disjoint set. In the literature, this set is known as RCC8.

According to [15], an *RCC model* consists of a set R, an $u \in R$ element, a unitary set $\{n\}$ $R-$disjoint, a complementary unitary relation (compl): $R - \{u\} \to R - \{u\}$, two binary relations $+ : R \times R \to R$ and $\times : R \times R \to R \cup \{n\}$ and a binary primitive relation on R, denoted by C. This model satisfies certain axioms:

$$(\forall x \in R)C(x,x) \quad (1)$$

$$(\forall x,y \in R)[C(x,y) \to (y,x)] \quad (2)$$

$$(\forall x \in R)C(x,u) \quad (3)$$

$$(\forall x \in R)(\forall yR-\{u\})[C(x,\text{compl}y) \leftrightarrow \neg NTPP(x,y)] \quad (4)$$

$$(\forall x \in R)(\forall yR-\{u\})O(x,\text{compl}y) \leftrightarrow \neg P(x,y)] \quad (5)$$

$$(\forall x,y,z \in R)[C(x,(y+z)) \leftrightarrow C(x,y) \vee C(x,z)] \quad (6)$$

$$(\forall x,y,z \in R)[y \times z \in R \to [C(x,(y \times z)) \leftrightarrow (\exists w \in R)[P(w,y) \wedge P(w,z) \wedge C(x,w)]]] \quad (7)$$

$$(\forall x,y \in R)[(x \times y) \in R \leftrightarrow O(x,y)] \quad (8)$$

A. The convex hull function

RCC8 relations are not sufficient to express all possible spatial relations [14] since (for instance) they do not deal with *containment* or *support* relations and these are crucial to represent spatial expressions [6]. In this work we use a function called *convex hull of* x, denoted by $conv(x)$ (first defined in [14]), that maps a region x to the lowest convex region which x is part of. With this function, three containment relations are defined between two regions x and y, namely:

- $INSIDE(x,y)$ reads x *is inside* y:
$$INSIDE(x,y) \equiv DR(x,y) \wedge P(x,conv(y)); \quad (9)$$
- $PINSIDE(x,y)$ reads x *is partially inside* y:
$$PINSIDE(x,y) \equiv DR(x,y) \wedge PO(x,conv(y)); \quad (10)$$
- $OUTSIDE(x,y)$ reads x *outside* y:
$$OUTSIDE(x,y) \equiv DR(x,conv(y)). \quad (11)$$

III. New relations for support and pose

In this section new relations are introduced in this paper in order to model the uses of the preposition "*em*". In Brazilian Portuguese by saying "*The penguin is* **in** *the fridge*" a precise location of the penguin is not specified; it could either be *on* the fridge, *inside* it or *at* the fridge door. In order to eliminate ambiguity, we have to identify the exact location of the object. Suppose the penguin is on top of the fridge and between the penguin and the fridge there is a third object, for example a towel. We can still say that "*The penguin is* **in** *the fridge*". The relations defined in this section help us to locate an object in a scenario when it is described with the preposition "em". These are relations about support and pose and are based on RCC8 and on the convex hull notions defined above.

A. Proportional Function

The proportional relation returns true if the rate between the convex hulls of x and y is below a given threshold φ. This relation complements $PINSIDE$ (defined in Section II-A), that is not capable of representing whether a region is located within another. If two objects x and y have disproportional areas, we can not say that x is contained in y using only $PINSIDE$.

- $PROP(x, y)$ reads *x is proportional y*.

$$PROP(x, y) \equiv \frac{area(conv(x))}{area(conv(y))} < \varphi \tag{12}$$

B. Support and Height Functions

This section introduces two functions that will be used along with the RCC8 and the convex hull function: $sup(x)$ and $height(x)$. The former is defined as a support region which says that an object remains off the ground when it is supported or fixed onto another object; the $height(x)$ function gives the height of x. With these functions, we define the relations $SUPPORT(x, y)$ and $VERT(x, y)$, as follows:

- $SUPPORT(x, y)$ reads *x is the base of y*:

$$SUPPORT(x, y) \equiv EC(x, sup(y)); \tag{13}$$

- $VERT(x, y)$ reads *x is above y*:

$$VERT(x, y) \equiv (height(x) > height(y)); \tag{14}$$

- $VERTi(x, y)$ reads *x is below y*:

$$VERTi(x, y) \equiv (height(x) < height(y)). \tag{15}$$

The $SUPPORT$ relation [illegible] externally connected to a bas[illegible] returns true if the height of a [illegible] greater than that of an y region.

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C. The Global and Complement functions

Considering regions x and y as $DC(x, y)$, the $global(x, y)$ function returns the smallest convex region that includes both x and y. The function that returns the complement of $global(x, y)$ is denoted as $diff(x, y)$. Figure 2 shows an example of these functions.

Fig. 2. The Global and Complement functions

Using the $global$ and $diff$ functions, we can define some further relations: $BETWEEN(x, y)$, which returns true when there is a z region externally connected to x and y that is also part of the resulting region of $diff(x, y)$; the $OVER$ and $UNDER$ relations return true when the region returned by $vert(y)$ is either over or under x, respectively. The AD relation implies support but not verticality.

- $BETWEEN(x, y)$ reads *there exists z such that z is between x and y*.

$$BETWEEN(x, y) \equiv \exists z[EC(x, z) \wedge EC(z, y) \wedge (INSIDE(x, diff(x, y))] \tag{16}$$

$$BETWEEN(x, y) \equiv \exists z[EC(x, z) \wedge EC(z, y) \wedge (PINSIDE(x, diff(x, y))] \tag{17}$$

$$BETWEEN(x, y) \equiv existsz[EC(x, z) \wedge EC(z, y) \wedge O(z, diff(x, y)] \tag{18}$$

- $OVER(x, y)$ reads *x is over y*.

$$OVER(x, y) \equiv SUPPORT(x, y) \wedge VERT(x, y) \tag{19}$$

$$OVER(x, y) \equiv BETWEEN(x, y) \wedge SUPPORT(z, y) \wedge VERT(x, y) \tag{20}$$

$$OVER(x, y) \equiv BETWEEN(x, y) \wedge SUPPORT(z, y) \wedge VERTi(x, y) \tag{21}$$

- $UNDER(x, y)$ reads *x is under y*.

$$UNDER(x, y) \equiv SUPPORT(x, y) \wedge VERTi(x, y) \tag{22}$$

- $AD(x, y)$ reads *x is near y*.

$$AD(x, y) \equiv SUPPORT(x, y) \vee \text{[illegible]}\, SUPPORT(z, y)) \tag{23}$$

The [illegible] relation presupposes the existence of a region z that is connected at the same time with x and y; the $OVER$ and $UNDER$ relations assume that the regions in their arguments are vertical to one another, which is required in AD.

D. The CROSS relations

We define the $CROSS(x, y)$ relation by dividing the x region into three parts x_1, x_2, x_3 such that:

- $CROSS(x, y)$ reads *x crosses y*.

$$CROSS(x, y) \equiv EC(x_1, y) \wedge EC(x_3, y) \wedge INSIDE(x_2, y) \tag{24}$$

Fig. 3. The CROSS relation

This relation is depicted in Figure 3. Note that x has been subdivided into three parts: two are externally connected to y, and the third is within y. In this case we say that the object x *crosses* the object y. In Portuguese we could describe this scenario as "*x está em y*" ("*x* is **in** *y*").

E. Inclusion and Encapsulation

This section shows in which situation the relations of inclusion INC and encapsulation ENC occur.

The INC relation represents the cases where we use the term "inside" as a synonym for the preposition "in". In the case of the encapsulation function, the idea is also of content and container, but without the need of having the support relation between them.

- $INC(x, y)$ reads x *is included in* y:

$$INC(x,y) \equiv INSIDE(x,y) \vee PINSIDE(x,y) \wedge PROP(x,y) \vee \exists z[(INSIDE(z,y) \vee PINSIDE(z,y)) \wedge PROP(z,y) \wedge BETWEEN(x,y)]. \quad (25)$$

- $ENC(x, y)$ reads x *encapsulated by* y:

$$ENC(x,y) \equiv INC(x,z) \wedge INC(z,y) \wedge (TPP(x,y) \vee NTPP(x,y)) \wedge \neg SUPPORT(y,x) \quad (26)$$

The difference between INC and ENC is that the former needs a support for it to occur while the latter does not. If an object x is within another object y, but there is not a support relation between y and x, so it is said that x is encapsulated by y ($ENC(X, Y)$).

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IV. The preposition "em" in Portuguese

The work presented in [16] divides the application of the preposition "*em*" into three major areas: *spatial location*, *temporal location* and *non-locative* uses. Furthermore, it frequently occurs in its contracted forms together with articles (e.g.: *na* = *em* + *a* (definite feminine singular article); *nos* = *em* + *os* (definite masculine plural article), etc.). Consider the following examples[2]:

(1) *A água está na garrafa*
the.SG.F water is in+the.SG.F bottle
"The water is in the bottle."

(2) *O menino está no prédio*
the.SG.M boy is in+the.SG.M building
"The boy is in the building."

(3) *Vou viajar em outubro*
go.1SG.FUT travel in October
"I will travel in October."

(4) *Meu aniversário é no dia 25*
my.SG birthday is on+the.SG.M day 25
"My birthday is on the 25th"

(5) *O filme era em preto e branco*
the.SG.M movie was in black and white
"The movie was in black and white."

[2]Standard abbreviations: SG: singular; F: feminine; M: masculine; 1: first person; FUT: future.

The first two examples express some notion of spatial location. The third and fourth examples show the preposition "*em*" being used to describe the time when an action occurs, while in the last instance the preposition "*em*" is used to describe a fact without any reference to the idea of location.

In the present paper, we highlight three sub-areas of spatial location to define the uses of the preposition "*em*": *inclusion*, *contact* and *adherence*. We provide below a brief description of these applications from the point of view of a *trajector* object in an environment (or object) called *mark*:

- *Inclusion*: provides a container/object interface contained for the scheme mark/trajector, in which the trajector is contained in the mark. This means that if any moving action is applied to the mark, the trajector will also be moved.
- *Contact*: in this application the mark is seen as a surface that supports the trajector (supportive/sustained object relation).
- *Adherence*: a variety of the contact application, in which there is also a sustainer/sustained object relation, but without the idea of verticality.

In order to formalise the multiple meanings of the preposition "*em*", in this paper each use of this preposition is replaced by a precise definition using the relations introduced above. In the next section we use Supervaluation Semantics to model the multiple meanings of the term by means of precisifications.

V. Supervaluation Semantics

Supervaluation semantics beholds a vague language as a set of distinct meanings of itself, each one of these meanings is called a *precisification* [4], [17]. A *supervaluation model* is a set of precisifications which may be true in all interpretations or true to at least one interpretation.

In this paper, we use supervaluation semantics in order to model the various meanings that the preposition "*em*" assumes in Brazilian Portuguese. In this work, the possible interpretations of this term are given through the relations between domain objects and the verb associated to the preposition "*em*". In order to map a polysemic term to its precise (and unique) definition, given its use in the sentence, we use Table I. For each use of the preposition "*em*", Table I gives a precisification by means of some of the relations introduced in Section II.

If there are no precisifications for some term in the relations defined above, we will make use of $NREL$ (no relation) such as it is defined in Formula 27.

$$NREL(x,y) \equiv \neg INC(x,y) \wedge \neg AD(x,y) \wedge \neg OVER(x,y) \wedge \neg UNDER(x,y) \wedge \neg ENC(x,y) \wedge \neg CROSS(x,y) \quad (27)$$

A. Examples

Figure 4 shows a number of examples where an object x is described as "*em*" (in) another object in Brazilian Portuguese: Figures 4 (a), (b), (e), (i), (k), (l) and (m) are described as"x

TABLE I
TABLE WITH POSSIBLE INTERPRETATIONS OF THE PREPOSITION "EM"

Precisification	**Substitution**
$INC(x, y)$	*inside*
$INCi(x, y)$	*contains*
$AD(x, y)$	*near*
$OVER(x, y)$	*over*
$UNDER(x, y)$	*under*
$ENC(x, y)$	*encapsulated*
$ENCi(x, y)$	*encapsulates*
$CROSS(x, y)$	*crosses*

está **no** *semi-círculo*" ("*x is* **in** *the semi-circle*"); Figures 4 (c) e (d): "*x está* **no** *suporte preto*" ("*x is* **in** *the black board*"); Figures 4 (g), (h), (j): "*x está* **no** *y*" ("*x is* **in** *y*"); and Figure 4 (f) "*x está* **na** *região de y e z*" ("*x is* **in** *the region of y and z*").

Table II relates the examples shown in Figure 4 to the possible interpretations summarised in Table I[3].

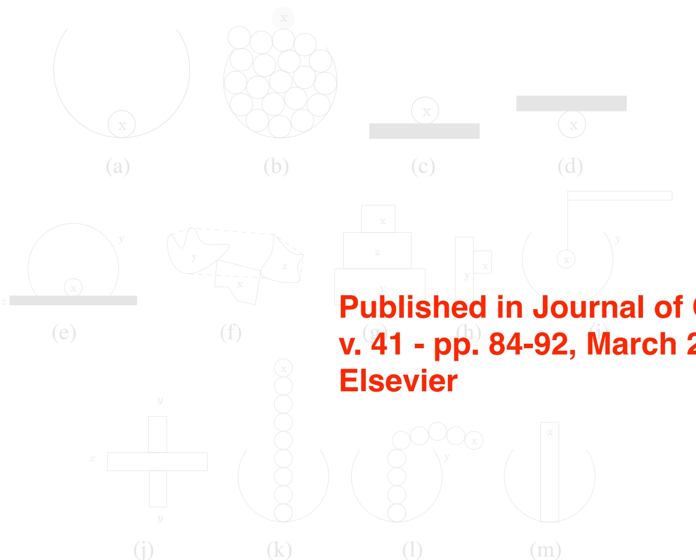

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Fig. 4. Examples

TABLE II
PRECISIFICATIONS

Fig.	INC	AD	OVER	UNDER	ENC	CROSS	NREL
(a)	•						
(b)	•						
(c)			•				
(d)				•			
(e)					•		
(f)							•
(g)			•				
(h)		•					
(i)					•		
(j)						•	
(k)							•
(l)							•
(m)	•						

Exemplifying the use of the tables, take for instance Figure 4(b) and assume that y is a container accommodating a set of white balls denoted as $z_1, \cdots, z_n$ plus x, the gray ball on the top. By the definition of INC, we have that $PINSIDE(z_1 \cup \cdots \cup z_n, y)$ and $PROP(z_1 \cup \cdots \cup z_n, y)$ are true. It is also true that $BEETWEN(x, y)$. We can then replace the polysemic expression "*x está em y*" ("*x is* **in** *y*") by the its more precise meaning "*x está dentro de y*", ("x is inside y").

[3]For better viewing, only True values are marked.

VI. CONCLUSION

This paper introduced a number of qualitative spatial relations in order to provide precise meanings for the preposition "*em*" in Brazilian Portuguese. In this work we also used a fragment of supervaluation semantics, initially employed in vague languages, to model polysemy. Future work shall take into account the full logical apparatus of supervalution semantics in order to model and make inferences about polysemic terms. We will also consider further applications of "*em*" (e.g. those assigned $NREL$ in Table II). Our long term goal is the development of a formal general theory for spatial expressions capable of modelling the human conceptualisation of space that would also be capable of facilitating the communication between humans and machines.

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Integration of the basal ganglia connectivity and structural information to enhance the default mode network detection perturbed by motion artifacts

Aura Maria Forero Pachón
Universidad Nacional de Colombia
Bogotá, Colombia
amforerop@unal.edu.co

***Abstract*— The basal ganglia are subcortical structures important for motor, cognitive and emotional processing. [4] . The default mode network is one of the most studied networks in resting state. Using noninvasive techniques of imagenology, such as fMRI, it is possible analyze the structural, functional and effective connectivity in the brain. sc-fcMRI data are useful for observing functional organization within the human basal ganglia [4]. Based on the anatomical and functional organization of the basal ganglia as prior information, the approach of this work is to perform a new method to detect the default mode network with more robustness. Taking into account that the basal ganglia has been studied since different levels (histological, anatomical, topological and functionally) [2][4][5] and has been demonstrated that the patterns of connectivity with the cerebral cortex and the spatial constraints are two properties of the basal ganglia divisions that facilitate identification with noninvasive neuroimaging methods [1]. The challenge of this work is to use the information from the structural and effective connectivity and present a multiscale [7], multivoxel and statistic method which allows a robust detection of the default mode network in images with artifacts due to movement. The methodology proposed includes a preprocessing of fMRI images using FSL, registration based on an atlas of the basal ganglia [6]. Independent component analysis and anisotropic filtering based on the direction of the connectivity information. Finally, the importance of the research and analysis of structural and functional connectivity in the brain is highlighted. Also, is important indicate that the method proposed could be helpful for the analysis of cases which involves troubles with memory and learning like Autism spectrum disorder. But specially for diagnosis, control and treatment of pathologies where patients move due their stage such as Alzheimer and Parkinson.**

Keywords—Basal ganglia, default mode network, connectivity.

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Behavior Analysis and Neuroscience

Exploring frontiers for a new neuroscientific model

Ricardo Tiosso Panassiol, Marcelo Frota Benvenuti, Christina Joselevitch
Department of Experimental Psychology
University of São Paulo
São Paulo, Brazil
ricardo.tiosso@gmail.com

The nature and basic processes that underlie behavior and cognition is under constant scrutiny [1]. Experimental Analysis of Behavior (EAB) provides a methodological and theoretical framework that allows the study of the neural bases of behavior without the need to separate behavior processes of learning from basic cognitive processes [2, 3]. According to this school, behavior can be acquired and maintained in either of two ways: by consequences (i.e. positive reinforcement or aversive stimuli trigger the desired behavior), or by association (i.e. an innate physiological stimulus is triggered by the conditional stimulus). However, this framework is underused: EAB does not seek to explain the physiological basis of these behaviors, even though it could [4, 5]. In this context, Neuroscience and EAB can offer each other complementary information. This work reviews the literature in both areas as regards different learning processes and how they can be integrated to research with neural stimulation and reinforcement pathways to seek common grounds for interfaces. Our scientific effort is to investigate how learning and its neural bases can interact in the generation of complexity, without judgment as regards the investigative approach.

Keywords—Neuroscience; Experimental Analysis of Behavior; conditioning; neural stimulation; reinforcement pathways

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Etho-robotics - an insight

Ágnes Urbin, Beáta Korcsok
Department of Mechatronics, Optics and Mechanical Engineering Informatics
Budapest University of Technology and Economics
Budapest, Hungary
urbin@mogi.bme.hu, korcsok@mogi.bme.hu

***Abstract*—As service robots gain more ground compared to industrial robots, the field of robotics needs to face new challenges regarding Human-Robot Interaction. Etho-robotics offer a new approach based on human-dog interaction in comparison to the previous approaches mainly based on human-human interaction. Etho-robotics research integrates ethological principles and methods, mathematical modelling and robotic applications. The interdisciplinary system built up from these helps to create coherent behavior models. The main contribution of this paper is to show an introduction to the mechanism of etho-robotics researches showing how can these scientific fields work together in order to support the unavoidable changes in the field of robotics.**

Keywords: Man-Machine Interaction, Behaviour-based Control, Human-Robot Interaction, Etho-robotics

I. Introduction

In the trends of robotics service robots become more and more significant as they gain more ground compared to industrial robots. As the report of the Japanese Ministry of Economics and Trade [1] predicts, in the following years the field of service robots will grow more remarkable than the field of industrial robotics.

The field of robotics needs to face new challenges regarding Human-Robot Interaction (HRI). These changes involve many scientific fields besides robotics including psychology, cognitive science, social sciences, artificial intelligence and computer science. Current researches assume that the new intelligent HRI systems have to be able to express patterns of sociocognitive and socioemotional behavior [2,3].

II. From Industrial Robotics to Etho-Robotics

One of the main differences between industrial and service robots is that service robots have to interact with humans during functioning while with industrial robots humans interact mainly on the level of control.

Service or social robots therefore have to be able to adapt to more dynamically changing environments and have to be prepared to function with less technologically literate users than the users of the industrial ones.

These new needs lead to new levels of interaction between robots and users. In contrast to previous approaches based on human-human interactions, etho-robotics offers a new direction based on human-dog interactions [4]. Etho-robotics research uses ethological principles and methods to derive complex behavioural models which can be transcribed to mathematical form and implemented into robots [5].

III. Etho-Robotics Research

The first steps of an etho-robotics research are ethological observations of human-animal interactions through experiments. The interactions are selected due to the proposed functional similarity of the behaviors displayed and the behaviors wished to be implemented in the robot. Further on a coherent behavioral model is formed based on the behavioral analysis and the statistical results.

The next step is to find the key components of the model, translate them to a mathematical form and based on the mathematical model to build control model for robotics.

The implemented control model is then used in human-robot interaction experiments corresponding to the starting experiments. After the analysis and evaluation the possible shortcomings of the model can be discovered, e.g. behavioral elements that were present during the initial human-animal interaction but were not implemented in the model. Therefore a feedback is created which helps in further research to refine the model.

IV. Example

See the situation illustrated on Fig. 1 as an example. This scenario could be applied in HRI as a way to enhance the robot's proximity seeking behaviour towards different users e.g. in an object retrieving task.

A dog is standing next to his owner. In the same room there is an unkwnown human and a ball. The ball is behind the stranger but the dog can clearly see that.

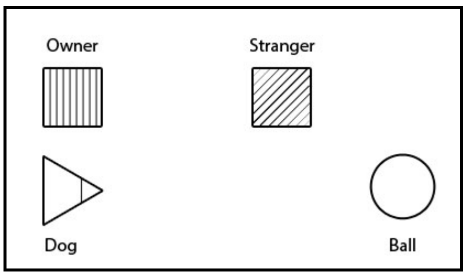

Fig. 1: The initial scene of the example

Assume that there are four basic rules:

- R1 When the dog is close to its owner its anxiety level is low.
- R2 When the dog is not anxious it intends to play.
- R3 When the dog is close to an unkwon human its anxiety level gets high.
- R4 When the dog is anxious it trys to get back close to its owner.

R1 and R2 conclude that as soon as the dog will see the ball it will start to get it as illustrated on Fig. 3

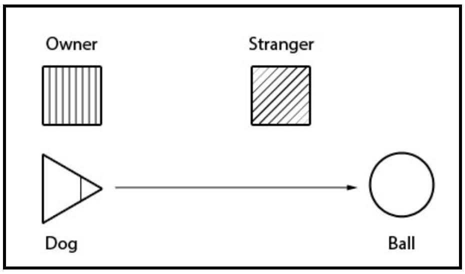

Fig. 2: The dog starts to get the ball

Before reaching the ball the dog has to pass close to the stranger. Since the dog doesn't know the other human according to R3 reaching the stranger its anxiety level is getting higher and does not want to play anymore so it stops as seen on Fig. 4.

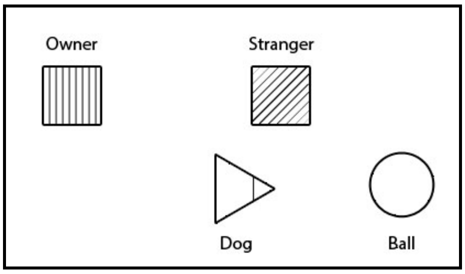

Fig. 3: The dog stops when it reaches the stranger

According to R4 the dog will return to the owner as shown on Fig. 4.

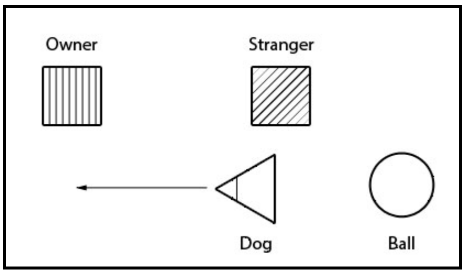

Fig. 4: The dog returns to its owner

After getting back as R1 says the anxiety level becames low again and the according to R2 the whole process could start again.

Based on these four rules the dog would shuttle between its owner and the stranger and never reach the ball. The limes in infinite time of the mathematical model of this situation would result that the dog stays exactly in the middle of the path between the two humans as seen on Fig. 5.

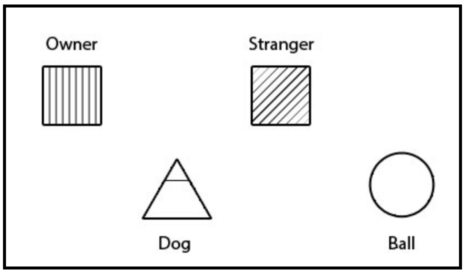

Fig. 5: The dog will always stay between its owner and the stranger

Even though the model gives this result this is not what happens in the reality. Creating the model based on this four basic rules and comparing the results with experiments based on the same situation gives quite important feedback.

Conducting human-dog interaction experiments would most likely shed light to the many deficiencies of this example, e.g. it only considers the dog's anxiety level as its inner state while in reality the dog's behaviour is modulated by numerous factors such as previous experiences, learned behaviours, the exploratory behaviour and the sociality of the dog [6] etc.

Since the ethologist experts define the rules based on experiments where dogs are observed, the dog itself is an essential part of the modelled system. This does not mean that every observed behaviour should be implemented into robots. The key is to find the simple behaviours that are functionally relevant in the case of service robots but which also enhance the human-robot interaction and make communication with the robot easier.

Therefore verifying the models by observing human-robot interactions in the same experimental setup with a robot that is built up solely based on the defined rules can help to find those behavioural aspects that were previously not applied in the model, but which bring it closer to reproducing the desired behaviour.

This way based on the feedback the group of rules can be extended and improved and so with continuous iteration more and more complex situations can be modelled and simulated.

V. Conclusion

Social robotics is a dinamically developing field of robotics that will gain more ground in the following years. The goal of this paper was to show a short example how can the integration of ethology, mathematical modelling and application of robotics build an interdisciplinar system, hence how can etho-robotics help to support this trend.

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Assessment of Fun in Interactive Systems: a Survey

Luiz Carlos Vieira*, Flávio Soares C. da Silva†
Laboratory of Interactivity and Digital Entertainment Technology, University of São Paulo
Rua do Matão, 1010 – 05508-090 – São Paulo (SP) Brazil – Email: *lvieira@ime.usp.br, †fcs@ime.usp.br

***Abstract*—Fun is a fundamental aspect of life, that fosters interaction and learning. Hence, it is an important factor for engagement with digital artefacts. The design of engaging artefacts is not a trivial task since fun is subjective: it is context dependent and relies upon the preferences and history of users. A designer must choose the best approach to maximize the chances of an artefact to generate fun. In this process, assessment is essential. Traditional methods involve observation of users interacting with artefacts, and questionnaires to ask what users felt while doing so, while more recent methods involve data collection and physiological measurements. This paper presents a survey on the existing methods for the assessment of fun, considering its constituent elements - attention, flow, immersion and emotions.**

I. Introduction

The pleasure and excitement experienced when playing games or doing other enjoyable activities is generally known as *fun*. Fun is an important aspect of life because it satisfies curiosity and fosters learning [1], and consequently it is something designers want to imbue their artefacts with. It is an obvious requirement for games - otherwise people would simply not want to play them - but it is also important for "serious" artefacts, including commercial and scientific software systems. The satisfaction obtained by interacting with an artefact, that used to be searched for by Human-Computer Interaction (HCI) researchers just in terms of utility and absence of physical and cognitive discomfort, is also considered to include other non-utilitarian aspects of the *user experience* related to appeal, preference and emotions [2], [3] - which are, after all, aspects of fun [4]. Current deployment technologies (e.g. on-line mobile markets) make very easy to have access to many similar artefacts, particularly software systems. In cases in which users have several options, the use is discretionary, or involves sustained activity, ease of use and simplicity are not enough and developers must stimulate users to *want to* use their systems by making them fun [5].

However, fun is difficult to design because it is an experience essentially made of emotions. Human emotions result from the conscious judgement of events and are complementary to reason in the decision process by making memory of past experiences relevant, reinforcing intentions and preparing the body for action [6]. People interpret experiences in different levels of emotional details depending upon context of use, past experiences, preferences and expectations, and this causes emotions to be ephemeral and hard to guarantee as a result of the interaction with an artefact [7], [4]. The fleeting character of fun is evident in video game design. Even though video games are software systems, there are no functional requirements in them to solve real problems. Instead, video games are supposed to elicit pleasurable emotions in a very similar fashion to what other media do (like films and music). Hence part of the work that game designers are used to do involves the use of heuristics to fulfil "situational needs", such as challenges, social interaction and aesthetic preferences, in order to increase the odds that the resulting experiences are pleasurable beyond the fulfilment of pragmatic aspects [2]. Additionally, video games involve more interaction and control than other types of entertainment media, what produces experiences much less linear and makes the distinction between artefact and experience much more obvious [8]. Consequently, game designers must continuously learn what their users (the players) want [4]. That explains why testing is arguably the most important step of game design.

Designing for fun, with games as well as with other artefacts, requires a two-way communication between designers and users, in order to allow all patterns to be exercised throughout the entire artefact development and to gain insights into whether or not the aimed experiences are being achieved [9]. By creating prototypes of increasing quality, reviewing ideas, identifying potential users and asking them to test the artefact, the designer can have valuable feedback on her design choices and apply the needed changes as soon as possible [9]. Also, since the emotional experience is much more subjective than the satisfaction aspects of usefulness or safety, only the observation or inquiring of people using the artefact can help identifying obscure aspects of the design and provide opportunities to incorporate good unexpected events discovered by users themselves [8]. Therefore, the practise of testing is fundamental to help improving the possibilities of an artefact being fun to broader audiences and contexts.

This paper presents a survey on the existing methods for assessing the fun aspects of the experiences people have while using interactive systems. To do so, it starts by briefly describing what those aspects are, and then explores the methods used to help evaluating them.

II. The aspects of the fun experience

Fun is something hard to define in a few sentences. The main reason is that, like any affective subject, fun intersects different concepts such as enjoyment, amusement, pleasure and satisfaction. Pleasure, enjoyment and fun are particularly close, and this proximity can be observed in their semantics:

- **pleasure**: enjoyment, happiness or satisfaction[1]; something that is done for enjoyment or satisfaction[2]

[1] from the Cambridge Dictionary
[2] from the Merriam-Webster Dictionary

- **enjoyment**: the feeling of enjoying something[1]; a feeling of pleasure caused by doing or experiencing something you like[2]
- **fun**: pleasure, enjoyment or entertainment[1]; someone or something that is amusing or enjoyable[2]

Although those definitions seem very similar, there are important distinctions that humans intuitively understand because they have personally experienced such feelings many times in their lives, either by spinning with chairs, playing hide-and-seek and walking on parks as children, or by going to theatres, doing hobbies and driving cars as adults. It seems obvious that an evening sipping wine with friends lacks the intensity commonly related to fun, despite probably being enjoyable. Humans know they had fun when they have experienced an intense, fleeting and desirable moment in which they enjoyed doing an activity and completely forgot about time and problems. In the domain of interactive systems, aspects that have been described as contributing to that intense pleasure include attention, play, interactivity, conscious and unconscious control, engagement, and style of narrative [10], which are explored next.

A. The psychology view of fun

Whenever a person has fun, it only happens because she is somehow *interacting* with an object or an activity in the world. This phenomenon of mutual influence is important for the subsistence of living organisms because it allows for perceiving, reasoning and acting upon changes in the world and hence dealing with uncertainty. Due to that, the evolution made the brain a system very interested in novelty, and the human limited attention is constantly trying to focus into the perceptions captured from the senses that are more in accordance to internal intentions [11]. This continuous process leads to the improvement of the *self* – a sum of all memories, actions, desires, pleasures and pains experienced so far – in the sense that what becomes known is "chunked" into bits of information that are handled by the autonomous nervous system [11].

The intentional focusing of attention requires effort, what is known as the spending of psychic energy. The condition in which the information on the senses threatens one's goals is known as *psychic entropy*. The opposed condition, when the focus of attention becomes effortless, it is called the *optimum experience* (or *flow*) and it is the moment in which a person experiences enjoyment at the most. The reason is the feeling of being in control (*in the flow*), facing meaningful challenges that are difficult enough and yet unattained, but with compatible skills capable of aiding in the task ahead [11]. According to the flow theory, the properties that an enjoyable task usually has are related to the existence of challenges and compatible skills, and also to the ability for total concentration, spontaneity of actions, clear display of goals and feedback, strong sense of control, and reduction of both self-awareness and perception of time passage [11]. The improvement of the self is related to learning, since all efforts performed when facing an interesting challenge translate into the improvement of skills.

The fun in learning activities has been further studied as a composition of three main aspects: curiosity, fantasy and challenge [1]. Curiosity is directly related to the brain's natural interest for unknown patterns, disregarding the fulfilment of any conscious goals [1]. Challenge is related to "opportunities for action" [11], as described in the flow theory. Fantasy is about "mental images of things not present to the senses or within the actual experience of the person involved" and are related to how memories and new information are processed [1]. Those aspects interoperate because curiosity helps generating initial interest, challenge helps improving abilities and keeping the interest, and fantasy helps understanding the world from relations to previous experiences [1].

There are different levels of attention as a person becomes involved in the interaction with an object or an activity. This has been initially explained by the flow theory and also studied as immersion. Immersion describes the feeling of being totally involved by the environment of an interactive system (like video games, interactive narratives and virtual reality environments, but also books and films), sometimes reaching the extreme of being completely transported into a different world and profoundly related to constructional elements such as characters and their stories. In this state, a person is not only attentive due to a challenge, with pleasure resulting from its achievement. She may also be absorbed in trying to fit the fantasy into a single known schema, with pleasure deriving from the recognition of a long-familiar pattern infused with unique or unpredictable elements [12].

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In meaningful and motivated tasks, the immersion is said to start from the moment that curiosity is triggered, when a person starts doing an activity simply because it seems interesting. It eventually evolves to engrossment, when the person becomes more involved as challenge and fantasy become more relevant. Only then it might evolve to total immersion, when the person's cognitive and perceptual system is tricked into believing she is somewhere else [12]. The concepts of immersion and flow are very close to each other, but most researchers share the belief the immersion provides a sub-optimal experience that does not guarantee enjoyment *but is still valuable*. Immersion differs from flow in the sense that the former is required so the latter can be ever achieved as an *extreme experience* [12], [13], [14].

Fun is a subjective matter because things like fantasy and immersion depend upon past experiences, preferences and current mood, and because challenges and goals have distinct appeal to people with different abilities and skill levels. But the subjectivity of fun is also due to its strong relation to human emotions. Emotions are an essential part of entertainment, as it can be seen in classic sports and games: "they have win-lose states that elicit strong emotional and ego-gratification responses, which are a big reason for their attraction" [15]. Emotions used to be considered obstacles to good decisions because emotional behaviour was seen just as the opposite of rational thought. Nevertheless, modern researchers believe that emotions serve as markers that make successful past decisions more relevant and, in that sense, helpful to rationality [6].

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Emotions occur on many levels in the body and have an important role altogether with reason in influencing behaviour [6]. There is a hierarchy of three emotional levels[16]: the visceral, the behavioural and the reflective levels. The visceral level is the most basic one, totally primitive and reactive, and straightly related to the expression of bodily changes. It is triggered by both internal and external perceptions, and it can be *inhibited* by the behavioural level due to unconscious behaviours automated from past experiences. The behavioural level can be further inhibited by the reflective level due to *conscious* considerations done by a person experiencing an emotion. Most importantly, information flows between these levels, so new behaviour dispositions can be acquired by skill training and a person may intentionally attempt to control physical and mental bodily changes.

As a consequence of this emotional mechanism, the human perceptions produce "singular coloured versions of the world as opposed to objective data", and hence actions are not just driven by utility but also by values, needs, desires and non pragmatic goals that are unique to each situation [17]. This makes experiences and emotions inseparable because interacting may have many affective consequences. The emotional aspects of fun happen in all visceral, behavioural and reflective levels, consistently with the components of intrinsic motivated activities of curiosity, fantasy and challenge. The emotions experienced in the visceral level are directly connected to sensory perception and arousal, hence being about physical pleasure obtained from the satisfaction of curiosity. The emotions experienced in the behavioural level are connected with the unconscious execution of well learnt routines and tasks that result from the building of the self, hence being about developing skills and overcoming challenges. And the emotions experienced in the reflective level are connected to the study and interpretation of things and to the pleasure obtained from that, being thus about fantasy and immersion. For instance, a fun experience like riding a roller coaster is a complex set of events, capable of being related to all of these levels interconnected. In one level people may feel excited about the speed and the fall, but in another they may also be trilled by the enhanced self-image achieved after they complete a fearful task that many others are not willing to do [16].

A more comprehensive review of these psychological aspects of fun can be found elsewhere [18].

B. The design view of fun

In Interaction Design, designers and HCI researchers have been traditionally concerned with the achievement of design objectives taken from the user's perspective, what is called *usability*. These design objectives include utility (provision of features needed), effectiveness and efficiency (good results and their easy achievement), safety (prevention of serious errors and easy recovering from them), learnability (easy learning on how to use an artefact), memorability (easy remembering on how to carry out tasks) and satisfaction (freedom of discomfort and positive attitudes towards an artefact) [10].

But for more than two decades there has been a shared understanding that satisfaction is not just about the absence of discomfort and positive attitudes due to the achievement of practical goals. It should also include non-utilitarian aspects of the interaction, such as pleasure, appeal, preferences and emotions [10], [17], since actions and results are respectively shaped and interpreted by unique values and feelings [17]. Also, users take functional features and quality for granted [2], immediately searching for more (such as aesthetic pleasure and emotional benefits) once the utility of an artefact is acknowledged [19]. *User experience* (UX) is the subjective relationship between user and artefact that includes those non-utilitarian aspects as the newer view of the Interaction Design [20]. The design objectives in UX are making artefacts enjoyable, fun, entertaining, motivating, aesthetically pleasing, supportive of creativity, rewarding and emotionally fulfilling [10], and they are sought by focusing attention on human factors and considering the user as more than just a physical and cognitive system component and the artefact as more than a tool [19].

Nevertheless, usability and UX are not opposing concepts. Usable artefacts will not necessarily be pleasurable, but if an artefact is not at all usable it is unlikely that it will provide any positive experiences or allow for immersion and engagement [19], [12]. Indeed, it has been shown that in order for people to allow themselves to enjoy using an artefact, they first need to achieve high levels of efficiency, effectiveness and satisfaction regarding their own goals, which requires them to at least be able to easily understand how the artefact works [21]. This is strongly consistent with the feedback attribute of enjoyable activities in the flow theory presented before. Thus, in a more operational and specific character, usability can be seen as a key component to positive experiences; and, in its turn, UX can be seen as an aggregation of flexibility in favour of more meaningful experiences and the fulfilment of the needs of different users in different contexts [10]. This relation has been compared to Maslow's "Hierarchy of Human Needs", indicating that the *consumer needs* evolve in a similar fashion [19]: users of an artefact first need to crave satisfaction regarding any functional aspects (i.e. having the need or desire to interact with it, basically evoked from curiosity), to then achieve satisfaction regarding easy of use (i.e. being able to interact with it) and finally reach pleasure (i.e. enjoying interacting with it).

Thereby, the HCI community recognizes that both utilitarian and non-utilitarian aspects of a artefact need to be combined, and more importantly, that positive experiences can not simply be guaranteed: it is only possible to design *for* an experience [7], [17]. As argued before, people may have different internal goals and experience ephemeral emotions as they interact with artefacts, and that is why the design of positive experiences is seen as attempts to promote general needs [7] and to provide increasingly meaningful choices as the users interact with the artefacts [4]. Due to the relevance of emotions, the experiences people have with man-made artefacts occur in a feedback loop. Past interactions affect the future experiences creating changes in the general sentiment towards artefacts or classes of artefacts that may be either positive or negative [17]. Therefore, a sequence of bad experiences (even if just related to aesthetic preferences) can be harmful for engagement even to the most useful of artefacts. On the other hand, sequences of positive experiences make engagement stronger and do not seem to have negative effects to usability. For instance, it has been shown that elements of non-aggressive humour, in the form of jesting error messages or fantasy supporting characters, may increase the satisfaction with a artefact without causing advert effects like distraction or lack of seriousness [22].

Indeed, the aesthetics of the user interfaces are known to have effects on how users perceive a artefact's usability because the real utility of a artefact is the result of the perceptions users have regarding the task difficulties and their own abilities to address them [10]. Additionally, being happy is known to help improving health and well-being in the sense traditionally aimed from ergonomics [5]. That is why flow, immersion, beauty and aesthetics are considered important dimensions of the user experience [21]. Because of those reasons, fun is becoming a very important aspect of the Interaction Design and almost a direct synonym of satisfaction in the context of UX, as the motivator for discretionary and sustained use [5].

III. An overview on how fun is assessed

A. General approaches

Evaluation, that is, testing the design choices regarding usability and UX objectives, is the heart of the Interaction Design because it focus on ensuring that the artefact is usable and potentially pleasurable [10]. And this is achieved by observing users, talking to them, interviewing them, testing them using performance tasks, modelling their performance, asking them to fill in questionnaires, and even asking them to become co-designers [10].

In the video game industry, the one particularly interested in the design of interactive systems that are fun to use, tests are performed with distinct purposes depending on the stage of the development process. For instance, they are used in design review to internally experiment and discuss ideas, in quality assurance to verify and remove errors and in marketing assessment to estimate interest and sales [9]. *Playtesting* refers to the type of tests that are performed in a larger scope, namely throughout the entire development process, in order to understand the kind of experiences players will have during play sessions and to evaluate the game potential for fun [9], [20]. Designers use a lot of prototypes of different fidelities to evaluate their artefacts throughout the steps enumerated above, seeing the playtests as prototypes of the fun experience [8]. Playtesting used to be performed in a very informal manner [23], with most developers simply testing their games themselves or with the help of friends and family. That approach is known to bring problems to the resulting general experience, since designers are too close to the game to the point of having distorted opinions, and friends and family don't want to hurt the designers' feelings in a way that they commonly provide untruthful predispositions towards the experience [8].

Nowadays, it is more common for even small developers to involve participants representative of the intended audience and to employ methods borrowed from the HCI for both quantitative and qualitative comparisons of players' behaviours. Such methods include focus groups, semi-structured interviews, observation and video coding, data hooking (automatic collection of performance measurements), questionnaires and heuristic evaluations of playability [9], [23], [20]. Among those, heuristic evaluation, observation, inquiries and data hooking are the most used methods in the game industry [20]. Expert analysis is also a common practice borrowed from HCI, with Heuristic Evaluation being the most employed method in the game industry. Besides serving as golden rules to try to predict what would be useful and interesting for users during the design conception, heuristics can be employed by several expert evaluators to role-play as users and critique the artefact regarding the principles stated by their rules [10]. This technique does not have a direct involvement of real users, so archetypes called *personas* are usually employed to formalize the targeted audience of a game [3]. However, even with good heuristics and well-defined personas it is difficult to foresee real bottlenecks in experience, since it strongly depends upon the context in which the artefact is used. Hence heuristics are used more frequently in informal manners to aid in other evaluation methods [3], particularly in the preparation of interviews and in the production of inquiring questionnaires. The expert analysis also involves observation and field or laboratory studies.

Observation is a method in which specialists watch users as they interact with the artefact to collect data and analyse the experience. The interaction can be observed and analysed as they are occurring, either in close contact or through a glass window, or also from video recordings taken from the artefact's screen and the user's face and hands [8]. The observation can be carried on either in a controlled laboratory, in which users perform the same pre-planned task, or in a field environment, in which the artefact is used more freely and in real-like conditions [10]. Laboratory studies allow the analysis of details in interactions, making the recording and comparison of results a lot easier due to the controlled environment. Hence, they are traditionally useful for the quantitative evaluation of usability aspects. However, these tests are more artificial and make more difficult to observe real variations in qualitative aspects of user behaviour, since they are strictly directed and controlled. On the other hand, field studies allow the observation of real scenarios and may give useful insights into the emotional aspects of the experience. But these tests are usually more difficult to execute, requiring the designer to move herself and her equipment into the field – where the tests are subject of interruptions and other forms of disturbing noise. Also, field studies have the additional difficulty that the conditions and events triggering interesting experiences are not easily reproduced [10].

Field studies are usually preferred because disturbances

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can indicate flaws in the intended design that are useful for its improvement [10]. This is particularly interesting for entertainment artefacts, since it can show the exact moments in which users loose interest or immersion or it can show the reasons why aesthetic aspects are not interesting or appealing. Those types of tests are also useful when there are multiple participants, since the social aspect is very important to entertainment. In an open environment, like the users' homes, sessions can start and stop quickly and informally. The presence of others – even if just for watching – certainly have impact in the users' interests, learning curves, perceptions of responses and moment-to-moment experiences [8]. Even so, there is usually a balance between laboratory and field studies, based on analysis of the loss of contextual information in laboratory against the increased costs and difficulties of field studies [10].

The user experience always has a subjective and interpretative element arising from emotions and context, so the behaviours involved in experiencing fun can not be observed from outside the framework within they exist. Once a researcher gets to observe the user experience she becomes part of the phenomenon that is being studied [24]. Therefore, no matter where the location is, observation has to be executed carefully to avoid tampering the experience as much as possible. The presence of an observer may be dangerous to a test particularly by infecting the user with the designers emotional investment in the artefact or by interrupting the experience for the collection of data [8]. Also, if users easily acknowledge that they are being observed (what is more common in laboratory environments), they may feel uncomfortable, afraid of making mistakes or making noises that would disturb others or embarrass themselves [8].

Inquiring techniques are also largely used to evaluate the UX. An example of inquiring technique is the Think-Aloud protocol [10], that requires users to say out loud everything that they are thinking, planning and feeling as they interact with an artefact. The designer involvement is minimum, practically without interruption of the user activity. However, that approach has also its problems. Users may still feel embarrassed to do it, and it is not easy for them to keep speaking for long, because as the demands of the activity increase there is less freed attention to be used for vocal externalization of thoughts and feelings [10]. The most employed alternative is to use questionnaires and interviews taken before and after participants interact with the artefact, so that information can be gathered directly from the users (self-reported) about expectations and their fulfilment without possibly disrupting the natural interaction patterns by asking questions during the sessions [8]. The drawback of these approaches is that by the time the test session is finished the user mind is no longer in the exact state as it was when the artefact was in use. There is a difficult trade off in the choice of interrupting or not users as they interact to ask questions. The general agreement is that fun requires immersion, and hence most designers are in favour of only interrupting players if they are doing something really surprising, and which it is not understandable by the designer [8].

In the attempt to simplify the evaluation while avoiding interruptions, automated recordings are also largely employed. Data hooking involves logging of timestamped quantitative numerical values programmed in auxiliary devices or directly into the computational artefact in order to completely avoid the presence of the designer. The captured data commonly includes performance measurements such as number of errors, hits and misses and total kills (in case of games) [23]. These measurements are objective and numerical, can be captured in large numbers and are easily mapped to specific points in the interaction, being helpful in assessing how usable the artefact is regarding its utilitarian aspects [23]. However, by themselves they are not enough to explain non-utilitarian aspects of fun [23], such as immersion and emotions.

With the evolution of technology related to biometric sensors and digital microphones and cameras, it is now also common to collect data from psycho-physiological measurements like skin conductance, cardiovascular and respiratory activity and muscle contractions [25], as well as non-verbal behaviours of bodily movement, vocal tone and facial expressions [6], [26], [27]. The valence and arousal dimensions of feelings are believed to covariate with such bodily changes [6], hence the collection of this type of data may be helpful in improving the evaluation of fun, specially if combined with other methods like questionnaires and utilitarian metrics [23], [25], [27]. Nevertheless, those approaches also have their difficulties. The use of intrusive sensors applied to the body may also influence results by causing discomfort and breaking immersion [27].

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B. Assessment from the different aspects of fun

1) Assessing attention: Attention has been traditionally assessed from performance tests, by measuring reaction time or number of omissions related to surprising (alertness) or frequent (vigilance) stimuli, change of focus (divided attention) and classification (visual scanning and pattern filtering), or by direct observing behavioural cues as users perform activities [28]. Overt attention, the one that is associated with external stimuli and involves the movement of a sensory organ to capture the stimuli data, can be assessed by observing display behaviours related to bodily posture (leaning towards devices), facial expressions and eye movements [28].

When humans watch each others' faces, they pay much attention to the facial expressions and the gaze. Changes in the face can indicate many important things for communication, like intentions, active listening and pondering a point [29], but gaze in particular can also indicate the direction of the focus of attention. Following gaze is an important behaviour for survival, helping in foreseeing danger [29], and it has been shown that head and gaze are both naturally directed towards focus of visual and auditory attention [30], [28]). Leaning the body or moving the head also provides clearance regarding sensory data. It can indicate curiosity and increasing interest due to the user being in the state of flow – when the movement is an attempt to receive more of the desired stimuli – or confusion and frustration from not being able to understand the information – when the movement is an attempt to resolve the source of frustration [28].

