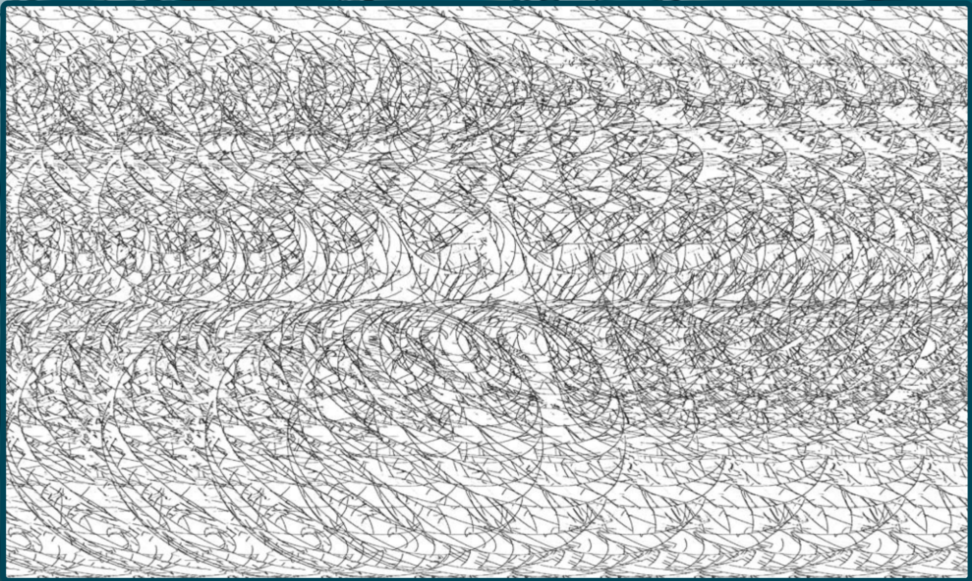
GABRIEL VACARIU

Cognitive neuroscience *versus* epistemologically different worlds



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COGNITIVE NEUROSCIENCE
VERSUS
EPISTEMOLOGICALLY DIFFERENT WORLDS

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In memory of my parents

In a sense, in biology we always start by looking in the wrong place. It is therefore vital to keep an open mind, to expect the unexpected.

Baars and Gage

We seek reality, but what is reality? The physiologists tell us that organisms are formed of cells; the chemists add that cells themselves are formed of atoms. Does this mean that these atoms or these cells constitute reality, or rather the sole reality? The way in which these cells are arranged and from which results the unity of the individual, is it not also a reality much more interesting than that of the isolated elements, and should a naturalist who had never studied the elephant except by means of the microscope think himself sufficiently acquainted with that animal?

Poincaré

CONTENT

Introduction

Cognitive neuroscience is nothing more than accumulation of experimental and theoretical information from two fields, neuroscience and psychology. Different people constructed various theories using the combination of this information. “Accumulation” has to be associated with “correlations” between neuronal and mental states, the main notion of cognitive neuroscience. What exactly “correlations” means is not very clear. On the one hand, many people working in this area pled for the identity theory: a mental state is identical with some activated neuronal patterns. Nevertheless, at least from an epistemological viewpoint, the identity theory is avoided by many researchers. From an epistemological viewpoint, a mental state cannot be reduced to certain neuronal patterns. On the other hand, many important researchers in cognitive neuroscience and philosophy of mind think that the neuronal states “*produce*” the mental states.[1] In this way, the problematic identification between any mental state and neuronal state is partially avoided. We can talk of “correlation” between these states. Nevertheless, “correlations” require *localization* of mental functions/state in the brain. As