Levialdi et al. [31] attempted to automate the assessment of attention in interactive systems from the analysis of facial expressions. Using a video chat system without voice (just text messages and the visualization of peers' faces) as test-bed, they combined the analysis of facial expressions with the counting of the number of mouse clicks and keystrokes in a given time interval. Using a Naïve Bayes classifier and the tracking of facial features from a simple web cam, they first detected the seven prototypic emotional states (neutral, joy, anger, disgust, fear, sadness and surprise) to form a 7-component vector with the probabilities of occurrence of each prototypic emotion. Together with the 2-component vector of the number of mouse clicks and keystrokes in the defined period of time, the attention was classified in three levels: low, medium and high. Classifiers were trained from labelled images collected among users, after interviewing them about the emotions and levels of attention experienced. The results demonstrate that there is a correlation between the active expression of emotions and the level of attention involved.

Stanley [28] attempted to assess attention from bodily posture and gaze. Using Microsoft Kinect[3], the author collected bodily posture, gaze direction and speech activation and compared it to performance data collected from the execution of attention-competing tasks performed accordingly to well-established methods in psychology. The data recorded included head distance, bodily orientation, head pose, head position, forward and side body leaning angles and if the person was talkative or not. The comparison between behavioural and performance data indicated that there is a strong correlation between eye gaze and attention, but that bodily posture requires multivariate measurements for a relatively good degree of predictive power. Also, there is no correlation between speech and attention, which may be explained by the fact that the tasks used in the tests were entirely visual, with no auditory stimuli.

Eye blinking, pupil diameter and eye movement are other possible sources of information regarding attention. The spontaneous eye blinking rate decreases during high-attention tasks in order to maximize stimulus perception, but also when the "mental tension" is low due to task completion, serving as a relief mechanism [32]. It is also related to the levels of dopamine, which occurs in the reward and pleasure centres of the brain and are reported to decrease when individuals are exposed to attractive visual stimuli [33]. The eye blinking rates are co-related to the variations in heart-rate and skin conductance and are also activated in startle response, what suggests that it is representative of attention to both visual and acoustic stimuli [33]. The increasing in pupil diameter has also been shown to mark attentional shift. However, pupil changes that reflect variations in cognitive activities are relatively small compared to changes due to other things, like light reflexes [32], what makes pupil responses potentially not as robust to lightning variations as eye blinking. The eye movement is characterized in terms of fixation and saccades, the former being the stationary position of the pupil on a region of interest, and the latter being the rapid focus changes from one position to another. They occur in turns when eyes are viewing a scene and can indicate the degree of importance of elements [32].

Chen and Epps [32] attempted to measure attention from pupil changes, eye blinking and movement in terms of cognitive load, and comparing with the effect of emotional responses. The cognitive load was induced by arithmetic tasks and the emotional responses by labelled images (with samples relevant for valance or arousal) from a public image database. Pupil dilation and position were tracked with a commercial application and blinks were processed from scripts developed in MATLAB. Fixation and saccade measurements were extracted from the pupil positions recorded from the tracker, and subjective ratings of difficulty and emotion were collected from participants with self-reports. In their preprocessing analysis the authors concluded that pupil diameter average was the most significant feature to the emotional arousal and cognitive loading, and then trained a Gaussian Mixture Model classifier to confirm that pupil size and blink number increased with more difficult tasks and with higher arousal regardless the valence of emotions. Their work suggests that cognitive load dominates emotion in eye features.

2) Assessing flow: Flow has traditionally been assessed with the use of questionnaires. A notable example is the one created by Jackson and Marsh [34] to measure flow in sports. It is a self-report set of thirty-six Likert-scored questions asking participants on weather they felt challenged but with enough skills to meet the challenge, for instance. But there has been many attempts to automate the assessment of flow, particularly in games due to the need for implementing Dynamic Difficulty Adjustment (DDA). In such cases, the assessment is based on the comparison of challenges and skills in terms of user performance [35].

A representative proposal of this approach was made by Spronck et al. [36]. Their research aimed in balancing the difficulty of challenges by adjusting the tactics of enemies controlled by Artificial Intelligence (AI) from reinforcement learning. The game AI scripts are formed from weighted rules, with the probability of a rule being selected and executed being proportional to its weight. The rule database is adapted by updates in the rules' weights, performed according to the success or failure associated with the rule execution in encounters with real players. A fitness function for the AI-controlled characters is composed of performance indicators relative to victory/defeat, death/survival, amount of remaining health and damage done to the enemies after each encounter. A reward or penalty is added or subtracted from the rule's original weight depending on the value of the fitness being over or bellow a break-even parameter. The idea is that the AI tactics can gradually improve with success (player failure) to a point closer to optimal, when then those best rules can be eventually ignored so the AI can have the chance to test other

[3] http://www.xbox.com/en-US/kinect

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weaker tactics. The adjustment that result from subsequent losses (player success) will eventually put back in use the strongest rules, keeping the challenge level high while still manageable.

Hunicke and Chapman [35] measured the amount of damage taken by players of a first-person shooter game in order to try to predict repeated inventory shortfalls: moments in which the players available resources (in this case, the health level) fail to meet immediate demands. Using inventory theory they have modelled the probability distribution of damage and characterized shortfalls in the health level when the cumulative probability of damage exceeds the initial level (that is, when the demand in the "inventory" surpasses the "supply"). When shortfalls are detected in the player's near future, indicating that she is "in need", the DDA system can take actions to easy the difficulty of challenges or to provide help in the form of additional resources (like more ammunition or medical packs).

A similar work was proposed by Shaker et al. [37]. They used a freely available clone of the classic Nintendo's platform game Super Mario Bros. and collected from many players three types of data: scenario features (such as number of gaps and average gap width), player statistics (such as number of jumps and direction changes), and player experience self-reports. The self-reports included impressions on three dimensions: fun, challenge and frustration. The authors performed a feature selection procedure, and then used the number of gaps, average gap width, gap placement and number of player direction switches to construct a Multilayer Perceptron to predict fun, frustration and challenge, obtaining respectively 64%, 85% and 70% accuracy. The level generation mechanism of the game was dynamically adapted by searching in the space of these controllable features the values that maximized the classifier output value.

Even though a general balance between challenges and skills is a requirement for flow in a macro level, it is not always necessarily a requirement for all smaller experiences to be fun. In other words, "performance does not exactly mirrors flow" [4]. For example, players enjoying suicidal stunts in racing games should not be considered as poorly-skilled or as not having fun just because of crash counting [4]. Physiological measurements such as heart rate and skin conductance may provide additional information to better predict whether an user is in the state of flow [21].

A work that uses such measurements was proposed by Nacke and Lindley [14]. The authors customized levels of a commercial game to include intentional design characteristics of boredom, immersion and flow in different levels. Experiments were conducted while recording physiological responses taken from facial muscle activity and skin conductance. Also, the Game Experience Questionnaire (GEQ) [38] was used to collect the subjective scores of fun in terms of immersion, flow, challenge, and positive and negative affects (valence) for qualitative comparison. The comparison of self-reported responses with the physiological recordings showed statistically significant differences between the game levels, with players experiencing higher arousal (from skin conductance) and positive valence (from muscle activity) in the flow level. Though, the boredom and immersion levels had very similar responses, indicating that they are very close or simply more difficult to differentiate using such measurements.

3) Assessing immersion: Immersion has also been traditionally assessed with the use of questionnaires. Read et al. [39] used direct observation and self-reports to assess immersion in the interaction of children and computer systems. They firstly measured expectations and their fulfilment by using visual signs (the Funometer and the Smileyometer) to inquire the equivalent of "how much fun will this be?" and "how much fun was that?". The comparison between the states measured before and after the interaction seems to be a good approximation of how appealing the activity is. Then they also assessed engagement using direct observation of display patterns like smiles, frowns, laughs, concentration signs (fingers in mouth and tongue out), boredom signs (ear playing and fiddling), bouncing and positive or negative vocalization, and measured remembrance by applying post-experience questionnaires inquiring how willing the children are to perform tasks again. The high returnability, argued to be due to the human natural remembrance of fun experiences, is said to help in indicating and qualifying engagement.

The existing literature does not always clearly differ the assessment of attention and immersion, particularly because the later requires the former and engagement is sometimes seen as a stronger attentive state. So, just as with the case of attention, it seems that automated immersion assessment can be more precisely achieved from the analysis of facial expressions and gaze. In the studies of immersion performed by Brown and Cairns [12] with video recording of gamers whilst playing, there were found little to no indications of whole-body behavioural associated with immersion in playing.

A very comprehensive research work on the automated assessment of immersion was performed by Jennett et al. [13]. Their work is founded on both concepts of flow and immersion, considering that these concepts intersect regarding temporal dissociation, reduction of self-consciousness, sense of control and emotional involvement. Three experiments were conducted using a proprietary eye tracking system, the State-Trait Anxiety Inventory (STAI) [40] and the Positive and Negative Affect Schedule - Expanded Form (PANAS-X) [41], and an immersion questionnaire they have created with thirty-three Likert-scored questions related to emotional involvement, transportation, attention and control. The experiments investigated immersion from the perspectives of the task performance, the movements in the user's eyes and the pace of interaction, in which the questionnaires were used to qualitatively compare the objective measurements to the subjective feelings self-reported. Their first finding is that the level of immersion seems to have a direct effect to the late performance of execution in external tasks, in the sense that the more immersed a person feels while playing a game the more time she takes to perform activities not related to the game later on. Or, in other words, the longer she takes to re-engage into the "real world". Another finding is that the participant's

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eye movements decreases significantly over time when she feels immersed, most probably as a result of focused attention on visual components of the game. And the third finding is that increasing pace of interaction elicits strong negative affects and high anxiety, although the activity might still be perceived as immersive. The reason is argued to be due to challenges becoming “provoking”: they induce more pressure to win because the player may have developed a certain level of proficiency that made her emotionally charged.

In a different domain, Bidwell and Fuchs [30] worked in the automated engagement assessment of students in a learning environment. From video recordings taken from the classroom and a commercial face tracking software, they estimated the students’ head direction, position and orientation in each second, and then manually labelled the patterns found regarding the gaze target (whiteboard, teacher and other student) and eight discrete behaviours (engaged, passively attending, transition, non-productive, inappropriate, attention seeking, resistive and aggressive). Those patterns were used to produce a Hidden Markov Model to classify gaze target sequences into a probable behaviour. Results indicate that there is some correlation of sustained gaze with engagement, since the model is able to do correct predictions 80% of the time. But, less attentional states are very poorly predicted, suggesting that other behavioural measurements are necessary.

4) Assessing emotions: The emotional aspects of experience also have been traditionally assessed with self-reports, and there are indeed a vast number of tools available for that. Two most famous ones are the PANAS-X [41] questionnaire and the Self-Assessment Manikin (SAM) [42]. The PANAS questionnaire is composed of two sets of ten Likert-scored questions used to measure the valence of both positive and negative affects, and its extension includes measurements on eleven specific discrete affects: fear, sadness, guilt, hostility, shyness, fatigue, surprise, joviality, self-assurance, attentiveness and serenity. The SAM is a 1-5 pictorial measurement of all three dimensions of affect (valance, arousal and dominance), using figures of an humanoid drawn from frown to happy (valence), excited to relaxed (arousal) and smaller to big (dominance). The STAI [40] is intended to assess high arousal, being composed of twenty Likert-scored questions to measure the state anxiety (how an individual feels at the moment) and the trait anxiety (how an individual feels in general). There is also the Geneva emotion wheel [6] which graphically represents sixteen discrete emotions in the four quadrants of the valence-arousal dimensions. Each emotion has four circles of increasing size placed away from the wheel’s centre, which can be easily marked by a respondent to graphically indicate her emotional state in terms of valence, arousal, dominance and discrete emotion.

A comprehensive automated measurement of emotions would require to assess all bodily processing components, including the subjective mental representation of the feeling. This is something unlikely to be achieved, and there is no way to really know the emotional state of a person than to ask the individual to report on the true nature of her feelings [6]. It is however possible to *infer* the emotional state from the bodily displays of physiological response patterns and expressive behaviour that accompany the experience of emotions [6]. Even so, this inference is always subject to noise due to the fact that the body is constantly under the effect of other stimuli sources independent from the artefact being evaluated, and therefore measures of bodily display should not be used alone but in conjunction with other measures like self-reports [25].

The physiological responses are produced by the Autonomic Nervous System, and its indices activation are based on electrodermal (sweat gland) and cardiovascular (blood circulatory system) responses. Electrodermal responses are quantified in terms of skin conductance level, and cardiovascular responses are quantified in terms of heart rate, blood pressure, total peripheral resistance, cardiac output, pre-ejection period and heart rate variability [26]. The relation of such individual measurements and discrete emotions, like fear, anger, joy, etc., has been shown to be highly inconsistent, so the physiological responses are best seen as indicators of broader values such as arousal, reflecting a level of affective state in that dimension rather than in its discrete emotional basis. The responses operate independently, and some of them – like blood pressure and heart rate – may also map to valence. The skin conductance, for example, increases linearly with the rated arousal of emotional stimuli, but it is independent of valence and of any specific prototypic emotion targeted. Nevertheless, the combination of multiple measures is reported to yield better predictions of discrete emotional states [26].

Expressive behavioural responses were first studied by Darwin and described as the primary evolutionary function of communicating the emotional state to others. Modern theories also relate this displays to dispositions intended to prepare the body for action [26]. The behavioural responses include patterns of facial and vocal expressions as well as whole-body movements [6], [26], and are commonly accessed through recording devices (such as audio and video recorders) or muscle activity (electromyography) [25]. Vocal expressions are measured in terms of sound amplitude (loudness) and pitch (fundamental frequency). Arousal and pitch are directly associated, and discrete emotions with high levels of arousal, like fear, joy and anger, are linked to higher-pitched vocal samples [26]. However, there is no relation of either amplitude or pitch to valence, and hence is very difficult to differentiate discrete emotions that are closer in arousal but distant in valence, like anger and joy, just from the vocal expression [26].

Facial expressions are measured in terms of skeletal muscle activation (electromyography) [25] or visual inspection of permanent features such as eyes, eyebrows and lips and textural changes in transient features such as lines, wrinkles and furrows [43]. It is believed that facial expressions are the displays most closely tied to the organism behaviour [26], and that the expression of at least the six prototypic emotions (happiness, anger, sadness, fear, disgust and surprise) are consistently recognized cross-culturally, even though their display is regulated according to cultural norms [29], [43],

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[26]. The region of eyes and mouth, particularly the eyebrows and the mouth corners, are the facial elements most relevant to the expression of emotions [43], being capable of reliably indicate the valance of a person's emotional state [26], [25] and provide good accuracy in the indication of the prototypic emotions [43]. Besides the fact that the facial displays are dependent upon cultural context, another important caveat of this approach is that spontaneous expressions are usually subtle, making more difficult the measurement in nature [43].

Whole-body expressions have not received much attention as the others, but are usually measured from electromyography, accelerometers or visual inspection of pose. Certain emotional states are supposed to have distinct bodily behaviour signatures, and particularly pride and embarrassment are respectively linked to expansive and diminutive bodily postures [26]. The scarcity of works in this area is probably due to the difficulty in recognizing whole-body expressions, since the configuration of the human body has much more degrees of freedom than the voice or the face [44] and different emotions have many similar patterns of bodily motion [29].

There are many works that explored expressive behaviour to assess emotion. One of them is the work of Schindler et al. [44]. The authors explored the classification of prototypic emotions from bodily poses. Their training data is taken from a dataset of fifty actors posing whole-body standing-up expressions labelled to the six prototypic emotions plus a neutral pose. The features are extract from a set Gabor filters applied to the image, to which a Principal Component Analysis is performed to extract the "eigen-image" and then to train a Support Vector Machine. The tests performed obtained an overall accuracy of 82%, with disgust and anger being the two most difficult emotions to predict (both around 70% accuracy).

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Yannakakis et al. [45] also worked in assessing emotions and fun. They used two test-bed games which are built in a physical matrix of tiles and played by pressing buttons with the feet and observing light displays. The authors recorded heart rate signals while children played the games, and collected self-reports about their judgement of fun using the Funometer tool already cited. They used an Artificial Neural Network and performed several steps of feature selection, ending up with the average rate and the correlation coefficient between recordings as the best features. Results are around 80% of correct predictions of fun.

Tan et al. [27] investigated weather sufficient facial expressions are elicited when games are played, and if those expressions can be robustly captured to help assessing the emotional states of players. In tests with voluntaries playing two mainstream commercial games, they tracked face landmarks in video recordings using a deformable fitting algorithm. Then, they classified the probability of six prototypic emotions based on an Artificial Neural Network trained from the local responses of a Gabor filter in each facial landmark. After playing the two games, the participants filled the GEQ questionnaire already cited. The authors observed that a good variety of facial expressions other than neutral were exhibited with rich variance. Comical scenes accurately followed the elevated detection of happiness, and anger also increased over time according to self-reported frustration in figuring out puzzles. The authors also observed that the presence of others considerably increased the occurrence of facial expressions in the players.

On another domain, McDuff et al. [46] worked on the prediction of likeness and desire to re-watch commercial ads based on the amount of smiles detected in viewers' faces. They recorded videos of volunteers watching famous comical commercial ads and collected their answers to questions regarding their liking, familiarity and rewatchability of the videos. Smiles were detected using facial features and a decision tree was used to produce the probabilities of smiles in each frame, resulting in an one-dimensional set of values indicating the smile intensity along the duration of each video. These tracks were filtered with a low pass filter to reduce noise, and then divided into twenty windows from which the peak values were used to build the feature vector. A Linear Dynamic Conditional Random Fields classifier was used to obtain an accuracy of 80%. Most errors were due to inaccuracies on the smile classifier, and some participants showed no smile activity even when reporting to like the commercials.

IV. Conclusion

Fun is an important requirement for interactive artefacts. But due to its subjective character and the strong dependence upon context and personal preferences, it simply can not be guaranteed. Therefore, during the creation process the designers have not only to use the best design heuristics known but they also have to evaluate those choices with real users in order to try to maximize the chances that the artefact is fun for a broader audience.

There are many methods and tools for aiding with this evaluation, including observation, interviews, questionnaires and, more recently, data collection of utilitarian aspects of the artefact and of psychological measurements of users. A strong tendency seems to be focusing on psychological measurements, since they can help evaluating the emotional aspect of fun, arguably one of the most important in characterising this affect.

The completely automated assessment of fun is probably an unachievable task, since emotions can only be inferred and the only way to truly know what a person is felling is asking her. Emotions are an important part of the fun experience, and any utilitarian aspect of a artefact (like the data recorded from performance in games) can only account for the challenge aspect of flow. But a mix of approaches can definitely help a designer in evaluating her choices and maximizing the fun in her designed artefact.

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A concurrent, minimalist model for an embodied nervous system

Luciana M A Campos*,†,
Ronald Dickman‡,
Frederico G Graeff§,¶ and
Henrique E Borges‖

* Federal Centre for Tecnological Education of Minas Gerais,Belo Horizonte, Minas Gerais, Brazil
† Postgraduate Program in Neuroscience, Federal University of Minas Gerais, Belo Horizonte, Minas Gerais, Brazil
Email: luciana@decom.cefetmg.br

‡ Department of Physics and National Institute of Science and Technology for Complex Systems, ICEx,
Federal University of Minas Gerais, C.P.702, 30123-970, Belo Horizonte, Minas Gerais, Brazil
Email: dickman@fisica.ufmg.br

§ Institute of Neuroscience and Behavior (INeC), Ribeirão Preto, Brazil
¶ Neurobiology of Emotion Research Center (NAP-NuPNE), University of São Paulo, Ribeirão Preto, Brazil
Email: hegog@hotmail.com

‖ Department of Computer Engineering,
Federal Centre for Tecnological Education of Minas Gerais,Belo Horizonte, Minas Gerais, Brazil
Email: henrique@lsi.cefetmg.br

***Abstract*—The nervous system has inspired many computational simulations modeling systems capable of learning through interactions with their environment. We propose a minimal model of a nervous system operating in a concurrent manner, capable of maintaining behavior homeostasis of a virtual organism. The model nervous system includes subsystems which, according to the functions performed, may be classified as sensory, effector, cognitive or emotional. These subsystems, while autonomous, exchange messages between one another. The organism is endowed with innate behaviors of exploration, approach, eating and resting; the nervous system affords the possibility of learning through evaluation and memory of experiences associated with these behaviors, interacting with a virtual environment. These experiences influence the selection of subsequent actions, to promote self-regulation, and thereby, survival of the organism. The proposed model is concurrent, asynchronous and non-deterministic. We simulate a simple realization of the model. Our results show that the expected behaviors of establishing food preferences in fact emerge. We conclude that the model is functional and robust and that learning increases longevity.**

I. Introduction

The development of a nervous system depends on the actions and history of the organism in its environment. From this perspective, thoughts, concepts and perceptual categorizations are based on interactions between brain, body and the environment ([1]). The evolutionary developmental approach to cognition begins with a situated vision of organisms in their environment, as explained by various authors ([2], [3], [4], [5], [6], [7]), who are in fundamental agreement regarding the principle that organism and environment are inseparable, possessing a reciprocal relation, and must be understood as a co-evolving whole.

These ideas have influenced research in artificial intelligence (AI) since the early 1990s ([8], [9]); according to [7], the notion of embodied cognition is essential for modeling intelligent systems. Various bio-inspired models of the brain have been elaborated ([10], [11], [12], [13], [14]) as well as biologically inspired cognitive architectures (for a review see [15], [16] and references cited therein). Interesting models in this context have also been developed as entertainment software agents ([17],[18]).

Florian [13] asserted, 'genuine, creative artificial intelligence can emerge only in embodied agents capable of cognitive development and learning by interacting with their environment'. This author simulated a model including an agent with innate behaviors, capable of learning through its experiences, and highlighted the importance of drives or reflexes to impel the agent to explore its environment. Without such exploration, learning would not occur.

Fujita [19] sought a realization of 'intelligence' as opposed to symbolic manipulation, the latter being the hallmark of conventional AI. By proposing 'Intelligence Dynamics,' he tried to integrate the ideas of embodiment and dynamics in a constructive approach. Fujita [19] also incorporated intrinsic motivations in his models, which permit the continual functioning of control, planning, prediction and action. In the two models proposed, which are organized in hierarchical layers, [19] is concerned with furnishing the conditions for spontaneous learning.

Agmon & Beer [20] adopted a perspective he called 'embodied dynamicism', 'which sheds the assumptions of higher-level decision-making process and instead commits only to dynamical systems explanations. This allows for more integrated architectures, which embrace nonlinearity and aim to describe behavior as emerging from rich interactions across the brain, body, and environment.' This author proposed artificial life models with autonomous agents which select actions guided by their internal state as well as sensory input.

Ignasi Cos & Hayes [14] devised a model organism that learns to adjust its consumption in an adaptive manner. The agent possesses drives characterizing the urgency of action based on bodily needs, which motivate its actions. Despite the emphasis placed on the dynamics of sensory-motor interactions and homeostasis, which typify the process studied, the model is sequential in nature.

Our objective in the present work is to create a functional minimal model of a nervous system, understood as an embodied system, which possesses subsystems operating concurrently, in an asynchronous and nondeterministic manner. Based on the operation of this dynamical system, the global behavior that arises should be coherent, and capable of maintaining behavior homeostasis of the virtual organism. This organism is endowed with innate behaviors of exploration, approach, eating and resting. The bodily needs or drives of hunger and need for rest must be satisfied if the organism is to survive.

We emphasize the concurrent, asynchronous, nondeterministic operation of subsystems associated with visual and tactile perception, eating, and movement, within the model nervous system. Nevertheless, given the extreme complexity of real nervous systems, we allow ourselves to include constructs and characteristics not directly related to biological reality. Thus, in the interest of simplification, the model includes entities which, while performing a biological function, do not correspond to a unique anatomical structure. Specifically, we employ elements such as 'HomeostaticRegulation', 'Valuation', 'Partial Appraisal', 'Full Appraisal' and 'Locomotion Effector' which subsume diverse cerebral regions and interactions.

II. Theoretical and Conceptual Issues

A. Why emotion in a cognitive model?

Phylogenetically older cerebral structures, such as the 'limbic system', formerly understood as specifically responsible for the manifestation of emotions, highlight the fact that emotions are necessary for survival, since they enable animals to explore, communicate and interact more effectively with their environment ([21]). Despite the importance of the 'limbic structures' [1] from both the historical viewpoint and that of emotional expression, emotions cannot be restricted to a specific region of the brain ([22]).

[1]Discussion continues regarding the definition of these structures and, for this reason [22] suggest that the notion of the limbic system should be abandoned.

Similarly, advances in neuroscience indicate that complex feedback loops connect distant brain regions, without any explicit subordination. Such evidence suggests that the concept of a sequential top-down hierarchy requires revision; such a hierarchy is not found in the prosencephalon ([23]).

From the neuroanatomical point of view, as well as that of brain dynamics, there seems to be little reason for separating emotion from cognition. Thus we consider it essential to include emotion, in the restricted sense explained below, in our model.

B. What is emotion?

Buck [24] proposes a classification of affects in which phylogenetically older motivational systems are involved in the manifestation of innate (non-learned) reactions. These systems are, however, also involved in more complex emotions. In order of increasing complexity, [24] classifies motivational/emotional systems as: reflexes, instincts, bodily needs and affects. He further proposes that emotional manifestations are perceived in distinct levels: emotion I (arousal)[2] important for adaptation and homeostasis; emotion II (expression) involved in social coordination; and emotion III (experience) which involves self-regulation through subjective experience, sentiments, desires and affects. In the present work we consider emotion in the form of bodily need, restricted to the level denoted emotion I in the scheme of Buck [24]. Inspired in Hebb [26], behavioral efficiency E was modeled (at least for simple tasks) to the level of emotional arousal A through a concave, quadratic function

$$E = -aA^2 + bA + c \tag{1}$$

such that there is an optimal level of physiological excitation, at which efficiency is maximum. In the present work we use the parameter values $a = \frac{-40}{49}$; $b = \frac{40}{7}$; $c = 0$.

In the model, behavioral efficiency governs the speed of movement. In this sense, the level of arousal (emotion I) affects the ability of the organism to navigate its environment.

C. What about homeostasis?

The notion of homeostasis assumes a central role in the incorporated approach to cognition. Homeostasis is broadly understood as a state of dynamic equilibrium, attained when all the internal systems of an organism work in harmony to maintain its stability. Our understanding of behavioral homeostasis is similar to the idea proposed by Walter Cannon ([27], [28]), who sees organisms as open systems, responsive to changes in the environment, and subject to fluctuations as it varies. The resulting fluctuations in physiological variables are nevertheless maintained within narrow limits by internal regulation mechanisms. Reviews on the concept of homeostasis can be found in ([28]) and ([23]).

[2]One of the most important and fruitful aspects of the arousal theory was that it assumed that arousal can be measured directly, by psychophysiological measures that reflect autonomic, somatic, and central nervous system activity ([25]).

In our model, the internal subsystems designated as Partial and Full Appraisal, and Homeostatic Regulation, function to maintain the dynamic equilibrium of the organism, based on its physiological necessities, sensory-motor capacities and cognitive functions. These subsystems confer a measure of autonomy to the organism, in the sense that it responds to environmental stimuli with the aim of satisfying preprogrammed objectives (i.e., satisfying its needs for food and rest), with external intervention, in an environment that is unknown a priori.

D. *Affordances*

In the situated approach, the cognitive-emotional process is seen as an indivisible whole: one cannot be understood without the other. Cognition and emotion are co-dependent ([29], [30]). But how does this process occur?

Following the suggestions of Gibson [3] and Maturana & Varela [5], we see this as the organism actively identifying the relevant features in its world. In this process, called *affordances*, the organism constructs distinctions, thereby identifying features relevant for action.

III. Model of the organism-environment system

We regard the nervous system as an open dynamic system ([31]), and living beings as open systems ([28]). Our model treats the brain and body as inseparable, and possesses an internal dynamics that is concurrent, asynchronous and nondeterministic. The dynamics of the model is implemented via multiple threads. [3].

Much of the complexity of the model arises from its biologically inspired nature. An example is the apparent duplication of elements, e.g., the sensory organ 'eye' and the internal sensory system 'vision sensor.' At first glance one might suppose that one of these might be eliminated. The structures represent, however, an external organ and an element within the nervous system, respectively, which operate via mutual interactions. Thus the threads internal to the virtual organism are inspired by neurofunctional aspects of biological organisms, while realizing a simple, local task. That is, each thread simply follows a cycle of receiving messages, changing its internal state, and emitting messages.

Fig. 1 shows the internal subsystems of the virtual organism, which bear names alluding to their functions. In the upper part of the diagram are the sensory organs, which coincide in large measure with the motor organs appearing in the lower part, except for the 'skin', which does not assume a sensory function in the present work.

Except for the sensory-effector organs[4], represented in Fig. 1 by rectangles, the remaining subsystems comprise the nervous system. All the structures enclosed in dotted lines represent threads executing independently, which exchange messages amongst one another. The remaining elements, enclosed by solid lines, do not operate as threads, but cooperate with the latter. The sensory system mediates the messages received from the sensory organs. In addition to this subsystem, the nervous system comprises the emotional, cognitive, memory and sensory subsystems, whose operation is explained in the following section.

As mentioned above, behavioral efficiency is assumed to be a concave function, see 1, of the level of deprivation ([26], [25]). Thus, as the level of deprivation of bodily needs increases, particularly in the case of hunger, the efficiency in satisfying it grows until an optimal level is attained; at this point, speed of movement take its maximum value; beyond this point, the speed decreases.(See Fig. 8)

Another important aspect of the model is the modulation of sensory capacities, through variation of the field of view, which becomes smaller as the organism approaches an object. This highlights the object selected and reduces the likelihood of new sightings. The opposite occurs when there is no object in the visual field (see Fig. 2). These changes in effect permit the organism to scan the environment, as biological organisms do, typically through movement.

A. *Cognitive-emotional process*

The cognitive-emotional process occurs via interactions with the environment and via internal messages. The sensory organs receive stimuli from the environmental, while motor organs act within or upon it. Environmental stimuli are of three kinds: nutritional, visual and mechanical; each is perceived by a specific sensory organ. Similarly, each type of internal message is received by a specific subsystem or subsystems.

All the structures that operate via threads realize an operation consisting in (1) receiving a stimulus or message; (2) processing it; (3) generating new messages, which are perceived by other structures.[5] Messages are exchanged via buffers shared amongst the threads. These buffers contain all the conditional locks which characterize the relations between threads emitting messages and those receiving messages. The conditionals lock certain threads from executing until the most recent message emitted by it has been received. For other threads, execution is not locked by the buffer. These locking conditions are necessary because the order of execution of the threads is not fixed, or controlled by any supervising agent.

For purposes of illustration, we describe two examples in which the organism interacts with its environment; the first involves eating a fruit, followed shortly thereafter by an evaluation of this experience. Suppose that initially, the organism is touching (and seeing) one or more fruits. In this case, eating one counts among the set of possible actions. The internal operation in this case may be described via the steps enumerated below, remembering that the order of execution of the threads might not follow the sequence described. A possible sequence of events, then, is as follows:

[3]In computation, a thread is a unit of execution, i.e., a component of the program that can be executed in a concurrent manner with other threads. Multiple-thread programming therefore permits one to simulate parallelism, since a single processor realizes 'simultaneous' execution of all the threads designed to run concurrently.

[4]The arrows leaving the lower part of Fig. 2 represent interactions between the body and the environment. These interactions occur via stimuli designated as: mechanical, luminous and destructive, the latter corresponding to removal of fruit when 'swallowed' by the mouth organ.

[5]Certain threads may, in particular cases, not generate a new message.

1) Having neared the fruit, the organism can turn and touch it, in which case the Eye receives a visual stimulus ('image') of it, while, at the same time, the Mouth receives a mechanical stimulus corresponding to the fruit. (Recall that, for simplicity, we assume that the Mouth is the organ that receives mechanical stimuli associated with eating. If another part of the body receives such a stimulus, the affordance of eating does not arise.)
2) Having received a visual stimulus corresponding to a fruit, the Eye emits a visual message, which is recognized by the nervous system.
3) Concurrently, the Mouth emits a tactile message, recognizable by the nervous system.
4) The Vision Sensor receives the visual message and sends a Spatial message to the buffer called InnerMessagePool.
5) The Spatial message is received by Partial Appraisal, which begins its operation. The Spatial message communicates to Partial Appraisal part of the current internal state of the organism, together with the environmental situation (what is visible). In addition, complementing the information about the environmental situation, a Tactile message, signaling that something has been touched, is received by Partial Appraisal. The internal state is also characterized by the levels of deprivation, and drives. On this basis Partial Appraisal elects the drive exhibiting the highest level of deprivation as the one to be to be attended, and adjusts the Behavioral Efficiency (that is, the length of the next step taken by the organism). This partial appraisal is then grouped into an Emotional message generated to Full Appraisal. At the same time, Partial Appraisal produces an Increase message, responsible for maintaining the metabolic activity, to stimulate HR, corresponding to a correction in the levels of deprivation.
6) Stimulated by the Increase message, HR updates the deprivation levels of the drives Hunger and Rest, (that is, the level of emotional Arousal), in this case, increasing the levels of both. [6] With this, HR terminates its activity. Up to this moment, the organism, although touching the fruit, has not eaten it; we assume that the organism has not chosen to rest.
7) Meanwhile, the Affordances[7] are established, according to the situation. In the case under discussion, the organism can eat the fruit, avoid it, rest, or, if there are other fruits in its field of vision, choose to approach one of the latter.
8) Concurrently, an Emotional message is received by Full Appraisal (FA), which performs a full evaluation of the internal state of the organism, as well as the current state of the environment, so as to select the best action available. To this end, FA activates Action Selection (AS).
9) If the selection criteria used previously have not led to a unique choice of action (see Algorithm 1), AS performs a search in Long Term Memory (LTM), for past experiences of the same kind, and their emotional value, to assist in the decision of which action to perform now.
10) Once the action to be performed has been selected - say, eating the fruit with which the organism is in contact - AS alerts FA, which registers this action in Working Memory as the next to be executed. (In the near future this action will receive an emotional evaluation, to be registered in LTM.) Next, FA generates a Cortical message alerting the effector system to realize the recently selected action.
11) The Cortical message is received by three effector components: the Mouth Effector, Focus Effector (FE)[8], and Locomotion Effector (LE) [9].
12) The Mouth Effector, on receiving the Cortical message, emits a Somatic message for the Mouth to eat the fruit with which it is in contact.
13) The Somatic message is received by the Mouth, which eats the fruit. The latter is removed from the environment.

Once an action is realized, it is evaluated. In the present case, the evaluation proceeds as follows:

1) The organism receives a Nutritive message from the Mouth, which is transformed into a Nutritional message, signaling that something with nutritional value was eaten;
2) On receiving the Nutritional message, the Gustatory Sensor emits a Decrease message;
3) Having received the Decrease message, HR updates the level of Deprivation of the drive Hunger, reducing it in this case, according to the nutritional value of the fruit eaten. HR then emits a Valuation (V) message;
4) The V message is received by Valuation, which verifies the value (positive or negative) of the recent action. If there is no record of this kind of fruit in LTM, such a record is created, including its emotional value. In this manner, this experience evaluated emotionally, enters the catalog of experiences, which may be consulted by FA to aid in the selection of future actions. If such a record already exists in LTM, its emotional value is updated.

The weight W_i of an experience in LTM is updated as follows,

$$W_i = W_{i-1} + Q_i \qquad \forall i \in \{fruits\} \tag{2}$$

Where Q is the nutritional value of the recently consumed fruit and i is the index of the fruit eaten. [10] The emotional value of

[6]This increment is fixed, given by the Δ in Table II.

[7]See TableI for a list of possible affordances.

[8]This effector focusses attention on the object in view. In this case, however, the object is touching the organism, so that such an attentional focus is unnecessary. Thus the FE is not activated in the present example.

[9]The LE signals the Body of the need to move in order to realize the action selected. In the present case no such movement is required, and so the LE is not activated.

[10]The weight of the action *resting*, while not considered in the present example, is updated in an analogous manner.

TABLE I
AFFORDANCES: POSSIBLE SITUATIONS AND ACTIONS.

Target	Situation		
	Seeing	Seeing and touching	Not seeing
Redfruit Greenfruit Grayfruit	to approach to avoid to rest	to eat to avoid	to rest to wander

an experience stored in LTM takes but two values, *true* or *false*. Let D be the deprivation level of the emotion attended and N be nutritional value of fruit consumed. Then the emotional value is *false* if $N + D < 0$ and *true* otherwise. Note that the two interactions described above are not the only ones the organism is capable of. All of the affordances described in the following section represent possible interactions. In addition, we note that at any moment during the chain of events characterizing an interaction, another stimulus or message may arise, provoking its own sequence of events, independent of (and not synchronized with) the first (see Fig. 1) . It is also possible for two or more chains to converge on a given internal subsystem, which may then emit a single message, resulting in a single behavior.

B. Affordances

The structure Affordances in Table 1 corresponds to the combinations of situations the organism may face and its respective actions. For example, if the organism sees a target of the kind Redfruit, Greenfruit ou Grayfruit, the possible actions are 'to approach', 'to avoid' or 'to rest'. If it both sees and touches a fruit, the possible actions are 'to eat' or 'to avoid'. If no target whatsoever is in view, the possible actions are 'to rest' or 'to wander' (see Table I). Affordances are hardwired not learnt. They represent the limitations imposed by the sensory-motor capacities of the model organism, and depend directly on the environment, as understood in the definition of the term (see [3]).

C. Working memory and long-term memory

Working memory (WM) and long-term memory (LTM) are modeled in a highly simplified manner. They nevertheless provide a basic mechanism for associative learning through operant conditioning, implemented via reward and punishment ([32]). WM registers the action selected most recently, and so is updated at each new choice. LTM, by contrast, records each of the organism's experiences, along with its emotional value, the latter attributed by Full Appraisal (see Fig. 1), following the emotional evaluation performed by Hedonic Valuation (see Fig. 1). Shortly after an action is taken, its emotional value is determined, given by the difference in deprivation levels of the relevant bodily need immediately prior to and after the action. Actions with a positive value are selected with a probability proportional to this value; those with a negative value are not selected.

D. Action selection

The structure Action Selection selects the next action to be performed depending on the situation, the bodily need to be attended, and the existing affordances. Selection occurs via application of a series of filters, until just one possibility remains. The selection algorithm is summarized below (see Algorithm 1), including the following possibilities: selection based solely on the existing possibilities (affordances); when there are two or more similar targets, only the nearest of each kind is maintained (nearest); selection determined on the basis of the valuation in LTM (memory); finally (if the other criteria do not lead to a unique choice), random selection between alternatives (random).

Algorithm 1 Action Selection Algorithm

Require: Action Tendency and current state of organism
Ensure: Action to be realized

$PossibleActions \leftarrow Affordances(situational)$;
$Drivewithhighestdeprivationlevel \leftarrow verifyGreatest(drives)$;
$Actions \leftarrow PossibleActions \cap ActionTendency(drivewithhighestdeprivationlevel)$;
if $|\ actions\ | > 1$ **then**
  $actions \leftarrow excludeIdenticalTargets(actions)$;
else
  $actionToExecute \leftarrow action$; ▷ (Affordances)
end if
if $|\ actions\ | > 1$ **then**
  if (∃ experience in LTM with object) **then**
    $actionToExecute \leftarrow Random$(weighed)$LTM(actions)$; ▷ (Memory)
  else
    $actionToExecute \leftarrow Random()actions$; ▷ (Random)
  end if
else
  $actionToExecute \leftarrow actions$; ▷ (Nearest)
end if

IV. SIMULATION

To test the model, we devised an artificial life application in a two-dimensional world using multiple threads to simulate the concurrent behavior of the organism. Dispersed in the environment are three kinds of nutrients (fruits)[11]. We adopt the pixel as our unit of area. The organism, which resembles a PacMan[12], is represented by a blue disk of diameter 30 pixels. Its eye is represented by its visual field in the form of an arc, whose extent varies from 50° to 150°, with an initial value of 70°. The radius of the visual field is fixed at 150 pixels; when the organism is sleeping, the visual field closes. The orientation of the body coincides with the bisector of the visual field. The body is limited to just a head, an eye and a mouth. It has a tactile sense through both its mouth and through the rest of the head. Eating, turning, and moving (with variable speed) are the three actions the organism is capable of. It can also rest, that is, remain in the same place, with its eye shut. Initially the organism is able to perform the following innate actions:

[11] The fruits are designated Redfruit, Greenfruit e Grayfruit. Their respective nutritional values are given in Table II.

[12] The well known video game of the 1980s featuring a round head with a mouth that opens and closes. See http://pacman.com/ja/index.html.

TABLE II
VALUES OF THE MAIN PARAMETERS IN SIMULATIONS.

Configuration	Parameter	Value
Final[a]	**Nutritional value**	
	Redfruit	0.1
	Greenfruit	0.2
	Grayfruit	0.0
	Δ	0.005

a.The nutritional density (fruit /area) was maintained constant via replenishment of eaten fruits.

TABLE III
RELATIVE UNCERTAINTIES IN NUMBER OF SELECTED ACTIONS, $\overline{S}$ (95% CONFIDENCE INTERVAL).

Property	Action selection		
Experiment	$\overline{S}$	σ	$\frac{E}{\overline{S}}$
With mem.	2.8 $\times 10^4$	1.4 $\times 10^4$	1.3 $\times 10^{-1}$
Without mem.	0.3 $\times 10^4$	0.04 $\times 10^4$	4 $\times 10{-}2$

σ = standard deviation; $\frac{E}{\overline{S}}$ = standard error relative to mean

wander, that is, move in a direction chosen at random, uniform on the interval between -30° and $+30^\circ$ with respect to its present orientation[13]; avoid, which corresponds to moving in a direction chosen uniformly on the interval between -45° a $+45^\circ$ with respect to its present orientation; approach, that is, move toward an object in the field of vision; rest; eat a fruit that is touching the mouth.

The two-dimensional world inhabited by the organism measures 860 x 720 pixels (width x height), and possesses periodic boundaries. The organism is initially placed at position (430,360); its initial orientation is chosen at random, uniformly over the interval 0° to 360°. Deprivation levels are measured in arbitrary units, such that the maximum level is 7.0; a level above this value results in death of the organism. Initially the deprivation levels are both set to 0.18, because this was considered the minimum level of physiological activity. If the organism does not eat, the number of steps it may take is limited, since its level of hunger increases by a fixed amount, Δ at each step, and it begins with a deprivation level of $P_{min} = 0.18$ and dies when this level reaches $P_{max} = 7$. The number of steps possible without eating is $M_{max} = (P_{max} - P_{min})/\Delta = 1364$ The main screen of the application is shown in Fig. 3.

V. COMPUTATIONAL EXPERIMENTS

An initial series of experiments was performed in order to identify a convenient set of parameter values, such that the organism could lives long enough to explore its environment and exhibit learning. Of particular importance are the following parameters: sleeping time of threads; priorities of the threads; nutritive value of the fruits; metabolic rate Δ. The values of these parameters are given in Table II.

The experiments were designed to measure the following properties: lifetime; number of nutrients consumed; total distance traveled; and number of selections realized. Since that all four quantities are strongly correlated, we chose the number of selections, S, as the quantity of reference in analyzing our results for the organism's lifetime. Each experiment consists of fifty independent realizations, allowing us to calculate mean values to reasonable precision. Specifically, the relative uncertainty of the mean (95% confidence interval) is $\frac{E}{\overline{S}} =$ 0.13, where the mean number of selections per realization is $\overline{S} = 2.82 \times 10^4$ for the experiment with memory.

[13]At each step, one decision. Avoiding means to turn the body in a random direction (on that interval) and do one step. The same process occurs to the others actions.

In all fifty realizations, 100 fruits (20 redfruits, 20 greenfruits and 60 grayfruits) are distributed in randomly chosen positions. In all studies, fruits are replenished by adding a new fruit of the same kind in a random position each time a fruit is consumed. We verified that the organism explored all the available space, moving in an unbiased manner. The internal aspects of interest in these studies are: the mechanism of action selection; the influence of memory on this mechanism; the temporal evolution of the levels of hunger and need for rest. In the following subsections we discuss our simulation results, seeking the relation between the internal dynamics and behavioral variables (specifically, S).

VI. RESULTS AND DISCUSSION

To understand the role of learning in the behavior of the organism, we performed a set of control or baseline studies in which memory was deactivated, but with all other parameter values (see Table II) as in the studies with memory, referred to hereafter as the *final* experiment. As expected, memory permits a greater level of adaptation (in particular, a longer lifetime).

We observed that the organism develops preferences for different kinds of fruit through its interactions with its environment, and that the evaluation of these experiences was considered necessary and sufficient to establish a minimum criterion of associative learning.

To understand the effect of a nonuniform nutrient density, we performed experiments (with and without memory) with the fruits restricted to half of the environment, i.e., to the left of the midline. All other parameters, including the total number of fruits and the proportions of different kinds of fruits, were maintained at their previous values (i.e., as per Table II). These results indicate that the performance of the organism is poorer with food restricted to half the space, but that memory nevertheless increases the lifetime significantly. (While the mean lifetime in the experiment with a uniform distribution of nutrients with memory was $1.4{\times}10^4 s$ $(\sigma = 7.8 \times 10^3)$ and without memory $2.1{\times}10^3 s$ $(\sigma = 3.1 \times 10^2)$; the mean lifetime in a not uniform environment with memory was $4.1{\times}10^3 s$ $(\sigma = 1.5 \times 10^3)$ and $1.1{\times}10^3 s$ $(\sigma = 1.5 \times 10^2)$ without memory).

The frequencies of the criteria used to select actions are shown in Fig. VI.

In Fig. VI, illustrating typical realizations from each experiment, the cumulative number of selections is plotted over the lifetime of the organism. Although the total number of selections differs by approximately 2×10^4, it is evident that both with and without memory, the criteria 'Nearest' and 'Affordances' are used in a very similar manner.

The initial phases of the same experiments are shown in Fig. VI, which allow one to follow the evolution prior to the formation of memories. Up to approximately interation 150 of the final experiment, memory is not used to select action, although memories have begun to be formed; the choice is based principally on random selection and affordances. Following the initial phase, memory is used as a criterion, and random choices are no longer needed. In the control group, without memory, the selection criteria do not exhibit any trend over time.

In a typical realization of the final experiment (see Fig. 7), the organism regulated its levels of hunger and need for sleep.[14] In this realization the organism maintained behavioral homeostasis at a level compatible with its survival over a period of 4×10^4 selected actions. Note that the number of steps far exceeds 1364, the maximum possible without regulating the level of hunger. In the control group realization, shown in Fig. 7, the organism survived for only about 2×10^3 selected actions. (In Fig. 7, the hunger levels in both realizations - with and without memory - are shown to facilitate comparison.)

The behavioral efficiency is determined by the level of deprivation via (1); the longest-lived realizations, the efficiency was typically between 70% and 100%. Recall that the behavioral efficiency governs the speed of movement, and therefore the ability of the organism to find food. From time to time the organism rests, staying in a fixed position with its eye closed. In the realization shown in Fig. 8 (control group) the organism suffered a higher level of deprivation, reducing its efficiency. The consumption of food during the lifetime of the organism is shown in Fig. 9.

The lack of synchronization imposes limitations which, while showing a certain robustness of the model, leads to difficulties in the analysis of results, since the repeated execution of a given internal structure generates multiple internal messages. The multiple messages are interpreted by the recipient structure as a single message, thereby reestablishing stability. Besides that, this lack of synchronization complicates processing of stimuli. Nevertheless, the majority of stimuli (84%), produce only local effects, while only 40% of stimuli produce global effects stemming from self-organization of the dynamical system [15].

VII. Conclusion

Based on our simulation results, we conclude that learning increases the lifetime of the virtual organism. A key point of our model is the concurrent nature of its dynamics, the absence of synchronization points, and the fact that these features do not hinder the emergence of adaptive behavior. Thus despite the difficulty resulting from lack of synchronization, we have shown that it is possible to construct a model of an asynchronous dynamical system which allows the emergence of a behavior consistent with the internal dynamics of the nervous system.

[14] The graph of need for sleep is very similar to that of hunger, and so is not shown.

[15] These values were obtained from the mean number of selected actions of eating (3.67×10^3); mean number of realized actions of eating (3.09×10^3); mean number of fruits consumed (1.26×10^3), in experiments with memory.

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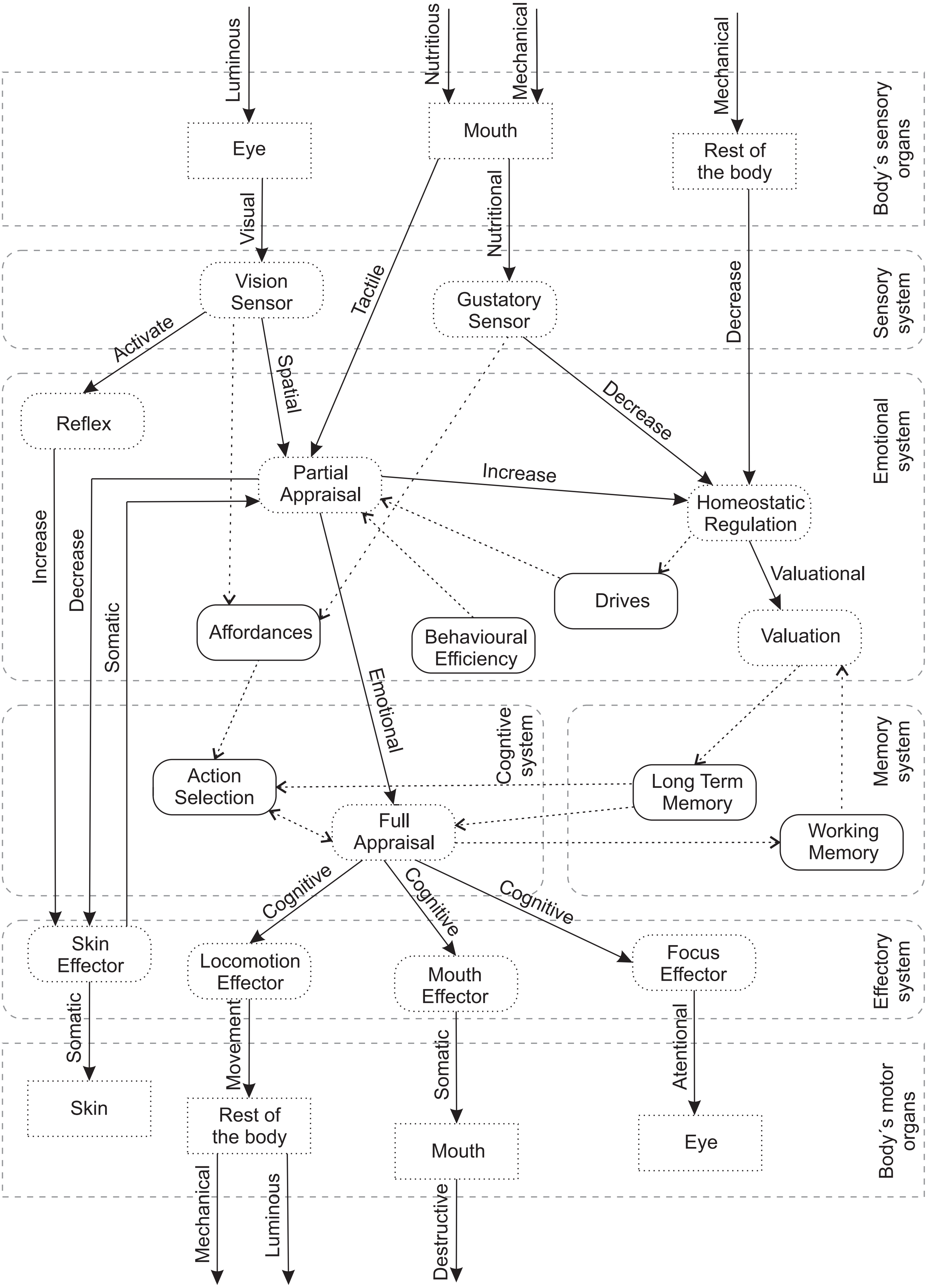

Fig. 1. Stimuli and messages exchanges when a recent action is evaluated.

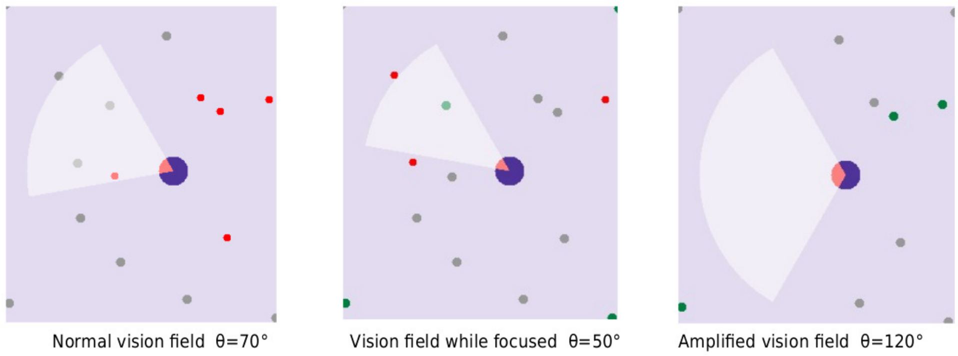

Fig. 2. Variations of the visual field.

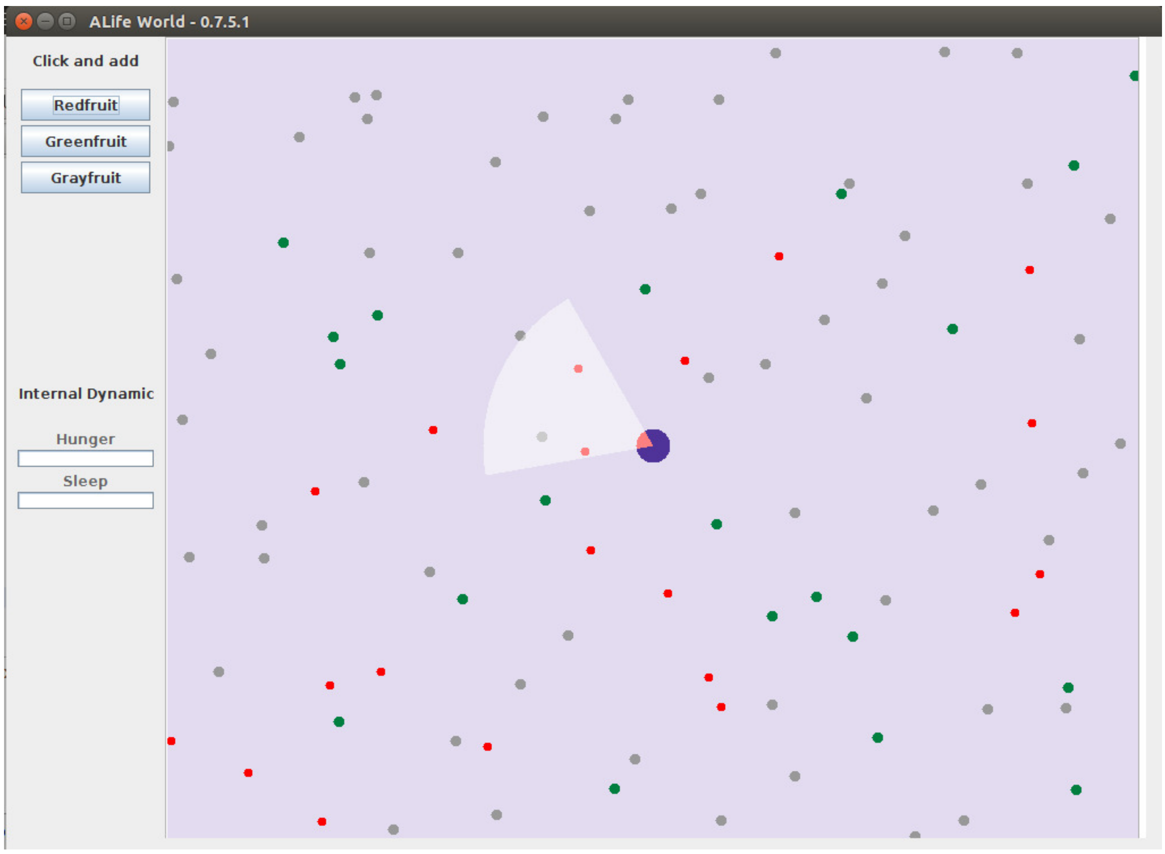

Fig. 3. Main screen of the A-Life application developed for testing the model, with various fruits distributed randomly in space. On the left are bars showing the levels of hunger and need for rest.

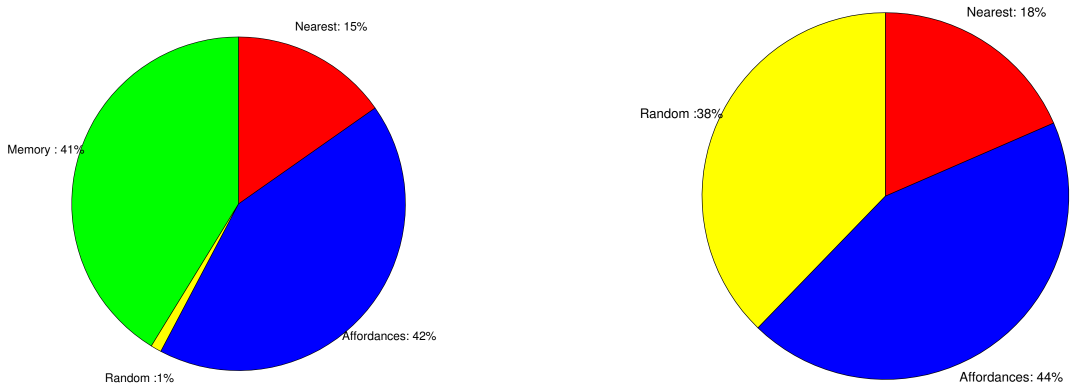

Fig. 4. Frequencies of action selection criteria / Control study in the right side.

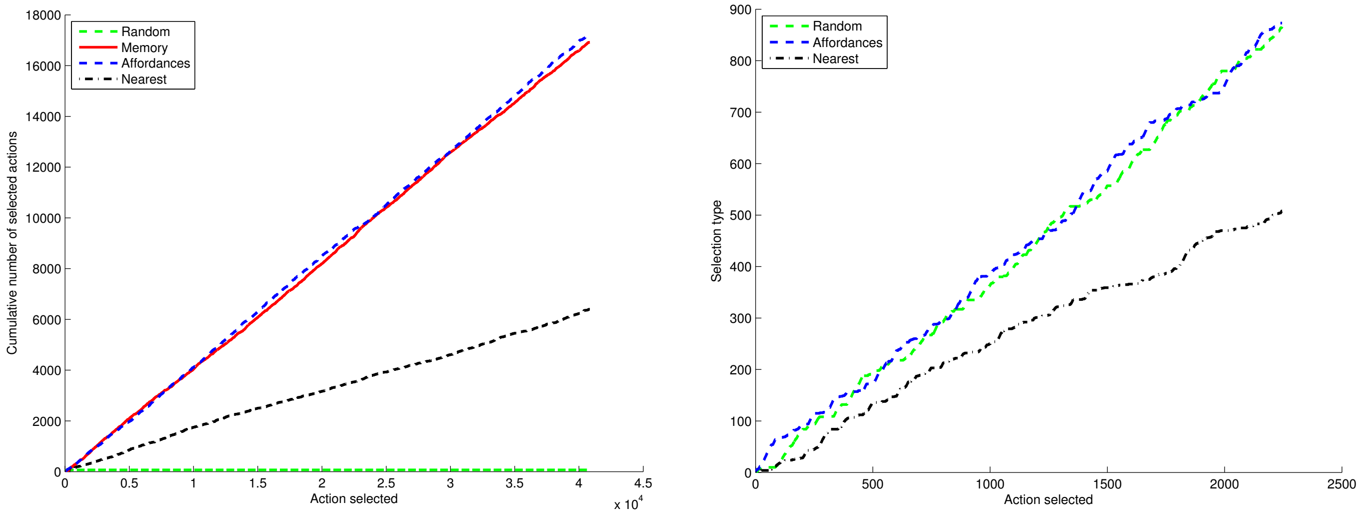

Fig. 5. Cumulative number of actions selected by different criteria / Control study in the right side.

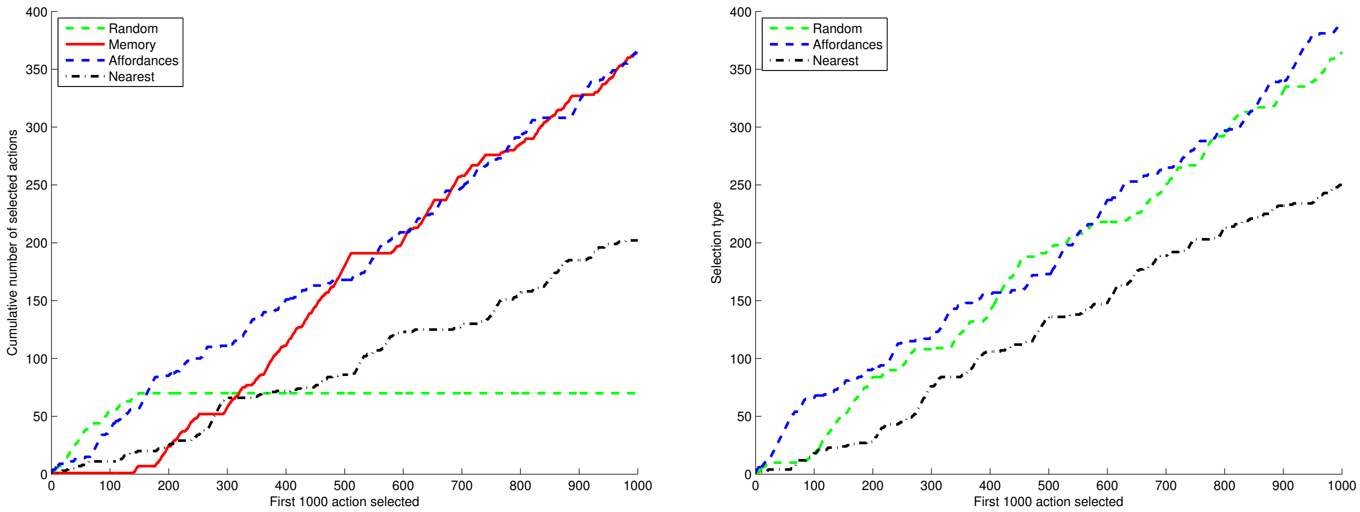

Fig. 6. Cumulative number of actions selected by different criteria (first 1000 interactions) / Control study in the right side.

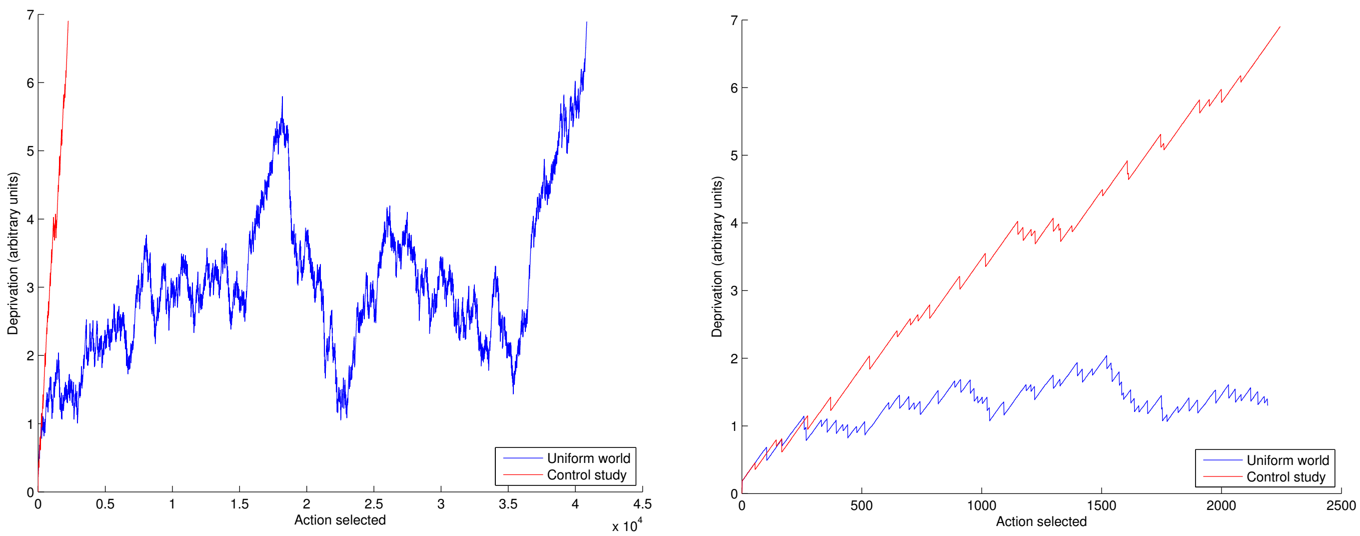

Fig. 7. Deprivation levels versus time / Control study in the right side.

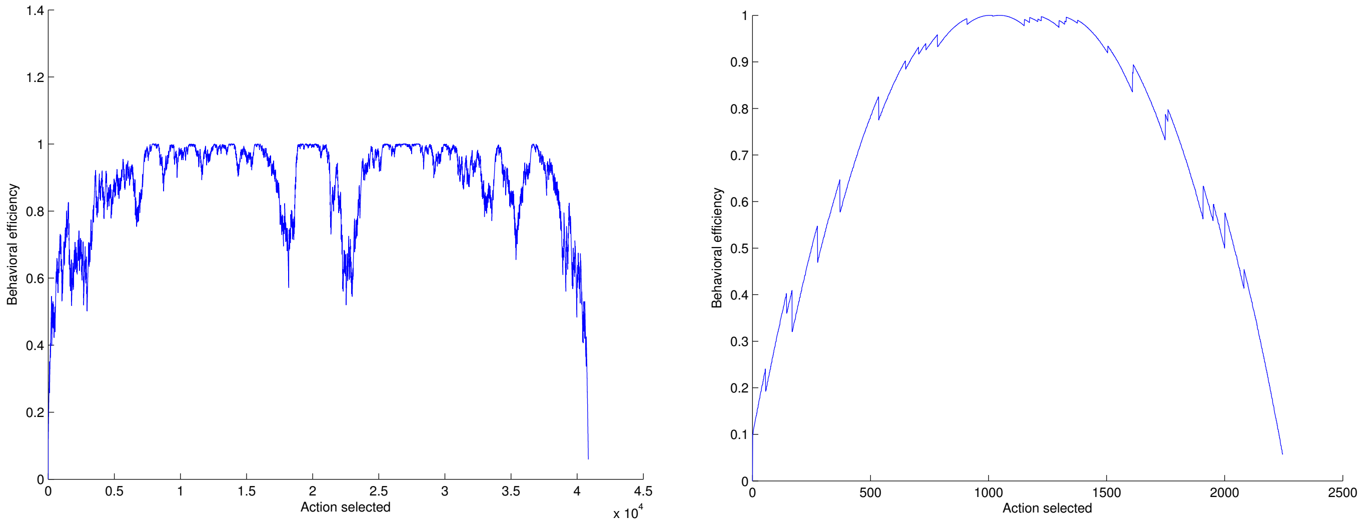

Fig. 8. Behavioral efficiency versus time / Control study in the right side.

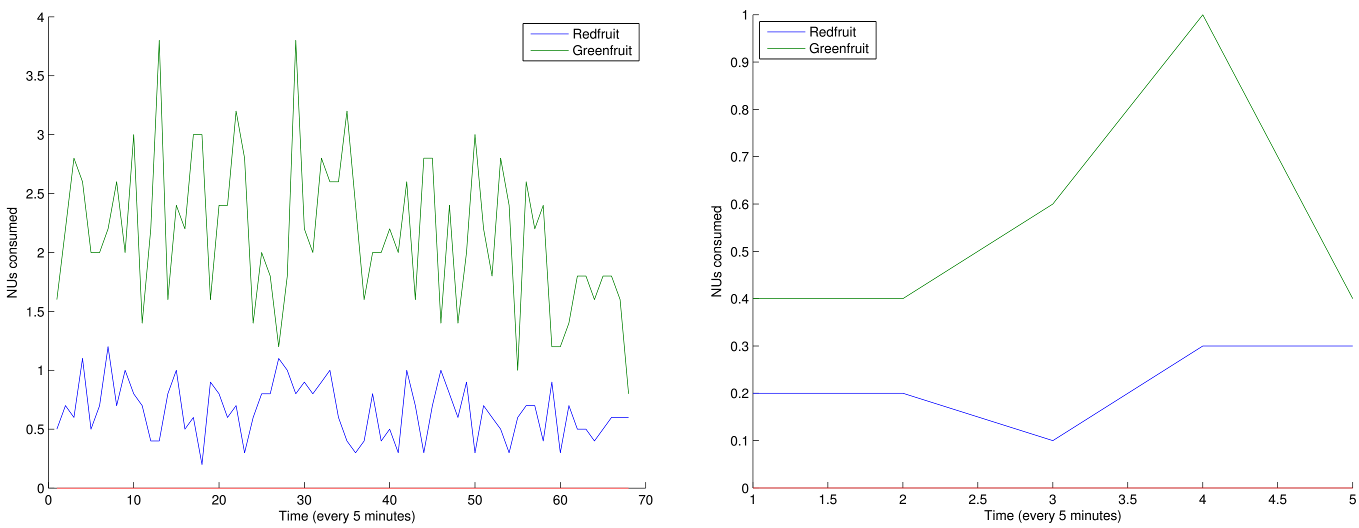

Fig. 9. Nutritional intake versus time / Control study in the right side.

Pointing gesture for communication between robots

Wallas Andrade Pereira
Postgraduate Program in Applied Computing
Universidade Estadual de Feira de Santana (UEFS), Brasil
wallas.andrade@gmail.com

Angelo Loula
Intelligent and Cognitive Systems Lab
Universidade Estadual de Feira de Santana(UEFS), Brasil
angelocl@uefs.br

João Queiroz
Institute of Arts And Design (IAD)
Universidade Federal de Juiz de Fora (UFJF),Brasil
queirozj@pq.cnpq.br

Communication has an important role among social animals, being a fundamental trait for their organization and survival, nevertheless, its origin and evolution still holds several open questions [1, 2]. One of the many studied forms of communication are gestures, used as symbolic conventions and also to support verbal communication. A particularly interesting gesture is human pointing, for it does not present a unique meaning, contrariwise, it provides contextual information (deictic) by directing attention to an object of mutual interest establishing shared and joint attention. The pointing gesture is an indispensable precursor to social learning among humans[3].

One of the most significant difficulties to the studies of the origins and evolution of the communication is the lack of empirical data, once such processes do not leave fossils, with which one could perform observations and analysis [1], and the established systems come from many generations, in such a way that that, adopting a new system is not interesting for their users [4]. Computer models and simulations are a way to circumvent these issues, giving a great contribution on this subject [2].

Computational approaches allow to express theories and hypotheses as computer programs, granting a way of defining different scenarios with the possibility of manipulating several aspects, which permits the investigation of the influence of many of them in a given subject [5]. Many models and simulations involve agents in an environment, which are meant to perform a given task or a set of particular tasks, for which they can obtain any kind of benefit by using communication. Individuals are evaluated, not directly in relation to their communicative capacity, but, by the benefits brought by the development of their capacities for communication [6].

We propose to investigate conditions for the emergence of pointing gesture interpretation among robotic agents, applying a computational modeling approach. As pointing gestures have referential properties, we bring forth the theoretical framework of C.S. Peirce semiotics, to define the pointing gesture as an index, such that the pointing gesture is connected to its referent by means of a relation of physical contiguity, holding no resemblance or symbolic relation to it [7]. Accordingly, the interpreter must rely on spatial temporal relations to determine the referent for such gesture.

As an initial experiment a community of simulated robotic agents are evolved to recognize a pointing gesture, performed by one robot agent and seen by another one. The ability to interpret the gesture and determine its referent is not pre-defined, but we apply techniques of artificial evolution to adapt the neural cognitive architecture of the robot, which are equipped with cameras as inputs. Objects with different colors are randomly placed in the environment and robots are evaluated according to their ability of identifying the pointed object in the scenario.

Simulations of this experiment indicate that agents can successfully interpret the pointing gesture by returning the color of the pointed object. This is a work in progress with initial results. We plan the next experiments to allow the emergence of both the gesture producing and gesture interpretation and further analysis of how the indexical relations are established in the cognitive architecture of the agents.

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Long-term Time Perception: a Pilot Study

Camila Silveira Agostino
Mathematics, Computing and Cognition Center
Federal University of ABC
Brazil
camila.agostino@ufabc.edu.br

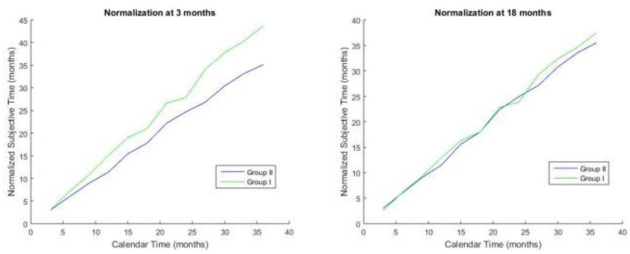
Yossi Zana
Mathematics, Computing and Cognition Center
Federal University of ABC
Brazil
yossi.zana@ufabc.edu.br

ABSTRACT

Line length is the most frequently used paradigm to measure time perception in calendar time intervals. Previous results [1-3] show a perception bias in relation to the calendar time in an exponential manner and theoretically can explain discount rate behaviors found in intertemporal choice tasks. Our working hypothesis is that estimation of calendar time intervals follows a linear, not non-linear, behavior. The results show that using previous or an improved experimental paradigm, a linear model is preferable to a non-linear model. Ten healthy adults (ages 17 - 27 years, mean 21.6), 7 women and 3 men, participated as volunteers, all undergraduate students. Each participant was assigned randomly to one of two experimental groups. Group I: The participants were asked to imagine a given time interval, ranging from 3 to 36 months, and indicate with a mouse click in a line the length that corresponds to the time interval duration. The line had 180 mm (685 pixels), with "very short" and "very long" labels. The mouse cursor was always initiated in the middle of the line. There were 5 blocks per subject and 12 time intervals per block. Group II: Subjects were asked to imagine how long a given time interval lasts. Each trial begun with a fixation cross for increasing subject attention and reducing between trial variability. In the following screen, a line was presented at randomized coordinates, excluding the center of the screen, and without any labels. This experiment was performed on a touch screen monitor. There were 5 blocks per subject and 12 time intervals per block. The subjective time interval estimation was normalized in respect both to the 3 (Fig.1) and 18 (Fig.2) months interval.

Linear regression analysis showed that calendar time intervals explained 98% of the variance of the subjective time estimation in both experimental conditions. The slope was 1.23 and 1.00 for Group I and Group II, respectively. Normalization in respect to the mid-range interval showed more stable behavior.

The results suggest that a linear model can explain calendar time interval estimation and that a mid-range time interval point is more suitable for normalization.



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E-picturebooks and Cognitive Niche Construction

Thales Estefani
Institute of Arts And Design (IAD)
Universidade Federal de Juiz de Fora (UFJF), Brasil
thales.chaun@gmail.com

Pedro Atã
Institute of Arts And Design (IAD)
Universidade Federal de Juiz de Fora (UFJF), Brasil
ata.pedro.1@gmail.com

João Queiroz
Institute of Arts And Design (IAD)
Universidade Federal de Juiz de Fora (UFJF),Brasil
queirozj@pq.cnpq.br

This research project, which is still in its initial steps, introduces a theoretical framework for investigation of the cognitive and semiotic impacts of digital storytelling. Our approach is based on recent approaches in situated cognitive science and cognitive semiotics -- distributed cognition and cognitive niche construction -- that reconsider the relation between human cognition and the environment [1,2]. The notion of distributed cognition has challenged the relevance of skin and skull as clear spatial boundaries of mental activity. Niche Construction Theory [3,4] re-frames the discussion on evolution, moving the co-influence between organism and environment, from a peripheral position to the center of the evolutionary process. Cognitive niche construction can be characterized as evolution of cognitive abilities through a feedback cycle between problem spaces and cognitive artifacts [5,6,7]. Initial modifications in the artifacts available in the environment alter problem-spaces that pressure for further developments in the artifacts and so forth, specializing cognitive activities.

We analyze e-picturebooks (digital picturebooks) as cognitive artifacts and their role in cognitive niche construction. As we are dealing with cognitive niche construction, our framework can be applied to cultural evolution in general, such as in other types of recent transformation in interactive media (computer games, audiobooks, digital photography, hyperliterature).

We investigate (i) how the problem space of storytelling is structured on cognitive artifacts, (ii) what are the specific semiotic features of e-picturebooks and how these features can alter storytelling production and interpretation, and (iii) how these alterations influence cognitive abilities regarding storytelling tasks. Answering question (i) requires an operational definition of storytelling as a problem space and identification of specific artifacts and semiotic features which produce effects that are observable and relevant for that problem space. Answering question (ii) requires analysis of examples and comparison between e-picturebooks and other forms of storytelling (digital or not). Answering question (iii) requires a model of the integration of the semiotic features identified in the answer (ii) and the inference of probable effects of these features in the storytelling niche. In the following paragraph we present an initial plan for the investigation on the cognitive-semiotic nature of e-picturebooks and some of its most salient features.

The task, or problem, that the term 'problem space' refers to in the first question (how the problem space of storytelling is structured on cognitive artifacts?) is that of story. How do people produce and interpret stories to make sense of the world? [8] The problem space (and the set of possible problem states) can be described as the possible causal links between semiotic entities and processes and high level structures (defined as boundary conditions or organizational principles) that influence these links. The "boundary conditions" have a downward effect on the spatiotemporal distribution of lower-level semiotic items [9]. Cognitive artifacts are the devices that allow navigation through the problem space (i.e., transition between problem states). What are the specific semiotic features of e-picturebooks and how these features can alter storytelling production and interpretation? Specific semiotic features of e-picturebooks include gestural repertoire, superposition of non-linear interactive elements, tendency of gamification, navigation conditioned to a specific interaction, multimodal textual forms, multimedia resources (video, animation, audio).

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Computational tool for structural analysis of concept maps for assessing mappers proficiency

Assessing mappers' proficiency on representing their own knowledge

José Francisco Santos Neto
Escola de Artes, Ciências e Humanidades
Universidade de São Paulo
São Paulo, Brazil
jose.francisco.neto@usp.br

Paulo Rogério Miranda Correia
Escola de Artes, Ciências e Humanidades
Universidade de São Paulo
São Paulo, Brazil
prmc@usp.br

I. ABSTRACT

Concept maps are graphical organizers containing concepts embedded into a propositional network. Each proposition (initial concept − linking phrase → final concept) presents a linking phrase to explicitly declare the conceptual relationship between the concepts. The meaning can be easily checked and commented for any reader due to the role of propositions as semantic units. Therefore, concept mapping is a powerful way to externalize and share meaning with clear applications in any educational setting[1].

Other graphical organizers (*e.g.* mind maps) are associative in nature and the conceptual relationship is implicit at best. For example, there are several different forms to relate the concepts "cognitive science" and "field of research" and all of them can fit into an associative map. On the other hand, the concept map asks for a linking phrase ("cognitive science − is an interdisciplinary → field of research") to reach a precise and understandable message. The meaning of this proposition can be readily discussed by anyone interested in the mapped topic.

The creation of concept maps is a complex task because it involves the content to be represented (intrinsic cognitive load) and the procedures to set up an acceptable map (extraneous cognitive load)[2]. A training period on the technique is critical to support beginners to avoid cognitive overload. Our research group has investigated the effect on training strategies on mappers' proficiency during the last 5 years. We observed that specific structural changes in the propositional network indicate the increase of proficiency on the concept mapping technique[3]. The aim of this paper is to model and build a computational tool to automatize the structural analysis of concept maps and to provide a feedback about the user's proficiency level. The effective use of concept maps in large scale (*e.g.* MOOCs and corporations) requires a training period that must be scaffold by experts through an automated system[4-6].

The structural analysis we developed consider 8 parameters to fully describe the propositional network morphology[7]. The design of the computational tool consider the following steps: (a) receive the file containing the concept map, (b) validate the received file, (c) calculate the parameters related to the structural analysis, (d) select a specific feedback considering the concept map morphology and (e) show the feedback and additional instructions to keep the users improving their proficiency on concept mapping. Preliminary results will be shown during the poster presentation.

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Modeling the body temperature regulating system through artificial neural networks

Lucas A. Caetano, Reginaldo Palazzo Júnior (advisor)
Faculdade de Engenharia Elétrica e de Computação
UNICAMP
Campinas, Brazil
lucas.a.caetano@hotmail.com

Nelson Afonso Lutaif (co advisor)
Faculdade de Ciências Médicas
UNICAMP
Campinas, Brazil

***Abstract*— The artificial neural network have become a powerful tool for, among other tasks, perform system identification. By an unknown system of interest is possible to get several labeled examples T, which can be seen as pairs of input values x_i and desired outputs d_i. This data are sufficient to train a neural network using the supervised learning, making it capable of mimic the system behavior. If the net have enough plasticity and the set of sampled data are representative this net will operate transforming the input signal, xi, in an output signal, yi, with a small approximation error ($d_i - y_i$). Lutaif in [1] formulated an autoregressive (AR) model capable of performing early identification in the physiological signals of rats fed with a rich fat diet through the identification of a stochastic process associated with the animal's temperatures.**

This work use artificial neural networks with supervised learning applying then in the problem studied by Lutaif. The MatLab Neural Network toolbox are used to model and train multilayer perceptron and recurrent networks at last the problem is approached by Echo State Networks (ESN) presented by Jaeger in [2]. The training set was get from the data collected in Lutaif's work. After the performance of the nets and Lutaif's AR model are compared to validate the neural network.

Through the experiments is possible to realize that multilayer perceptron, even appearing to be able to handle the task, do not present a good performance because of the complex nature of the times series studied. The second, recurrent networks, proved to be difficult due to the problem of the traditional way of training feedforward networks when they have feedback loops, which causes an exponential increase in the time required to train, rapidly becoming unworkable.

The third approach, the ESN, were able to surpass both problems. They simplify the training since it is only needed for the output layer and has capacity in its reservoir to work with data that require memory. An ESN with linear activation function for the output layer and hyperbolic tangent function for the reservoir, with input and output with one dimension, is able to model the answer of the body temperature control system. When the reservoir has a number of neurons equal to 850 the mean squared error for training and test, is of the order of 10^{-3}.

Keywords—Artificial Neural Network, Echo State Network, supervised learning

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Emergence of Bodily Gestural Communication among Robots

Maria Alice Leal
Departamento de Ensino
Instituto Federal da Bahia (IFBA)
Seabra, Bahia, Brasil
mariaalice@ifba.edu.br

Angelo Loula
Intelligent and Cognitive Systems Lab
Universidade Estadual de Feira de Santana (UEFS)
Feira de Santana, Bahia, Brasil
angelocl@uefs.br

Communication, one of the most outstanding traits in animals, has inspired interest and curiosity in researchers for a long time concerning its origin and evolution, but it is still unknown how this social phenomenon emerged or how it has been modifying itself to become what it is nowadays [1]. One particularly important type of communication are gestures, visible body actions used to convey intention, interest, feelings and ideas [2]. It still an open question whether gesture or vocalization came first in communication traits, or whether gesture only has a complementary role in oral communication. In fact, some [3] advocate in favor of a co-evolution of these two cognitive skills. Others [4] study the possible influence of the gestures in the emergence of vocalization, as in some primates with common ancestor to human beings gestures are more developed than vocalization, suggesting gestures could be the first cognitive skill to emerge. So, its extremely important to study gestures, to understand its nature and provide more evidence to determine which of these cognitive phenomena derived first or how they are related.

As there are no fossil artefacts associated to communication and language [5], it is not possible to determine how different types of communication have emerged or which are the conditions related to its origin. Thus, computational modeling has aroused and been established as a fruitful tool to study such processes. Through computer simulation it is possible to test and run a great amount of scenarios about cognition skills evolution in a shorter time than if it was to follow its natural course [6]. In such studies, basic cognitive principles are predefined for artificial agents, but the particular process of interest must emerge by means of adaptive or evolutionary mechanisms during agents interactions. In many previous works, a dedicated communication channel is present (e.g. sound channel, radio frequency channel, or light color channel).

We propose to study the emergence of gesture communication among robots using their body movement as the means for communication. Here we use motor skill and visual perception, as the basis for gesture communication will take place. One of the situated agents should provide movements (bodily gesture) to convey a meaning, while the other agent should perceive that movement and determine the original meaning from the first agent in the interaction. More specifically, as an initial step of this project, we have developed an experiment where robots, controlled by artificial neural networks, are evolved to perform a double task of generating different body movements depending on the scenario and also of recognizing these bodily gestures from other robots.

The robots have ground sensors for color perception and proximity sensor to perceive movements from the other robot. The robots also have wheels and motor, besides a LED ring that can be lit with different colors. The speaker robot may move right or left depending on color of the ground. The interpreter robot should grasp the speaker movement with its proximity sensors and turn a given color on in its LED ring. The purpose of this initial experiment is to observe if the interpreter is able to determine the ground color perceived by the speaker, only by perceiving its movement. Initially, we have the speaker skills and actions pre-programmed, so we are evolving only the interpreter, which has input neurons with time decayed activation.

This is a work in progress, and first results show that he interpreter is able to partially perform the task. We are running more tests and adjusting experimental parameters to find out why the interpreter wasn‘t able of recognize bodily movements in al test configurations. After that, we are going to model a more complex experiment with the evolution of both agents in a more demanding task.

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Skepticism Revisited

Chalmers on *The Matrix* and brains-in-vats

Richard Hanley
Department of Philosophy
University of Delaware
Newark, DE, U.S.A
hanley@udel.edu

***Abstract*—Thought experiments involving The Matrix, brains-in-vats, or Cartesian demons have traditionally thought to describe skeptical possibilities. David Chalmers has denied this, claiming that the simulations involved are real enough. Through an examination of kind terms I argue that, though the Chalmers view may be otherwise attractive, it is not an antidote to skepticism.**

***Keywords*—Putnam; Chalmers; brain-in-a-vat; Matrix; skepticism; kind terms**

I. Chalmers vs Putnam

In "*The Matrix* as Metaphysics," [1] David Chalmers argues that we in the philosophical tradition have gravely misunderstood hypotheses such as Descartes' demon, the brain-in-a-vat (BIV), and the Matrix. These are not really (very) skeptical hypotheses, Chalmers tells us. Rather, they are interesting metaphysical hypotheses.

Chalmers' basic argument is an extension of some points that Hilary Putnam made in "The Meaning of 'Meaning'." [2] Putnam uses a theoretical background of the causal theory of reference, which Chalmers claims to avoid relying on; Chalmers tells us he wants to derive the causal theory rather than assume it. But for now let's ignore the order of dependence, and assume the causal theory.

Let's rehearse the tradition. Suppose that I am not a BIV. Then I am not now in Tucson. And a good thing, too, since I believe I am not in Tucson right now, and like Russell's pedant I prefer my beliefs to be true. Suppose further that there is a BIV in Tucson right now, having experiences that, on the traditional way of conceiving of BIVs, seem to justify it in believing it is not in Tucson right now. It seems to believe it is not in Tucson right now, and this belief seems to be false, since the BIV *is*, we just supposed, in Tucson right now. Bad news for the BIV.

Moreover, the tradition continues, bad news for me, since although it's true that I am not in Tucson right now, nothing in my present experience conclusively rules out the possibility that I am a BIV in Tucson having an experience of not being in Tucson right now, in which case my belief would be false. Given epistemic closure and a few bits and bobs (for instance, assume that I never in fact will be a BIV, and assume a BIV hypothesis where I always am a BIV), it follows that I don't know much. At least, and this will be our focus, my empirical beliefs about the external world, no matter how justified, fall short of propositional knowledge.

Putnam used considerations from his Twin Earth case to argue that a BIV could not have the thought that it was possibly a BIV, and so could not falsely believe that it was not a BIV. Suppose for simplicity that there is a language of thought, and for me it is English. My mental token "I am not in Tucson right now" is true because the indexical "I" picks out Richard Hanley, "right now" picks out a certain time *t* and "Tucson" picks out a certain desert city; and Richard Hanley is not in that city at *t*. If Putnam is correct, then the BIV's mental token "I am not in Tucson right now" is *not* in English. In particular, the BIV's token "Tucson" does *not* pick out the desert city that my mental token "Tucson" does.

The causal theorist explains this in terms of a causal network of public language tokens of "Tucson" that I am appropriately linked to, but the BIV is not. And the network I am linked to is ultimately grounded in a certain desert city, whereas the BIV has no such link. Hence the BIV can have no thoughts about Tucson, and so cannot falsely think that it is not in Tucson right now.

"Tucson" in English is the proper name of an individual. But the same point goes for general names such as natural kind terms. So, just water-ish thoughts on Twin Earth are not thoughts about H_2O, brain-ish thoughts in a BIV are not about *brains*. The BIV is not party to a causal network of public tokens of the English word "brain", and so cannot have thoughts about brains, even though it is one!

But this can seem an excessively negative strategy. On Twin Earth, water-ish thoughts are about some natural kind, after all—they are about XYZ, the stuff that plays the water-ish role on Twin Earth. And on Twin Earth, Tucson-ish thoughts are about a desert city, after all—they are about Twucson, the place that plays the Tucson-ish role on Twin Earth. If the BIV's empirical thoughts weren't about anything at all, then the BIV seems to altogether lack empirical beliefs, and so would anyway lack the empirical beliefs required for empirical knowledge.

On this reading, Putnam's argument might anyway fail to undercut skepticism about empirical beliefs. The traditional worry is that my present true belief that I am not in Tucson would be false if I were a BIV. Putnam says don't worry. Your present belief wouldn't be false, and it wouldn't even be not true. And not because it would lack what the positivists called "cognitive value." Rather, you wouldn't have your present belief at all.

But this answers only one skeptical challenge, to the effect that even if true and as justified as they could be in the circumstances, your empirical beliefs can never be justified enough for knowledge. Here's a different skeptical challenge: if you are a BIV the mental states that you think are empirical beliefs are not empirical beliefs at all; they are not even false. But no matter how much justification you have for thinking your present states have cognitive value, you cannot rule out the possibility that they do not have cognitive value. Bad news for you.

Chalmers' strategy would help us against this second skeptical challenge, for he argues instead that a BIV would have (the typically assumed number of) true empirical beliefs. For Chalmers, there is a close analogy between Twin Earth and the BIV. Just as Twin-Earthers have relevant experience of Twucson playing the Tucson-ish role, the BIV has relevant experience of something—Chalmers calls it "Tucson*" that plays the Tucson-ish role for the BIV. So the BIV's Tucson-ish thoughts are about Tucson*. Moreover, just as Twin-Earthers have relevant experience of XYZ playing the water-ish role, the BIV has relevant experience of something—call it "brains*" that play the brain-ish role for the BIV. So the BIV's brain-ish thoughts are about brains*. Ditto for vats*, which play the vat-ish role for the BIV.

How can there be such things as Tucson*, brains* and vats*? They are, according to Chalmers, *virtual objects*. Such virtual objects are possible, he claims, because a certain hypothesis is possibly true: the *Computational Hypothesis* that "microphysical processes throughout space-time are constituted by underlying computational processes." Roughly, the idea is that if the Computational Hypothesis is true, then it is possible to simulate microphysical processes and anything—such as Tucson, brains, water, and vats—that supervenes on microphysical processes.

Now I am, in fact, a friend of virtual objects. So I am just going to assume their possibility. The following quote from Chalmers illustrates the idea's application (he is considering a series of objections [1]:

> **Objection 5**: You just said that virtual hands are not real hands. Does this mean that if we are in the matrix, we don't have real hands?
>
> Response: No. If we are *not* in the matrix, but someone else is, we should say that their term "hand" refers to virtual hands, but our term does not. So in this case, our hands aren't virtual hands. But if we *are* in the matrix, then our term "hand" refers to something that's made of bits: virtual hands, or at least something that would be regarded as virtual hands by people in the next world up. That is, if we *are* in the matrix, real hands are made of bits. Things look quite different, and our words refer to different things, depending on whether our perspective is inside or outside the matrix.
>
> This sort of perspective shift is common in thinking about the matrix scenario. From the first-person perspective, we suppose that *we* are in a matrix. Here, real things in our world are made of bits, though the "next world up" might not be made of bits. From the third-person perspective, we suppose that someone *else* is in a matrix but we are not. Here, real things in our world are not made of bits, but the "next world down" is made of bits. On the first way of doing things, our words refer to computational entities. On the second way of doing things, the envatted beings' words refer to computational entities, but our words do not.

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STRUCTURAL KINDS VS FUNCTIONAL KINDS

But there can be overlap in the languages of empirical claims between Twin Earth and Earth. For instance, it seems that on both planets the water-ish stuff fills their rivers and lakes. Does a river or lake *have to* contain H_2O? Consider with Chalmers some terms that might be shared between my and the BIV's:

> **Objection 7**: An envatted being thinks it performs actions, and it thinks it has friends. Are these beliefs correct?
>
> Response: One might try to say that the being performs actions* and that it has friends*. But for various reason I think it is not plausible that words like "action" and "friend" can shift their meanings as easily as words like "Tucson" and "hair". Instead, I think one can say truthfully (in our own language) that the envatted being performs actions, and that it has friends. To be sure, it performs actions in *its* environment, and its environment is not our environment but the virtual environment. And its friends likewise inhabit the virtual environment (assuming that we have a multi-vat matrix, or that computation suffices for consciousness). But the envatted being is not incorrect in this respect.

A footnote accompanies this response:

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Note 9: Why the different response to objection 7, on "action" and "friend"? We noted earlier (note 1) that not all terms function like "water" and "hair". There are numerous *semantically neutral* terms that are not subject to Twin Earth thought-experiments: any two twins using these terms on different environments will use them with the same meaning (at least if they are using the terms without semantic deference). These terms arguably include "and", "friend", "philosopher", "action", "experience", and "envatted". So while an envatted beings' term "hand" or "hair" or "Tucson" may mean something different from our corresponding term, an envatted beings' term "friend" or "philosopher" or "action" will arguably mean the same as ours.

It follows that if we are concerned with an envatted being's belief "I have friends", or "I perform actions", we cannot use the Twin-Earth response. These beliefs will be true if and only if the envatted being has friends and performs actions. Fortunately, it seems quite reasonable to say that the envatted being *does* have friends (in its environment, not in ours), and that it does perform actions (in its environment, not in ours). The same goes for other semantically neutral terms: it is for precisely this class of expressions that this response is reasonable.

It seems that the kind terms Chalmers calls "semantically neutral" are names of broadly *functional* types, whereas the terms subject to Twin-Earth response are names of broadly *structural* types. H_2O is structurally different from XYZ, and (if we're not envatted) hair and hands are structurally different from hair* and hands*. Hair* and hands* are "made of bits" and hair and hands are not. A philosopher, though, is a functional type, and Chalmers is a philosopher whether or not he's made of bits.

But now, some trouble lurks. Notice that "envatted" is one of Chalmers' semantically neutral terms. Now suppose that I were envatted, having the experiences I'm having now. If I believed I were not envatted—and I *don't* mean not envatted*, because we don't need the "star"—would my belief be true? On the one hand, *in the world of the simulation*, which we're granting is virtual but nevertheless real, I would not be envatted. So my belief would, it seems, be true. But on the other hand, as we began by supposing, *I would be envatted*! So my belief would, it seems, be false. It's tempting to add "in the real world," but let's just say, in the *other* world, or O-world. And let's contrast it with the S-world of the simulation.

There are options, of course. If one is an occupant of both the S-world and the O-world, then perhaps semantically neutral terms, although they apply in both worlds, have odd extension conditions. Ordinarily we might think "I am not envatted" is true only if there is no world in which you are envatted, but perhaps instead it's true if there's at least one world in which you are not envatted. That would be strange. Or perhaps one world somehow has priority. (Though I find myself tempted to give priority to the O-world in such a case, and "I am not envatted then comes out false, anyway.) The problem with this option is that it works best for terms that are *not* semantically neutral. Moreover, it seems that in any case, I can just go ahead and believe "There is no world in which I am envatted," and thereby believe something false. How could *that* belief extensionally strange? Is such a belief domain-restricted, willy-nilly?

There are two other ways out. One, Chalmers only said "envatted" was *arguably* semantically neutral. So maybe we just discovered that it's arguably *not*. Two, perhaps "envatted" is both semantically neutral and extensionally strange, but it's very rare for a term to be in this predicament and so will not give skepticism much of a foothold.

I don't recommend either of these alternative ways out, though. First, to put it in my terms, "envatted" is a good candidate for a semantically neutral term precisely because it names a broadly functional type. Second, whatever we say about "envatted," there are many other candidates for functional types lining up to cause the same trouble. Consider "desert" and "city." These seem to me to be just as semantically neutral as "friend." If I am not a BIV, then I am not in a desert city right now. Good thing I believe I am not in a desert city right now! But if I were a BIV in Tucson, then I would be a BIV in a desert city right now believing I was not in a desert city right now. Wouldn't I? And would I be wrong, or both right and wrong, or some other weird alternative?

The problem concerns the nature of kind terms and our ability to refer by means of them. A proper name reaches back through appropriate causal links to only one individual, so it is very plausible that I could not think about Tucson if I were a BIV (assuming I'm actually not). But kind terms have this marvelous feature: that their extension is not restricted to those instances that we are appropriately causally linked to.

Call the predicament of an occupant of an S-world whose semantically neutral terms reach extensionally into an O-world *semantically strange*. There seems to be but one way to avoid it. Let's go back to Putnam's BIV and its brain-ish and vat-ish thoughts. Are brains and vats structural types? Or are they broadly functional types? Take brains, which are at least a candidate for a natural kind. Perhaps nothing is a brain unless it's organic, and being organic entails something not realizable in an S-world. Then anything playing the brain-ish role in an S-world is a brain*. Take vats, which are members of an artifactual kind. Perhaps nothing is a vat unless it's made of metal or glass or plastic (etc.), and being any of these entails not being realizable in an S-world. Then anything playing the vat-ish role in an S-world is a vat*. And anything playing the desert-ish role in an S-world is a desert*. Anything

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playing the city-ish role in an S-world is a city*. And so on. For everything. And for everything*.[1]

On this *global structuralist* suggestion, a broadly functional type is still a structural type, at a fundamental level. It's just that, within a world, the structure required is realized *in everything*, and so it tends to drop out when we're doing the semantics of kind terms and thinking about their extensions.

III. Skepticism Revisited

As promising as the global structuralist strategy might seem, it opens us up to a new version of the skeptical challenge. First, imagine the best case scenario for responding to the skeptic. It's the one Chalmers and Putnam have already described: you are not envatted, and you are imagining what would be true if you were envatted. That is, you are in an O-world that is not a world of bits, and you are imagining what would be true if you were in an S-world that is a world of bits, being directly simulated by occupants of the O-world, the "next world up," as Chalmers puts it. In such a world, you would think you were not envatted*, and you would be right.

Now consider a variant. As Chalmers writes, the "next world up" "might not be made of bits," but it also *might* be made of bits. One way for this to be true is if the O-world is an S-world itself, with another O-world as the "next world up" again. Imagine a scenario in which an occupant of such an O-world of bits is in a BIV-ish role, such that their ("next world down") S-world experience is of not occupying a BIV-ish role. Then they are in a semantically strange predicament, even given global structuralism.

So far this is not a problem if the scenario is begin imagined by a being who is not a BIV or otherwise envatted.

Variant 1

Suppose that I am not envatted, and not made of bits. Then there are two reasons that I should not be concerned about the scenario where I am in a semantically strange predicament. The first is that such the occupant of the BIV-ish role just described is not a BIV; rather it's a BIV*. And it cannot think about Tucson, or deserts, or cities, or hands or hair. Secondly, if I am an occupant of a world not made of bits, and I am not made of bits, then the occupant of the BIV-ish role (the BIV*) could not *be* me.[2] It's at best Hanley*. So at most I can imagine Hanley* being a BIV*.

Variant 2

Next, suppose I am envatted, and not made of bits. Then the extension of "BIV" includes all things made of bits and that play the BIV-ish role. So I can imagine something playing the BIV-ish role, and that would be to imagine it being a BIV. But can I imagine *myself* being a BIV? It seems not, since, like Tucson, I am not made of bits. At most, I can imagine Hanley* being a BIV.

Variant 3

But suppose I am envatted, and made of bits (since the "next world up" is also made of bits). Then the extension of "BIV" includes all things made of bits and that play the BIV-ish role. Then I *can* imagine myself playing that role, and so can imagine myself being envatted. I can imagine Hanley being a BIV. And that is to imagine Hanley being in a semantically strange predicament.

How bad is that? Well, it isn't all good. My problem is that I don't know which of the three variants I am in. My *Cartesian predicament* is of not being able to tell them apart. So nothing in my present experience rules out my being in Variant 3. So nothing in my present experience rules out my possibly being in a semantically strange predicament.

Of course, the global structuralist can assure me that if I am not in variant 3, then when I think I am imagining being Hanley being a BIV, I'm not really imagining that, and instead imagining either Hanley* being a BIV or Hanley* being a BIV*. But that at best puts me in a sort of stand-off with the skeptic. Can I play the apparent odds, and say there's a 2/3 chance that I can't imagine a skeptical scenario?

There's something else that's a bit odd about the global structuralist strategy, something it shares with Putnam's original response to the skeptic. If I am in Variant 3, then I am not just *imagining* being in a semantically strange predicament; I'm also actually *in* one. So it seems I should hope that I'm not in a semantically strange predicament. Suppose that hope is realized. (Hey, 2/3 isn't bad odds, after all!) Then I'm not hoping that if I were a BIV, then my empirical beliefs would still be largely true—that would be the

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[1] There seems little point to hanging on to semantically neutral terms that don't cause trouble, like "action" and "friend." But hold on to them if you like, and ignore them in what follows.

[2] It's unclear to me whether or not Chalmers can say this second thing. His Matrix hypothesis of envattedness includes the *Mind/Body Hypothesis* that "my mind is (and has always been) constituted by processes outside physical space-time, and receives its perceptual inputs from and sends its outputs to processes in physical space-time." This sounds like immaterialism, and I don't know if it reconciling it with ordinary statements like "I have hands" will leave open the possibility of "being a BIV*." In any case, *I* don't want to assume immaterial dualism.

Chalmers' strategy. Rather, I'm hoping that when I think I imagine that I were a BIV, I'm really mistaken about the content of my imagining. And that's a Cartesian predicament of its own.

We could escape this consequence by appealing to a version of counterpart theory. In its cross-possible-world and cross-time versions, counterpart theory allows occupants of one world or time to satisfy suitably abverbialized open formulae in virtue of having other-worldly (or timely) counterparts who satisfy the formulae directly. We could extend this to allow for next-world-up or down counterparts (and next-to-next, and so on), that do the same.

This would affect only Variant 2. It would enable me, other things being equal, and given the global structuralist strategy, to imagine myself being Hanley being a BIV. Moreover, if Hanley were as imagined a BIV, then Hanley's empirical beliefs would be largely true. So if I am in Variant 2, then my imagining being Hanley being a BIV would not be a skeptical scenario…. So should I hope that I am in Variant 2? (1/3 odds aren't so bad!) But that is to hope I am envatted—a curious response indeed to the traditional skeptical worry!

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The Persistence of Mental Representation

And the different levels of representation

Rogério de Souza Teza
Department of Philosophy
FFLCH / University of São Paulo
São Paulo, Brazil
rogerio.teza@usp.br

Osvaldo Frota Pessoa Junior (*Advisor*)
Department of Philosophy
FFLCH / University of São Paulo
São Paulo, Brazil
opessoa@usp.br

***Abstract* — Issues concerning the reality and the nature of mental representations are central in the debate of cognitive sciences [1]. This work, a currently graduation research in philosophy of mind, proposes a concept of representation which allows to clarify different uses, and to show that considering different levels of representation there is no room for anti-representationalism.**

Regarding the morphology of the word, it is necessary bear in mind that a "representation" is "something which is in the place of something else", "which stands for this". In this broad sense, the representation phenomenon is ubiquitous, and anti-representationalist views [2], e.g. Dynamicists, also have parameters which own this characteristic. In spite of the simplicity of this definition, two aspects of the representations are overshadowed and usually forgotten: a representation must carry information about "this something else", and as any information-bearer, it must have a material substract that can be arranged in different structures. These aspects allow us to propose three levels for representations.

At the lowest level, there are information-bearer units in isolation, despite any inner structure of this unit. It is e.g. the spiking of a neuron [3]. At this level, it is not possible to find the "aboutness", i.e., the relation or reference to anything else being represented. Consequently, it does not have functional role, but it is still something in the place of something else. Inserted in a system, the informational-bearer unit can produce causal effect, e.g. the neuron in the brain network. It is the second, intermediate level. Because of its relations with other neurons it can start a behavior process, or even show or reveal its cause, "the represented state". Participating in a causal chain, it allows a being to react to surrounding states. This level is applied to the natural representation [4] as internal representations, found in all live organisms, but also e.g. in thermostats [5]. At an upper level, the information-bearer unit is structured in a way that can preserve and carry, in the inner relations between its elements, information about extrinsic relations. Thus, because of highly organized, this unit has much more information than in the other levels, and can be called symbolic, supporting the "mental representation" concept. The word "mental" adds to the term "representation" the meaningful aspect. At this level, moreover, the representation can be structured so that it can exhibit systematic and compositional aspects in relation to other representation of the same kind. This is the kind of linguistics and symbolic representations like those of the Intentional Realists [6].

These are three levels of representation, which are all based on material basis. So Eliminativists question [7] ("how can atoms in the void represent something?") does not threat the mental representation concept, since in this sense the latter is not only a higher instance, but also a more complex arrangement, built on physical representations. The big challenge, however, is to explain how a system is organized and structured to reconstructs the reality metaphorically in a mental representation [8]. It is the mystery of "the mind". In other words, the challenge is to find the theoretical coherence between representation, information and enaction [9].

Keywords— representation; anti-representationalism; mind

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É a consciência uma tela que vê a si mesma?

Lucas Nascimento Machado
Departamento de Filosofia
FFLCH-USP
São Paulo, Brasil
lucasmachado47@gmail.com

Resumo: Em nossa apresentação, proporemos, a partir da discussão sobre a natureza do fenômeno da percepção visual e de sua relação com a consciência, uma concepção sobre o âmbito em que o fenômeno visual se daria que, acreditamos, pode contribuir para conceber a consciência *como uma tela que vê a si mesma*, ou seja, como um sistema cuja informação produzida só é acessível ao próprio sistema que a produziu. Esperamos, assim, pela metáfora da tela que vê a si mesma, fazer uma pequena contribuição para a reflexão filosófica sobre o fenômeno da percepção visual e, por extensão, para a reflexão filosófica sobre a consciência e sobre *o problema difícil da consciência*.

Palavras-chave: percepção visual, homúnculo, consciência

Na discussão sobre o fenômeno da percepção visual, haveria uma disputa de filósofos e cientistas entre aqueles que, por um lado, defendem que não há algo como cores dentro de nosso próprio cérebro, e aqueles que, por outro, defendem a existência delas no mesmo. Se, para os primeiros, a noção de que haveria uma espécie de "tela interna" ao cérebro, no qual o quadro visual percebido seria reproduzido e teria as mesmas características visuais daquilo que é visto, parece uma ideia insustentável[1], os segundos, por outro lado, defenderiam que unicamente dessa forma o fenômeno da experiência visual seria explicável.

Para aqueles que defendem a existência de uma "tela interior"[2], contudo, impõe-se, inicialmente, um problema. Pois, para efetuar tal defesa, recorreriam à afirmação da existência de uma espécie de homúnculo que, sendo aquele que vê essa tela no interior do cérebro, é o que possibilita que tenhamos a consciência daquilo que estamos vendo. Contudo, essa hipótese, como apontam os seus críticos, possui uma grande dificuldade, pois parece nos levar a uma regressão ao infinito. Afinal, para que esse homúnculo fosse capaz de ver a tela no interior do cérebro, ele mesmo, por sua vez, precisaria ter uma tela no seu interior, a qual deveria ser vista por um outro homúnculo dentro do primeiro, e assim ao infinito. Como tréplica, afirmariam os defensores da tese do homúnculo que ele seria de natureza completamente distinta, não necessitando dessa regressão ao infinito para possibilitar, pela sua visão da nossa "tela interna" do cérebro, a experiência da percepção visual consciente.

Sendo assim, encontramo-nos em um inquietante impasse. Afinal, é preciso que haja algo como cores no nosso próprio cérebro, para que possamos perceber cores? Ou a percepção nada tem a ver com tal reprodução material das cores em nosso cérebro, e deveria ser compreendida de maneira menos imediata e por processos puramente físicos? Se não há nada que seja nem sequer vagamente semelhante a cores dentro de nosso próprio cérebro, como podemos percebê-las? E, por outro lado, se nossa experiência das cores está relacionada com uma reprodução delas que se assemelha a elas, então, por que não encontramos nada em nosso cérebro que corresponda e reproduza as cores daquilo que vemos? E, supondo que haja uma tela interior em que tais cores são reproduzidas, e que essa tela seja "vista" pelo nosso cérebro, como não incorrer em uma regressão ao infinito, já que a visão, para ser explicada, teria já que pressupor que uma tela é vista?

Acredito que é possível jogar uma nova luz sobre o tema – e, por implicação, sobre o tema acerca da natureza da consciência em geral e de seu estatuto ontológico – se considerarmos a seguinte hipótese, que pode parecer, inicialmente, talvez um pouco absurda: a hipótese de que a consciência (pelo menos, nesse caso, a consciência visual), é *uma tela que vê a si mesma*.

Busquemos esclarecer esse ponto, recorrendo ao exemplo concreto do qual essa ideia se originou. Pensemos na tela de um computador. Pensemos, além disso, que um jogo esteja sendo rodado nesse momento nesse mesmo computador – um jogo complexo, com um grande mundo de gráficos muito ricos – talvez GTA V ou Skyrim, não importa. O que importa é que, nesse jogo, há um grande universo, um mundo gigantesco que é reproduzido na tela pelo computador na medida em que o jogador joga, e que possui uma grande riqueza em estímulos e detalhes visuais.

Nesse jogo, o jogador possui um avatar – uma entidade a qual ele controla e que determina o campo visual do jogador. Suponhamos que o jogador se encontre em uma reprodução de uma enorme cidade, andando por suas ruas. O campo visual do jogador é determinado pela direção para que seu avatar está virado, e é essa parte unicamente que ele vê da cidade. Contudo, a cidade – ou pelo menos, uma parte significantemente maior dela do que aquela que é vista pelo jogador – já foi carregada pelo computador, de tal forma que,

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[1] Cf. DENNETT, 1991, p. 251.

[2] Uma concepção que, atualmente, costuma ser mais associada a David Marr, o qual seria, por essa razão, acusado de cometer a "falácia do homúnculo". Cf. MARR, 1982.

se o jogador virar o seu avatar para outra direção, outra parte da cidade, que não estava sendo vista antes, será imediatamente vista. Supondo que o computador seja capaz de executar perfeitamente bem o jogo, a transição será completamente suave e contínua, e o jogador terá pura e simplesmente a impressão de ter deslocado a sua visão de um ponto da cidade para outro, sem, contudo, que aquilo que ele passou a ver *só tenha passado a existir enquanto uma informação visual no momento em que ele se voltou para aquela direção*. Assim, é perfeitamente natural que um jogador tenha a ilusão de que, *em algum lugar dentro do computador*, *aquilo que ele vê já estava, exatamente como ele vê, presente*. Contudo, se abríssemos o computador, sem com isso interromper o seu funcionamento – se, de alguma forma, pudéssemos deixá-lo rodando perfeitamente, inclusive sua tela, ao mesmo tempo em que o abrimos e abrimos o monitor para examinar os seus componentes, não encontraríamos, em nenhum lugar nem dentro do computador, nem dentro do monitor, a informação visual do restante da cidade que não está no campo visual do avatar do jogador naquele momento.

O motivo disso é bastante simples: toda a informação visual fornecida pelo computador se encontra *apenas* em sua tela – e não em nenhum componente quer do computador, quer de seu monitor. A ilusão de que haveria uma informação visual dentro do computador que não estaria na própria tela se deve ao fato de que o jogador, ao mudar a direção do campo visual de seu avatar, encontrar uma informação visual que não estava ali antes e supor que, portanto, ela mesma, em sua forma de informação visual, já deveria estar em algum lugar, para que pudesse por fim vir a aparecer na tela. Mas a verdade é que essa informação só surge no momento em que o jogador muda a direção de seu avatar e como o resultado de um processamento de informações, tanto do programa do jogo quanto do input que o jogador fornece a ele, informações que não são de modo algum em si mesmas visuais, mas que são traduzidas para a informação visual que só existe na tela do computador – e só nela é uma informação visual.

Entretanto, ainda que assim seja, ninguém estaria disposto a dizer que, porque a informação visual fornecida pela tela não se encontra em nenhum lugar dentro do computador ou do monitor, que essa informação visual não exista de forma alguma. No jogo, posso ver uma árvore com folhas verdes; certamente, se abrir o monitor de meu computador ou o próprio computador, não encontrarei, dentro dele, nenhuma informação visual correspondente, nenhum componente no qual se encontre uma imagem verde correspondente àquela que vejo na tela. Mas, nem por isso chegarei à conclusão um tanto excêntrica de que porque as cores daquilo que vejo na tela não existem dentro do monitor ou dentro do computador, que essas mesmas cores não existem *na tela mesma*. Pelo contrário, apenas concluirei que a informação visual fornecida pela tela do computador não se encontra *dentro dele*, em seus componentes, mas sim *unicamente na tela*, que é o único lugar no computador em que essas informações visuais são fornecidas *enquanto* informações visuais.

Do mesmo modo, poderíamos dizer que *a nossa experiência consciente visual é como uma tela de computador*. De nada adianta buscarmos, *dentro de nosso cérebro*, onde estão as cores, onde a imagem daquilo que vemos estaria de alguma forma armazenada, pois essa informação não existe em lugar nenhum em nosso cérebro, senão *em nossa experiência consciente da própria visão*. Certamente, não encontraremos as cores *dentro de nosso cérebro* – contudo, isso não quer dizer que elas não existam *em nossa consciência*, da mesma maneira que não encontrarmos as cores daquilo que é exibido na tela dentro do computador ou do monitor não significa que essas cores não existam *na tela mesma*. Assim, por esse lado, acreditamos negar a hipótese dos que defendem de que a cor não exista, de modo algum, no cérebro; dizemos, pelo contrário, que ela existe, que há algo de efetivamente colorido em nossa consciência, mas que esse algo que é colorido só se encontra em nossa experiência visual, que nada mais seria do que nossa "tela de computador pessoal", e não "dentro" de qualquer componente do cérebro que não essa mesma experiência visual.

Por outro lado, poder-se-ia nos objetar que a analogia com a tela de computador não é satisfatória, pois a tela pressupõe, sempre, um observador externo que possa interpretar suas informações, para que elas possam fazer sentido. Ao defendermos a analogia da experiência visual com a tela de computador, não estaríamos escapando do problema da regressão ao infinito que a hipótese do homúnculo suscita, pois essa tela precisaria ser interpretada por alguém, ser traduzida em uma informação visual e, se esse alguém, novamente, precisasse ser uma tela para traduzir essa informação visual, então continuaríamos indo indefinidamente de tela em tela.

É precisamente para responder a essa objeção que formulo a minha hipótese nos termos que dão nome a esse artigo: a consciência como uma tela *que vê a si mesma*. Em certo sentido, a minha proposta seria a de escapar a regressão ao infinito recorrendo a uma circularidade – não, contudo, aquela da ausência de um fundamento sólido, mas sim de uma autorreferência pela qual a explicação de um processo possa encontrar um fecho apropriado.

Sem dúvida, a tela de um computador, na medida em que é um instrumento projetado para a produção de um output externo, que deve ser processado *por outro sistema que não o próprio computador*, não satisfaz as condições necessárias para explicar o fenômeno da experiência visual consciente. Contudo, para que nossa experiência visual possa ser desse modo explicada, me parece que a única alteração necessária é não mais conceber essa tela como um instrumento de produção de um output visual pura e simplesmente externo, mas sim de um output visual que é retroalimentado para o próprio sistema e é, portanto, simultaneamente, um input visual *para o mesmo sistema que o produziu*. A nossa dificuldade de se imaginar tal sistema, quando se trata de informações visuais, talvez se deva ao fato de não estarmos acostumados a pensar em sistemas nos quais a informação *visual* produzida seja produzida *para o próprio sistema* que o produziu, já que os sistemas que criamos com a finalidade de criar alguma informação visual geralmente produzem essa informação para sistemas externos a eles próprios (quer dizer, nós mesmos) ou meramente traduzem informações visuais para outros tipos de informações, mas não traduzem, *para si mesmos*, outros tipos de informações em informações visuais[3].

Concebendo-se a experiência visual consciente como um sistema em que a informação visual produzida é um output para o *próprio sistema*, parece-nos que superamos algumas das dificuldades envolvidas no problema da descrição da possibilidade da experiência visual consciente e, mais do que isso, no problema da natureza própria da consciência. Pois essa concepção explicaria porque, apesar da cor efetivamente existir na consciência, ela não pode ser vista em nenhum lugar do cérebro: porque a informação visual produzida pelo cérebro não é produzida como um output externo, mas sim como um output *para o próprio cérebro*, como em um circuito em loop, e por isso não é nenhuma informação acessível por qualquer outra entidade senão pelo próprio cérebro[4] – *tal como a consciência em geral o é*. Só poderia acessar essa informação ou o próprio cérebro, ou alguém que se colocasse de alguma forma na posição dele, deslocando, por exemplo, os estímulos que esse cérebro sentiria para o seu próprio cérebro – o que já implicaria, contudo, nesse caso, que a informação só é acessível no interior de um determinado sistema, e não fora dele. Nesse sentido, talvez fosse até melhor descartar de uma vez a analogia com a tela, na medida em que a tela sempre supõe um output para um sistema outro do que aquele da própria tela. E, devido à nossa experiência cotidiana nos levar a associarmos a experiência visual à tela, imaginamos que a experiência visual como um todo pressupõe algum observador externo que não seja o produtor mesmo da informação visual e aquele na qual ele se encontra, mas pura e simplesmente aquele que a recebe de uma outra coisa e já enquanto informação visual. Assim, abandonemos a escada que era a tela e digamos, por fim: a consciência não precisa de tela alguma, não porque não haja cores na consciência, mas sim porque não precisamos de telas para encontrar as cores e, enquanto aquilo que vê a cor, não precisamos que ela exista como uma informação visual em qualquer outra coisa senão *em nossa própria consciência* para que possamos vê-la.

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3 O que dizemos aqui tem um paralelo muito interessante com aquilo que Pessoa (2015) diz em seu artigo sobre a mente enquanto observação do cérebro: “Pode parecer estranha a constatação de que o cérebro (ou uma parte dele) observa a si mesmo, pois temos o hábito de representar o processo de observação a partir do par sujeito-objeto, com os polos deste par sendo mediados por uma relação representada talvez por uma flecha. Quando tentamos tomar o sujeito como sendo o próprio objeto, a flecha sai do sujeito e retorna para ele mesmo, e esse retrato gera problemas conceituais, pois a representação do sujeito teria que representar esta mesma representação, e isso parece ser consistente somente em casos muito restritos.” (PESSOA, 2015, § 6). Contudo, perguntamo-nos se o modelo mais adequado para se pensar uma tal relação do sujeito consigo mesmo seria o de um materialismo redutivista, como parece ser a proposta de Pessoa, ou se a constatação de uma tal possibilidade de “auto-observação” não deveria nos levar necessariamente para uma além desta visão, e talvez para algo mais próximo de Searle (2006) quando este defende que a subjetividade, *enquanto subjetividade*, e não reduzida à objetividade (ou seja, àquilo que comumente se entende por matéria), deve ser entendida como sendo física, real.

4 Ou, para falar de maneira menos generalizante, pelo sistema nele responsável pela percepção visual.

Creativity as niche construction and some examples in theatrical dance

Daniella Aguiar
Graduate Program in Literary Studies
Universidade Federal de Juiz de Fora
Juiz de Fora, Brazil
daniella.aguiar@gmail.com

Pedro Ata
Instituto de Artes e Design
Universidade Federal de Juiz de Fora
Juiz de Fora, Brazil
ata.pedro.1@gmail.com

Joao Queiroz
Instituto de Artes e Design
Universidade Federal de Juiz de Fora
Juiz de Fora, Brazil
queirozj@gmail.com

***Abstract*— Creativity can be regarded as a property of semiotic resource exploration and niche construction. More specifically, and according to this perspective, creativity is distributed, in cognitive niches, as opportunities for niche-construction. Artistic cognitive niches represent established ways to exploit available artistic semiotic resources. When such opportunities are explored so that new relations between cognition and artistic semiotic resources are established (i.e., the artistic cognitive niche is constructed), then creativity is observed. This process of niche construction involves the transformation of problem spaces ("a branching-tree of achievable situations") through the exploration of cognitive artifacts design of new of artifacts (in dance, for example, softwares, techniques, equipments such as dance shoes, stage, dance and music notations). Our approach is supported by specific examples in history. In each of these examples, the introduction of artifacts changed not only how to make dance, but also the very concept of dance, opening opportunities for the exploration of new niches.**

Keywords—creativity; dance; cognitive niche; niche construction.

I. INTRODUCTION

Artistic creativity has often been associated with mysterious, inexplicable, or vaguely formulated concepts such as appeals to “talent or gift”, “subjective expression”, “intuition”, “inspiration” or “geniality”. A common view is that creativity possesses an unaccountable element of subjectivity and cannot be understood [1, 2]. Differently, psychological approaches to creativity have investigated personality and psychological traits, cognitive abilities, emotional dispositions and the relation between "creative individuals" and cultural and social institutions [3]. As Mayer [4] demonstrates, it has been almost a consensus in Creativity Research to ground definitions of creativity in the features of the products of the creative process, typically originality (novelty) and usefulness (value). Boden, for instance, defines creativity as

“the ability to come up with ideas or artefacts that are new, surprising, and valuable. ‘Ideas’, here, includes concepts, poems, musical compositions, scientific theories, cooking recipes, choreography, jokes…and so on, and on. ‘Artefacts’ include paintings, sculpture, steam engines, vacuum cleaners, pottery, origami, penny whistles…and you can name many more” [5].

Despite the centrality of “ideas and artifacts” in this definition, they are regarded as mere products of a mental ability. This type of approach is consistent with internalist paradigms in cognitive science that regard cognition as the processing of internal, discrete and intentional units of information and in which the role of context, situation and external tools is secondary. In opposition to such paradigms, situated cognitive science [6, 7, 8] has questioned the legitimacy of skin and skull to serve as criteria for the demarcation of the boundaries between mind and the world. This approach stresses that the capacities of mind are shaped by non-biological tools for thinking (the most radical example of which is constituted by language) and that decisive stages of cognitive processing can happen externally to the brain [9].

In our approach, “ideas and artifacts” whether internal or external to the brain, are all captured by the notion of semiosis (action of sign), as defined by C.S. Peirce. Peirce's definition of semiosis [see 10] treats it as relational and processual, so that it is distributed in space (it cannot be located neither in the brain nor in the environment alone), and in time (it evolves and develops) [11]. For Peirce, cognition is semiosis, embedded in a dialogical material form, and includes the development and manipulation of artifacts, such as softwares and digital technologies, writing tools, instruments of observation, notational systems, artificial and natural languages, and so forth [12].

Differently from Boden, we approach creativity not as an "ability" of individual minds to produce creative signs ("ideas and artifacts"), but as patterns of semiotic resource activity. As semiosis evolves and develops in time, distributed patterns of semiotic resources give rise to new cognitive capabilities. Resource, in this case, is an epistemic metaphor related to the notion of niche. Semiotic resource is near to the notion of cognitive artifact: Cognitive artifacts are objects made by humans for the purpose of aiding, enhancing, or improving cognition [see 13, 14].

The search for creativity in individual psychological traits has long served as an alternative to the conception that creativity cannot be studied. It gives it a recognizable locus for examination. In this sense, any distributed approach to creativity has the challenge to also offer a locus for the study of creativity. In this work we suggest that creativity is to be found in cognitive niches [15] in the form of opportunities for niche construction through the exploitation of available semiotic resources, which can often be external artifacts. Similar approaches include Magnani [16], Bardone [17]. We give some examples of how the availability of external artifacts has participated in dance cognitive niche construction.

II. CREATIVITY AND NICHE CONSTRUCTION

The notion of niche involves an environment and its resources but is not reducible to them. In ecology, while environment indicates the physical habitat of an organism, niche indicates not only the organism's "address" but its "profession" [18], i.e. its ecological role and way of life, or, in a more modern definition, a niche is an imaginary n-dimensional hypervolume whose axes correspond to several ecological factors decisive for the welfare of the organism [19]. Extending the concept of ecological niche to cognition, the notion of "cognitive niche" stresses the environmental offer of opportunities (and boundaries) for thought as a major process in cognitive evolution. A cognitive niche can be understood as materially extended sets of problem spaces that demand or select a set of cognitive abilities.

A fundamental property of niches is that they are self-constructed: they are not previously existing environmental factors to which organisms adapt, but instead co-evolve with organisms. Niche Construction Theory (NCT) reframes the understanding on evolutionary processes [20]. In classic darwinian evolution the environment unilaterally exert selective pressure on genetically generated and genetically inherited traits. Under the perspective of NCT, environments and organisms mutually influence each other and niches are systems for generating and inheriting traits (especially behavioral) parallel to genetic variation and inheritance. Examples include the construction of dams by beavers which generate an aquatic niche that selects for adaptations fit for this aquatic niche [21] and animal husbandry as basis for selection of lactose tolerance in humans [22]. In cognitive niches, niche construction is related to the co-evolution of cognition and semiotic resources, such as external artifacts and language [23].

Creativity can be regarded as a property of semiotic resource exploration and niche construction. More specifically, and according to this perspective, creativity is distributed, in cognitive niches, as opportunities for niche-construction. In other words, artistic cognitive niches represent established ways to exploit available artistic semiotic resources, but they also embed opportunities for evolution. When such opportunities are explored so that new relations between cognition and artistic semiotic resources are established (i.e., the artistic cognitive niche is constructed), then creativity is observed. This process of niche construction involves the transformation of problem spaces ("a branching-tree of achievable situations", [24]) through the exploration of cognitive artifacts design of new of artifacts (in dance, for example, softwares, techniques, equipments such as dance shoes, stage, dance and music notations). Our approach is supported by specific examples in history. In each of these examples, the introduction of artifacts changed not only how to make dance, but also the very concept of dance, opening opportunities for the exploration of new niches.

III. DANCE AND NICHE CONSTRUCTION

External semiotic resources in dance constrain the dancers' and choreographers' action in different levels [26, 27, 28]. Therefore, it must be possible to analyse the coercions of the niches over an aesthetic program development and over the creation/composition of specific dance works. In this section we approach how this constraining is related to the cognitive niches in theatrical dance. Codified dance techniques, presentation spaces, conceptual ideas about composition, and many other resources, function as boundaries for creating choreographic pieces. When new resources are introduced new niches can be constructed, inaugurating new artistic paradigms. Below we briefly introduce some examples that constitute dance niches, and indicate some semiotic resources that contribute to their construction.

A. Classical ballet

What is today known as classical ballet is related to the construction of a dance niche, which involved the production and introduction of novel artifacts, such as the changes in the relative position of the observer originated by Renaissance exploration of one-point perspective. Before the use of theaters based on Jean Battista Alberti's perspective (Fig. 1), dance pieces were watched in great halls either from the same level as the dancers or from higher positions, what contributed to the exploration of geometric patterns of dancers displacement in the space floor. The alteration of the place of presentation has lead to preference for more vertical morphologies of movements, strategies that emphasize the frontality of choreography such as en dehors and pirouette, one-point perspective scenery paintings, hierarchical occupation of stage which values the center, among others. As a cumulative process, the preference for verticality has lead to the introduction of point dance shoes, which participated in the evolution of a new aesthetic landscape in which the dancer became an "ethereal figure". For Smith, one-point perspective lead to a "heavy visualism" in different art forms:

"Beyond its political implications, ballet was lodged firmly in the eye: mirrors were critical to bodily training, performers went to lengths to minimize the sound of their steps and breathing, bestowing at once a silent and hyper-visual quality on the performance, and performers aimed to look similar" [29].

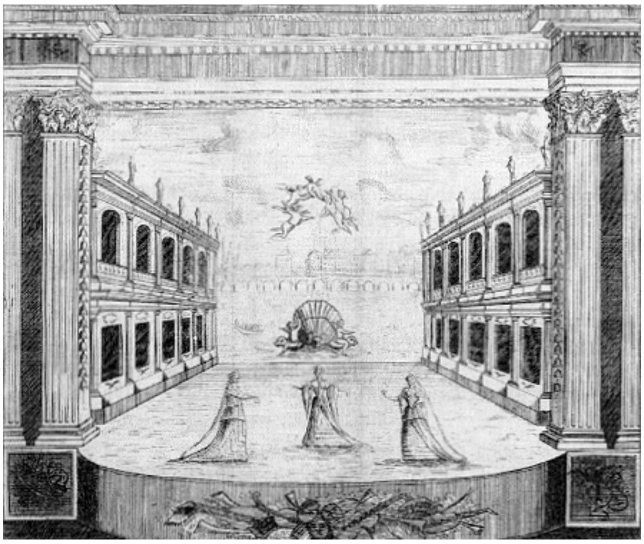

Fig. 1: Renaissance theater.

B. Merce Cunningham

The innovations of Merce Cunningham are related, among other things, to the exploration of chance procedures (such as coin-tossing, or the I-Ching, the Chinese book of changes) as a methodology for choreography creation. The operation of coin-tossing, in special, can be regarded as a form of proto-computing binary artifact to create and explore new syntactical problems in dance [see 30]. The use of chance operations impact dance in several ways: the sequences of performer's actions are changed, creating unusual dance syntax and forcing dancers to acquire new skills and reorganize motor coordination; the hierarchical structure of space is reframed, as well as the nature of observer positions; the relations between music and dance are reconceived so that a "non-representational" character of dance is stressed, i.e. dance as body movement dissociated from anything else.

C. Postmodern dance

Postmodern dance, a movement of the beginning of the 1960's in New York, is another example of a paradigm change in dance. In response to modern dance and also to Merce Cunningham, a new niche arised based on the exploration of everyday objects and locations, ordinary rules of action and patterns of motor behavior as dance artifacts. Simone Forti, for example, presented "Five dance constructions and some other things" (1961) (Fig. 2) at Yoko Ono's loft, where several artifacts, as a ramp, boxes, see-saw and verbal instructions were introduced to drive the performance [31]. In this example, there is the introduction of available semiotic resources. A see-saw, for example, is a very well known child playground artifact. When it is used in dance to create movement new possibilities to the performance are opened. In this new dance niche, pedestrian movements can be part of a dance performance, thus conventional dance techniques are not what constitute a choreography anymore.

Fig. 2: "Five dance constructions and some other things" by Simoni Forti

In the table below (Table 1), we summarize the dance paradigms, their new semiotic resources and the innovations related to them:

Table 1. A Summary of the niche construction examples discussed above.

Dance Paradigms	**Semiotic resources**	**Innovations**
Classical ballet	- One point perspective - Point dance shoes	- alteration of the observer position, hierarchical - occupation of stage which values the center, - strategies to deal with the frontality of the choreography, - vertical morphology of movements
Merce Cunningham	- proto-computing binary artifact inspired by I-Ching	- chance operations as a methodology for choreographic creation
Postmodern dance	- everyday objects and locations - ordinary rules of action and patterns fo motor behavior	- dance codified techniques are not essential to dance creation - vocabulary of body movements can be created for each artistic project - dance can be performed in any space (art galleries, roofs, walls, streets)

IV. DISCUSSION

Cognitive science has difficulty dealing with creative dimensions of cognition, particularly under the information processing paradigm and its computational strategy of approaching a complex phenomenon by breaking it into gradually simpler sub-tasks. Differently, creativity has been treated as an irreducible experience by aestheticians, anthropologists, art scholars and artists themselves, often however suffering from lack of systematicity and referring to non-operational mysterious notions. Artistic creativity, in particular, has often been regarded as a deeply subjective and personal phenomenon that cannot be properly explained. In our approach, creativity is causally distributed in space in time. It is not to be found neither in a given entity (such as a "creative person") nor in a given point in time (such as a "moment of insight"). The term "creative artist" takes the meaning of someone who participates in a semiotic process of niche construction, and not the other way around (i.e., the creative artistic process as something inherent to a creative artist). Individual features such mental abilities or psychological traits, as well as expertise and training, influence the creative artistic process in the sense that they contribute or not to the exploration of opportunities for cognitive artistic niche construction. However, they are not viewed as the locus of creativity.

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Proprioceptive-visual integration and situated embodied cognition:

a developmental perspective

EDISON DE J. MANOEL

Grupo de Estudos do Desenvolvimento da Ação e Intervenção Motor – Escola de Educação Física e Esporte
Universidade de São Paulo, São Paulo, Brasil
ejmanoel@usp.br

PEDRO FERNANDO VIANA FELICIO

Grupo de Estudos do Desenvolvimento da Ação e Intervenção Motor – Escola de Educação Física e Esporte
Universidade de São Paulo, São Paulo, Brasil
brpedrofernando@ig.com.br

ROBERTO GIMENEZ

Grupo de Estudos do Comportamento Motor – Universidade Cidade de São Paulo, São Paulo, Brasil
roberto.gimenez@unicid.edu.br

CRISTIANE MAKIDA

Grupo de Estudos do Comportamento Motor – Universidade Cidade de São Paulo , Brasil
cristiane.makida@gmail.com

RAFAEL DO NASCIMENTO SOARES

Grupo de Estudos do Comportamento Motor – Universidade Cidade de São Paulo , São Paulo, Brasil

ALESSANDRO DE FREITAS

Grupo de Estudos do Comportamento Motor – Universidade Cidade de São Paulo, São Paulo, Brasil
ale.educacaofisica@uninove.br

Abstract—**Knowledge and sensory-motor integration are related in situated embodied cognition. In the present paper, we investigated whether the transition between egocentric and decentred mode of thinking are associated to the development of intra-sensory and inter-sensory integration. Thirty six children with ages between 5, 7 and 9 years performed a paramedian correspondence task with conditions requiring inter-sensory integration (visual-proprioceptive) and a problem solving task. Using a mirror perturbed the sensory judgments in the paramedian correspondence taks. The results did not corroborate the thesis presented, nevertheless the increasing importance of proprioception in the perceptual judgments for older children suggests that although younger children maybe body centred (egocentric mode of thinking), older children seemed more able to use body to mediate their perceptual judgements.**

Keywords—proprioception, embodied cognition, development

I. INTRODUCTION

From a developmental point of view, there are at least three possibilities to account for situated embodied cognition (cf. Overton, Müller & Newman, 2007): (a) embodied knowledge underlies symbolic knowledge; (b) symbolic knowledge emerges from embodied knowledge; (c) knowledge is bodily grounded. For the present paper the second alternative will be considered. The notion that symbolic knowledge grows out of embodied cognition dates back to Jean Piaget and his notion that knowledge about something implies acting upon it (Piaget, 1982). Symbolic knowledge would depend upon sensory-motor transformations (Spencer & Schönner, 2003) making with that knowing and doing are complementary setting the ground for reasoning, memory, language, among other aspects of mental life. Hence to say that cognition is embodied and situated is to say that it emerges from the bodily interactions with the world in a self-organising manner (Felicio & Manoel, 2014). Cognition emerges from sensory-motor transformations depending upon the kind of experiences one has because of having a body with unique perceptual and motor capacities linked in a perception-action coupling (Thelen et al., 2001).

Knowledge and sensory-motor integration are related both in philosophical terms (the basis for empiricism) and also in biological and psychological terms (the very essence of situated embodied cognition). Sensory-motor integration has been investigated over the last hundred years simply because the organisation and control of actions depends on the sensory-motor coordination. One such coordination of particular interest for actions is that involving proprioception and vision. Proprioception refers in general to the sense of position and movement of one body part; many body parts and the body as whole (cf. Lent, 2001; Sugden, 1990). Vision consists of the identification of quite a number of features in the world that reflects or emits light such as spatial location of a given object, light intensity, form discrimination, detection of moving things and colour vision (Lent, 2001). The definition of both senses is oriented to the source of information one has to sense, light outside the body in the case of vision, and the own body in the proprioception. In fact, both are dependent of a body and are interdependent (for instance, some authors speak of visual proprioception). The exchanges between vision and proprioception are seen as crucial for the development of perception and action (Jones, 1982; Gibson & Pick, 2000).

Although, the development of intersensory integration has been studied on its own, this process needs to be considered in regard to situated embodied cognition. In this sense, it is interesting to consider a transition Piaget (1982) pointed out between two modes of thinking during infancy and early childhood: the egocentric and self-centred mode to non-egocentric and decentred mode. The self-centred mode corresponds to the preoperational stage and is typical of children around seven years old or less. The decentred mode is typical for children older than seven years who are entering the operational concrete stage and then formal operational stage.

The thesis and hypotheses the present paper intended to address were:

The cognitive development expressed by the transition between self-centred to decentred may be a rate limiting factor in the development of visual-proprioception integration.

Children with ages between five and seven years will base their perceptual judgments biased by proprioception since this is the sense which is egocentric.

Children older than seven years will show a more balanced judgement with the visual-proprioception integration.

II. EXPERIMENT

The goal was to investigate the acuity of vision and proprioception and their integration in a spatial location task when a source of disturbance is introduced in the children's egocentric space by means of a visual illusion. The experiment took into consideration two aspects: (a) age as factor related to the modes of thinking, self-centred (five and seven year old children) and decentred (nine year old children), which would in turn bias perceptual judgements; (b) active vs. passive movement in the spatial location task[1].

The investigation on visual-proprioception integration has been conducted with tasks that involve manual coincident spatial location. The subject task is to reach and grasp one small dowel flush with a plate with one hand and reproduce the same location on the other side of the plate by the other hand placing another dowel. Conditions vary in regard to which sensory modality has the access to the target (visual, proprioception or both). The reproduction of the target is also manipulated by visual occlusion (making the response based only on proprioception) or not. The investigation using this experimental paradigm (von Hofsten & Rosblad,1988; Wann, 1991) have shown that the judgment errors can be fairly described by the following equation:

P-P>V-P>VP-P, where > means "more inaccurate than", P refers to proprioception and V to visual.

In this equation P-P and V-V involved intra-sensory judgments, and V-P and P-V refer to inter-sensory judgments. The first letter, V or P, indicates how the target was located. In the P-P condition, the subject has to reach and locate the target without vision and once it has been grasped, the subject locates the dowel with other hand as better as he can in regard to the target without visual information. In the V-P condition the subject sees the target on one side of the plate but do not touch it and reproduces its location with the dowel on the other side without vision. The VP-P is variant of V-P the difference being that the target located visually and manually. In the present experiment we have reproduced these conditions but we also added more. We have stressed the importance of active movements in comparison to passive movements. Hence, we had a condition where the target is located with actively - the subject sees the target and goes on to grasp it (Va), or the subject without vision locates the target by manually exploring the plate (Pa) – and one in which the target is located passively – the subject only looks at the target (Vp), or has his hand taken by the experimenter to the target (Pp). What is totally new in this kind of paradigm is the use of a mirror to distort the perception of the spatial location. The use of mirrors to distort perceptual judgments has been done quite a lot in the past (cf. Held & Hein, 1962; Howard, 1982), the novelty here is to use the mirror as the source for the subject to identify the target location on one side of the plate and to reproduce the position on the other side. Our hypothesis in this particular case was that nine-year-old children (more likely to show a decentred mode of thinking) would deal better with the perceptual distortion because they could decentres their thought from the body and assume another frame of reference. By the same token, five and seven-year-old children would be more perturbed because the illusion would confront their body information. Since these children are very likely to be cognitive egocentric this perturbation of body perception might lead to a quite loss of performance.

Method

A- Participants

Thirty six children took part in the study divided in three groups, G5, n= 12, mean age of 72 months; G7, n= 12, mean age of 84,5 months; G9, n= 12, mean age of 122,9. They all came from two local public school, next to each other, from a district, Parque Novo Mundo, East zone of the city of São Paulo. All parents were informed about the research by the experimenter, read and agreed with a formal consent to let

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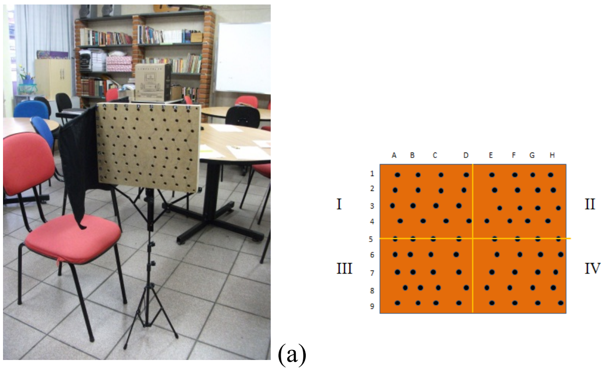
[1] It has long been shown that active movements lead to better perceptual judgments due to the comparisons between efferent copy and corollary discharge and sensory information resulting from the movements (Paillard & Brouchon, 1968).

their children to take part. Each child was also free to leave the investigation at its own will.

B- Apparatus, experimental task, cognitive assessment and procedures

The apparatus called paramedian correspondence was specially designed for the present study (Figure 1a). Its main body is wooden plate supported by steel adjustable bar. On each side of the plate there was a curtain used for visual occlusion when necessary. Each side of the plate had 72 spatially coincident holes in which the dowels could be inserted. For the purpose of establishing the conditions the plate was divided in four quadrants and it position was labelled by a coordinates, letters on the horizontal axis and numbers in the vertical axis (Figure 1b).



(a) (b)

Figure 1. (a) Paramedian correspondence apparatus; (b) Schematic representation of the holes by coordinates an quadrants.

The experimental setting is depicted in Figure 2. The mirror was inclined about 40 degrees to allow the child to have full view of each side of the wooden plate when looking just over the curtains.

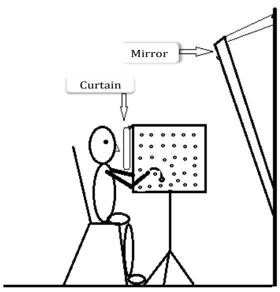


Figure 2. Experimental setting

To assess the children's mode of thinking a problem was presented before the beginning of the actual experiment. The problem was proposed in a kind of symbolic play: the child was said to own a boat in which he or she had to use to take three things from one side of a river to the other. The things to be carried to the other side of the river were a wolf, a sheep and a pile of grass. The rule of the game was to carry only one thing in the boat per trip. The experimenter also gave one advise stressing that wolf and sheep could not be let alone or the wolf would eat the sheep, and the sheep could not be let with the pile of grass, otherwise the sheep would also eat it. There was actually a blue cartoon representing the river, a toy boat and small wolf and sheep toys and a pile of grass made of paper. Hence the child could manipulate the object concretely. If the child broke the rules and overlook advises the experimenter would give feedback and start the task again up to three times. The scoring of the task had three alternatives for each child: (1) Yes – the child solves the problem showing a decentred mode of thinking; (2) Yes with feedback – the child shows a mode of thinking in transition to the decentred mode of thinking; (3) No – the child did not solve the problem after three trials and shows an egocentric mode of thinking.

C- Design and statistical analysis

There were six conditions for the spatial matching task:

Condition	Stimulus presentation	Matching response
1. Visual/passive-Proprioceptive Vp-P	The child looks at the dowel by the mirror on one side without touching it	The child tries to match the position placing the dowel to the other side without vision
2. Visual/active-Proprioceptive Va-P	The child looks at the dowel by the mirror on one side, reaches, grasps and holds it	The child tries to match the position placing the dowel to the other side without vision
3. Proprioceptive/ passive –Visual Pp-V	Without vision, the child has its hand taken to the target by the experimenter	The child tries to match the position placing the dowel to the other side with vision by the mirror
4. Proprioceptive/ active-Visual Pa-V	Without vision, the child searches for the target and then grasps and hold it.	The child tries to match the position placing the dowel to the other side with vision by the mirror
5. Visual/passive-Visual Vp-V	The child looks at the dowel by the mirror on one side without touching it	The child tries to match the position placing the dowel to the other side with vision by the mirror
6. Visual/active-Visual Va-V	The child looks at the dowel by the mirror on one side, reaches, grasps and holds it	The child tries to match the position placing the dowel to the other side with vision by the mirror

The order of conditions was balanced among the subjects to minimise the order effect. The correspondence paramedial apparatus provides two kinds of results: (a) hit, the child placed the dowel in the corresponding spot of the target; (b) error, the child placed the dowel in a spot different to the corresponding target. From these two kinds of results, we calculated: (1) number of overall errors for each condition; (2) number of adjacent and non- adjacent errors. This second kind of error indicates whether the child mistook the target by one cell in either position (adjacent) or by two or more cell away from the target position (non-adjacent). Considering the design we conducted a Two Way ANOVA, G(3) x Conditions (8) with repeated measures on these three measures: overall error, adjacent error and non-adjacent.

III. RESULTS AND DISCUSSION

The effect of the visual illusion caused by looking at the mirror is quite evident for Condition Vp-P for all groups (Figure 3). A similar effect was also observed for Condition Vp-V mostly for the younger children (G5 and G7).

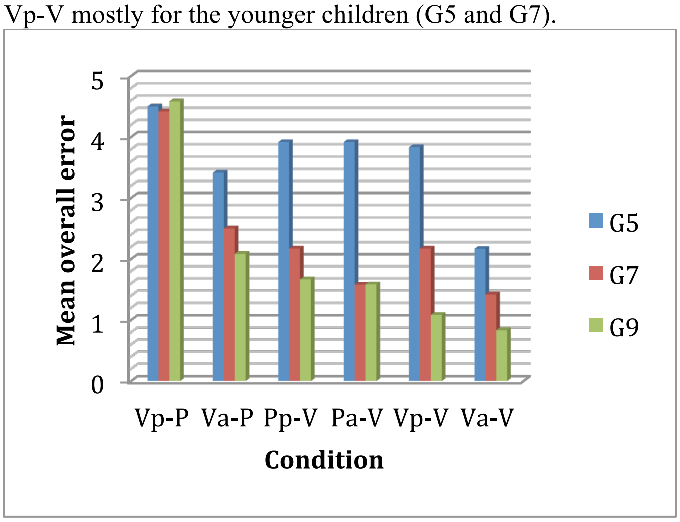


Figure 3 . Mean overall error in each condition for groups G5, G7, and G9.

The conduction of a Two-Way ANOVA G(3) X C(6) for the mean overall error indicated an interaction, $F_{10,56}$= 2.727, p=.008, η_2=.327. The description of adjacent error (Figure 4) indicates that it contributed less to the overall error, i.e. errors in the present experiment were of greater magnitude for all groups. This is corroborated greater quantity of non-adjacent errors (Figure 5).

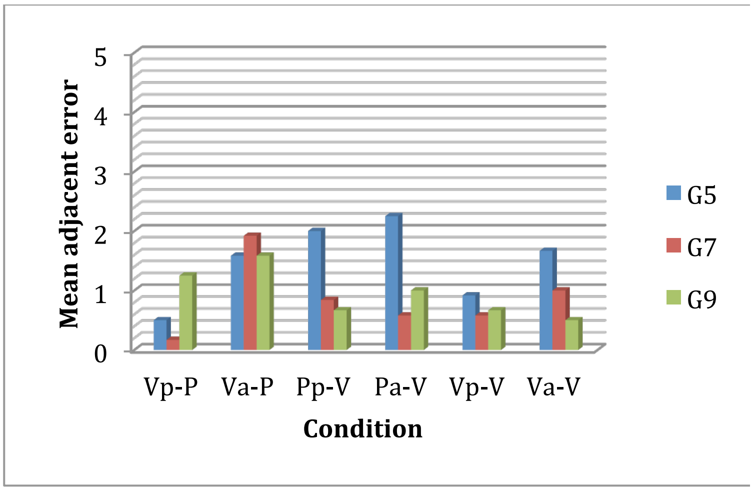


Figure 4. Mean adjacent error in each condition for each group G5, G7, and G9.

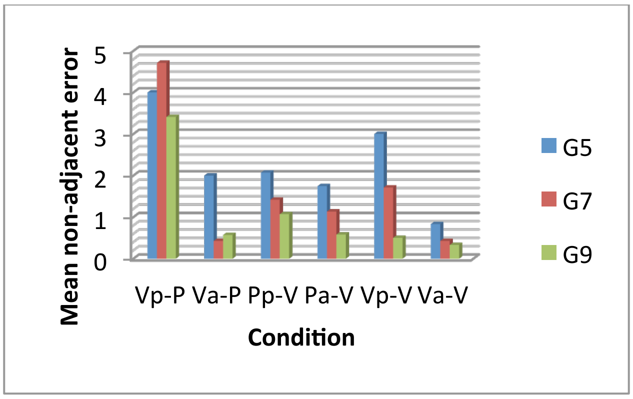


Figure 5. Mean non-adjacent error in each condition for each group G5, G7, and G9.

The five-year-old children are the most affected by the visual illusion and we suggest that this might be related to their egocentric mode of thinking as this mode is expected to be predominant among this group. The Two-Way ANOVA G(3) X C(6) for the mean overall error indicated an interaction, $F_{10,56}$= 4.511, p=.000, η_2=.446. In the problem solving task children in G5 showed predominantly an egocentric mode of thinking (Figure 6). In fact this task proved to be very difficult for all children as can be seen in the mentioned figure.

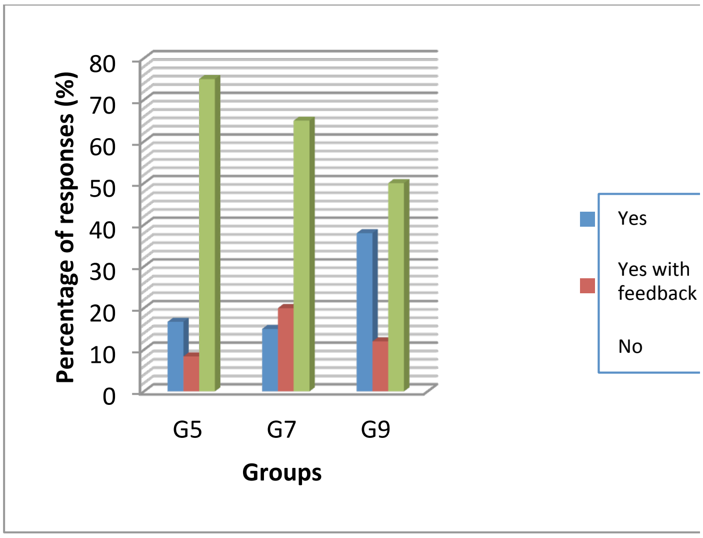


Figure 6. Percentage of responses per category: Yes – decentred mode of thinking; Yes with feedback – transition to decentred mode of thinking; No – egocentric mode of thinking.

Overall, the illusion created by the mirror led to greater disruption of the younger children's performance. Judging by these results we can present a new equation for intersensory judgments taking into consideration the performance of nine-year-old children:

Vp-P>Va-P> Pp-V>Pa-V>Vp-V>Va-V, where > indicates "more inaccurate than".

This equation just about describes the performance of the five- and seven-year-old children as well. They were more inaccurate in the conditions Vp-P e Pp-V, whilst their best performance was condition Va-V.

Younger children maybe "body centred" but nine-year-old children seemed to be more accurate to use their bodies to mediate sensory integration. In this sense the present results does not comply with our thesis. Nevertheless, it shows that proprioception increases in relevance for intersensory judgments. Younger children relied more on visual information than we deduced from the thesis presented. This might explain their difficulty to deal with the distortion of visual information that played with their proprioception as well.

Ernst (2008) points out that there is a mismatch between intra-sensory discrimination and inter-sensory integration. Van Beers, Sittig & van der Gon (1999) proposed a model to tackle both processes (intra-sensory and inter-sensory) called *Optimal Integration Model*. It argues that the Central Nervous System uses all sensory information available for *weighing and re-weighing* each information to decrease uncertainty associated multisensory stimuli. Ernst & Banks (2002) stated that sensory integration relies upon redundant sensory information in a statistical way. When there is a conflict between vision and proprioception there is a trend to rely on visual information for children from two years of age to five years (cf. Shummway-Cook & Woollacott, 1985; von Hofsten & Rosblad, 1988). Proprioception began to be privileged from seven years onwards (King et al. 2010; Gori et al. 2008).

In spite of the data presented here did not comply as deduced by thesis, we can say the results might contribute to a view where embodied cognition makes with which to know is to be embedded into the context and grounded by the body (Robbins & Aydede, 2009; Thompson & Varela, 2001). The results reported here indicates that the conflict between information sources, what is seen and what is felt, led older children to rely more on their proprioception. King et al. (2010) found results similar to the ones found here for children with 10 to 13 years of age. At the same time, van Beers, Wolpert & Haggard (2002) have shown that adults in conflict situation between vision and proprioception, will be resolved by resorting to proprioception information. Jola, Davids & Haggard (2011) have found that adult ballet dancers showed better sensory integration relying upon on proprioceptive information in comparison with non-dancers.

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Society semantics as the logic of quasi-truth

Luiz Henrique da Cruz Silvestrini
Department of Mathematics, School of Sciences
São Paulo State University, UNESP
Bauru campus, Brazil
silvestrini@fc.unesp.br

Abstract — In this presentation we investigate the theory of the society semantics, in particular the paraconsistent logic, a sort of three-valued logic as introduced by A. M. Sette in 1973, obtained from the open societies, in order to formalize the notion of quasi-truth introduced by da Costa and collaborators in 1986.

Keywords — paraconsistent logic; society semantics; quasi-truth; multiple-valued logics.

I. Introduction

The Society Semantics is a type of logical construction, which was introduced in 1999 by Carnielli and Lima-Marques [1] and it allows obtain new logics from the combination of the agents, i.e., the evaluations of a previously established logic. This approach is situated in a relatively new area of study within the logic, which studies combinations between different logical systems.

The view of the combinations of semantics and non-classical logics allows us to solve some problems present in the "state of the art" of research in logic, such as Artificial Intelligence and Belief Revision.

This proposal was the initial motivation to study the processing of information obtained from observations made by "classical" agents, but where the outcome of such a process could not have classic features, such as the rejection of the principle of excluded middle or rejection of the principle of non-contradiction, without this negation trivialize the calculus obtained (Paraconsistent Society).

In this context, we intend to define the concept of quasi-truth by da Costa through a paraconsistent logic obtained from society semantics.

We intend to investigate the theory of the society semantics, in particular the paraconsistent logic, a sort of three-valued logic as introduced by Sette [4], obtained from the open societies, in order to formalize the notion of quasi-truth introduced by da Costa and collaborators [3].

Thus, this is a work in progress and we intend to provide a formal treatment for a type of society semantics, and show that the formalization of the notion of quasi-truth through an open Society contemplates the notion of pragmatic satisfaction.

II. Society Semantics

In certain cases, inconsistency may even be desirable and useful. We can use society semantics to give an interesting new approach to the question of handling inconsistent knowledge. Society semantics are a particular case of the possible-translations semantics (cf. [1]).

Let *CPC* be the Classical Propositional Calculus. A *classical agent*, or bivalued, is a classical valuation $Ag: L \rightarrow \{f, T\}$ defined in the language L of the *CPC*. A *society of the classical agents* is a non-empty set S of the classical agents.

III. Quasi-truth

Newton Da Costa and his collaborators (cf. [3]) have introduced the notion of *quasi-truth* by means of *partial structures*. The notion of predicates as triples is extended recursively to any complex (i.e., non-atomic) formula of the first-order object language (cf. [2]). Thus, the interpretation of any formula φ in a partial structure $\mathfrak{A}$ inductively originates a triple $(\varphi_+^{\mathfrak{A}}, \varphi_-^{\mathfrak{A}}, \varphi_u^{\mathfrak{A}})$, generalizing da Costa's approach to atomic formulas.

IV. Partial Results

Carnielli and Lima-Marques [1] have proved a result that determines the equivalence between open societies and the P^1 logic. From this, we establish a possibility of formalizing a sort of society semantics, and we obtain the formalization of the notion of quasi-truth by means of an open biassertive society, for conflicting information contexts, hence providing a new approach for the notion of pragmatic satisfaction. Therefore, we can consider P^1 as the logic of quasi-truth.

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Self-organization and circular causality: where are we going with neo-mechanicism?

Mariana Matulovic
Philosophy Department, Faculty of Philosophy and Science, FFC/UNESP, Marília, Brazil
marianamatulovic@gmail.com

Maria Eunice Quilici Gonzalez
Philosophy Department, Faculty of Philosophy and Science, FFC/UNESP, Marília, Brazil
gonzalezquilici@gmail.com

***Abstract*—** In this paper, we investigate the role of self-organization processes in the dynamics of complex systems. Our investigation is grounded on the four principles of adaptive information processing in decentralized systems, proposed by Mitchell [2] and summarized here as: i) Global informational patterns are encoded over the system's components; ii) randomness and probability are essential to the dynamics of systems with a relatively small number of components, enabling exploration of different connection possibilities; iii) complex systems often carry out a fine-grained parallel search for possibilities; iv) the systems express continuous bottom-up and top-down systemic interactions. It is argued that a common characteristic of these four principles is the presence of feedback mechanisms applied to self-organization processes in systems that deal with situated and embodied information. In this kind of system, order parameters might emerge (at the macroscopic level) from spontaneous interactions established among elements at the microscopic level [1]. According to Haken [1], when order parameters emerge, they enslave the behavior of the elements that gave them origin, in a kind of circular causality. Our goal in this work is to provide evidence to support the hypothesis that the development of self-organized systems grounded on feedback mechanisms (expressed as circular causality) might bring about a type of neo-mechanism. When operating in accordance with the four principles of adaptive information processing proposed by Mitchell, such neo-mechanism could cause unpredictable outcomes in the physical, biological, and social spheres of life.

***Keywords*: Neo-mechanicism; feedback; circular causality; complex systems; information processes; self-organization.**

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A non-linguistic analysis of information:

the possibility of other forms of expression of thoughts

Amanda Veloso Garcia
Departamento de Filosofia
Universidade Estadual Paulista, UNESP
Marília, Brazil
amanda.hipotenusa@gmail.com

***Abstract*— With the advent of science and technology, the relation of a large portion of human beings with each other and the world has changed significantly. Increasingly specific exams and treatments for diseases, the possibility of communication through image and sound at any time with people from different locations, the use of the Internet for different everyday tasks, including banking, etc., have made our relations more "fast". On the other hand, the Internet has made globalization possible for the subjects of industrialized societies (those who have access to the internet and technological resources), allowing knowledge and experience of different cultures of the world. This leads to estrangement from the other and a questioning of oneself through the drawing of comparisons with other habits and practices. Expanding this viewpoint, made possible by information technology, requires a different view of the world, since it involves indirect contact between people. Questions like "Is my culture actually the best existing one?", or the adoption of the local habits of a different culture, have become commonplace today. In a world where borders are becoming less rigid, a new look is necessary. The great diversity of habits with which we have contact every day requires us to consider various points of view for thinking about current problems. Thus a view through the paradigm of complexity looks promising and convenient at present. The paradigm of complexity provides a view of the world through different methodological and epistemological perspectives for understanding a phenomenon. Starting from the need to expand this view, the aim of this paper is to discuss the relation between the study of the thought and the presence of oral/written language as parameter for thinking. During the twentieth century there was a paradigmatic revolution in philosophy, which was later called the "linguistic turn". This paradigm shift was made through an overvaluation of language, understanding it as the center of discussion. In other words, with the linguistic turn, oral/written language came to be seen as capable of solving philosophical problems, so that the task of philosophy would be to clarify language. From this perspective, several problems were seen as pseudo-problems due only to difficulties in the use of language. The linguistic paradigm spurred a series of debates about thought and intelligence, and researchers are busy trying to simulate human mental processes in machines in order to find out what is the mind. Such studies make use of linguistic rules for simulation and linguistic expression as a criterion for evaluation of the tasks performed by machines. This study intends to discuss the limits and possibilities of linking thought to language, in order to analyze other forms of expression of thoughts. The linguistic paradigm generates consequences for what we mean by "thought", excluding other ways of thinking which include some indigenous and Oriental thought. In this work, we will try to discuss the potential of thought expression in other forms such as painting and gesture.

Keywords— thought; language; complexity.

Dynamics of Subjective Contrast in Sequential Comparison of Gabor Patches

Bruno J. M. de Camargo
Universidade Federal do ABC, UFABC
Santo André - SP
bruno.camargo@aluno.ufabc.edu.br

Peter M. E. Claessens
Centro de Matemática Computação e Cognição
Universidade Federal do ABC, UFABC
São Bernardo do Campo - SP
peter.claessens@ufabc.edu.br

Abstract— **In a comparison of two asynchronous and spatially-separated luminous disks, the second stimulus has a tendency to be evaluated lighter against a dark background and darker against a lighter background, suggesting a temporal context effect to the perceived contrast rather than on luminosity. The current study confirms this hypothesis by direct evaluation of contrast comparison of Gabor patches, stimuli that have intrinsic contrast.**

Keywords— contrast perception, temporal context effect, Gabor patch

I. INTRODUCTION

Luminosity and contrast are physically measurable variables; their perception, however, is subjective and can be modulated by events nearby in space and time. As isolated stimuli, lights or luminous dots have already for over a century been known to be subject to near-threshold energy summation (Bloch's law), and to a biphasic response as a function of duration [1][2]. Flicker modulates brightness as a function of flicker frequency [3]. When presented in pairs, luminance stimuli reveal interactions through mutual suppression or facilitation, some of which are mediated by attentional mechanisms [4]. In their proposal of an experimental method to systematically measure and model spatiotemporal dynamics, Wyble and Swan [5] list attentional blink and dwell time, sparing in rapid serial visual presentation, competitive interference, localized attentional interference and temporal order errors as instances of stimulus interactions hypothetically related to attentional dynamics. Visual masking is another label often used in the context of spatiotemporal dynamics of pairs of stimuli. Masking is multifaceted, and a description rather than a causal mechanism for luminance interaction [6].

When the order of presentation of two stimuli influences their appearance, the resulting phenomenon is generically called a temporal order effect, one instance of which is called a temporal context effect by Eagleman, Jacobson, and Sejnowski [7]. In some textbooks on psychophysics and signal detection theory (e.g. Macmillan and Creelman [8]) temporal order effects in two-interval forced choice designs are dismissed as a type of response bias; while in some circumstances this might be the case, evidently they might result from genuinely sensory interactions between the stimuli presented. In the psychophysics literature on discrimination threshold estimation, many experimental designs are variations of two-alternative forced choice procedures in which a recurring standard stimulus is to be compared with a varying comparison stimulus (e.g. see the analysis of Raviv, Lieder, Loewenstein, and Ahissar, 2014 [9]). Repetition of a standard stimulus introduces the possibility of memory representation or prior expectation to influence judgment, and it is unclear if performance represents recognition of the standard stimulus or pure discrimination.

In the current line of research, we do not use a repeated standard stimulus to force the observer to rely on comparison. The task for the observer is, in this case, to indicate the stimulus with the higher or the lower magnitude of the pair rather than to indicate the interval of the reference or non-reference stimulus. The spatiotemporal dynamics are investigated in a design in which stimuli are both temporally and spatially separated. In this design, rather than inquiring whether the first or second stimulus presented is of the largest (or smallest, see below) magnitude, which due to misjudged order would be noisy when small stimulus onset asynchronies (SOAs) are used, observers indicate whether the stimulus with the largest magnitude occurred at the left or right side.

One other design manipulation is in order. Supposing one would find that, when observers are asked to indicate the highest-magnitude stimulus, they favor the second interval, would that show that the second stimulus has subjectively a higher intensity? It would not: observe that a pattern of results would be compatible with a perceptual boost for the second stimulus of the pair as well as with a response-level bias to select the most recently presented alternative in doubt. In order to separate order-based response bias from perceptual effects in magnitude discrimination, it is necessary to apply a crossed design in which observers are to indicate either the stimulus with the highest or with the lowest intensity, preferably in a blocked fashion, or in separate sessions, so as to avoid confusing the participant.

Claessens, Pereira Oliveira and Baldo [10] used exactly this design, combining spatial and temporal separation with

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response categories that alternated across sessions, to evaluate spatiotemporal dynamics in luminance perception in a discrimination task. Participants were to indicate, upon presentation of pairs of luminous disks of varying luminance, one on each side of vertical midline of the screen, at which side either the brighter or the darker stimulus had appeared. As the target was relative to the other stimulus in the pair, there was no reference/standard stimulus. Spatial order (left-right or right-left) and luminance order (brightest first or brightest last) were counterbalanced and crossed. Upon finding that, against a dark background, proportion correct responses were compatible with a subjective boost for the second stimulus, the experiment was replicated using positive and negative stimulus contrast, that is, with a CRT screen background that was black in some sessions and white in other, for grey luminance dots. The additional manipulation was motivated by the need to identify whether the order effect was due to luminance-level modulation (as the temporal context effect of Eagleman, Jacobson and Sejnowski [7]) or contrast-level modulation. The authors found that, in comparison with the objectively correct reply, the second of a pair of disks separated by a small time interval tends to be evaluated as lighter against a dark background, and darker against a light background. This combination suggests that the temporal context induces an illusory effect at the level of contrast. The effect reaches its peak near a stimulus onset asynchrony (SOA) of 100ms.

The present study aims to address the possibility of a modulation of subjective contrast directly. Rather than requiring the judgment of relative luminance of two luminous disks, the current experiment uses relative contrast judgment of odd-symmetric Gabor patches, spatial patterns with an intrinsic contrast but average luminance equal to the background.

II. Methodology

A. Participants

Thirteen students, one of which the first author of this manuscript, completed both sessions of the experiment. They reported normal or corrected-to-normal vision. All participants singed an informed consent declaration before starting the experiment. The procedure was approved by the Ethical Committee of the Universidade Federal do ABC.

B. Apparatus and Stimuli

The code to run the experiment was written in Python 2.7 using PsychoPy libraries (version 1.82.01) [11]. The experiment was running on a Windows 7 PC, with stimuli presented on a 17-inch cathode ray tube (CRT) monitor placed at 57 cm from the participant. The screen resolution was set to 1024×768 pixels at a 85 Hz vertical refresh rate.

During the entire experiment a gray background with 30 cd/m² was used. Pixel RGB values were chosen to reflect linear luminance. The correction was based on photometric measurements of the screen with a Konica Minolta LS-110 luminance meter. A color bit stealing strategy was used to increase the resolution from 8 to approximately 10.8 bits. Each trial started with a 1000 ms blank screen (Fig. 1). A red fixation cross was shown in the center of the screen during a minimal time of 500 ms and an additional duration randomly drawn from an exponential distribution with mean of 500 ms. In practice, this means that, after the first 500 ms, any new frame might contain the first stimulus with equal probability, thus maximizing temporal uncertainty. The fixation cross was visible until the end of the trial.

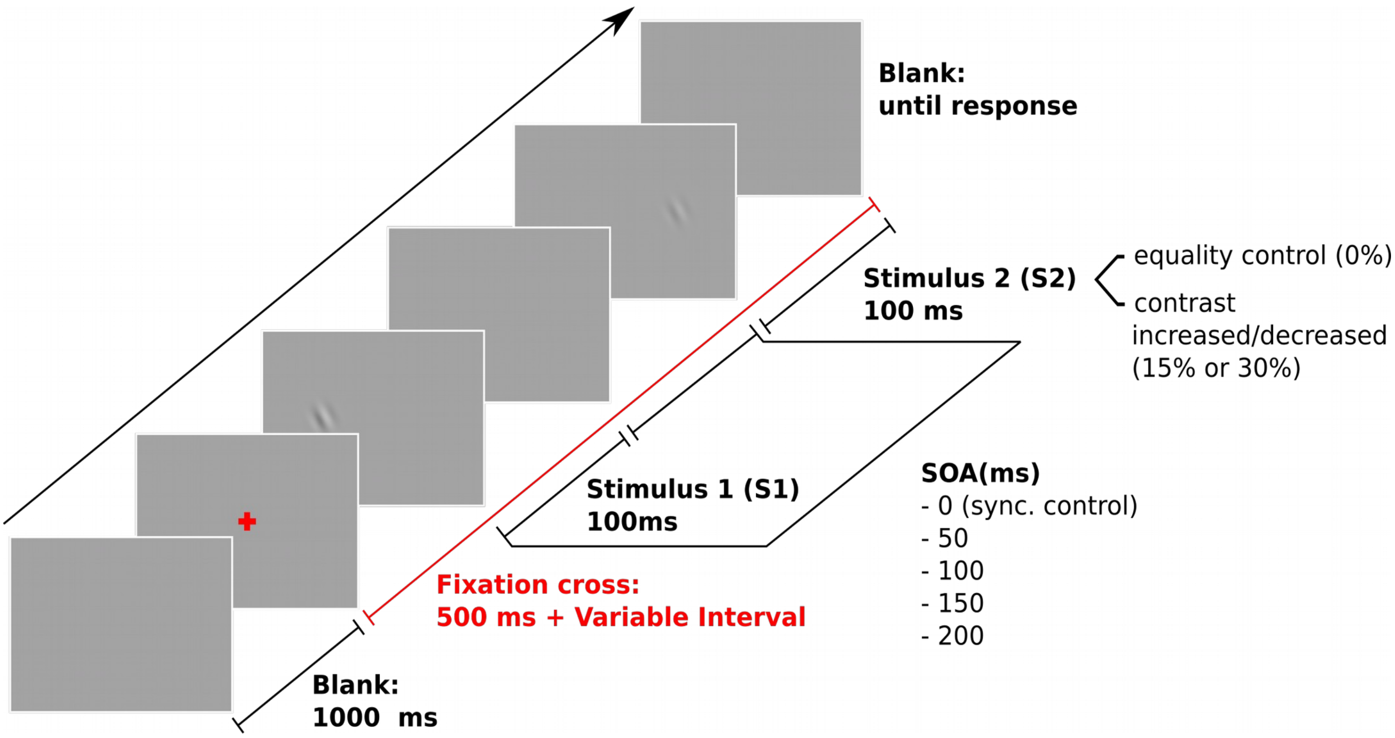

Fig. 1 Trial event sequence and main experimental variables.

The target stimuli used were pairs of odd-symmetric Gabor patches, presented in the same parallel orientation, randomly drawn in each trial. Gabor patches are localized sine-wave gratings enveloped by a two-dimensional Gaussian window. The sine period was set to 40 pixels, corresponding to about 0.7 cycles per degree visual angle, and the Gaussian standard deviation to 20 pixels. In the case of this study, the Gaussian envelope was radially symmetric. The first stimulus (S1) was shown at the left or right side, on the horizontal meridian of the screen, at an eccentricity of 4º visual angle. The side of the first stimulus was chosen arbitrarily across trials, and counterbalanced throughout the session. The amplitude of S1 was randomly chosen from a uniform distribution over the range of 5 to 25 cd/m². Given the spatial parameters used to generate the Gabor patches, maximal and minimal pixel luminance of the stimulus are about 89% of the amplitude above and below the background luminance, which yields a minimal and maximal Michelson contrast for S1 of respectively about 15% and 74%.

After the stimulus onset asynchronous (SOA), chosen among the values 0 (simultaneous control) to 200ms in steps of 50ms, the second stimulus appeared at the opposite side of the screen. The contrast of S2 could be the same as the contrast of S1 (equality control) or either increased or decreased with either 15% or 30%. Due to this experimental manipulation, S2 has a contrast of 70% to 130% of S1, and therefore an even wider range than S1. All stimuli, however, are suprathreshold and within the dynamic luminance range of the monitor. Both stimuli had the same duration of 100 ms, which means that S1 and S2 partially overlap in time when SOA is lower than 100ms. Another blank screen, only containing the fixation cross, was shown after the stimuli. The fixation cross remained on screen throughout the trial until the participant gave a response using the fire buttons of a gamepad.

C. Procedure

In an experimental session, five SOAs (0-200 ms in steps of 50 ms), five contrasts steps (equality control; increase/decrease: 15% or 30%) and two spatial orders (left-right or right-left) were cross-combined, creating a total of 50 different combinations. Each condition was repeated 15 times throughout the session, totaling 750 trials, presented in random permutation. The session was divided into five blocks by breaks with a duration determined by the volunteer.

Specifically, the task consisted in the judgment of the relative contrast of the stimuli. The subject was brought to a darkened room and instructed to the procedure by a demonstration with audible feedback. The demonstration consisted of a short block using contrast increments and decrements of 50% and a longer stimulus duration (200 ms rather than 100 ms). After this step the observers participated in a 36-trial practice block without feedback. Demonstration and preparation took about 10 min, such that volunteers were well adapted to the darkened room to start the experimental session.

Participants were submitted to two experimental sessions during about 40 min, on different two days, yielding a total of 1500 trials. In one of both sessions, observers were to indicate the side of the patch with the highest contrast, and in the other, the side with the lowest contrast, in order to measure perceptual effects without response bias. The order of these sessions was randomized across volunteers.

III. RESULTS

The main experimental variables in this study are contrast ratio and stimulus onset asynchrony (SOA). Two crucial control conditions are the baseline in which both stimuli, S1 and S2, appear simultaneously (SOA 0ms) and the one in which both stimuli have the same contrast. As explained in the methods, the spatial order (left-right or right-left) is counterbalanced within sessions, and all observers participate in one session in which they indicate the highest-contrast stimulus, and one in which they indicate the lowest-contrast stimulus, in an order randomized across volunteers. Spatial or order-based response biases are therefore averaged out in the results we present here. Because the number of participants is too large to have their data presented separately, many graphs and descriptive statistics are of aggregated data, but statistical analyses work either with aggregated proportions or taking individual variation into account. Analyses reported here are performed in the R Project of Statistical Computing environment (r-project.org), version 3.2.2.

As convention, we use the notation S1 and S2 for the first or second stimulus in the stimulus pair, thus using the subscripts to reflect their temporal order. In the special baseline case in which the stimuli appear simultaneously, which Gabor patch gets to be called S1 is a matter of labeling. The contrast ratio is determined as the contrast of the second divided by the contrast of the first Gabor patch, C2/C1. The average performance of the observers as a function of contrast ratio, for the SOA=0 baseline, is shown in Fig. 2). In order to provide a succinct quantitative model of the data, consider that, when the contrast ratio equals 1, there is literally no difference between both Gabor patches, and the replies will be arbitrary or dictated by pure response biases. There are a number of models, such as logistic regression and probit models, that absorb this fact when using adequate transformation of the contrast ratio. We found that, after fitting several models through maximum likelihood on the aggregated data, a zero-intercept logistic model with log-contrast ratio, i.e., log(C2/C1) (rather than for example C2/C1-1), as independent variable, provided the better fit as evaluated through the Akaike information criterion (AIC). We will therefore use this specific generalized linear model as a reference model for both aggregated and individualized models.

If the previously found effect indeed increases the subjective contrast as a function of temporal order, we expect more responses favoring the interpretation that S2 has a higher contrast, in a modulation that is SOA-dependent. The baseline condition that measures this effect in isolation is the one in which the contrast ratio equals one, for SOA ranging from 0 to 200ms. Fig. 2 shows the proportion of responses in this sense; a box plot was chosen in order to present some meaningful individual variation for longer SOAs, except for the general tendency to indeed judge the second stimulus of higher contrast in those presentations in which the contrasts were physically identical. While the logistic function provides a good fit for proportion as a function of contrast ratio, there is

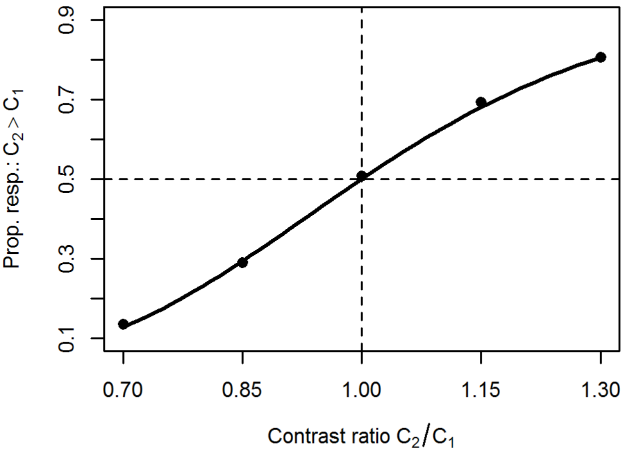

Fig. 2 : Performance for simultaneous Gabor patches as a function of contrast ratio (data aggregated across participants).Each data point is calculated as the average proportion responses equivalent to a judgment that S2 has larger contrast than S1, which, in this experiment, can mean responding the side of S2, if the observer is to indicate the side with the higher contrast, or S1, if the observer is to indicate the side with the lower contrast. As these proportions are calculated on 60 presentations for each of the thirteen observers, the standard error on the proportion for a contrast ration equal to 1 is 0.018.

no clear standard functional relation between SOA and average proportion. This factor will therefore be included in the logistic model as a free intercept, except at SOA=0, where the intercept should be 0.

This points towards a generalized linear model for the whole set of data, with a logit link function, log contrast ratio as a quantitative predictor, and SOA as a qualitative factor corresponding to a set of dummy variables marking 1 for each of the SOA's above 0. This model was applied to both aggregate and individual data sets. On aggregate data, comparing the fit through maximum likelihood estimation in a likelihood ratio test to evaluate if the set of SOA parameters was necessary for adequate modeling of the data, the chi-square statistic was very high (2038.4, for df=4), corresponding to a p-value smaller than 0.0001, showing that SOA is an important predictor in the results. All SOA parameter estimates were above 0, indicating that the number of responses indicating higher subjective contrast for the second Gabor patch is shifted upwards in comparison with the SOA=0 control. There is, however, a model that provides an even more adequate description of the pattern of data. Possibly, besides a perceptual boost of contrast for the second stimulus in a pair, contrast sensitivity changes as a function of SOA. One can imagine, for example, that, possibly due to decay of the information in the sensory buffer over time, comparison of two stimuli with an SOA of 200 ms (or an interstimulus interval of 100 ms) is harder than comparison of simultaneously presented stimuli. This can easily be accounted for in the generalized linear model through an interaction between the SOA dummy variables and log contrast ratio. Visually, this is a model in which sigmoids are shifted leftwards, because of SOA intercepts, and with varying slopes, using Fig. 2 as reference. This model was compared with the no-interaction alternative, and had a significantly better fit, with a chi-square statistic of 40.10 for 4 degrees of freedom, corresponding to a p-value smaller than 0.0001. In the interaction model, slope for SOA=0 was 5.40; negative estimates of the slope difference shows that indeed contrast sensitivity, independently of the subjective contrast modulation by order, diminishes as a function of SOA, especially until 150 ms, with values of -0.38, -0.85, -1.32, and -1.30 for SOA 50 ms through 200 ms. The shift estimates for these SOA conditions repeat what can be inferred from Fig. 3: the subjective contrast boost for the second stimulus increases up to 100 ms, and decreases for longer SOAs, with values of 0.80, 1.08, 0.77, and 0.59 in logit space. Fig. 3 visualizes what these numbers mean for the underlying psychometric functions.

One way to aid the interpretation of Fig. 3 is to verify the values where each of the curves crosses either the vertical or horizontal reference axis. The data point of SOA=100, for example, at approximately 0.74, shows that 74% of the responses were compatible with a higher perceived contrast of the second stimulus, when stimuli are in fact identical, against a chance level of 50%. The interpolated crossing of each curve at the horizontal level of 0.5, on the other hand, shows for which relative contrast S2 is perceived to have the same subjective contrast as S1. This is commonly called the point of subjective equality (PSE) in the psychophysical literature. Again taking SOA=100 ms as a reference, one can read off the graph that a contrast ratio of about 78%, that is, C2 being 22% lower than C1, would generate an impression that S1 and S2 have the same contrast if they are initiated with a 100 ms lag. A more accurate estimate of the PSE can be obtained by calculating the exponential function of the root of the logistic regression equation for the specific condition. For example, in the case of SOA=100 ms, the full logistic equation would be: est[log(prop)-log(1-prop)] = (5.40-0.85)*log(C2/C1)+1.08; solving for 0 gives log(PSE) = -1.08/(5.40-0.85) = -0.237, therefore PSE = exp(-0.237) = 0.79, approximately.

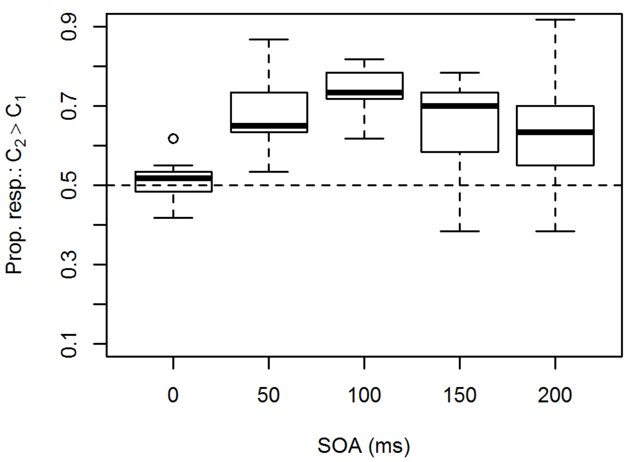

Fig. 3 Box-and-whisker plot of the proportion responses compatible with higher subjective contrast of the second Gabor patch for presentations in which the physical contrast of S1 and S2 is identical (C1=C2). Box bounds indicate first and third quartiles, the central line the median, while the whiskers show the most extreme data points within a range of 1.5 times the interquartile range. The binomial proportion standard error of individual data, with n=60, is .065 at proportion 0.5.

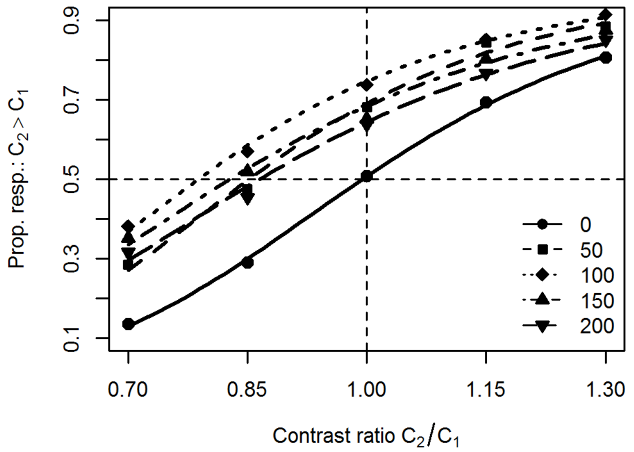

Fig. 4 Aggregated proportions and logistic model fits for combinations of SOA and contrast ratio. See text for details.

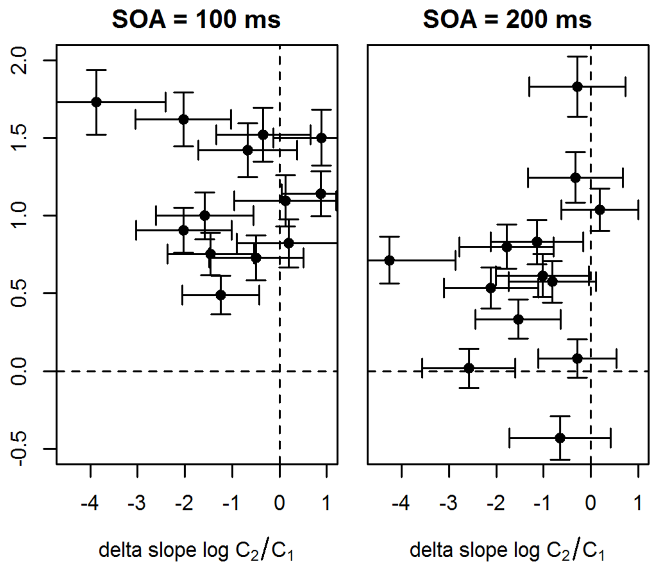

Fig. 5 Parameter estimates with 95% confidence intervals for the SOA=100 (left) and SOA=200 ms (right) conditions. Each point corresponds to the estimates for one observer. The horizontal axis shows the estimated value for the difference between the slope for the specific SOA, and baseline SOA=0. The unlabeled ordinate shows the estimate of the shift, in logit space, due to the SOA.

While analyses on aggregated data are very useful to understand the pattern of results, reported p-values for aggregated data are not entire trustworthy because differences among the observers are not taken into account by the statistical model. A more appropriate approach, from a purely statistical point of view, would be to implement mixed logistic models, in which individual values for slope, SOA-specific intercept and their interactions are allowed to vary around a mean. Given that there are 9 model parameters only for the fixed effects, which would be combined with parameters responding for a large set of variances and covariances, determining values for a complete model involves multidimensional integral in the optimization process, which is computationally challenging. As a compromise, we will present some summary results from fitting the 9-parameter model to individual data sets. In this process, some patterns emerge that might be informative as to the mechanisms that might be responsible for the relative contrast boost of the second stimulus of the pair.

Data were fitted using the same generalized linear model as presented for the aggregated data, with log contrast ratio as quantitative predictor, and intercept and slope parameters for SOA 50 to 200 with a zero value for global intercept. Using, among other methods, AIC as criterion for best fit, models with and without interaction between log contrast ratio and with and without parameters for SOA were compared. For all observers, SOA, at least as variable modulating the logit intercept, was a significant factor. For example, coefficient estimates for SOA=100 ms ranged from 0.49 to 1.73, $p<0.0001$ for all volunteers. The interaction between SOA and log contrast ratio was not significant for all observers. In other words, all observers reported higher subjective contrast of S2 as a function of SOA, but some observers have approximately parallel sigmoids fitting their data points (comparing with the aggregate standard in Fig. 4). For some observers, a better fit was obtained using C2/C1-1 as a predictor, but differences are small, and we will continue using the log contrast ratio as quantitative predictor.

There was considerable variation between participants, as can be observed in Fig. 5. The graph shows the estimates, for the logistic model, of the parameter responsible for the interaction between SOA and log contrast ratio, that is, the SOA-specific change in slope, along the horizontal axis. The vertical axis corresponds to the shift (in logit space) of the logit as a consequence of the SOA, in other words, the strength of the effect that produces the relative contrast boost of the second stimulus. Note that (1) there is a general downward shift of the point estimates from SOA = 100 to SOA = 200 ms. The subjective boost is therefore lower for longer SOA. In one observer the effect is even significantly *inverted*. The pattern of data for this observer seems to extrapolate an effect that is present in all but one observers: a declining trend of C2 choices after SOA=200. While the fact that we only found this inversion for the longest asynchrony in one observer renders explanations speculative, it is tempting to deduce that there might be an active suppression of S2 at longer interstimulus intervals rather than a regression to chance level.

IV. Discussion and Conclusions

Our intention, with this study, was to verify whether the effect found by Claessens, Pereira Oliveira and Baldo [10], in which the second of a pair of dots seem to exhibit higher contrast, would be reproduced in direct contrast evaluation with Gabor patches rather than dots. The data we obtained leave no doubt as to the fact that the second of a pair of Gabor patches indeed seems to be subject to an increase in subjective contrast. We have made sure that this is not an artifact of some kind of response bias through experimental design and procedure, with observers responding the subjectively higher and lower contrast of the stimulus pair in separate sessions. The course of the effect with increasing SOA also mimicks what was found earlier with simple dot stimuli: the relative contrast boost of the second stimulus in the pair is largest at an SOA of 100 ms – at least at this spatial separation – and decreases subsequently. For one observer, as we have shown, the effect even inverses at an SOA of 200 ms.

The joint data are intriguing, apparently related but different from other results concerning spatiotemporal dynamics in the literature. Given that this is a *contrast* rather than a luminance effect, it seems to be a different phenomenon than the temporal context effect described by Eagleman, Jacobson and Sejnowski [7]. The explanations are still in the phase of hypotheses. Two main categories of explanations can be considered: one relating to low-level visual processes, the other to attentional processes.

As to the first group of explanations, it has long been known that all levels of the visual system implement complex architectures for modulation and feedback. Because the dynamics of the relative contrast boost seems to be fast, being already solid at SOA=50ms, it is unlikely that a pupilary reflex is causing the phenomenon. Possibly, the presentation of a first suprathreshold stimulus after a blank display creates a propagating wave of activation throughout the lowest levels of the visual system. One might imagine, for example, that long-range horizontal connections among pyramidal neurons in V1 (see for example Polat [12]) might mediate facilitation of stimuli with similar characteristics presented in brief succession. These long-range connections have been hypothesized to be responsible for contour integration and should, if this is the case, give stronger modulation for aligned Gabors than for Gabor patches that are only parallel. We have looked for, but not found this difference in the currently reported data. Of course, it is possible that the difference in modulation between aligned and non-aligned but still parallel elements is too small to be detected. An experiment with orthogonally oriented Gabor patches might be informative in this sense. Also, if a propagating facilitating wave is the cause of the effect, it would be interesting to test whether the dynamics changes when other eccentricities and patch distances are used.

The decrease of the effect for larger SOAs, including an inversion we found in one observer, is suggestive of a fast-facilitation-slow-inhibition account, with individually tuned temporal parameters. This hypothesis can possibly be checked in an experiment in which SOAs extend beyond 200 ms; if the facilitation is followed by slow inhibition, the inversion might be detected in more volunteers. An experiment with longer SOAs would require rigid fixation control.

In a second line of hypotheses, it is not impossible that attentional processes modulate the subjective contrast in ways that produce the effect documented here. Because of the short time frame, these would be more likely automatic rather than voluntarily controlled attentional allocation processes. Studies conducted in the lab of Carrasco point towards the possibility that attention modulates subjective contrast (eg. Carrasco, Ling, and Read [13]). Supposing that more attention produces higher subjective contrast, this explanation would require a mechanism in which the second stimulus is more attended to than the first. Remember that the first of target stimulus has large temporal uncertainty; once the first stimulus appeared, spatial uncertainty for the second is nonexistent, and the temporal uncertainty is lower than for the first stimulus. But this is a rather fast modulation of attention in time, especially for SOA equal to 50 ms. It would be more likely that the onset of the second stimulus produces a type of attentional capture that interrupts ongoing processing of S1. An experiment in which stimuli appear that are unexpected and unrelated to the contrast comparison task at hand might shed light on this possibility. However, attentional capture alone would not be sufficient to explain how the phenomenon might invert, in case this finding gets replicated.

V. Acknowledgment

We are grateful for the comments of three anonymous reviewers. We also thank our volunteers for their participation in this study.

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A software platform for adaptive systems modelling and simulation, with application to the experimental study of cognitive processes

Ian Silva Oliveira, João Eduardo Kogler Junior
Department of Electronic Systems
Polytechnic School of Engineering, University of São Paulo
São Paulo, Brazil
kogler@usp.br

***Abstract*— we present *AWARE* 2.0 and propose its use in two scenarios of experimental study of cognitive processes. AWARE[1] is a software metasystem based on *dataflow*, *event* and *object* oriented programming paradigms, targeted for building applications using Adaptive Finite State Machines (AFSM). We first describe some of the new features added to the original version of AWARE [1], in order to provide more flexibility and easiness in the visualization of the *adaptations* undergone by the AFSMs, and their effects. As proposed by Neto [2], adaptations are topological changes in the dynamics of a rule-driven device triggered by events. Although very simple, the compositional action of these changes in a system delivers enough complexity in the visualization and assessment of their effects. AWARE helps with this task, being a useful tool for the conception, implementation and simulation of AFSMs and Deterministic Finite State Machines, and to the exploitation of the rule of adaptations.**

AWARE aids AFSM specification and simulation providing graphical visualization of the AFSM topology and changes under adaptations, and for monitoring interactions with peripheral devices usual in robotic agents (sensors and actuators). However, its former version required user familiarity with implementation domain specific knowledge (*LabVIEW*)[2] and did not provide means for debugging in the development and simulation user interface. This new version frees the user from AWARE implementation aspects and provides automatic error detection, in accordance with the adaptive computation abstraction model of Neto [2]. We also added to AWARE templates for creation of state machines (with or without adaptiveness) and new resources for interoperability with C/C++ coded functions exported as dynamic linked libraries (DLLs), enabling the use of pre-compiled modules and of peripheral device drivers, for sensors and effectors.

We conceived and developed AWARE for application to the study of cognitive processes modelled with AFSMs, and we are beginning two projects in this research line. The first project aims to the understanding of the dynamics of learning by external reinforcement and/or internal modulation. We intend to accomplish this by studying the behavioral control of robotic agents with AFSMs and analyzing the adaptations resulting from the machine learning. AWARE provides means to follow the topological changes in the dynamics of knowledge acquisition resulting from the interaction with the environment. This project considers both virtual and physical versions of the robotic agents and the surrounding environment. We are currently specifying improvements in the sensor system used with an Arduino[3] **based robotic platform, including a video camera embedded in the agent, with remote image processing for vision-based tasks. The second project proposes the study and formal modelling of the topological transformation sequences resulting from adaptations underlying learning.**

Keywords—adaptive; state machines; modelling; simulation; cognition

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[1] Acronym of Adaptive softWARE.
[2] Graphical programming language and environment.
[3] Microcontroller hardware architecture.

The Consciousness Concept as Pattern Recognition

Theoretical Implications over a Definition of the Consciousness Concept as Pattern Recognition Properties of Cognitive Systems

Gilberto de Paiva
Curso Superior em Tecnologia em Manutenção Industrial
Fatec Osasco Prefeito Hirant Sanazar
Cotia, Brazil
gilberto.dpaiva@fatec.sp.gov.br

***Abstract*— The cognitive sciences does not have a consensual definition to the concept of consciousness as a function of cognitive systems properties. Different functions and properties of cognitive systems such as complexity, emergence, integration, etc, were intensively discussed as possible solutions with little agreement. This paper proposes one definition of the consciousness concept as simple pattern recognition mechanisms and properties of system-subsystems cognitive structures.**

Keywords—Consciousness; Definition; Pattern Recognition;

I. INTRODUCTION (*HEADING 1*)

One open question in cognitive science is how to define the concept of consciousness [1] as a function of cognitive systems properties, more specifically as a function of properties of physical systems, mainly neural (connectionist) and computational systems. Various functions and properties of cognitive systems (complexity, emergence, integration, etc) [2] were intensively discussed as an attempt to solve this problem with little agreement. This paper proposes one definition of the consciousness concept as simple pattern recognition mechanisms and properties of system-subsystems cognitive structures.

To explain the ideas proposed in this work, and to overcome some existing controversy, we discuss the concepts of physical systems, cognitive systems, physical pattern recognition and cognitive pattern recognition. To clarify their differences a physical then a cognitive description and interpretation of these concepts are exemplified with physical interactions properties and examples, computational and neural-connectionist properties and examples.

Then this paper proposes one definition of the consciousness concept as a pattern recognition mechanism of cognitive systems sets. We justify why this definition accounts to the general notion of "cognitive awareness" of a physical system [3], and we discuss the specific uses of the consciousness term in philosophy, artificial intelligence, animal and human context.

Some key solutions this definition gives to some problems associated to the consciousness word are:

1. a clear distinction of a conscious and unconscious processing concept.
2. a clear description of the self-consciousness concept.
3. a clear description of the self-cognitive-consciousness concept, the concept that a cognitive system can have consciousness of its own mind.
4. an uniform description of machine, animal and human consciousness concept.

All this are exemplified in detail on how a machine can have conscious processing of a set of patterns, and how a machine cannot have conscious processing (is unconscious) of other set of patterns. Also how a machine can be conscious of some patterns of itself and have self-consciousness. This is easily applied to explain animal and human consciousness.

One simple example is the operational system and application programs of the standard computer architectures. The definitions proposed here shows how an operational system can be conscious of some computer data and processing activity of a computer, and unconscious of others.

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Learning and perception of causality

Peter Maurice Erna Claessens; Victor Gregório de Queiroz Lima; Manasses Pereira Nóbrega
Centro de Matemática, Computação e Cognição - CMCC
Universidade Federal do ABC - UFABC
Santo André, Brasil
peter.claessens@ufabc.edu.br; gregorio.victor@gmail.com

Manasses Pereira Nóbrega
Departamento de Matemática e Estatística - DME
Universidade do Estado do Rio Grande do Norte - UERN
Patu, Brasil
manassespereira@uern.br; nobrega.manasses@gmail.com

Causality is the term used to refer the relationship between a "causative event" and a "subsequent event" that former seems to be inducing. The sense of causality is an assignment of the mind that is not immediately given by the impact of the physical world on the subject. According to Hume [1], the idea of causality must be derived from three basic criteria: (1) contiguity: if *A* causes *B*, then *A* and *B* are contiguous both time and space; (2) temporal succession: if *A* causes *B*, then *A* precedes *B* in time; (3) required connection: if *A* causes *B*, then *B* invariably occurs when *A* occurs. As a first approach, the principles of causality described by Hume look pretty solid, both natural and scientific inference of causation. The pioneer in scientific research on the perception of causality was undoubtedly Albert Michotte [2]. As Gestalt psychologist, Michotte was interested in the factors that cause the sense of causality as an emergent property of visual stimulation. His experiments suggest that an important aspect in the sense of causality is the temporal contiguity. However, recent studies have been shown the relationship between voluntary action and subjective time, called *intentional binding*: in those situations which subjects are agents of the actions, the perceived time between action and its consequence is smaller than the subjects of passive situations [3]. Since, many studies have been considered both the role of causality and agency in *intentional binding* [4-6]. We present a study about the role of spatial and temporal intervals on the sense of causality in agency situations. A new paradigm centered on dynamic Poisson process as stimulus was implemented. In the pilot experiment reported here volunteers are tasked to press the mouse button at any time and position in the computer screen and to observe a presentation of random points at the monitor. Maximum distance, time intervals and the rate of points per second was controlled. After each trial the volunteer indicated his "belief" to have caused or not the event indicating a level of certainty handling a featured slider on a numerical scale at the screen, from 0: 'certainly I did not cause' to 100%: 'certainly I caused' the points presentation. The data analyzed so far indicate a systematic negative trend only in the time interval, i.e. the higher the temporal interval between the action and the appearance of the stimulus, the less the sense of causality. We also discuss how the random aspects in the presentations may have influenced the sequence of events and this is a basis for a more detailed future analysis.

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Keywords – causality, agency, perception.

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From Licklider to cognitive service systems

José Reinaldo Silva
Mechatronics Engineering Department
at the University of São Paulo
São Paulo, Brazil
05508-030
reinaldo@usp.br

Walter Teixeira Lima Junior
Social Communication Graduate Program
at Methodist University of São Paulo
São Bernardo do Campo, Brazil
09641-000
contato@walterlima.net

***Resumo*—This article investigates the evolution of the concept man-machine symbiosis from the seminal paper of J.C.R. Licklider "Man-computer symbiosis",in 1960, to the current days. We will try to analyze how cognitive aspects appear and disappear in this discussion and the current demand of a real cognitive man-machine symbiosis, where all machines have a computer inside. Licklider´s work went through epistemological cuts, distinct scientific advances, technological innovations, and new possibilities of relationship between human and computational machines occurred in the last 50 years. On the other hand, both technological and philosophical thinking evolved and contribute sometimes to refrain man-machine symbiosis to finally put it as a next step in the relationship between man and machines.**

I. Introduction

The term "man-machine symbiosis"acquire the glamour of science fiction and even today carries a flavor of unreachable technological frontier, and therefore something that does not belong to scientific universe of discourse. Actually, the relation of man and machines were always unbalanced, since only man can perform a real cognitive process, which detached man as a superior being. Even intelligent machines can do only a mathematical simulation of a cognitive process based on a subset of first-order logic. Thus, man-computer relation has been basically a master-slave relation, involving a unique cognitive agent and a replicating machine, and therefore it is not possible to expect a real collaboration. On the other hand, a man-machine symbiosis was present in the seminal paper of Licklider of 1960, and this idea appear and disappear from the debate that occurred since the 50's about cybernetic, technology and the relation between man and computer machines[1].

The history of Cognitive Science [1] cross the history of Artificial Intelligence and the the 50's decade started with a good interdisciplinary interaction between AI and Psychology and the creation of several automatons. This interdisciplinary relation was broken - we are still investigating this occurrence - after the 60's and AI was dedicated to solve industrial problems. We believe that such disclosure contributed to refrain that cognitive models to play a more important role in the evolution of technology and in the interaction man-machines. A similar process seems to occur with the discussion about man-machine symbiosis which appears in the seminal articles of Licklider and instead of entering the great debates concerning Artificial Intelligence and Cognitive Science just was guided to peripheral scientific discussion, isolated from the main journals and philosophy books.

We investigated more than 100 articles, book chapters and all sort of written work from Licklider since 1960 and also related work and interactions between him and other great names of sciences looking for a further cognitive model of man-machine symbiosis as it was described in the pioneer work. After that we looked at other works and to the possibility of this tendency reappear today, leading to new technological and cognitive processes. The tendency to transfer the production process from a natural product-based flow to a service-oriented approach carries this expectation. First of all, to raise more scientific data about the evolution of the seminal ideas of Licklider we introduced a statistic study of bibliometric citations since 1960.

[1]In this same year the interaction man-computer were the focus of the discussion and new physical interaction in two dimensions were proposed by Douglas Engelbert and Bill English: the mouse.

II. Bibliometric Analysis of Licklider's work

Bibliometry is concerned with s quantitative and statistic analysis of publications to support some hypothesis. It could be traced to a seminal article by E. W. Hulme, derived from two lectures given at the University of Cambridge in 1922 [2]. This study evolved since then to the current days where, besides a direct statistic study it is possible to add new methods and use computers to analyze a huge amount of data about publications in a sort of publication big data analysis. More recently analysis of citation has become a parameter of analysis in science and opened space to what is called Scientometrics with jumped to the focus of a debate that divides the academy.

However, Bibliometric Analysis and Scientometrics could also be used to analyze the evolution of some debates in science, as for instance the discussion about man-machine symbiosis or man-computer symbiosis. Using both terms as keywords we investigated how a discussion about this term evolved in the scientific and technological community since 1950 to the current days. Of course that analysis could be done over different databases and we used so far those databases most recognized by the academy: web of science, enhanced with some data from similar bases. In other words, we treated data most considered to evaluate research in current days.

We could also use the name of Licklider as the key to guide the clusterization of citations in the space of publications about the themes proposed, and expect to find the paper Man-computer symbiosis[3] in the center of these clusters. Unexpectedly, although Joseph Carl Robnet Licklider's theoretical framework about a new way of cooperative interaction between man and computational machines is mentioned in several papers and researched by enterprises as IBM and Microsoft, the seminal article is not found and indexed in the Web of Science. A database service informed that, because the coverage of IRE Transactions on Human Factors in Electronics ended with Volume 3 (issue 2) publication year (1962), any missing issues or individual articles in this journal will not be indexed for inclusion in Thomson Reuters, what could explain partially this fact.

Nevertheless, the Licklider's influence could still appear in papers after 1962 if this debate were alive and present in the scientific community, instead of being considered as futuristic projection. It could also be reached in other citation bases, as in Google Scholar. Going through this database using it the article title (Fig.1) and Google Trends, which shows the results of the search terms in relation to name of J.C.R. Licklider through the years (Fig.2).

Figura 1. Article citations Man-Computer symbiosis in Google Scholar

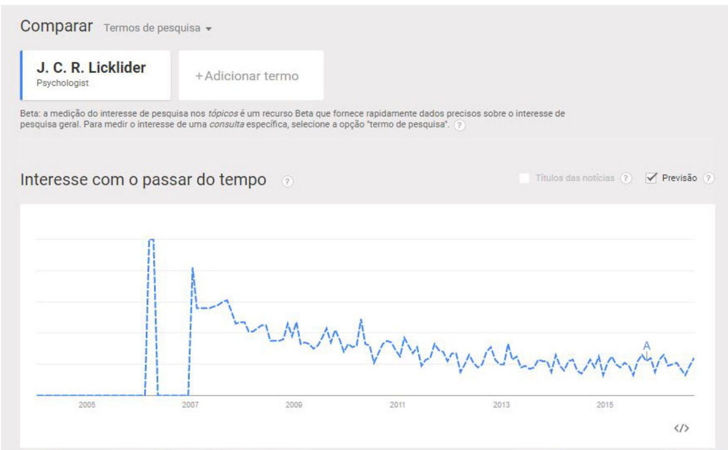

Figura 2. The results of search terms in relation to name of J.C.R. Licklider

In a similar study, Tami Tomasello presented a PhD thesis to the Dept. of Communication of Florida State University [4] with the title "A content analysis of citations to J.C.R. Licklider's 'Man-Computer Symbiosis', 1960-2001: Diffusing the Intergalactic Network". According to the author the "purpose of the study is to investigate the spread and influence of the ideas expressed in “Man-Computer Symbiosis” among published citing works in order to clarify our understanding about the article's contributions. She was interested in evaluate how the "diffusion of innovation"was related to the "spread of Licklider's ideas among citing authors". Therefore we have similar interests.

As a method, Tomasselo utilized citation analysis and quantitative content examination to identifies the influence of Licklider seminal paper, combined with contents analysis, that is, the intense use of citation keywords and contents in a two-pronged approach. The results revealed that from the 110 citing articles examined, Licklider's vision was "diffused widely among this set of individuals, helping to promote a research agenda focused on achieving human-computer symbiosis"[4]. The study analyzed the network influence produced by a set of articles that cite Licklider from 1960-2001, in order to clarify the understanding about the article's contributions.

But, the researcher advised that "the small number of articles examined in this study provides a conservative estimate of the article's influence". Inasmuch the resources and the power of the PhD work we also agree that even considering a more powerful database and extending the research to 2015 we got the same results, meaning that Licklider seminal paper was not in the focus of the academy debate since its publication.

There are several hypothesis concerning different contributions to this result, but we prefer to nominate a possible and clear refrain in the academic discussion to merge the emergent technology, based on electrical and computer engineering, with human and social sciences. That was important, in a epistemological analysis, to the further development of technology, but - as there is not a unique face in a coin - also limited the cognitive approaches to the man-machine relation.

Licklider seminal paper is pointed as a publication that predicts the evolution of computer network and internet while treating the subject of man-computer interaction (the specialty of the author). However, the content of the term man-computer symbiosis or, as we use to extend to man-machine symbiosis present an innovative subject very strong for the time it was published, specially because of the cognitive content of the proposal. We also agree with the thesis of Tami Tomasello that such topic would open a research agenda to the future debate in the academy. However, we are not interested in this paper in the role of the publication as in the thesis, and this is only a parameter to analyze, according to current criteria the importance this topic had during last fifty years.

We revisit the research agenda identified by the Tomasello (2004) and inserted in the seminal paper as:

- (our work) overcoming the barrier of symbiosis man-machine or man-computer, which means proposing a relation that leave behind the master-slave relation and that are differentiated only by the capacity to involve intentions (exclusive from the man);
- (Licklider) speed mismatch, concerning the difference in reaction and processing of information in man and computer machines;
- (Licklider) memory hardware, which we expand to beyond of storage capacity and direct retrieve to include pattern recognition and its cognitive processing;

- (Licklider) Memory organization, which are very different in computer and machines, and we also include the capacity of treating large amount of data in a single process;
- (Licklider) the language problem, which we enlarge to include the problem of communication and sensorial communication detached from acts and not necessarily from speech;
- (Licklider) input and output equipment which means a different subject today compared with the days of the invention of the mouse. Today we interpret this topic as including the processing brain signals and neurophisiologic signals.

From a communication point of view, the key point is that the process on symbiosis depend on the capacity of communication between man and machine and that this process should have a strong cognitive content. However, this content is not restricted to have "language"as a vehicle and definitely not would not be based on unbalanced stimulus/response, although we recognize man as possessing the unique capacity of using intentions and intention analysis. That would means to have an open approach to the possibilities to achieve a symbiosis between man and machine [5].

The proposal include a rupture with the idea that “typically, computers are thought of as tools to make people more productive in their jobs”[6] even if we agree that computational technology is subordinated to human intentions. This concept has been consolidated and improved through complex control systems, which improve the performance of the man-machine relationship based on a fully asymmetric approach. Despite of technological difficulties to implement totally the (symmetric) concept of Man-computer symbiosis, the agenda proposed above brings back a multidisciplinary and trans-disciplinary evolution. On the other hand the evolution of many technological branches reveals that some concepts envisioned by Licklider are becoming feasible at least demanding, which can also promote this research agenda to achieve human-computer symbiosis by building suitable digital environment for updating Licklider’s notion of symbiosis, albeit not emulating it entirely, because "more than 40 years later, one rarely encounters any computer application that comes close to capturing Licklider’s notion of human-like communication and collaboration" [7].

“The hope is that in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today”[3].

Current technological development is already providing tools that involve, for example, the complexity of big data and exploiting the power of natural language processing and machine learning[8], which is considered a tremendous advancement to provide computers with cognitive capacity. Computational cognitive capabilities was one of the wishes expressed by Licklider in his seminal paper, more clearly, in the book "Libraries of the future"[9]. In this book, Licklider expands some of his thoughts implicit in Man-computer symbiosis, especially, concerning to how human being can process knowledge from a relationship with a computer machine.

According to Licklider, the "systems are intended to promote the advance and application of knowledge, they are "for knowledge," and thus precognitive Systems" [9]. The term created by Licklider, was thought for the synergistic knowledge systems that would go beyond Vannevar Bush’s Memex [10]. With the modeling described in the book “Libraries of the future”, the precognitive System was thought to facilitate the acquisition, organization, and use of knowledge, being a prescient view of how computer systems could work[11]. According to [12], Licklider chose this term because it would be a system for the advancement and application of knowledge. He elaborated his vision from an experience in the early 1960s, when it doesn’t exist a supercomputer technology to run semantic process through databases.

Arguing about the concept of precognitive systems, Licklider created the term "positive interaction" [9] to break barriers among the library sciences, computer sciences, system sciences, and the behavioral and social sciences. The necessary technological advances to accomplish the full scenario envisioned by Licklider, when human and machines will have a reciprocal dependence is already in course. We claim these current technological advances are precursors to the man-machine symbiosis, because they emulate conditions of information exchange in a symmetric way, thus, although computerized machines remain technologically subservient to human intentions, they could jump to a more symmetric relationship pushed also by market demands.

As we have seen a full cognitive machine, capable of a symmetric relationship with man was already among the ideas of Licklider and included in the concept of man-computer symbiosis - which we enhance to man-machine symbiosis. This idea appears in further publications but without influencing the scientific debate or influencing further research agendas [4]. This article suggests that there is an emergency for a technological stage that we named as presymbiotic where presymbiotic technologies will emulate the concept of human-machine relationship accomplished by in way of asymmetric information exchange, working in a complementary way. However, in this technological basis there are still an asymmetric relation, related to the possibility to expose intentions.

Licklider claims that Man-computer symbiosis is a subclass of man-machine systems, "that promises to be a distinct advance over the ’mechanically extended men’ who characterize the industrial era, but without the problems artificial intelligence of the future will bring"[13]

III. Companion technologies

As we mentioned before, even precognitive systems have to enhance a lot the communication that is supposed to be held between man and machine, which implies to use Cognitive Interaction Technology. That implies that a computerized machine be able to "understand"user intentions without a communication based on speech. There are many groups in the world working in that topic, most of them linked to the interpretation of facial expressions in what it called today a Neurobiological Inspired, Multimodal Intention Recognition for Technical Communication Systems or NIMITEK [14]. These systems can combine vision with the detection of movements and signs from the user and can accelerate the interpretation of intentions contributing to reduce the speed mismatch mentioned by Licklider.

A further step from multimodal interpretation of intentions would be if, even in this asymmetric mode of communication man-machine we also consider the communication context. For instance, the user could be writing while offering an object to the (robot) machine. A simple interpretation, which would be independent from speech is that he/she wants the robot take the object freeing both hands of the user. That would be quite different from a situation where the user has his/her full attention focused in the interaction with the robot and offers or show an object. The "taking"action is no longer obvious and probably the robot must wait for some more information to move. This is called and Adaptive Cognitive Interaction System, where the user state and the context is taken in account[15].

Licklider's vision about adaptation is also present in his work when he says that "there must be continual adaptation of the system to meet the needs of its users and a continuing development, on the part of the users, of the ability to take advantage of the services offered by the system and to improve the system in the process of using it"[9].

Cognitive Interaction System can give a new dimension in the tendency to have a partnership between man and machine: that what is called Companion Systems[16], Companion technology[17] or Artificial Companion[18]. Companion Systems should be able to provide solutions for complex tasks, all by itself or in cooperation with the user [16], considering "the entire situation of the user, machine, environment and (if applicable) other people or third interacting parties, in current and historical states. This will reflect the mental state of the user, his embeddedness in the task, and how he is situated in the current process"[16]. According to Glodek [17], a companion system becomes part of the user's everyday life such that the Cognitive Technical System can build up a sophisticated user model. The Artificial Companions (ACs) are typically intelligent cognitive 'agents', implemented in software or a physical embodiment such as a robot. They can stay with their 'owner' for long periods of time, learning to 'know' their owner's preferences, behavior and wishes[18].

This approach closely matches the ideas proposed by Licklider. In the Man-machine symbiosis, one of the goals is "to enable men and computers to cooperate in making decisions and controlling complex situations without inflexible dependence on predetermined programs. In the anticipated symbiotic partnership, men will set the goals, formulate the hypotheses, determine the criteria, and perform evaluations. Computing machines will do the routinizable work that must be done to prepare the way for insights and decisions in technical and scientific thinking"[3].

According to Wendemuth [16], the Companion technology for cognitive technical systems includes interdisciplinary research in the methodological basis of three key areas: planning and decision-making, interaction and availability, situation and emotion. Thus, two complementary perspectives on the interaction of user and system are relevant: system and user perspectives. Interdisciplinary approaches were fundamental in Licklider's proposals and appear in several articles as a way to "break down the barriers that separate potentially contributory disciplines"[9].

IV. Humans and technology cohabit: cooperation and complement

In the overall conceptual model for man-machine interaction human beings and technologies coexist so well that human beings shape technology just as technology shapes human beings[5]. The viewpoint is similar to Licklider and Clark thinking about man-computer symbiosis where " man and computer complement each other, and the intellectual power of an effective man-computer symbiosis will far exceed that of either component alone"[19]. Licklider´s complement can be based on holonic systems concept, where parts can be coupled to form one machine that is more than its components. Halpin[20], says that "the goal of 'Man-Machine Symbiosis' is the enabling of reliable coupling between humans and their 'external' context where digital computers are present. To obtain this coupling, some barriers of time and space needed to be overcome so that symbiosis could operate as a single process". The benefits of mutual adaptation between computational machines e human beings "envisaged the emergence of an era of interdependence between human beings and computers, where the interaction between the two would become tightly linked or symbiotic"[5].

According to Brangier [5], symbiosis between humans and technologies produces permanent interactive loops enabling technology and human psyche to be develop in parallel. To summarize, the human-technology symbiosis theory can be synthesized into the following four ideas: Co-extension; Co-evolution; Co-action; Co-dependence [5]. The concept of Co-evolution "defines the transformations occurring during the evolution of the two elements: Human beings benefit from their relationship with technology, which in its turn (via inventors, designers and engineers) benefits from successive improvements. In the living world, co-evolution is often observed in the the relationship between natural symbionts and their living hosts. The interaction with technical devices would be inserted in this scope which is also a way to connect in major context composed by a net of man-machine clusters.

A. *Cooperation and companion*

Licklider also showed the importance of the concept of cooperation in the summary of his seminal article. According to Licklider, Man-computer symbiosis is an expected development of the cooperative interaction between men and electronic computers. It will involve very close coupling between humans and electronic devices[3]. Licklider point out that cooperation between men and computers would improve the process of making decisions and controlling complex situations. Cooperation is a central concept in Companion Systems, which depends on the adaptation of systems to each user (in an asymmetric relation). 'They are geared to his abilities, preferences, requirements and current needs, and reflect his situation and emotional state. They are always available, cooperative and trustworthy, and interact with their users as competent and cooperative service partners [16].

According to Traue[21], computational machines with these communication capabilities will allow for human-companion interactions in many areas of life such as at work, in daily life, with regard to health maintenance, mobility, and social networking, which will make feasible that computational "machines will outdo the human brain in most of the functions we now consider exclusively within its province"[3].

The interaction attribute is also one of elements requested to accomplish a cooperative service partnership. Studies on human-machine interaction were the focus of the research conducted by Licklider between the 50s to 80s. Licklider started his academic career as an experimental psychologist, being his area of concern broadened from acoustics to engineering psychology[22]. In 1957, Licklider discovered the potential of the first digital computer, TX-2 to accomplish his idea about man-computer partnership [23]. Since them he turned his focus to human-computer interaction and computerized library systems [22].

The seminal paper summarize his thinking developed in the first ten years of research which evolved after that, even if detached from the main scientific debate. According to Licklider in the paper "The Truly Sage System, or Toward A Man–Machine System for Thinking"[24], the interaction man-computer would be greatly simplified if the machine could be developed in part as man's image. This same approach is described in the Companion Technologies' concepts, as claimed by [21]: "human-companion interactions will not be identical to human-human interactions, but will probably be very similar. This similarity is maybe not due to the humanoid design of the companion, but to structural similarities of communication as well as information transfer/processing".

V. Service systems

Nowadays, tendencies towards a presymbiotic technology development can be visualized in Intelligent Virtual Assistants (IVA). This devices are also known as "Mobile Virtual Assistant", "Virtual Personal Assistant", Intelligent Software Assistant", and "Knowledge Navigators". As reported by Riccardi[25], the mobile Virtual Agents (VA) provide a speech interface for question-answering and actively engage the user in a spoken conversation. They have ability to interpret Natural Language via spoken interaction and providing responses either in the form of a software program execution (e.g. opening the contacts folder) or a spoken response. These characteristics have theoretical connections with companion technologies. Traue[21] defines "digital companions are embodied conversational agents (ECA). They communicate in natural spoken language and realize advanced and natural man-machine interactions" An IVA is

> a software assistant capable of interacting with a user to support sense-making tasks, to determine information needs, to provide relevant information and to improve its performance based on user feedback. Currently, there is no integrated software environment available to develop such agents. We are exploring how we can integrate machine learning and natural language processing technologies, available as open source software, to support the construction of intelligent virtual assistants[26]

IVA Technology, as Siri, Amazon Echo, Google Now, and Microsoft Cortana, use adaptive technologies to create the illusion of intelligence by user's communication (based on speech) to provide a notion of companion service or virtual assistant.

However, the strongest approach to service was developed by IBM researchers [27] and were spread all over the world, in what is today known as Science Service[28]. Service Systems has been defined by Spohrer [29], as a dynamic value co-creation configuration of resources, including people, organizations, shared information (language, laws, measures, methods), and technology, all connected internally and externally to other service systems by value propositions. According to Stanicek [30], the nature of service provision, i.e. value co-creation, requires that service provider and the (human) client understand each other, or, in other words, that they communicate in terms of a mutually shared conceptual system. A

> Service system is a composite of agents technology, environment, and/or organization units of agents and/or technology, functioning in space-time and cyberspace for a given period of time [30].

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Similarly to biological symbiosis, the relationship must benefit both agents involved. Stanicek[30] describes a mutual relation called value co-creation. However, value co-creation is more than a mutual benefit and has also a characteristic to occur only when user and service are coupled together. That also involves some sort of communication, "using conceptual modeling as a tool capable of describing the domain of interest in comprehensible and unambiguous terms might prove beneficial in both service systems".

All services already existing use communication based on natural language and meaningful signs, generally interpreted by the human (client). However, it is not necessary a great imagination to envisage the difference in performance from services emerged from a research agenda as the one described above. Reducing peed mismatch would contribute to fast coupling in value co-creation. Hardware memory is already in use by systems supported by huge information systems, but memory organization is still a challenge. The whole process would be enhanced by using mores sensors, movement analysis and neurophysiologic signals, but that also demand a treatment by Artificial Intelligence to introduce cognition in the process.

Curiously, that were also anticipated by Licklider in his 1957 manuscript [24] , when he says that "

> there is little reason to restrict either the man or the machine to what, at the outset, appears to be his zone. In fact, the problem of coupling between the man and the machine would be greatly simplified if the machine could be developed in part in man's image. It is desirable, therefore, to explore the possibilities of the field of research currently designated by the terms artificial intelligence and self-organizing automata. That study and the study of human thinking and perceiving should be mutually facilitating.

VI. Conclusions

Nowadays, it is difficult to measure the expansion and influence the computational concepts proposed by Licklider, mainly because the articles and texts published by Licklider are not indexed by modern databases such as Web of Science. However, exploring the findings in the dissertation produced by Tomasello [4] and bringing the analysis to current days, we conclude that there is still a research agenda, similar to the one proposed by his original work that emerged not from the seminal article or other publications but from the convergence of technological development, scientific development and market needs.

He have a hypothesis about the reasons to explain why this discussion did not occur all these years even if digital convergence and other developments in computer science, Physics and Cognitive Science created a good environment for that: the detachment from a multidisciplinary development. Moreover, further developments bring the discussion back with a new demand to add Systems Engineering, Artificial Intelligence and Cybernetics in the multidisciplinary scope.

Among Licklider's concepts there is the the believe that a continual adaption of system meets its final purpose. That would be the complete requirement satisfaction. Companion technologies would also cooperate to complete and improve the scene, extending the notion of service to beyond market approach.

Stanicek[30] proposed a cognitive model to support services and value co-creation which was not fully explored and experimented. A further work would be just to revise this model and find an implemented version that could give support to the research agenda proposed here, based on Tomasello original proposal.

However, a more philosophic conclusion of this paper is that we are already in the course of a epistemology demand for the development of multi and trans-disciplinary studies that bring together Engineering, Computer Science, Cognitive Science, Neurosciences and Psychology, without which is not possible to face the proposed research agenda.

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Moral action and complexity: An essay on human morality based on self-organization theory

Josiane Gomes de Oliveira
Philosophy Department
State University Julio de Mesquita Filho
Marília – São Paulo - Brazil
josy.olvr@hotmail.com

Sílvia Helena Guttier Faria
Philosophy Department
State University Julio de Mesquita Filho
Marília – São Paulo - Brazil
silviaguttier@hotmail.com

Based on the systemic method of analysis, we propose in this paper to investigate the concept of human morality as a product of recurrent self-organizing processes in the society. We intend to analyze how the dynamics of systemic interaction between environment and individual can affect the production of the universality of moral actions in certain social groups and, above all, we intend to interpret this dynamic as a self-organized process. We will analyze some of the key concepts that integrate science systems, taking as starting point the Theory of Complex Systems, for the purpose of we enter into our discussion of the principle of moral action on the complexity science. Generally speaking, we can say that a complex system is composed of a set of individual elements in interaction expressing an organization, which has a functionality: contribute to the system behavior. According to this idea, the society can be understood as a system in which their individuals are the elements that maintain relations with each other and are in constant interaction. Considering the possibility of crediting the systemic interactions present in society to self-organized processes, we will adopt the perspective of the theory of self-organization proposed by Michel Debrun. According to this theory, self-organizing processes are those that grow up without a center-controller and are informationally open. Therefore, we understand that in the social groups occur self-organizing processes that result from the relationship between individuals who maintain a relationship with each other. So, our central question focuses on the following hypothesis: because the society is interpreted as a system, based on the perspective of analysis of the complex systems, can be the moral action understood as a product of self-organized processes?

Keywords— moral action, society, complexity, systemic, self-organization.

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Possible solutions to the mind-body problem: Nagel and Searle

Juciane Terezinha do Prado
Philosophy Department
State University Julio de Mesquita Filho
Marília – São Paulo - Brazil
jucianepradowb@hotmail.com

Luana Camila Marques
Philosophy Department
State University Julio de Mesquita Filho
Marília – São Paulo - Brazil
luanah.456@gmail.com

The mind-body problem is to explain, for example, how the mind and the body can affect each other. In the twentieth century, in particular, various perspectives were proposed in order to solve such a problem. In this work, we present and compare two approaches to mind-body problem, proposed by Searle and Nagel. One goal of these thinkers is to overcome the problems attributed to the dominant approaches in the study of the mind, both the materialists versions and the dualism of substances. The proposal offered by Nagel argues that there is only one substance involved in the mind-body relationship. It is a physical substance, attributed to the brain. However, although it is the basis of the mind, the brain is equipped with a special set of properties, not physical, which no other kind of object features. They are characteristic of conscious intelligence, considered not physical in the sense that they can never be reduced or explained in terms of the concepts of habitual physical sciences. Searle, in turn, develops a new perspective to this issue, seeking to eliminate the mind/body dichotomy in the existing dualistic approaches. According to Searle, the mind-body problem has a simple solution: mental phenomena are caused by processes taking place in the brain, but can not to be reduced to it. Thereby, such thinker argues that the mind-body problem can be easily solved from a Biological Naturalistic posture. He suggests a causal relationship between the brain and mental phenomena, irreducible to it. However, it does not propose two categories of phenomena. Somehow it can be said that because the brain itself. This presents a problem with regard to causality: the cause and the effect are directed to the same object. Mental phenomena are caused by processes occurring in the brain and are at the micro level, as of synaptic transmission between neurons, occurred in the macroscopic level. The purpose of these two proposals, the Nagel and Searle, is suggest a reasonable explanation of mind-body problem, looking suit his views in a scientific approach to mind. We going to compare these two approaches and analyze in what sense they are suitable for solving the problem of the mind body connection.

Keywords:

mind-body problem

biological naturalism

property dualism

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Physiological mechanisms underlying ON and OFF visual perception in humans

Mirella Telles Salgueiro Barboni[1], Balázs Vince Nagy[1], Cristiane Maria Gomes Martins[1], Tina Tsai[2], Francisco Max Damico[1], Givago da Silva Souza[3], Marcelo Fernandes da Costa[1], Luiz Carlos de Lima Silveira[3], Jan Kremers[2], Dora Fix Ventura

[1]Núcleo de Neurociências e Comportamento and Departamento de Psicologia Experimental
Instituto de Psicologia, Universidade de São Paulo
São Paulo, Brazil
[2]Department of Ophthalmology, University Hospital Erlangen, Germany
[3]Instituto de Ciências Biológicas and Núcleo de Medicina Tropical, Universidade Federal do Pará
Belém, Brazil
Universidade do Ceuma, São Luís, Brazil

Abstract— **Electrophysiological methods such as electroretinography (ERG) and visually evoked potentials (VEPs) allow the assessment of retinal and cortical physiological mechanisms for specific visual functions that can also be assessed by psychophysical methods. The present report compares results obtained with the two methods to show that they can be relevant in understanding visual cognition.**

Keywords — vision; retina; visual cortex; electroretinogram; psychophysics

I. Introduction

Visual information is initiated by phototransduction – the transformation of light into neural signals – performed by the retinal cone and rod photoreceptors in daytime and nighttime light levels, respectively. Electrical and chemical signals generated by the photoreceptors are transmitted to ON and OFF bipolar cells that either depolarize or hyperpolarize to luminance increases owing to the different types glutamate receptors they have. The bipolar cells transmit their signals to ganglion cells with specific morphological and physiological properties. The main types of retinal ganglion cells belong to magno-, parvo- or koniocellular pathways. The neural signals are subsequently sent to the brain through the axons of the ganglion cells. The primary visual cortex receives these inputs to encode the retinal information [1,2].

The neural activation in the retina can either be measured by electrodes placed on the eye (close to the cornea) to record electroretinograms (ERGs) or by visual evoked potentials (VEPs) that reflect activity of the visual cortex and are recorded by means of electrodes placed on the occipital area of the scalp. ERGs and VEPs have been long used to study the physiological mechanisms underlying the processes of visual information, besides diagnosing several abnormalities affecting the central nervous system. In both ERG and VEP, the visual stimulus initiates a cascade of electrical and chemical signals in which the potentials can be recorded noninvasively. Taken together, ERG signals give information about the neural activity of the retina [3] and VEP signals bring information about the activity of the primary visual cortex [4]. They have the advantage that they also can be recorded simultaneously enabling the joint analysis of the visual process in the retina and in the visual cortex.

Visual processing can be evaluated through psychophysical tests using visual stimuli that can elicit specific visual mechanisms. The visual scene continuously changes it luminance. In order to study how the visual system responds to these luminance changes, psychophysical experiments can be designed to measure contrast sensitivity to luminance increments (ON) or decrements (OFF) thereby evaluating the ON or the OFF visual mechanisms. Likewise, similarly designed light stimuli can be used to activate such pathways individually in electrophysiological measurements.

The results of the electrophysiological and psychophysical measurements can then be compared to obtain a better understanding of the visual information processes. Since electrophysiological methods are objective and thus can be used with patients that have cognitive or motor problems, it is useful to know if they correlate with the behavioral psychophysical methods.

These methods allow the assessment of retinal and cortical physiological ON and OFF mechanisms by showing results from ERG and VEP measurements to luminance increases and decreases that can also be assessed by psychophysical data. We show the comparison of the results obtained with the two methods.

II. Methods

A. Subjects

The experiments adhered to the tenets of the Declaration of Helsinki and were approved by the institutional ethics committee (CEP-HU/USP 156.826). Signed informed consent was obtained from the subjects after explanation of the nature and possible consequences of the study. Subjects were 25 healthy young volunteers (mean age = 21 ± 9 years old) with normal ophthalmological examination.

B. Recordings

One eye of each subject was dilated with a drop of mydriaticum (0.5% tropicamide). A Ganzfeld stimulator (Q450 SC Roland-Consult, Germany) with six differently colored light-emitting diodes (LEDs) was used.

ERG: corneal ERG responses were measured with a DTL fiber electrode attached at the outer to inner canthus of the eye. The reference and ground skin electrodes were attached to the ipsilateral temple and forehead, respectively.

VEP: electrodes were placed on the scalp to obtain recordings from OZ (active electrode), FZ (reference electrode), and FpZ (ground) according to the International 10/20 System (Odom et al., 2004).

The accepted impedance was 5 KΩ or less for both active and reference electrodes. The signals were amplified (100,000x) filtered (1 to 300 Hz), and sampled at 1024 Hz using the Roland Consult (Germany) RetiPort system. At least 20 one second episodes were averaged.

C. Stimulus

The Ganzfeld's white LED array with CIE coordinates (0.37, 0.42) was used to generate 4 Hz flicker stimulation. The modulation around the mean luminance (60 cd/m²) was of the sawtooth type (Figure 1): rapid-ON sawtooth and rapid-OFF sawtooth each at 100% of contrast. In the ON protocol the luminance of the stimulus increased instantaneously from 0 to 120 cd/m² and decreased back to 0 in 250 msec. In the OFF protocol the luminance of the stimulus decreased instantaneously from 120 cd/m² to 0 and increased back to 120 cd/m² in 250 ms.

D. Analysis

The recordings were Fourier analyzed using self-written software (MATLAB, The MathWorks, Natick, Massachusetts, USA). The amplitudes (in microvolts) and phases (in degrees) of the 1st (fundamental) and 2nd harmonic components were analyzed. Noise was quantified by the average of the response amplitudes adjacent to the response components. Phase values were disregarded when the signal-to-noise ratio was less than 3.

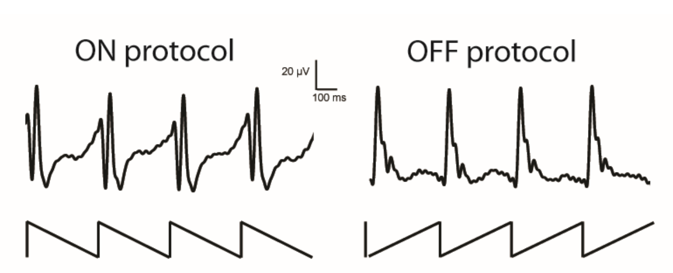

Figure 1. Luminance modulation (lower) and ERG recording (upper) from the ON (left) and OFF (right) protocols. For both protocols the parameters of the stimulus is the same, only the polarity of the modulation changes.

E. ;Psychophysical tests

Psychophysical achromatic (ON and OFF) contrast sensitivities were tested using the computer program MatLab for Windows version with which the stimuli were created using a VSG 2/4 graphics board (Cambridge Research System, Rochester, UK). The stimuli were presented on a monitor with 100 Hz refresh rate and 600 x 800 pixels spatial resolution.

The stimulus to test achromatic contrast sensitivity was a checkerboard (spatial frequency = 2 cycles/degree) with fast increase of the luminance from grey to white and slow decrease to black ON protocol and the reverse for the OFF protocol. The mean luminance of the stimulus was 34.4 cd/m².

To estimate the psychophysical threshold contrast, the subjects were instructed to choose the right or left bottom of a response box to indicate where the stimulus was placed using the forced choice method. Six independent trials were performed and the threshold contrast was expressed as the mean of these six trials.

III. RESULTS

Figure 2 shows individual recordings from a representative subject. The top part of the figure displays a continuous recording during 1 s, showing ERG responses to four cycles of the ON and the OFF stimuli, presented at 4 Hz. The middle panels display VEP responses to the same stimuli. The ON ERG response displays a negative peak [~ 47 (± 16) µV of amplitude, known as a-wave] followed by a positive peak [~ 72 (± 25) µV of amplitude, known as b-wave]. The a- and b-waves attain their peaks approximately 23 (± 3) ms and 40 (± 8) ms after the stimulation, respectively. The OFF ERG response presents only a positive peak [~ 41 (± 21) µV of amplitude, called d-wave] that occurs approximately 22 (± 1.5) ms after the stimulation.

The waveforms of the ON and OFF VEPs are different from those of the ERGs. They have lower amplitudes compared to the ERGs and longer implicit times. The ON and OFF VEPs present similar amplitudes [ON: 4.8 (± 1.9) µV and OFF: 3.3 (± 2.1) µV] when analyzed by the Fast Fourier Transform (FFT).

Figure 2 also shows the average psychophysically measured threshold contrasts (lower graph). Observe that sensitivity is very similar for the ON and the OFF protocols.

Correlation tests were performed in the group data of 25 subjects to find out if subjects with high ERG amplitude also had high amplitudes in the VEP and high sensitivity in the psychophysical test. To do this we compared ERG and VEP amplitude and phase responses of the first and the second harmonics among themselves and with the psychophysical thresholds. We have found generally no correlation between the ERG, VEP and psychophysical results. In addition there was no correlation between ON and OFF ERG responses. On the other hand, there was a positive correlation between ON and OFF VEP responses and between ON and OFF thresholds of the psychophysical tests.

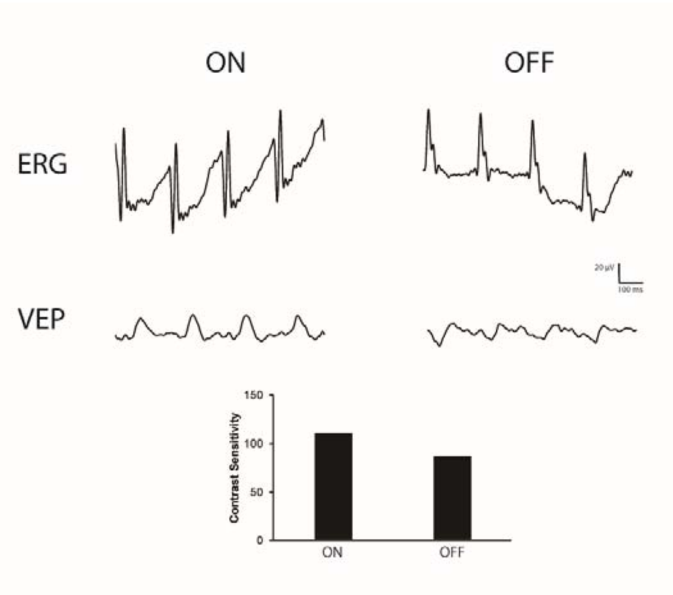

Figure 2. Recordings from a representative subject for the ERG (upper) and VEP (middle) responses of the ON (left) and OFF (right) protocols, and psychophysical results.

IV. DISCUSSION

The ERG and VEP responses can be used in humans to objectively measure neural ON and OFF activity that are the basis for visual functions such as the perception of luminance increments and decrements, respectively. They are important clinical tools because, unlike psychophysical tests, electrophysiological measurements are reliable even for patients with cognitive problems or motor limitation. The present report shows methods for measuring retinal and cortical activity that allow the study of physiological visual mechanisms underlying visual cognition.

In the retina, the ON and OFF information are processed by distinct pathways in which bipolar cells have different types of membrane receptors causing the cells to be depolarized or hyperpolarized by a luminance change [5]. This organization provides quite different responses when retinal ON and OFF activity is measured with ERGs. ON and OFF ERGs have been used to study asymmetrical responses in humans. Disease related neural changes can be more predominant in one of the pathways [6-10]

ON and OFF VEPs using full field rapid-ON and rapid-OFF sawtooth stimulation do not present such asymmetries as the ERGs. The ON and OFF mechanisms may interact extensively at the cortical level [11] thereby possibly reducing the differences.

Finally, behavioral contrast sensitivities measured by psychophysical methods with stimuli that emphasize the contribution of the ON and OFF pathways, are very similar in healthy people. This indicates that the combination of ON and OFF signals might be more prevalent at higher order levels of neural processing.

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A new hybrid training algorithm based on Bird Mating Optimizer (BMO)

Majid Rostami

Department of Mathematics, Islamic Azad University of Naragh

Arak, I.R.Iran

dr.mrostami@yahoo.com

Mehrnaz Piroozbakht
Department of Industrial Engineering, Islamic Azad University of Naragh
Arak, I.R.Iran
mpiroozbakht@yahoo.com

Abstract

Bird mating optimizer (BMO) is a novel heuristic optimization method based on the mating ways of bird species for designing optimum searching techniques. It has been proven that this algorithm has good ability to search for the global optimum, but it suffers from slow searching speed in the last iterations. This paper proposes a new hybrid algorithm based on opposition approach and BMO, named Opp-BMO. In this paper a comparison of the performance of BMO and Opp-BMO in feedforward neural networks (FNNs) training is performed, based on the case study of stock price forecasting. It is proven that an FNN trained with Opp-BMO has better accuracy than one trained with BMO.

Keywords: Feedforward neural network, Hybrid training algorithm, Bird mating optimizer, Opposition based learning, Stock price forecasting

Introduction

FNNs have various applications with great success. The first main advantage of FNNs is that they do not require a user-specified problem solving algorithm (as is the case with classic programming) but instead they ''learn'' from examples, like human beings. Their second main advantage is that they have inherent generalization ability. This means that they can recognize and respond to patterns which are similar but not identical to the ones with which they have been trained (Benardos and Vosniakos 2007, Yaghini, Khoshraftar et al. 2013)

An important part of FNN based model is training algorithm (Yaghini, Khoshraftar et al. 2013). FNN training process is an optimization task with the goal of achieving a set of weights to minimize an error measure. The problem of FNN training needs powerful optimization techniques, because, the search space is high dimensional and multimodal which is usually polluted by noises and missing data (Askarzadeh and Rezazadeh 2013).

Most often, some conventional gradient descent algorithms, such as backpropagation (BP)(Williams and Hinton 1986), are used for FNN training. The gradient-based algorithm is susceptible to be converged at local optima, because it is local search method and its final result depends strongly on the initial values of weights, biases, and its parameters. Learning rate and momentum are the parameters of these algorithm. If the initial weights are located near local optima, the algorithm would be stuck at them. To tackle the complexity of FNN training problem, metaheuristic optimization algorithms highly proposed to search for the optimal weights of the network (Askarzadeh and Rezazadeh 2013).

A lot of training algorithms with the aim of increasing the accuracy of FNN performance, reducing the problems of trapping in local minima and the slow convergence rate of learning algorithm, have been done since 2000. These algorithms are divided into three groups(Rostami and Piroozbakht 2015): metaheuristic algorithms, like (Kulluk, Ozbakir et al. 2011, Kalderstam, Edén et al. 2013) (Piotrowski, Osuch et al. 2014) (Askarzadeh and Rezazadeh 2013) (Askarzadeh and Rezazadeh 2013), hybrid algorithms based on metaheuristic algorithms and gradient based algorithms (in order to resolving problems of gradient based algorithms) such as (Piotrowski 2014) (Yaghini, Khoshraftar et al. 2013) and algorithms constructed by combination of two or more than two metaheuristic algorithms like (Mirjalili, Hashim et al. 2012).

Askarzadeh and Rezazadeh (2012) present a novel metaheuristic algorithm trying to simulate the evolution process of bird species. They used it for modeling of proton exchange membrane fuel cell (PEMFC) system. Then it was employed for FNN training and compared with other algorithms. The results were as follows:

CNNE > BMOANN > COOP > GANetbest> SVM-best > CCSS = EDTs > OC1-best > MGNN where BMOANN is the their proposed algorithm. Also, they used this algorithm to build an ANN-based model for proton exchange membrane fuel cell (PEMFC) system. Also, this model was trained with particle swarm optimizer (PSO) and BP algorithms. BMOANN yielded better result than the other artificial neural networks (ANNs)(Askarzadeh and Rezazadeh 2013).

opposition based learning (OBL) was first identified by Tizhoosh (2005) and it was applied to PSO. This approach is based on the concept of opposite points and opposite numbers (Tizhoosh 2005). Han and He (2007) proposed a modified PSO algorithm for noisy problems, which utilizes opposition-based learning (Han and He 2007). Wu et al. (2008) proposed an opposition-based comprehensive learning PSO which utilized opposition-based learning for swarm initialization and exemplar selection (Wu, Ni et al. 2008). Omran (2009) presented the improved PSO, which applied a simplified form of opposition-based learning. In this approach, the particle having worst fitness was replaced by its opposite particles (Omran 2009). Yaghini et al.(2011) proposed a Hybrid Improved Opposition-based particle swarm optimization and genetic algorithm (HIOPGA) method that combines ability of two populations based algorithms (Yaghini, Khoshraftar et al. 2011, Yaghini, Khoshraftar et al. 2013).

As mentioned Askarzadeh and Rezazadeh proved the best application of BMO rather than some powerful algorithms like CNNE, COOP, GANetbest, SVM-best, CCSS, EDTs, OC1-best and MGNN (Askarzadeh and Rezazadeh 2013). Authors identified the best number of hidden layer neurons for FNN model used for stock price forecasting and compared the performance of BMO with GA and PSO for FNN training. The results show that the BMO has better performance than GA and has the same performance as the PSO (Rostami and Piroozbakht 2015).

Stock price data are one of the most important information to investors. Stock prices are essentially dynamic, non-linear, nonparametric, and chaotic in nature (Oh and Kim 2002). Past works on forecasting stock prices can be classified into two categories: statistical and artificial intelligence (AI) models (Franses and Ghijsels 1999). AI approaches, such as neural network, fuzzy system, and genetic algorithm, have been utilized in predicting stock prices in (Armano, Marchesi et al. 2005, Wang, Wang et al. 2011). Among a large number of various ANN applications, stock price forecasting like a bat-neural network multi-agent system (BNNMAS) for stock price prediction: Case study of DAX stock price (Hafezi, Shahrabi et al. 2015), an investigation and comparison of artificial neural network and time series models for chinese food grain price forecasting (Zou, Xia et al. 2007) and some of works in field of forecasting of financial market and forecasting stock indices with back propagation neural network (Wang, Wang et al. 2011) can be mentioned.

In this paper, the efficiency of Opp-BMO is investigated for training FNNs in comparison with BMO and PSO. The Case study using in this article is stock price forecasting of "Oil Industry Investment Company".

The rest of the paper is organized as follows: section 2 presents a brief introduction to the concepts of BMO and OBL. Section 3 identifies Opp-BMO algorithm and assumptions used in this paper. The experimental results are demonstrated in section 4. Finally, section 5 concludes the paper.

2. Literature review

2.1 Bird mating optimizer (BMO)

Given the novelty of the algorithm, a brief description is represented (Rostami and Piroozbakht 2015) (Askarzadeh and Rezazadeh 2013).

In this algorithm, there is a population of birds named a society. Members of this society are named as birds. Every bird is a solution for the algorithm. The first population of birds is produced randomly. Every iteration of algorithm is as follows:

Birds are divided into four groups: pa, mg, pg and pr birds. “pa” birds are female and “mg”, “pg”, “pr” birds are male. The presence of each bird in community is known in percentage. Usually, “pa” and “pr” birds include less, and “pg” and “mg” birds are more percentage. At first, we calculate the fitness function of any solution. Then, we order the birds (solutions) according to their fitness values. The best birds (the birds with best fitness function) are "pa" birds. Then the best of remain birds are respectively "mg" and "pg" birds and the last group is "pr" (worsts of the society). “pr” birds are deleted and replaced by solutions obtained by Eq. (1). In this equation, z is chaos variable and its initial value is a random number between 0 and 1 (not the points of 0.25, 0.50 and 0.75). At every iteration, the parameter z^{gen} is firstly to be updated by Eq. (2):

For j=1:d

$$x(\xi,j)= l(j) + z^{gen} *u(j)-l(j)) \tag{1}$$

End

$$z^{gen+1} = 4 * z^{gen} * (1 - z^{gen}) \tag{2}$$

After preparing the parent birds, it is time for brood production.

We show the set of birds in a society by λ, so that $\lambda=\mu \cup \xi \cup \psi \cup \kappa$, where μ, κ, ψ and ξ represent the set of “mg”, “pg”, “pa” and “pr” birds, respectively. Each bird is shown by a vector $\vec{x}(\lambda)$=(x (λ, 1), x (λ, 2),.., x (λ, d)).

In all formulas shown in Fig. 3, *d* expresses the dimension. *J,* is the variable index for which *d* is the maximum. *W,* expresses the weight in each iteration, with a changing value (according to time) and shows the importance of selected bird. r_1, r_2 , r_3 and r_4 are normally distributed random numbers between 0 and 1, m_w denotes mutation weight, and *u(j)* and *l(j)* are the upper and lower bounds of variable jth, respectively. Each gene of the brood may be produced by mutation in the bird gene. The probability of mutation is controlled by a factor named mutation control factor, *mcf,* which varies between 0 and 1. This factor helps the algorithm maintains the diversity and avoids premature convergence (Askarzadeh and Rezazadeh 2013).

1) Mating of "pa" Bird:

"Pa" bird mates with one or more males from the best ones ("mg" birds). It’s supposed that by mating a “pa” bird with multiple males only one brood is produced. A “pa” bird selects a male by use of an annealing function (Fig. 1.a). In order to increase the probability of raising a good brood, a predefined percentage of “mg” birds with better qualities are selected for mating.
Where *pr* is the probability of selecting, Δf denotes the absolute difference between the objective functions (fitness functions) of the “pa” bird and “mg” one, and *T* is an adjustable parameter to control the probability. Then a random number between 0 and 1 is generated and compared with the calculated probability. If it is less than the calculated probability, that “mg” bird is selected for mating. Otherwise, the selection of that male is failed.

After selecting of "mg" bird(s) and mating, brood genes are produced according to Fig. 1.b. Where $\vec{x}(\psi)$ is the “pa” bird, $\vec{x}(em_i,j)$ is the ith elite male, and n_{em} denotes the number of interesting elite males.

2) Mating of "mg" Bird:

“Mg” bird mates just with one female. The bird selects its pair among females, "pa" birds, using the roulette wheel approach (Fig. 1.c). In roulette wheel approach, the selection probability of the bird *kth* from a group including *m* birds is defined by formula shown on Fig. 1.c. Based on its selection probability, each female bird is devoted a range between 0 and 1. The female birds with better qualities have wider range than the others. Then, a random number is uniformly generated between 0 and 1. That range which includes the generated number is specified and the corresponding bird is selected as the interesting bird (pair). Birds with better quality have more chance of being selected.

After selecting a female and mating, the brood genes are obtained according to Fig. 1.d. Where x(brood,j), x(μ), and x(ef) are, respectively, the produced brood, “mg” bird, and interesting female.

3) *Mating of “pg” Bird:*

“Pg” bird mates with one or more female birds. It selects the pairs among "pa" birds through annealing method. The resulted brood genes are obtained through pseudocode shown on Fig. 1.e. Where x(κ, j) and x(ef_i,j) are, respectively, the *jth* jenes of “pg” bird and *jth* jenes of *ith* elite female, n_{ef} denotes the number of elite females, and r_i are normally distributed random numbers between 0 and 1. A “pg” bird combines the information of solutions.

4) Mating of “pr” bird:

As mentioned, “pr” birds, are replaced with a set of solutions resulted from Eq. (1), at the beginning of the algorithm. Now, the new birds come into mating process. The method of selecting a female bird and mating is the same as "mg" birds. The brood genes are obtained based on Fig. 1.f. Where x(ξ,j) denotes the “pr” bird.

Next step is replacement. In this step, the bird decides whether to replace the brood or not? If brood has better genes than bird, bird leaves and brood enters the community. Otherwise, bird stays and brood may not enter the community.

Fig. 4.a describes an iteration of BMO algorithm (Rostami and Piroozbakht 2015).

For j=1:d

If $r_1 < mcf$

x(brood,j)= x(ψ,j)+w $*\sum_{i=1}^{n_{em}} r_i$ * (x(em_i,j)- x(ψ,j))

Else

x(brood,j)=x(ψ,j)+m_w*$(r_2 - r_3)$*(u(j)-l(j))

End

End

(b)

$$p_k = \frac{1/_{\text{fit}(\vec{x})}}{\sum_{i=1}^{m} 1/_{\text{fit}(\vec{x})}}$$

(c)

$$pr = exp(\frac{-\Delta f}{T})$$

(a)

For j=1:d

If $r_1 < mcf$

x(brood,j)=x(μ,j)+w*r_2*(x(ef,j)-x(μ,j))

Else

x(brood,j)=x(μ,j)+m_w*$(r_3 - r_4)$*(u(j)-l(j))

End

End

(d)

For j=1:d

If $r_1 < mcf$

x(brood,j)=x(ξ,j)+w*r_2*(x(ef,j)-x(ξ,j))

Else

x(brood,j)=x(ξ,j)+m_w*$(r_3 - r_4)$*(u(j)-l(j))

End

End

(f)

For j=1:d

If $r_1 < mcf$

x(brood,j)= x(κ,j)+w $*\sum_{i=1}^{n_{ef}} r_i$ * (x(ef_i,j)- x(κ,j))

Else

x(brood,j)=x(κ,j)+m_w*$(r_2 - r_3)$*(u(j)-l(j))

End

End

(e)

Figure 1. Pseudocode of mating of "pa","mg","pg" and"pr" birds (Askarzadeh and Rezazadeh 2013)

2.2 Opposition-Based Learning (OBL)

The concept of opposition-based learning was presented by Tizhoosh (Tizhoosh 2005) and its applications were identified in (Tizhoosh 2005, Tizhoosh 2005, Tizhoosh 2006). Before concentrating on opposition-based learning, opposite numbers should be defined (Tizhoosh 2005):

Definition 1. Suppose *x* is a real number in an interval $[a, b]$ $(x\epsilon\ [a, b])$; the opposite number, $\hat{x}$, is defined by

$$\hat{x} = a + b - x \tag{3}$$

Similarly, this definition can be extended to high dimensional spaces as follows (Tizhoosh 2005):

Definition 2. Suppose $P(x_1, x_2, \ldots, x_n)$ be a point in n-dimensional space, where $x_1, x_2, \ldots, x_n \epsilon R$ and $x_i \epsilon [a_i, b_i]$ $\forall i \epsilon \{1,2, \ldots, n\}$. The opposite point of *P* is defined by $\hat{P}(\hat{x}_1, \hat{x}_2, \ldots, \hat{x}_n)$ where**:**

$$\hat{x} = a_i + b_i - x_i \tag{4}$$

Now, by using opposite point definition, the opposition-based optimization can be defined as follows:

Opposition-Based Optimization. Suppose $P(x_1, x_2, \ldots, x_n)$, a point in an n-dimensional space with $x_i \epsilon [a_i, b_i]$ $\forall i \epsilon \{1,2, \ldots, n\}$, is a candidate solution. Assume *f(x)* is a fitness function which is used to measure candidate optimality. According to opposite point definition $\hat{P}(\hat{x}_1, \hat{x}_2, \dots, \hat{x}_n)$ is the opposite of $P(x_1, x_2, \dots, x_n)$. Now, if $f(\hat{P})$ is better than $f(P)$, then point P can be replaced with $\hat{P}$; otherwise we continue with P. Hence, the point and its opposite point are evaluated simultaneously to continue with the fitter one (Han and He 2007).

3. Opp-based Bird Mating Optimizer (Opp-BMO) algorithm for training FNNs

In this section, the proposed hybrid algorithm to optimize the weights of FNN prediction models is explained. It is a combination of local search and global search algorithms.

3.1. Opp-based Bird Mating Optimizer (Opp-BMO) algorithm

The basic idea of Opp-BMO is to combine the ability for social thinking (gbest) in BMO with capability of OBL to accelerate convergence speed. In this study, OBL is combined with BMO through two steps: first, after birds' initialization and before entering into loop. Second, it's applied inside the loop.

3.1.1 Using OBL outside the loop

In this stage, after birds' initialization, opposition of generated population is produced. Suppose each bird is showed by a vector as followed:

$\vec{x}$ (i)=(x(i,1) , x(i,2),..,x(i,j),…, x(i,d)) (5)

Where x(i,j) is j-th gene of i-th bird. d is the number of genes (or dimension of solution vector). The opposition bird is defined as followed:

$\vec{\tilde{x}}$(i)=($\tilde{x}$(i,1) , $\tilde{x}$ (i,2),.., $\tilde{x}$ (i,j),…, $\tilde{x}$ (i,d)) (6)

Where

$\tilde{x}$(i,j)=l(i,j)+u(i,j)- x(i,j) (7)

l(i,j) and u(i,j) are the lower and upper bounds of variable j-th, respectively. Now fitness function of each bird (solution) and its opposition are calculated and compared. If fit($\vec{\tilde{x}}$(i)) is better than fit($\vec{x}$(i)), then the bird (solution) is replace by its opposition, otherwise algorithm continue with bird.

3.1.2 Using OBL inside the loop

In the second step, we use OBL inside the loop. As mentioned, inside the loop and after specifying each species, BMO algorithm replaces "pr" birds with birds (solutions) calculating by Eq. (1). It should be noted when the upper and lower bounds are equal, l(i,j)= -u(i,j), solutions generated through Eq.(1) are identical. So, these identical solutions are entered to mating step.

In this study, instead of deleting of worst solutions ("pr" birds) and replacing them by identical solution, opposition of these solution which are more probable to be near to the optimal point, are generated. So, Eq. (1) and (2) are replaced as followed (8):

```
for i= 1 to number of "pr" birds

  for j=1:d
        x̃_i = u(j) + l(j) − x_i
  end                                                    (8)
    If fit(x̃_i) is better than fit(x_i), x_i is replaced with x̃_i
   else
     continue with x_i
  end
end
```

Hence, the point and its opposite point are evaluated simultaneously to continue with the fitter one.

The pseudocode and flowchart of Opp-BMO algorithm are represented in Figs. 2 and 3: respectively.

Determine the society size, percentage of “mg”, “pg”, “pr”, and “pa” birds, maximum number of generations, and the other parameters
Initialization of the birds and **generation** of their oppositions:
Calculate fitness function of the birds and fitness function of their oppositions — Using OBL outside the loop
Select the best bird between bird and its opposition
Sort birds based on their fitness function
Specify “pa”, “mg”,"pg" and “pr” birds
Generate opposition of the "pr" birds and **select** the best bird between "pr" bird and its opposition — Using OBL inside the loop
For *i* = 1 **to** number of “pa” birds
Select its pairs based on Fig. 1.a
Produce the brood according to Fig. 1.b
Next *i*
Calculate fitness function of the broods
Do replacement step
For *i*= 1 **to** number of “mg” birds
Select its pair based on Fig. 1.c
Produce the brood according to Fig. 1.d
Next *i*
Calculate fitness function of the broods
Do replacement step
For *i*= 1 **to** number of “pg” birds
Select its pairs based on Fig. 1.a
Produce the brood according to Fig. 1.e
Next *i*
Calculate fitness function of the broods
Do replacement step
For *i*= 1 **to** number of “pr” birds
Select its pair based on Fig. 1.c
Produce the brood according to Fig. 1.f
Next *i*
Calculate fitness function of the broods
Do replacement step
Update the parameters

Figure 2. Pseudocode of Opp-BMO algorithm

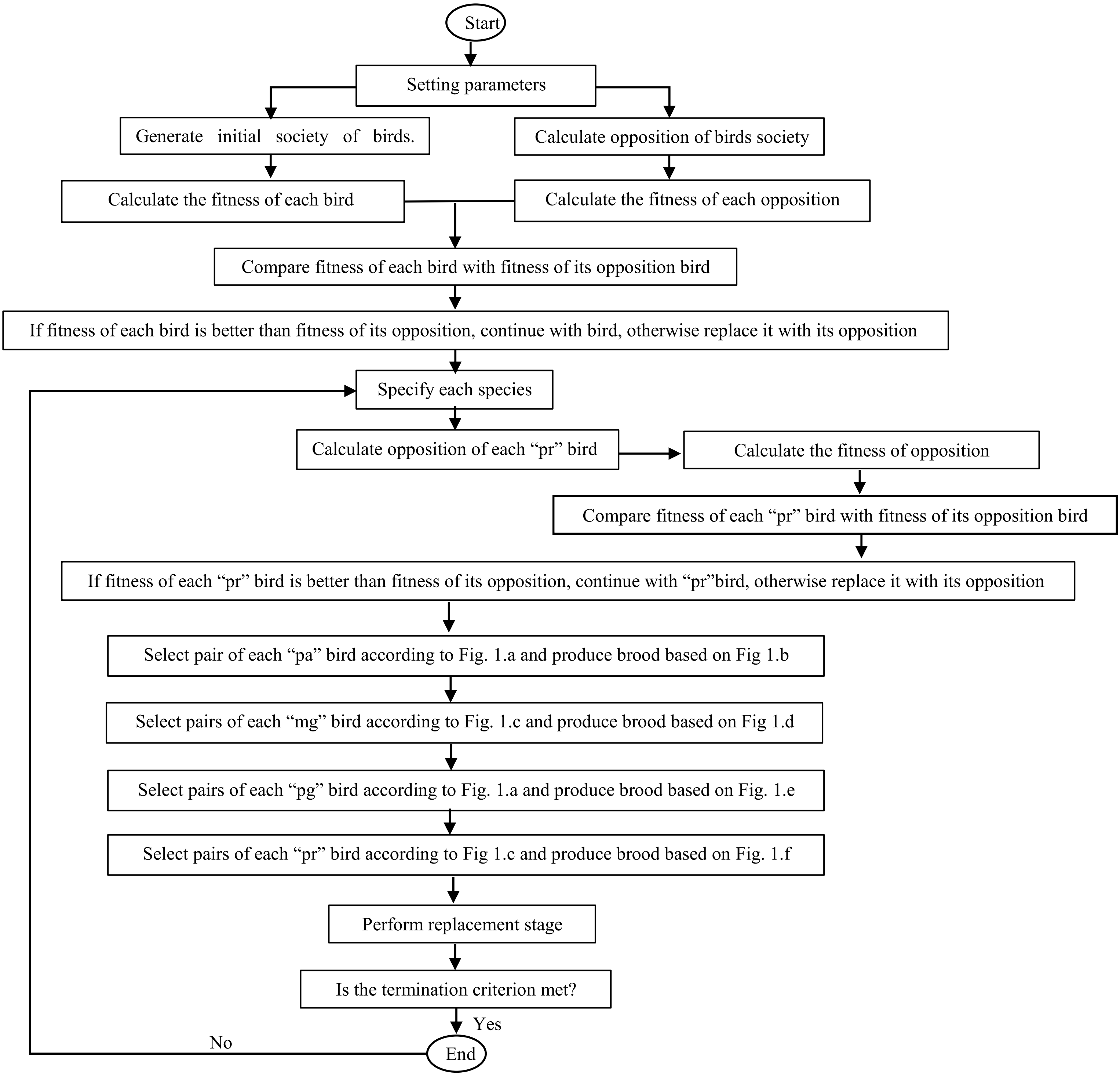
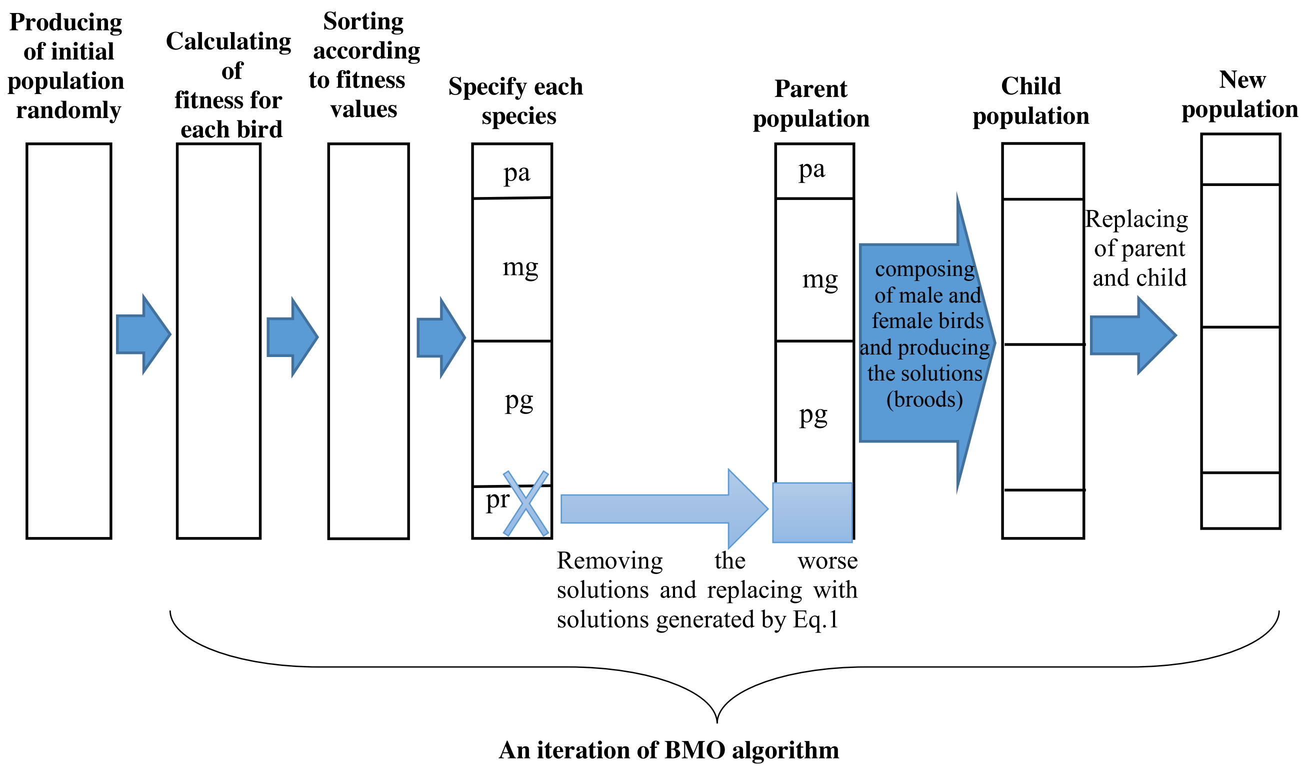
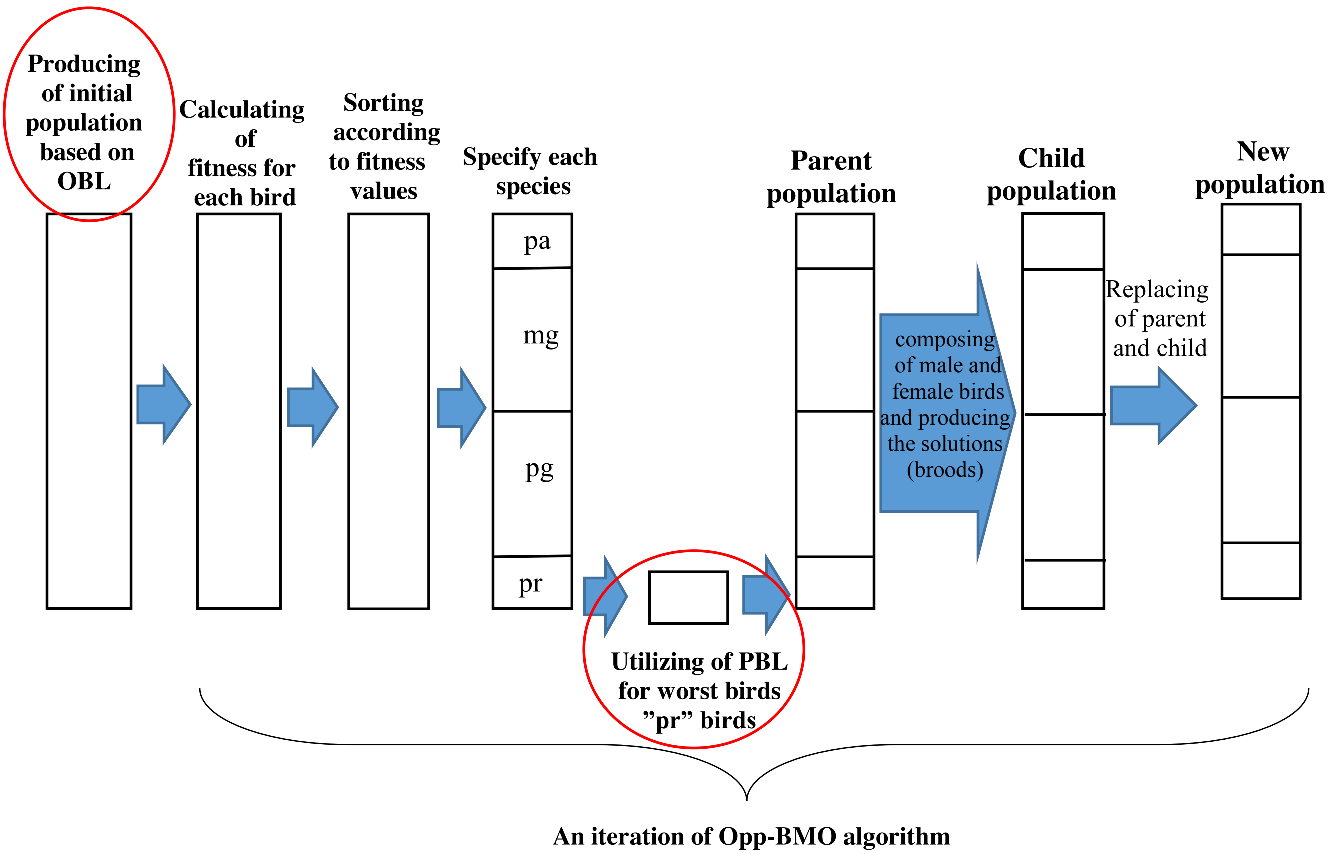


Figure 3. Flowchart of Opp-BMO algorithm

In Fig. 4, differences of two algorithms are shown. Fig. 4.a is related to BMO algorithm and Fig. 4.b. belongs to Opp-BMO algorithm. Variations are marked by circle.



a. An iteration of BMO algorithm (Rostami and Piroozbakht 2015)



b. An iteration of Opp-BMO algorithm

Figure 4. Differences between BMO and Opp-BMO

3.2. NN architecture used in this study

The architecture of FNN which is used in this article is acquired from (Rostami and Piroozbakht 2015). It is considered as follows: Number of nodes in the input layer is 4. The inputs are the Brent oil price, maximum price, minimum price, first (opening) price. Closing price is the output of network. Feedforward neural network using in this study, has three layers. The number of neurons in the hidden layer is considered 11. Hidden units employ hyperbolic tangent as their activation function, while output units make use of linear function. If we want to use this model for time series prediction, we will have:

$$P_t = f(P_{max,t-1}, P_{min,t-1}, P_{open,t-1}, P_{oil,t-1}) \quad (9)$$

where, P_t is the closing price at time *t*, and it is defined as output of network. $P_{max,t-1}$, $P_{min,t-1}$, $P_{open,t-1}$, denote maximum, minimum and opening stock price of "Oil Industry Investment Company" at time *t-1*. $P_{oil,t-1}$, is the Brent oil price at time *t-1*.

As shown in equation (9), the closing price is considered as the model's output, and four variables of the maximum price, the minimum price, the opening price, and the Brent oil price are supposed as inputs to the neural network model.

3.3 Data collection

Brent oil price can be acquired from the Eranico Website. Maximum price, minimum price, first (opening) price of Oil Industry Investment Company have been extracted from *Tehran* Securities *Exchange* Technology Management Co. . Time period in this study is from seventh September 2013 to sixth September 2014. Data has been collected and stored in EXCEL environment. MATLAB environment is implemented to code FNNOpp-BMO and FNNBMO.

3.4 Assumptions and parameter values

Parameter settings of FNNBMO and FNNOpp-BMO algorithms are according to the (Askarzadeh and Rezazadeh,2013); "mg", "pg","pa", and "pr" birds make 50%, 40%, 5%, and 5% of the society, respectively; T, w, and m_w are defined as decreasing linear functions where T_{max} = 300, T_{min} = 50, w_{max} = 2.5, w_{min} = 0.5, $m_{w,max}$ = 0.01, and $m_{w,min}$ = 0.0001; *mcf* is selected 0.9. For FNNPSO, c_1 and c_2 are set to 2, r_1 and r_2 are two random numbers in the interval [0,1], w is equal to 1, and the initial velocities of particles are randomly generated in the interval [0,1]. Minimum and maximum values of variables in each algorithms are set to -1 and 1, respectively. It should be noted that the parameter setting is based on trial and error and no attempt has made to optimize it. For two algorithms, the society size is set to 100 and maximum number of generations (epochs) is set to 50.

4. Experimental verification

Due to the fact that the nature of metaheuristic algorithms is stochastic, the results obtained in one attempt will differ from the results obtained in another attempt. Therefore, the performance analysis must be statistically based. Results of FNNGA, FNNPSO and FNNBMO are compared based on average, median and standard deviation of the Mean Square Error (MSE) for training set and testing set over 40 independent runs. Termination criterion of NN training is maximum epochs.

Table 1 reports the performance of FNNBMO, FNNOpp-BMO and FNNPSO statistically in stock price forecasting for training set. It is obvious that FNNPSO and FNNBMO have approximately the same performance, but according to average and median of MSE over 40 independent runs, FNNOpp-BMO has better efficiency and forecast accuracy. Best results are marked in bold.

Table 1:Average, median, standard deviation, and best of MSE (%) for all training set over 40 independent runs for FNNOpp-BMO, FNNBO and FNNPSO in order to modelling of stock price forecasting.

Algorithm	Min	Max	Average MSE	Std dev MSE	Median MSE
FNNBMO	0.93	4.88	2.28	0.88	2.22
FNNOpp-BMO	**0.88**	**2.77**	**1.49**	**0.48**	**1.45**
FNNPSO	1.04	4.42	2.16	0.77	1.98

Table 2 indicates, the results of three algorithms on testing set. As can be seen, FNNOpp-BMO produces better results than FNNBMO and FNNPSO.

Table 2: Average, median, standard deviation, and best of MSE (%) for all testing set over 40 independent runs for FNNOpp-BMO and FNNBMO in order to modelling of stock price forecasting.

Algorithm	Min	Max	Average MSE	Std dev MSE	Median MSE
FNNBMO	0.72	**8.5**	3.03	2.14	2.12
FNNOpp-BMO	**0.72**	11.85	**2.35**	**1.89**	**1.71**
FNNPSO	0.82	20.97	3.1	3.28	2.24

In summary, as the last column of Table 3 indicates, the capability of the algorithms tested here can be ordered as FNNOpp-BMO > FNNBMO = FNNPSO.

Table 3. Comparison of FNNOpp-BMO and the other FNNs in terms of average testing error rate (%)

Algorithm	FNNOpp-BMO	FNNBMO	FNNPSO
Test error rate(%)	3.03	2.35	3.1

5. Conclusion

The main goal of this paper is to define a new hybrid training algorithm based on the OBL and BMO. BMO is a recently devised population based optimization algorithm which imitates the mating behavior of bird species for breeding superior broods and provides different strategies to effectively seek the search space. As mentioned, this algorithm shows superior capability to tackle the problem of FNN weight training(Askarzadeh and Rezazadeh 2013). This algorithm divided the search space into four groups, then replaces worst solutions with solutions which are usually identical. Worst solutions are the furthest points from optima point, so it is more probable that the opposition of worst solutions be nearest points to optima solution. In this article, instead of removing the worst solutions, we use OBL technique in order to benefit the opportunity and possibility of BMO algorithm in classifying the solutions. This composition helps BMO algorithm to avoid trapped in local minima and improve slow convergence rate of BMO. Case study used in this article is stock price forecasting model. The results of the FNNOpp-BMO are promising when we compare its performance with FNNBMO and FNNPSO. Therefore, Opp-BMO algorithm can be an efficient candidate for training FNNs.

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AN EVENT-RELATED ANALYSIS OF THE TRADERS DECISION-MAKING BY USING ICA

Roberto Ivo da R. L. Filho
Federal University of Rio de Janeiro
University of São Paulo[1]

Marcelo M. Taddeo
University of São Paulo

Paloma V. Uribe
University of São Paulo

<u>INTRODUCTION</u>: The objective of this article is to identify, with the aid of an electroencephalogram (EEG) and by using a multivariate statistical tool called independent component analysis (ICA), the areas of the brain and their interconnection associated to the Traders' decision-making process. In order to assess such activity, a sample of forty (40) experienced traders were used, both divided equally into 50\% male and 50\% female. In Lima Filho (2014), it was found through brain mappings that such traders tend to make decisions by using an associative based rule process instead of any of analytical form, as posed by much of the classical financial literature.

<u>METHODOLOGY</u>: Volunteers participated in a simulation of investments on the São Paulo Stock Exchange - BM & FBovespa - whilst electroencephalogram (EEG) epoch was recorded. The total simulation time lasted 50 minutes, also subdivided into 25 minutes, primarily related to a bull market and then a down market. Thus, the purpose was to characterize brain activity patterns associated with the purchase, sell or hold decision of a set of shares comprising two experimental portfolios (called A – Upward Market and B - Downward Market). According to Onton and Makeig (2006), "electrode locations are at best quite crude indicators of the locations of even the strongest underlying cortical sources", resulting into EEG recordings with 'low spatial resolution.' Since we aim to isolate the areas of the brain that were activated, a way of tackling this problem is making use of the Independent Component Analysis (ICA). They decompose the data (input) into a set of components which are independent and explain the data itself and its variability by writing them as a linear combination of such factors.

<u>RESULTS:</u> Traders group proved to have a more heterogeneous decisions, given high standard deviation, with even negative values. It is also worth mentioning that the average decision time this group was fast, a total of 49.2 seconds/decision. This may also suggest a time discount regarding the expected reward, as advocated by Muller and Cohen (2001), since the activation of the decision-making process occurred late in the frontal cortex and prefrontal right. Additionally, this indicates an heuristic / associative system domain. The most interesting was the fact that the purchase and sale orders have triggered different neuronal circuits, even in a predictable market, as explained by Rocha (2013).

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[1] University of São Paulo – Medical School Address: Av. Dr Arnaldo, 455 , Oscar Freira Institute - 2º andar – São Paulo –SP. E-mail: roberto_ivo@hotmail.com.

A CRÍTICA DE ARMSTRONG À NOÇÃO SEARLEANA DE BACKGROUND

Paulo Uzai Junior[1]

O *background* é uma das noções mais importantes na teoria da intencionalidade de John Searle, por ser o fundamento para a existência de qualquer ato intencional. Por intencionalidade, Searle (2002/1983, p. 1) se refere "aquela propriedade de muitos estados e eventos mentais pela qual estes são dirigidos para, ou acerca de objetos e estados de coisas no mundo". Seguindo, em certo sentido, a tradição filosófica[2], a intencionalidade searleana é o fenômeno que faz com que a mente consciente perceba e aja em relação ao mundo. Seriam exemplos de estados intencionais crenças, desejos, intenções, percepções, ações e volições. Com efeito, a grande maioria dos estados mentais têm a característica de serem intencionais.

Contudo, a base em que se apoia toda a rede dos estados intencionais que subexistem a qualquer vida humana não é, ela mesma, intencional. Tal base não intencional é o que Searle (2002/1983) chama de *background*, que seria o fundo de todas as nossas capacidades básicas e *kwon-how*. O filósofo argumenta que não é possível que o *background* seja, ele mesmo, intencional, porque para se ter qualquer estado intencional é preciso saber como as coisas são e como agir sobre elas. E esse *saber como* e *agir sobre* é o que possibilidade os seres humanos (e outros animais) a terem estados intencionais. Em outras palavras, não poderia haver intencionalidade sem certos conhecimentos básicos fornecidos pelo *background*, e ao mesmo tempo este deve ser não intencional (ou não representacional).

Um exemplo simples de como o *background* age sobre os estados intencionais é o de abrir uma porta. Para os seres humanos abrirem portas eles devem *saber* o que aquele objeto é e como *agir* eficientemente sobre ele. Somente assim a ação intencional *abrir uma porta* se torna possível. Não obstante, o exemplo que demos é culturalmente especifico, ou seja, é possível concebermos uma cultura que ignore por completo a existência de portas e, dessa forma, não sabia o que ela é e nem saberia agir sobre ela.

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1. Psicólogo formado pela Universidade Estadual Paulista (UNESP), campus de Bauru. Atualmente é mestrando do programa de Pós-Graduação em Filosofia da Mente, Epistemologia e Lógica da UNESP-Marília. Contato: paulouzai@gmail.com

2. Tradição esta que, na modernidade, tem como grande representante Franz Brentano. Searle, em certo sentido, é herdeiro dessa tradição, pois postula que a mente subjetiva se volta para estados e objetos de coisas do mundo, dando a este movimento o nome de intencionalidade. Contudo, há um sentido em que a intencionalidade em Searle se diferencia radicalmente de Brentano, qual seja, que os estados mentais não são sempre intencionais. Em Searle pode haver estados mentais não intencionais.

Com efeito, Searle (2002/1983; 2006) sugere que o *background* seja classificado em dois tipos: básico e local, que correspondem, respectivamente, as capacidades biológicas básicas comuns a toda espécie humana e as práticas culturais locais. Dessa forma, o exemplo que demos se coloca dentro do *background* local. Assim, mesmo um ato culturalmente específico como abrir uma porta é encarado como algo que subjaz no *background local*, ou seja, faz parte do fundo não representacional local.

À revelia o aparente externalismo desta noção de *background*, Searle (2006/1983) argumenta que ele ainda é mental. Ele não se reduz às capacidades biológicas, nem às relações sociais, mas sim continua sendo uma capacidade da mente humana. Searle não nega que haja capacidades biológicas e relações sociais que influenciem no *background,* pois, de qualquer modo, somos seres biológicos e sociais. Sem uma constituição biológica e um conjunto de relações sociais não poderíamos vir a ter o *background* que temos. No entanto, isso não invalida o fato de que tal fenômeno é também um fenômeno mental. Todos os fatores sociais, biológicos e físicos só são relevantes na produção de um *background* específico por conta da relação que estabelece com cérebros e corpos humanos, ou seja, com a mente humana. Sem a mente não poderia haver *background* e é nesse sentido que ele é mental.

> O Background, portanto, não é um conjunto de coisas nem um conjunto de relações misteriosas entre nós e as coisas, mas simplesmente um conjunto de habilidades, suposições e pressuposições pré-intencionais, posturas, práticas e hábitos. Tudo isso, até onde se sabe, é realizado no cérebro e corpos humanos. (SEARLE, 2002, p. 214).

Este aspecto mentalista, i.e. irredutível[3] do *background* não agrada muitos autores que desejariam transformá-lo num fenômeno de terceira pessoa, entre eles David Armstrong. Para este autor, a persistente defesa da irredutibilidade ontológica da intencionalidade feita por Searle é inaceitável, pois dessa maneira torna-se muito difícil pensar como estudaremos cientificamente esse fenômeno em seus próprios termos. Como estudar a ontologia da intencionalidade se ela permanece um fenômeno puramente subjetivo? Armstrong (1991) não acredita que uma redução tipo-tipo, como é feita entre calor e movimento molecular, seria adequada para a complexidade do fenômeno mental intencional, mas ele argumenta que podemos fazer uma redução

3. Por conta do espaço, não tratamos da defesa que Searle faz da irredutibilidade ontológica do mental ao corporal. Grosso modo, Searle (2006) argumenta que sempre nos sobra o aspecto subjetivo quando tentamos reduzir (ou eliminar) o mental. Dessa forma, todos os fenômenos mentais (e isso inclui a intencionalidade e o *background*) seriam ontologicamente irredutíveis à processos neurofisiológicos.

ocorrência-ocorrência (*token by token*) com a intencionalidade. Dessa forma a intencionalidade humana tornar-se-ia uma espécie de sistema funcional, onde explicaríamos seu funcionamento através de um comportamento sistêmico.

O sistema funcional a qual Armstrong faz referência seria do mesmo tipo teleológico como ocorre na biologia. "[...] parece-me muito plausível dizer que ela é uma verdade conceitual de modo que um sistema intencional é um sistema funcional." (ARMSTRONG, 1991, p. 151, tradução nossa). Assim um sistema funcional intencional seria alguma coisa que executaria determinadas funções em circunstâncias favoráveis para tais. Em circunstâncias desfavoráveis, ou por pura má sorte, o sistema não executaria essas funções. Isso, para Armstrong (1991), é certamente algo intencional (ou alguma coisa que se aproxima muito disso). Então uma análise causal ou funcional da intencionalidade torna-se plausível, mais do que isso, um tipo de redução funcional seria possível[4].

Não obstante, Armstrong diz que os estados intencionais não são isolados, nem poderiam ser vistos dessa forma. Com isso, ele se volta para a noção searleana de *background*, dizendo que, apesar de ser uma noção muito importante, Searle não a trabalhou de maneira adequada. Searle (2002/1983, 2004) diz que o *background* careceria de intencionalidade por ser, ele mesmo, a base de toda intencionalidade. Contudo Armstrong (1991) não pensa dessa forma. Ele argumenta que podemos encarar o *background* como sendo intencional tal como qualquer outro ato intencional no nível mental humano. A única argumentação que Searle parece oferecer contra o *background* intencional seria que, caso isso ocorresse, deveria haver um outro fenômeno que o sustentasse, e caso esse outro fenômeno também fosse intencional, deveria haver um ainda mais básico, e assim *ad infinitum*. Contudo, Armstrong não acredita que postular um *background* não intencional invalida, de fato, a redução infinita. Ora, por que não deveríamos supor que há um *background*, também não intencional, ainda mais básico, uma espécie de *background* do *background*, e assim sucessivamente?

Retornando à abordagem dos sistemas funcionais, Armstrong (1991) diz que poderíamos encarar o *background* como um sistema mais básico que o mental. Mas ambos, tanto o nível mental quanto o nível do *background*, intencionais. Claro, por pensar em níveis de sistemas funcionais, em cada nível haveria um aumento ou

4. Não é difícil observarmos que esse tipo funcional de intencionalidade poderia servir para a matéria não biológica de forma geral. Um robô que se comporta de determinada maneira poderia ser visto como tendo um comportamento intencional tal como os seres humanos, ou ao menos um comportamento que se aproximaria muito do intencional humano.

diminuição da intencionalidade. Dessa forma, Armstrong utiliza a teoria dos homúnculos de Daniel Dennett, onde em cada nível haveria sistemas funcionais (homúnculos) cada vez mais estúpidos, i.e. cada vez menos intencionais.

Armstrong (1991) diz que esse tipo de visão é muito melhor, do ponto de vista evolucionário, do que qualquer tipo emergente "saltatório" de intencionalidade. Ou seja, que salta o *gap* entre a matéria física não-intencional direto para o mental intencional. Armstrong acredita que os naturalistas (Searle e ele, inclusive) devem evitar esse tipo de salto, ou tentar reconciliar o aparente salto com algum tipo de explicação causal explícita. No parecer de Armstrong, Searle não cumpriu nenhuma dessas duas exigências, tentando saltar, por assim dizer, de um *background* não intencional para o mental intencional.

Searle (1991) responde às críticas de Armstrong dizendo que, primeiramente, não seria possível fazer uma redução funcional da intencionalidade, onde o funcionalismo trabalhará teleologicamente, sem com isso fazermos uma terrível redefinição e subsequente eliminação do caráter mental subjetivo. "[...] não podemos eliminar a intencionalidade em geral e recolocá-la como função teleológica, porque a função teleológica apenas existe relativa a uma intencionalidade intrínseca." (SEARLE, 1991, p. 183, tradução nossa).

Já em relação ao *background*, uma pergunta que pode ser feita é o que pensa o homúnculo em cada nível explicativo? (SEARLE, 1991). Claro, a metáfora dos homúnculos não deve ser tomada demasiadamente a sério, mas Searle diz que essa seria uma pergunta interessante de se fazer. Se há intencionalidade em cada nível explicativo, de que tipo seria? Uma outra questão que poderia ser posta na formulação de Armstrong é que se o primeiro homúnculo, o mais básico de todos, o último na escala de estupidez, é balizado por uma matéria inconsciente, ou seja, no momento mesmo em que a intencionalidade é descarregada[5] (*discharged*), então como se dá o salto entre o não intencional e o intencional mais estúpido? Não seria também esse um salto explicativo?

Acreditamos, por fim, que nessa discussão acerca do *background* na intencionalidade ao menos uma questão muito importante deve ser refletida. Se a abordagem da intencionalidade de Searle é naturalista, então é lícito, seguindo esta abordagem, pensar que a intencionalidade é um fenômeno natural. Ora, se ela é um

5. Armstrong segue, *pari passu*, a formulação de Dennett que diz que a redução a homúnculos mais estúpidos deverá, num nível muito mais baixo, descarregar toda intencionalidade. Dessa forma, estaremos novamente trabalhando com a matéria inconsciente, mesmo que seja uma matéria muito sutil.

fenômeno natural, não poderia existir outros tipos de intencionalidade mais básicas (ou mais estúpidas, como diriam Armstrong e Dennett)? Se foi possível para alguns animais a emergência do fenômeno intencional, então seria inadequado pensar que existe um tipo de intencionalidade mais elementar na matéria dita inconsciente? Ou, ao contrário, todas essas questões apenas refletem o nosso modo de olhar o mundo, ou seja, porque somos seres intencionais é que tentamos atribuir ao mundo inanimado algum tipo de intencionalidade?

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Natural & Normative Dynamical Coupling

Garri Hovhannisyan* & Caleb Dewey*
Department of Philosophy
York University
Toronto, Canada

Abstract—The primary aim of cognitive science is to naturalize cognition, which requires the naturalization of the inherent normative character of cognition. Unfortunately, cognitive science runs into the so-called "problem of normativity", wherein normativity tends to resist naturalization. As it currently stands, dynamical systems theory (DST) is unable to account for the normative dynamical orientation of cognitive systems, leaving the path to naturalizing cognition unclear and rather intangible. The purpose of this article is to outline a path towards this aim by proposing a normative dynamical systems theory of cognition. We build up to this theory in three steps. First, we argue that cognitive systems, as dynamical—and autopoietic—systems, are not simply naturally coupled to their environment, but are also normatively coupled. We infer from this that the role of cognition is to achieve and maintain a normative coupling between the system and its environment through the process of real world problem solving. Second, we draw from Vervaeke, Lillicrap, and Richards' (2012) theory of relevance realization to develop a new theory of the nature of cognition, wherein cognition is modeled economically, rather than algorithmically. Third, we consider two important challenges that invalidate Vervaeke et al.'s theory of relevance realization and show that our theory resists them.

Keywords—*relevance realization; dynamical coupling; frame problem; autopoiesis; enactivism*

***The listing of author names is not meant to imply primacy over authorship.**

Monism of Triple Aspect

a proper concept to sustain the ontology of the nature of mind-body in Meditation

Edilene de Souza Leite
Philosophy. Advisor Dr. Alfredo Pereira Jr.
Universidade Estadual do Estado de São Paulo-Faculdade de Filosofia e Ciências
Marília, Brazil
edilenesz@hotmail.com

In the West Meditation has been for so long restrict to religious issues or to spirituality. However, after the popularization and increase of the debates and researches about consciousness issues in the latter century, the interest for the topic has increased on neuropsychological e philosophical studies, because it could offer as a technique tools for stabilization of the mental states. Pragmatically some areas related to health problems had since very early already taken advantage of the practice of meditation because of its beneficial effects, as for stress relive, arousal of attention and concentration, or treatment of chronic pain. In a published article, Attention regulation and monitoring in meditation (LUTZ et al., 2008), after monitoring neuronal activity during meditation, the authors related meditation states with very high frequencies. Beyond this there is many articles indicating that the practice of meditation affects not only the type of activity in the brain, but can also change its structure physically, strongly indicating correlation of mental activity and brain, but not enough to warranty casual correlation. Nevertheless, there is still a lot of debate about the possibility of this kind of measurement of mental activity. In addition, there is many different traditions and types of techniques for meditation, what leave us in this moment without an agreement about the concept of what is meditation and what would be a proper technique (SCHMIDT & WALACH, 2014). For some scholars meditation is the exercise of the consciousness turning it to its self. All this results, of the research on meditation, implies issues that affect many concepts of the ontological nature of the mind-body, leading to a star point where all those notions of body-mind must comply with the understanding that mind and body are an unity with complementary properties. Walach sustain that we should look for a monism where "Mind or consciousness would not have to somehow arise but it would be an original complementary aspect to matter." (2015, p. 81), he also proposed in the book Secular spirituality that we could have specific access to reality through meditation, in addition to what we can learn trough perception. In this work, we aim to exposes that the PEREIRA JR.'s concept of Monism of Triple Aspect could satisfy the requirements for the ontology of the nature of body-mind during meditation, and this concept could also offer a hypothesis to the relation of the practice and its effects on the behavior and in the physiology of the body.

Keywords—meditation; body-mind problem; complementary; monism of triple aspect;

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Synchronization, self-organization and creative action: new horizons in cognitive science studies

The goal of this paper is to investigate the notion of synchronization of rhythms and its possible contribution to the understanding of creative action in the context of cognitive science studies. The following question is therefore posed: how can the concepts of rhythm and synchronization help in understanding self-organized creative processes, in the context of human action? During the progress of human civilization and the emergence of complex social interactions that include specific routines, human beings have increasingly distanced themselves from their natural rhythms, gradually becoming dependent on specific non creative actions implemented at strategically planned times. As a result, the dynamics of synchronization of the body's rhythms to the environment has been reduced to a secondary role. In this context, we will argue that an understanding of the notions of rhythm and synchronization can provide a favorable context for creative action. In the terminology of Bohm (2011), a creative action lies in the perception of new orders underlying the organization of the environment. This order allows the creation of structures that are convergent with the characteristic of wholeness and perceived harmony. One of the main driving forces underlying creative action is given by the following dynamics: the perception of the lack of synchronization and the attempt to resolve it. This perception enables the search for ways of achieving harmonization between individuals and their environments. In our presentation, we are going to explain this dynamics in terms of processes of stabilization and rupture of habits, due to the perception of a given anomaly and the attempt to resolve it from building hypotheses that supposedly would solve the problem. This process characterizes what Peirce calls *abductive reasoning* (PEIRCE, 1977, p. 220). We understand that the perception of the origin of the lack of synchronization with natural rhythms may propitiate the search for ways of harmonizing individuals in their respective environments. In summary, our hypothesis is that the search for synchronization –given at different levels of analysis (social, biological, and environmental) – is one of the main driving forces underlying creative knowledge/action.

What we're made: An analysis of the relevance of the *body* in cognitive processes

Nathália Cristina Alves Pantaleão
São Paulo State University "Júlio de Mesquita Filho"
Marília, Brazil
nacherizah@gmail.com

Franciele da Silva Leal
São Paulo State University "Júlio de Mesquita Filho"
Marília, Brazil
franciele_leal@gmail.com
Advisor: Mariana Claudia Broens

The objective of this paper is to investigate the relevance of embodiment in cognitive processes from a situated and embodied perspective. For that we will use the critical by philosophers to the representative model of cognition (CLARK, 1997, 1999, 2003, 2008; CHEMERO, 2007, 2012). According to proponents of the theory of cognition situated and embodied, the process of cognition can emerge from the interaction of the physical attributes of the bodies with the environment in which these bodies are situated. Clark, one of the advocates of the approach, advocates, including the cognitive processes cannot be adequately investigated without taking into account the roles that embodiment, the action and the environment executes in such processes (1999). It is to be situated in an environment and incorporate relevant information for a given agent that is active and not just representations generator. Thus, we argue in favor of the hypothesis that the body structures in its systemic unit, play central roles, not just peripheral, in cognitive processes that involve complex skills. Thus, we will analyze what the process of acquisition and development of complex skills is not limited to the manipulation of mental representations, and what is the scope of the hypothesis of the existence of an intrinsic dynamics between agents and their environments.

Keywords: Body. Cognition. Complex Skills.

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The Revisionist Strategy in Cognitive Science

Samuel de Castro Bellini-Leite (UFMG PhD Student)
Samuelcblpsi@gmail.com

Abstract

In this paper I provide an analysis of the frame problem in order to propose the revisionist strategy for cognitive science. Such strategy aims to describe a recipe for how cognitive science should proceed in dealing with the frame problem. The idea is that theoreticians should start by identifying various sub-instances of the frame problem (of which we provide a first list) to be used as guides for reformulating frameworks of cognitive science and how they relate. Various approaches could follow this recipe but as an example we will see how the ideas of situated cognition can help re-think ways of dealing with these sub-instances which emerged in the classic symbolic approach. This also shows how the situated approach can be seen not as a new science but as new ideas that can shape the same science.

1 Introduction

When the foundation of cognitive science was conceived in the 60s, a clear, unified and coherent concept of the mind was established. It was proposed that a mind was an information processing mechanism that performed serial manipulations on symbols. Symbols were said to represent or refer to objects in any environment and that processing them could guide the actions of agents who possessed such computing abilities. This classical computational theory of mind united various disciplines such as Artificial Intelligence, Philosophy, Psychology and Linguistics in the common goal of understanding mind as a computation. However, since then various practical and theoretical difficulties emerged as a consequence of this foundational thesis. The most notable of these difficulties is called the Frame Problem. Such problem can be summarized as the problem for an information processing system to deal with a changing environment relevantly. Now faced with these difficulties, cognitive scientists are either reluctant to define their foundations precisely (e.g. the nature of computation which is used by cognitive agents) or have changed them in some radical fashion (e.g. radical embodiment). This also caused a breakdown of cognitive science into various distinct approaches, such as the connectionist approach, the embodied approach, the dynamical systems approach and the predictive coding approach. Also, there are those who have argued that the frame problem indicates that the mind is not an information processing mechanism (such as Dreyfus 1972 and perhaps Fodor, 2001), that is, that there is no hope in revising the science. I propose in this paper to elaborate a revisionist strategy, which is not a solution but rather a recipe for dealing with the frame problem. In a nutshell, the strategy is to identify sub-instances of the frame problem, and then take a given framework of cognition which seems to fall under some of these sub-instances and suggest how other frameworks in cognitive science could help overcoming these sub-istances to provide a revision for coherence and unification. In this paper we will use the situated approach as an example.

I start this paper with a revision of the frame problem to show why the revisionist strategy is necessary. Then I move on to list sub-instances of the problem. Finally I present a brief example of the revisionist strategy at work by showing how the situated approach can overcome some of the sub-instances.

2 The Frame Problem

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The frame problem emerged as a result of a methodology in AI which is now retrospectively called Good Old-Fashioned Artificial Intelligence (GOFAI, see Boden, 2014 for a recent review). The project of GOFAI was to make the computer agent represent the world by means of formal symbols which stand for aspects of the world in an internal model. In such approach, by means of an external programmer, instructions are given for how to manipulate these formal representations. These symbols are purely formal, syntactical in nature, however they are matched with meaningful stimuli to the outside observer.

Two fundamental concepts in GOFAI are heuristic searches and planning. A GOFAI problem is understood as a search space, say, the possible combinations of letters in the alphabet, and solutions are to be found inside such space, say, only the correct combinations of letters that form words in Portuguese. Since an item for item search could not be possible, GOFAI scientists use heuristic searches, searches which are guided by a rule a thumb which will get the right result usually (e.g. search for combinations of vowels and consonants). Planning in GOFAI is done a priori, the goals of the program is pre-specified and when meeting the world the programmer would hope all the steps would be carefully executed to guarantee success. This can be done by hierarchies which organize goal order in serial fashion.

The Frame Problem originally emerged in AI, however, since the disciplines in Cognitive Science are connected, philosophers (see Pylyshyn, 1987) generally agree that the problem extends to the other disciplines. McCarthy and Hayes (1969), Artificial Inteligence scientists following the symbolic agenda, started to model their AI by naming the complete state of the universe at a given time a "situation". However, given that the universe is too large, only facts about the situation were to be represented, instead of the whole situation. These facts were used to predict further facts about the current situation or about future situations. It is understood that an action changes a current situation, however it does not change all elements of the situation, there are things that change and things that do not change given the action. A problem arose in the task of determining how an agent can determine, in a situation, what should change and what should not, given a specific action. Originally they had to type in an incredibly huge list of statements, called frame axioms, determining what would not change in result of an action. McCarthy and Hayes (1969) saw this issue as one amongst many other technical difficulties they had discovered and coined the term Frame Problem to refer to this specific difficulty. However, this technical difficulty turned out to [illegible] debates between philosophers and artificial intelligence scientists (see Pylyshyn, 1987).

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2.1 The frame problem proper

Although there was some consensus in debates over how to understand the frame problem (Pylyshyn, 1987), various philosophers and scientists contributed with a unique way of defining and understanding it. One of the biggest disagreements was whether the frame problem was a specific problem as discovered or if it reflected the manifestation of a more general problem. The specific problem can be called the frame problem proper (a use suggested by Dennett, 1987). To illustrate it, Dennett (1987) imagines a robot whose task is to go into a room and get an extra battery from a wagon that has a time bomb attached to it. In its first attempt, it pulls the wagon out of the room but explodes since it brings the bomb along. So its designers had to teach it how to plan considering the side effects of its actions (considering changes and non-changes of the situation after his action). However, since he had to consider so many non-changes, such as "that the color of the room will not change", (we add) that the wagon will not change its shape, that the battery will not change any of its physical properties either, and that the wagon will not break by being pulled, the bomb exploded before he could act. Hayes (1987) argues this is the central point of the frame problem. That since these things could in principle change, these frame axioms need to be inserted in to state that in that specific time in that situation it will not change.

> "In this ontology, whenever something MIGHT change from one moment to another, we have to find some way of stating that it DOESN'T change whenever ANYTHING changes" […] *That* is the frame problem. If there are 100 actions, and 500 labile properties and relations, then we might need 50,000 of these silly "frame axioms," […]. (HAYES, 1987, p.125)

As Janlert (1987), Haugeland (1987) and Dreyfus (1972, 1987) notice, this seems to be a problem that arises from representing the world in such quasi-linguistic form, considering situations as the state of the universe and dealing with knowledge in encyclopedic statements. Since getting rid of the consideration of non-changes raise other related problems as well, philosophers like, Dennett, Haugeland, Dreyfus and Fodor suggested that the frame problem proper was only an instance of a broader problem which they call the general frame problem.

2.2 The General Frame Problem and The Revisionist Strategy

Janlert (1987) argues the original frame problem is just one manifestation of a general problem of dealing with the phenomenon of change. His general definition is the following: "The general frame problem is the problem of finding a representational form permitting a changing, complex world to be efficiently and adequately represented" (Janlert, 1987 p.7).

Dennett (1987) defines it somewhat differently. He suggests the problem is one of making good use of the knowledge one has given the requirements of the time-pressured world. Dennett (1987, p.52) suggests

> "the frame problem […] concerns how to represent (so it can be used) all that hard-won empirical information […] a problem that arises independently of the truth value, probability, warranted assertability, or subjective certainty of any of it. Even if you have excellent knowledge

> (and not mere belief) about the changing world, how can this knowledge be represented so that it can be efficaciously brought to bear?"

He argues the agent that solves the frame problem ignores most of what it knows and works with the portion of his knowledge that is relevant to the situation at hand. Also, it must know how to choose effortlessly the portion of knowledge he is to work on.

Glymour (1987, p.65) also agrees that there is a general problem. "I think the "frame problem' is not one problem, but an endless group of problems concerned with how to characterize what is relevant in knowledge, action, planning, etc." His main contribution, however, is seeing the problem by means of its relation to the computability constraint. He argues that the general problem is one of finding feasible algorithms. This is an important notion which we will have to describe in some detail.

An algorithm can be evaluated by the number of steps it takes or the time it takes to solve a problem, that is, the resources it uses. An instance of a problem is one specific input string for a computational problem. The longer (the size of) the instance, the longer resource consumption will be. A feasible algorithm is one in which the worst case resource consumption runs in less than polynomial time. That is, if a polynomial function of the input size is at least as large as the number of steps taken by the algorithm to solve the problem in the worst case scenario then the algorithm is feasible. In other words, given that a problem with the size X requires time T, the polynomial function with the input of size X needs to result in a number larger than T. These are problems of the class P, those whose solution can be found in polynomial time.

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In order to understand the feasibility of algorithms, computer theorists have created the class of problems NP, which can be defined as the class of algorithms for which the solution can be checked to be correct in polynomial time. Therefore, this class includes the problems of class P, but also problems for which there are no known algorithms to solve it in polynomial time. Notice that a clear distinction is made here between the time taken to solve a problem and the time taken to verify whether a solution is correct.

The class of NP-hard problems is composed of reference problems that are equivalent to any NP problem. That is, any problem of class NP can be converted into a problem of class NP-hard by an algorithm that runs in polynomial time. Therefore if a polynomial algorithm is found for a problem of class NP-hard, every problem of class NP would be solvable in polynomial time. This would imply that the class P is the same as the class NP. However, computer theorists believe this not to be the case, although no one has been able to give a definitive answer to this question to date. Among the class of NP-hard problems are the NP-complete, which are reference problems that are equivalent to any NP problem, which also have the property that its solution can be checked in polynomial time. Therefore NP-complete problems are in the intersection of the NP and NP-hard problems. (These technical concepts can be found in Ladner, 1975, and in Cormen et al., 2001).

To solve the frame problem as analyzed by Glymour (1987), therefore, one would need to follow the computability constraint. There are two strategies for that, what I call the "the revision strategy" (following Cherniak, 1986 and Van Rooij, 2008, 2012) and what I term "the magic strategy". The revision strategy proposes the theorist should revise how it is assumed that agents compute when attempting to find the relevant information for a situation in a fashion in which its computations do not run into to NP-hard problems. The magic strategy proposes that for cognition to work in complex environments one would need to be able to find a solution to NP-hard problems, which is beyond the current capability of computation theorists and mathematicians.

Following this computational reading of the frame problem proposed by Glymour (1987) and following the revision strategy, we get various hints of what theories of cognitive science should keep, avoid or revise. For example, Glymour (1987) presents one such hint: "All known algorithms for testing for consistency are worst-case exponential. If we decide nonetheless to do consistency tests, the machine must do as few as possible." This is what inspired the current paper. What I call the revision*ist* strategy is merely an expansion or adaptation of the revision strategy. The revision strategy states that algorithimic problems indicate problems that should be revised at the computational-level theory (the level that psychology, linguistic and philosophy mostly discuss) and suggests revisions. My expansion or adaptation, the revision*ist* strategy, is to use sub-instances of the frame problem as a guide to provide changes or unifications in philosophical-theoretical frameworks of cognitive science. It is in a way a similar endeavor, however, the revisionist strategy is specific in the sense that it uses the frame problem as a guide and broader in the sense that it applies to philosophical-theoretical frameworks of cognitive science.

It would seem that no one would advance the magic strategy. However, it seems Fodor (1987, 2001), who is one of the main advocates of the thesis that there is a general frame problem responsible for other specific ones, has something of the sort in mind. He seems to affirm implicitly that human brains solve NP-hard problems while mathematicians and computer theorists have not, and for that reason he sees a grim future for cognitive science. That is not, precisely, how he puts it however. Fodor (1983, 1987) believes the mind is divided into two general types of structures, a modular structure and a general (not modular) processor. The main characteristic of modules used for his argument on the frame problem is ‘information encapsulation’. By which he means “[…] one that has access, in the course of its computations, to less than all of the information at the disposal of the organism whose cognitive faculty it is.” (Fodor, 1987, p.139). In contrast, the mechanisms that deal with relevant thinking in complex situations are not encapsulated. That is, any knowledge that could be used must be available, the mechanisms need to be sensible to every aspect of our webs of belief (Fodor, 2001). That is why we interpret Fodor (1987) as following the magic strategy, since this necessarily invokes the need for a solution of NP-hard problems. Either that or it is not in the realm of cognitive science at all. Particularly, Fodor (1987) is skeptic that computations (a deduction process) could deal with the necessary inferences for cognition in context, induction and abduction.

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Dennett, Dreyfus, Janlert, Glymour and Fodor all agree that the frame problem is one of dealing with relevance and context. As Pylyshyn (1987, preface X) summarizes: “This, the problem of relevance, is what many believe lies at the heart of the frame problem, and which will continue to be a serious problem long after all the minor technical problems […] have been dealt with.”

2.3 Sub-instances of the General Frame Problem

Hayes along with McCarthy (1969) first proposed the concept of the frame problem. Hayes (1987) argues that the frame problem proper is the only real frame problem. He believes we cannot confuse it with other related problems because that would be a loss of scientific progress. It is argued that there is a generalized artificial intelligence problem (GAIP) which is how to get a machine to reason sensibly about the world. He blames philosophers for equating the frame problem with the GAIP, when it is rather a sub-aspect of the GAIP. This is problematic, so the argument goes, because AI scientists worked hard to identify specific sub-problems of GAIP, one of which is the frame problem proper, and the progress was in having carefully distinguished these so they could be tackled one by one as the scientific process requires. But what Hayes overlooks is that there are various dificulties which do not feature in the general frame problem such as learning, translating, long-term planning, abstract problem solving, etc. The general frame problem is not the whole problem of artificial intelligence.

I do, however, sympathize in part with both sides. I agree that subdividing the frame problem helps us understand it better. Specifically in our goal, it helps us study how cognitive science can avoid each of these sub-instances of the problem. However, we agree with philosophers that there is a broader frame problem that unites all these sub-instances, and particularly that solving one sub-instance alone is not going to help cognitive science progress if it just brings up new related problems. I will now review these sub-instances of the problem so they can serve as an example of how the recipe of the revisionist strategy for remodeling frameworks of cognitive science can work. One can see these sub-instances as components that form a single problem.

The first obvious sub-instance is the frame problem proper itself (SI-1) which we have seen in the previous section, the problem of modelling non-change; or a bit more broadly, the problem of ignoring irrelevant information. Janlert's (1987) definition can come in as sub-instance as well, we reach it if we extend SI-1 further to include generally the problem of modeling change (SI-2) (what changes along with what doesn't). Janlert (1987) helps divide some of other sub-instances (or what he calls related problems) of the general frame problem. He starts by characterizing what is termed the prediction problem (SI-3). He explains that cognitive systems need to have some sort of predicting mechanism, and that these predicting systems need to have information about the current state of the world. A completely reliable prediction system is one which lives in its own world, that is, one which a simulated world is all it needs to predict, not the world itself. Needless to say, such prediction system will not be useful since it will not help the system in the world. But whenever a system starts trying to predict the real world, the reliability of such predictions necessarily decreases. An agent faced with the task of predicting the real world has to have a way of knowing about the world in advance, without representing so much information that its computations explode. Traditionally, in an attempt to deal with the prediction problem (among others), problem worlds were reduced to idealized worlds, worlds with simple shapes such as cubes and pyramids. However, a system that inhabits and predicts in such world would have no success when transferred to the real world. Time is also a problem. One could end up with a fast but unreliable prediction machine or a machine whose prediction comes after the fact has already happened. The upshot is that a representation does not help in predicting both if it is too simple or too complex.

Janlert explains (1987) that in idealized box worlds the prediction problem does not come up while the frame problem still does, and that such is a simple way of showing how they are distinct. However, the reason philosophers probably would think this as a sub-instance of the general frame problem is because it is an instance of the difficulties of relevant use of information in real space and time. As response to Janlert, one could explain that if one were to solve the general frame problem, the prediction problem would truly be solved along with it, and it would be done 'without cheating', that is in a way where the agent could predict in the real world.

Janlert (1987) mentions the revision problem which is a problem of dealing with models of prediction after they have made mistakes. It concerns the updating needed to alter conflicting facts the system has generated. This seems related, but I agree it is really not a sub-instance of the frame problem since it is not directly a problem of relevant use of information. It is perhaps a distinct technical issue any prediction system has to deal with, frame problem solved or not[1].

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Janlert (1987) goes on to explain the bookkeeping problem (SI-4). It is the problem of keeping track of the various plans and hypothetical situations that the agent needs in order to solve a given problem. It includes keeping in storage different descriptions of the situation, maintaining for use what is necessary, and relating descriptions with another, knowing that one might be the consequence of the other. While this is not the problem of modelling non-change, this is also an instance of difficulties relating relevant information use, therefore, a sub-instance of the general frame problem.

Finally, Janlert (1987) distinguishes the qualification problem (SI-5). The qualification problem is the problem of identifying, in real-world situations, objects that are represented in the agents mind. We all know what a chair is, but what exactly counts as a chair? Is a tree stump a chair? Does a chair need to have legs? Although even humans sometimes fail to find the adequacy of real world objects with their own concepts, for an artificial intelligence it is even harder. We seem to use some sort of common sense to be efficient at answering these qualification questions. I believe this is a sub-instance of the frame problem, specifically because

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[1] (This can be used to show that the general frame problem is not the GAIP, since the GAIP includes problems such as the revision problem while the frame problem does not).

agents need to qualify objects as they show up in real time, and not a priori, therefore, it is a problem of relevant use of information.

An important sub-instance that is much related to the general frame problem is the problem of time pressure (SI-6). Dennett (1987) argues that knowledge must be used in a fashion that will be compatible with the time constraints imposed by the world. Fodor (1987) Hamlet's problem or the problem of induction is not consistent with this sub-instance. I am more in line with Dennett here since he makes an important distinction between problems of knowing and problems of using knowledge; induction is for knowing and learning, rather, all these sub-instances of the frame problem are related to the correct *use* of knowledge. Therefore, even if the agent had figured out induction and had all knowledge available he would still have the frame problem if he did not know how to use it. Fodor (2001) himself stopped talking about induction, switching it to abduction on later writings. One sense Hamlet's problem could be a sub-instance of frame problem is if not knowing how to decide when information gathered has been enough for a decision tempers with the agents role in deciding. That is, if the agent stops acting because it needs to decide, then yes we have a sub-instance of the frame problem here, but it is actually just SI-6, the problem of time pressure. The problem of induction per se is not what the cause of what is inhibiting the agent, as Dennett has argued.

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Haugeland (1987) speaks of the problem of keeping temporal knowledge up to date (SI-7). Hayes (1987) terms this the updating problem and argues that such is not the frame problem, since the frame problem is a matter of beliefs about a changing world, not about changing beliefs about a world. I side with Haugeland in this since it is also a consequence of not knowing how to make relevant use of information. If an agent cannot update his belief against change then he will not be able to use all the relevant necessary information and other sub-instances of the frame problem will invariably follow.

Hayes (1987) argues that the search problem (SI-8) is not related to the frame problem. I agree it is not the same as the frame problem proper, however, it is clearly a sub-instance of the general frame problem. Given that the agent has stored much knowledge, the problem becomes about how it is to search through such content efficiently and without running into computational explosion. Dennett (1987) and Dreyfus and Dreyfus (1987) agree this is a central aspect of the frame problem.

Fodor (1987, 2001) and Glymour (1987) worry about how an agent could reach at least some internal consistency (SI-9). Given that the agent must know so much it becomes hard to understand how all this knowledge could be at least partially consistent without running into computational problems. As also explained by Cherniak (1986), for relevant use of information at least some of our beliefs need to be consistent, and checking for their consistency must be done just right. Too much checking and we would not have an answer, and too little checking would render the agent irrational. This is deeply related to Glymours (1987) main worry, the problem of using feasible algorithms (SI-10). It seems almost necessary that for information to be used relevantly by a mechanical agent, it must use only polynomial feasible algorithms, and avoid NP-hard ones. A failure to avoid NP-hard problems would render the computation impossible.

Wheeler (2008), distinguishes two further sub-instances of the frame problem. The intra-contextual frame problem (SI-11) which concerns the problem of how a mechanical agent can use information in a given context to act fluidly and flexibly. Interestingly, this illustrates how "using information relevantly" does not mean only stored information in the brain but also information one might capture in the environment. Some autistic people, for instance, tend to focus much on irrelevant aspects, for example, ignoring people's faces and focusing on the shape of corners of tables. The second is the inter-contextual frame problem (SI-12) the problem of how mechanical agents can deal with multiple contexts, apply knowledge from one context to the other and learn to act in new contexts. That is, using information relevantly in various types of environments.

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Finally, although Hayes (1987) argues that the frame problem is not just a general representation problem, if Dreyfus (1987) is correct, the frame problem follows from the attempt of representing knowledge in language-like structures (SI-13). In fact, many of these subdivisions are necessarily a difficulty of attempting to relate the content stored in propositions.

Of course, these 13 problems are definitely not the only way to divide the frame problem, it is very likely that various many other sub-instances could be identified. The point is that they do need to be identified and, most relevantly, *used* in other to reshape frameworks of cognitive science. It seems the revisionist strategy is the only one which takes these problems seriously. The magic strategy hopes some fundamental principle is discovered which will help us understand relevance and abduction to be able to deal with all these issues without invoking computation or information processing. Another common path is to ignore the frame problem. The revisionist strategy needs urgently to be put in practice in Philosophy, AI, Psychology, Linguistic and Cognitive Neuroscience. To be clear, the point of the revisionist strategy is not to limit our minds to the level of current machines, it is rather, to avoid use of descriptions of information processing strategies which machines have already shown to be limited.

Name of sub-instance	**Brief description**
SI-1. The Problem of modelling non-change	How to know what will vary given an action
SI-2. The problem of modeling change	How to monitor what does change
SI-3. The prediction problem	How to predict in a changing environment
SI-4. The bookkeeping problem	How to keep track of goals
SI-5. The qualification problem	How to identify objects using concepts
SI-6. The problem of time pressure	How to use knowledge effectively
SI-7. The updating problem	How to keep knowledge updated in relation to the changing world
SI-8. The search problem	How to search through stored knowledge effectively
SI-9. The problem of internal consistency	How to keep beliefs coherent
SI-10. The problem of using feasible algorithms.	How to avoid NP-Hard algorithms
SI-11. The intra-contextual frame problem	How to deal with present environment
SI-12. The intra-contextual frame problem	How to transfer knowledge from differing situations
SI-13. The problem of propositional thought	How non-linguistic thought could work

Table 1 - List of sub-instances of the frame problem.

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3 Putting the revisionist strategy to use by the Situated Approach

We have decided to call the change in perspective of cognitive science that started roughly in the 90s "the situated approach". There are other labels such as embodied, embedded and enactive which comprise the same shift but each comes along with distinct specific claims. What we will use are some aspects Andy Clark's version of it.

Andy Clark resumed Dreyfus' project of altering the disembodied view of mind, only in a less destructive way. He is fully convinced that the processes that enable us to be situated agents are computational ones. Of course, he agrees and proposes that cognition must be the result of a coupling between brain, body and environment. However, he argues that the informational processing language is still required to explain such coupling.

A nice example of how our view of cognition needs to be altered is offered by the study of lower animals which behave deeply relevantly using fast sensing and acting without the use of any extensive knowledge banks. While studying Ritzmann's (1993) research on cockroaches, Clark (1997) noticed how their evasive actions are shaped by various internal and external factors. The wind disturbance caused by the motion of a predator is sensed and they differentiate those from other non-intentional winds; when it initiates an escape motion, it does not run at random but rather considers its own orientation, the presence of obstacles, the degree of illumination and the direction of the wind. It is so successful in fleeing because it has access to all the relevant input and responds to something like the "result of their sum". This response is not just one, not like discrete answers but a constant flow of changing actions, a coupled cycle of communication via informational exchange with the environment. These different sort of selected inputs go in on a network of computations that involve (1) each informational property of the environment which is captured relevantly by the cockroach because it has (2) the correct sensors and is tuned to capture them wisely, (3) the quick and effective inner cognitive accomplishments and (4) actions that further request more input from the environment in a coupled cycle.

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We wish already to explain that when we compare ourselves to cockroaches it by no means implies any return to behaviorism. Much to the contrary, it was rather the influence of behaviorist understanding of cockroach action (for example) in terms of "sense predator and initiate random run" that later led cognitivists to think that relevant contextual behavior required superior stored knowledge in humans. Instead, the situated approach is closely tied to the cognitive one because it explains mind as information processing of a coupling between agent and environment.. Further, the description of the cockroach in terms of stimulus-response does not explain it interestingly enough. The cockroach has sensors which indicate wind velocity and direction, it is tuned to initiate evasion only if the correct properties of the wind is sensed. This could be thought of as a detailed process of stimulus-response, but it also has a circuitry of more than 100 interneurons that modulates the final action taking account of information from many other neuronal populations sensitive to contextual features. This latter part sounds like a cognitive explanation. The situated explanation combines a more specific analysis of the architecture of sensors and how they are tuned to the environment with inner computation as directly related to such sensing and further acting.

Ritzmann (1993) argues that a car that used similar sensors and applied similar computational steps to that of a cockroach would be very successful, it would immediately discern regular movements of other cars from those of colliding ones, and when the latter were detected it would take into account various factors such as the road ahead, the engines, acceleration, its current state before evading. Such car sounds fantastic, but as Andy Clark notes:

> "'Buy the car with the cockroach brain' does not immediately strike you as a winner of an advertising slogan, however. Our prejudice against basic forms of biological intelligence and in favor of bigger and fancier 'filing cabinet/logic machines' goes all too deep." (CLARK, 1997, p.5).

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The considerations from this simple example already show three things: (1) arguing for a situated agent is not returning to behaviorism, (2) there should be a way of describing the situated agent by informational procedures which can be applied to machines just as the cockroach mind was applied to the car in the example, therefore preserving the basic structure of cognitive science and (3) that relevance obviously can obtain and probably does without consult to knowledge banks.

Now let us ask ourselves how the cockroach solves some sub-instances of the frame problem. The problem of change (SI-1 and SI-2) is avoided since the cockroach is deeply tuned to its environment through its sensors, so its sensors only inform it of the relevant information, its sensors does not inform it of the information that is not to be used. Likewise, even though it does not have abstract concepts, whatever the recognition strategy of an object is, it is done directly by the communication of information from the environment with the sensors, so there is no qualification problem for a cockroach (SI-5). The cockroach acts in milliseconds, so it must avoid the time-pressure problem (SI-6), it does so because its actions are coupled with the sensing of the correct stimuli, no knowledge is searched for how to evade predator attacks. This fast computation could probably be simulated without use of NP-Hard algorithms (SI-10), since the inputs and the problem space (possibility of actions) are small. So the cockroach behaves effectively without the use of linguistic thought (SI-13) since its informational exchange with the environment has been coupled by natural selection.

Before critics feel tempted to complain that the tasks of the cockroach are simplified in relation to that of a human it is good to remember that robots that first encountered the frame problem had even simpler task and even simplified versions of the world, basic geometric environments. Secondly, I understand that cockroaches are simpler beings and agree that one needs to address what changes in more complex animals.

We have now seen how it is possible for simple creatures to behave relevantly. And in sum it was by being tuned to the structure of their environments. Now, a crucial way of understanding how increasingly complex creatures started dealing with their own complexity, that is, with the vast amount of information they had to deal with is by alluding to what Clark (1989) terms the 007 principle.

> "In general, evolved creatures will neither store nor process information in costly ways when they can use the structure of the environment and their operations upon it as a convenient stand-in for the information-processing operations concerned." (Clark 1989, p. 64)

Therefore, if any of the strategies described in the last section can be used, they most likely will be used. This begins to diminish the abusive use of stored information as an explanation for cognition, since we understand that creatures will only store such information, or make use of the stored information, if the informational exchange with the current environment cannot help solve the problem. Moreover, it is often the case that when complex creatures are required to store too much, they start practicing what Clark (1997) terms "offloading". That is, they start storing information in the environment, literally offloading the information from their brains. In the case of humans it is very easy to see how this is done. With linguistic information we use text, agendas, notebooks, and so forth. Also, of course, other type of external representation can be stored in the environment like drawings and signs. However, there are also non-representational means of offloading, for instance, by leaving an empty bottle of oil by the door so when we leave to the market we remember to buy it.

We do not follow the 007 principle just by *storing* information in the environment that can later be used. We, and in this case it is simpler to see how other creatures also do it, ask our environment for the solution of problems in a way that will make us able to reason and act in it feasibly. This act of making the use of the environment reliable, Clark (1997) calls scaffolding. There is an obvious sense of scaffolding which is simple to see. It occurs when we use other animals to guide our learning, thinking and behaving. So when we follow a guide in a field trip, we are using his knowledge transferred through his actions as means to navigate the environment. A baby learns to walk with the guide of adults holding his hands to compensate for balance. A cub learns to hunt by mimicking his parents. We learn to think over complex problems by following someone else's reasoning steps. Other animals also, therefore, constitute the sort of things that leave useable information in the environment. And even cross species, we can learn about the time if we hear the specific way chickens sound. This type of interaction, although largely ignored by the knowledge base method of cognition, seems very obvious to us. We can use inanimate objects as well, the position of the sun to learn about time, a different looking tree as a guide for reminding us of a location where we usually find rewarding objects, a dense forest to indicate where we last found a predator.

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Moreover, humans seem to structure their environment in order to abuse of scaffolding abilities, keeping themselves committed to the 007 principle. The gear stick of cars is structured in a way that will help us control it, so the fifth gear is close to the fourth and moving the stick to the fourth gear works simply and smoothly while attempting to go from the fifth to the first in one hand movement is harder. This sort of simplification of movements allows us to concentrate on more relevant problems of driving, such as paying attention to the road ahead. Engineers structure our tools to enable efficient scaffolding. However, this is not only for specialized professionals and complex tools. When packing the groceries we structure our environment for the further task of accommodating them in the correct place, so we can have different packs for bathroom and kitchen items. Not only in packing but our whole house is already structured to facilitate computation. So when preparing a meal, procedures are facilitated by the fact that there are groupings of utensils, seasoning, plates, which limit the thinking you have to execute and can even invite alternatives. For instance, you might be thinking of using the salt but the environment shows you a new pepper you bought but had forgotten so you use it instead. This structuring of the environment is not limited to humans, for instance, dogs urinate in trees and other objects to leave cues which help them map their territory.

This sort of strategy can even be used when reasoning about puzzles. One might group similar pieces together or rotate them in order to see the varieties of ways which it might fit (without having to mentally rotate it or to consider the solution a priori). This last puzzle example takes us to a different strategy that also follows the 007 principle, the use of outputs as a procedures for thought. Clark (1997) uses the example of Tetris[2] to explain how the passive computation image is flawed in its understanding of the use made of outputs. An output was usually understood as a final answer in a problem solving procedure. However, when people play Tetris they usually rotate pieces not as final actions to solve the problem but as a way of manipulating the problem in order to simplify it. And simplifying it means structuring the puzzle in a way that our tunned triggers are fired by the environment. So by rotating a Tetris piece, reasoning mechanisms are trying to facilitate the task by asking perception for help.

This strategy treats output as a form of modifying the problem and not directly solving it. A sliding puzzle is one that naturally forces us to use outputs to modify our problems. It is (I believe) completely impossible to visualize a solution to a complex sliding puzzle if not by moving the pieces around. Moving the pieces [illegible] and rethink the problem. Reasoning, therefore, for many of our real problems, involves manipulating the environment in a dynamic informational exchange, where the problem comes and goes repeatedly from the subject to the world, which seems to characterize actions not as solutions but questions for simplifying the problem. Structuring the problem was a major issue for GOFAI, usually the programmers structured the problem as it would suit the AI best, or they kept feeding them the needed information through aided procedures.

Let us now see how the constant pursuing of the 007 principle by agents help them avoid some sub-instances of the frame problem. We might model change (SI-2) by constantly asking the environment how it looks like when changed, instead of trying to figure it out a priori. The bookkeeping problem (SI-4) might be tackled by our structuring of the environment in a way that reminds us of our goals. We leave cues in our house that help us reach our goals, sometimes when we fail to find such cues that match goals we might not fulfil them. We might leave our car

[2] the video game where jigsaw puzzle pieces fall from the top of the screen so you have a limited time to decide on how to fit it in with pieces already at the bottom.

keys in a key hanger in order to remind us of picking it up when leaving, but if we forget to leave the key there we might find ourselves in front of our car without the car key.

If the correct input is constantly available by the structured environment then we facilitate the problem of time pressure (SI-6). If your house is a mess, no knowledge bank will be large enough to help you get ready in time for your job. If all types of objects are thrown together we cannot recall where we left objects, and even after we have found it, when looking for something else we might forget where we had found the first one. Of course, by having a structured environment we are able to act effectively avoid postulating the use of NP-Hard algorithms (SI-10). The fact that we get lost in messy environments is further evidence that we do not rely on such powerful algorithms. That is, we do not have elaborate strategies to deal with mess, if not, by organizing them alluding to simple steps that will then facilitate acting.

We deal with a specific situation by relying on cues offered by it, by restructuring it, and by placing new cues that will help us proceed feasible through it (SI-11). Leaving the car keys in the key hanger to guarantee functioning is an example of how non-linguistic thought may proceed (SI-13). Not the act of thinking of placing it there, but the act of remembering that you need it by seeing it and recalling why you left it there. Non-representational offloading seems to be just the case when we "cheat coding", that is, we avoid holding all propositions such as "grab the car key" or "the car key is at place x". By forcing us to see it when we need it, we need not hold these propositions in mind and can therefore accomplish tasks without them, in a non-propositional form.

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Final Considerations

This last section aimed to show examples of how situated cognition can overcome some sub-instances of the frame problem but of course these are not supposed to be final answers, just examples of a possible path to follow the revisionist strategy. The revisionist strategy does not conclude that the classical approach should be abandoned. For instance, there seems to be no other better model for how our serial, linguistic-like, conscious inner-thoughts works and there seems to be every reason to adopt the classical computational theory of mind to explain these thoughts. Also, it is not only the classical approach which will need revision. Since anything like the revisionist strategy has barely been applied in actual scientific cognitive theories it is not uncommon to see new theories in need of revision. For instance, predictive coding, a new framework of cognitive science, has been starting to get much attention (see Clark, 2013 for a review). I am pretty sure it to fails to overcome various of these sub-instances, since it supposes a powerful model is intermediating our real-time fast intercourse with the world.

Although I focused on situated cognition, it seems plausible that connectionists strategies will be more suited to answer the search problem (SI-8), the problem of internal consistency (SI-9) and possibly the intra-contextual frame problem (SI-12). So it is clear that various approaches need to be used in order to have a better picture of the mind. The examples from situated cognition are merely to illustrate how the revisionist strategy works. The recipe is given; for certain it will end up providing a plural account of the mind. As Boden (2014, p.96) has put it: “The motto of both psychological and technological AI today might be ‘Let a hundred flowers blossom – or anyway, four.’ Those four are the approaches of GOFAI, connectionism, situated AI, and dynamical systems”. (I would add predictive coding).

In reality this is what most sciences of the 21st century look like. For instance, Physics no longer has an unified view of the universe but rather different theories for each aspect of the universe (such as classical, relativity and quantum). The difference is that usually each approach in cognitive science atempts to undermine the other. I think this is, for most part, a mistake. The revisionist strategy can be used as a way to help see that differences in frameworks might be atributed to differences in forms of processing of the same mind, just as there are (incompatible) models of different aspects of the physical world. But when asked: What unites cognitive science? How does it understand the mind? We can still have a very general but good response. Cognitive science is a collection of discipline studying the mind as a functionally explainable process whose description should be inspired by information processing. Of course, this will reject from the domain of cognitive science some of the theorists who claim the mind cannot be ‘functional’ by nature or that the mind is nothing like information processing, but yes, they should be rejected since their claims have gotten very different from what cognitive science has always aimed to be.

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The Emergence of cognitive process in concept formation

SERGIO NUNES (Universidade Federal do Pará)

Keywords: complexity, Language, Argument, concept

ABCTRACT

- Considering the hierarchical in complex, arbitrary systems, therefore, would not have a strict hierarchy, but a conglomerate, as the various layers that have a rock eg. in various forms of size, volume, height, width and salience, a lopsided complex allows us to talk about methodology in the emergence of semantic language, formation of concepts and arguments, does not allow us accurate or measurable accuracy, hence the haziness as an ally in the elucidation of this problem.

NTRODUCTION

- Considering the arbitrary tiering in the complex systems, therefore we strictly would not have a tiering, but a conglomerate such as the various layers which features a rock for exemple.
- Due to its complexity we talk about methodology in the emergency of semantic language, in the formation of concepts and arguments, does not allow us an accurate or mensurable accuracy, thence the inaccuracy as alied in the elucidation of this problematic. We are going to focus about the informational and mental system, as it concernning to language, cognition, although not flee ecology, not even technologic for disposal.
- Our problem resides in the emregency of arguments and/or transdisciplinary acquirements. How they would be possible?
- We do not have definitive answers, we probably will not have it, but what is intresting is notice that some provide evidences by the neurolinguistic, by the fysicalism, by cybernetic and also pragmatism give us some signals of acquirement about that.

SECTION

- As we can see:
- 1. Neurolinguistic introduces us the first pattern of cognitive Science, taking into account the organism as a whole, not limited only to brain component. The necessary interconnections between this and all neurophysiological peripheral elements form an information network, in which allow to develop a much more significant relationship than the simple motor and gramatical articulation of language.
- 2. Peirce will call abductive process the hypothetical reasoning that occurs in the confrontation with the experience e produce a constant self-improvement, which property of synthesis and improvement of itself, or by exploiting its potential, either by the confrontation with experience, the hypothesis is introduced as a diagrammatic reasoning model, which consists of intuitive construction of a figure or an equation where the relationship between elements at issued are established.
- 3. If the ratio is caused by the experience and requires the submission of its proposal to the experimental test, however does not decline of generalizing and its original power. Human knowledge was historically formed in this way and that is where, logically, it finds its legitmacy ([12, p. 145)
- 4. The meanders that lining the complexity of human cognition in articulation of concepts each other, such as in a mathematical equation allows the formation of a new informational network, resulting of the peculiar combinatorial human cognition from a methodological process that is intrisic to always in confrontation with the outside world.
- 5. So we can avaluate the possibilities of Artificial Inteligence (AI) retroactive, so to speak, the transhuman, since the AI the methodological working that is appropriate algorithmic combination that allows you to perform certain actions in the production of an informational network.
- 6. The mechanized human, the robot body contain only organic brain could lead to subsequent formation of sophisticated brain clones and screened for the new transhuman. The border is broken between the mechanical and the organic, natural and artificial, living information processing systems and non-living foreshadowing in a new bionic vision of the world. We see the attempt of a computational model of the mind, which information processing system may be purely formal, so consider therefore algorithmic.
- 7. The mechanized human, wich the roboti body contain only organic brain could lead to subsequente formation of sophisticated brain clones and screened to the new transhuman. The border between mechanic and organic is broken, the natural and artificial, living information and non-living informmation processing, foreshadowing in a new bionic vision os the world. We see the attempt of a pattern(model) computational of the mind, wich system processor of information can be purely formal, so consider therefore algorithmic.
- 8. We realized, therefore, a certain isomorphism between human cognition and machines. Now, if we consider cognition as a physical symbol system that can be manipulated or articulated to each other in diverse and multiple forms, as we have already commented above, we are able to combine a variety of concepts and generate new concepts in formal arguments.
- 9. In this regard, a computational conception of mind could correspond to a computational conception of langauge, unifying in this manner, na authomatic formal system with a physical symbol system.

CONCLUSION

- We have here, an epistemological exposure about tha methodology that we expose, but the especific in this explanation, that would be, operability of emergency or interconection between the concepts and arguments as transdiscipline generation, requires a more detailed and more estructural research, that is why(therefore) we introduce(launch) data so that we can proceed of this issue.Thank you so much.

Universidade Federal do Pará
Instituto de Filosofia e Ciências Humanas/Faculdade de Filosofia
sergiocertumiano@gmail.com
www.ufpa.br

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SENTIMENT ANALUSIS OF SOCIAL NETWORK MESSAGES: Twitter Data Mining

ARIANA MOURA DA SILVA
RICARDO LUIS DE AZEVEDO DA ROCHA
Escola Politécnica - University of São Paulo

Keywords: ***sentiment analysis, emotions classification, natural language processing***

ABCTRACT

- Simplistic method (positive and negative)
- Automatic rating semantic proximity
- Use of the method of Plutchik Wheel of Emotions

INTRODUCTION

- An emotion is not simply a state of feeling. Emotion is a string of loosely connected events that begin with a stimulus and includes feelings, psychological changes, impetus for action and specific behavior, directed by goals (PLUTCHIK, 2001).

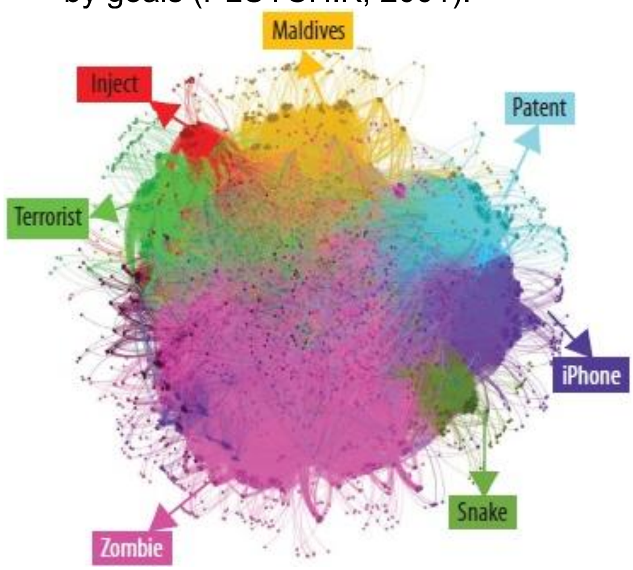

Figure 1: Rumors related about Ebola Set/2014 (FANG, 2014)

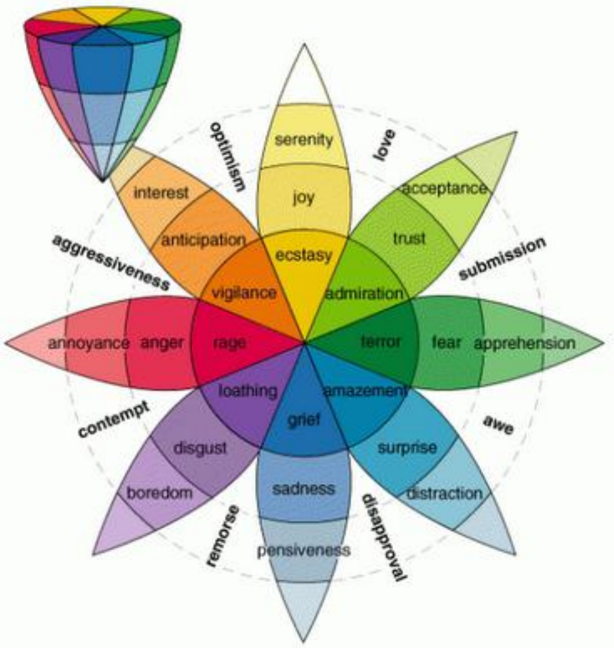

Figura 2: Wheel of Emotions (PLUTCHIK, 2011)

WHEEL OF EMOTIONS

- This model features eight basic feelings in circular shape, and feelings and emotions more complex as it moves away from the wheel center. The **main goal** is to establish computational criteria able to automatically recognize the lexicon of a given ontology and perform the classification of emotions in the categories that compose it.

CONCLUSION

- Through sentiment analysis and emotions classification technique is intended to generate a real-time emotions classification model, of the sentences published on the social network Twitter within a given ontology.

MAIN REFERENCES:

FANG, J. **Misinformation Propagation in the Age of Twitter**. 2014.

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University of Sao Paulo
Escola Politécnica / Computer Engineering Department
LTA - Languages and Adaptive Techniques Laboratory
Street Prof. Luciano Gualberto 530 tv 3 158 São Paulo SP Brazil
http://lta.poli.usp.br/
ariana.moura@usp.br / luis.rocha@poli.usp.br

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Essay on the description of human behavior in engineering research projects

Diego Queiroz (University of São Paulo)
Ricardo Rocha (University of São Paulo)

Keywords: ***human behavior, sentiment analysis, human cognition***

ABCTRACT

- This work intends to discuss how to best describe one person's behavior on engineering research projects, from an objective point of view.

HUMAN BEHAVIOR

- The definition of human behavior is extensively discussed in literature, however, it lacks a concise definition to guide engineers and computer science specialists to develop new technology able to interact with human beings.
- To this end, we propose a simple definition suggesting that behavior can be described as follows:

$$Behavior: IS \times EI \mapsto action$$

where

- IS: Internal State
- EI: Environmental Input

- The *internal state* (IS) is the state that the person presents to itself. It is not observable and is the most volatile part of this definition. It is disguisable from the state that one person present to others.
- The *environmental input* (EI) is everything that one person can feel to promote changes its internal state. It is clearly observable, but it is also very easy to overlook its value: negligible inputs like a mosquito bite, or the cold wind can promote actions as well as more significant inputs, like a slap in the face.

DESCRIBING BEHAVIOR

- Human behavior is related with uncertainty in a partially observed universe. We need to "guess" a person internal state based on human observable actions, which is error-prone.
- However, group the feelings demonstrated by an individual seems to be a good way to describe behavior.

CONCLUSION

- This work propose a simple definition of behavior and discuss the implications it.
- In further work, we intend to extend this definition and describe better the relationship of internal states and demonstration of human feelings.

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University of Sao Paulo
Laboratório de Linguagens e Técnicas Adaptativas, Escola Politécnica
Avenida Professor Luciano Gualberto, travessa 3, 158, Butantã
São Paulo, SP, Brazil
lta.poli.usp.br
diego.queiroz@usp.br, luis.rocha@poli.usp.br

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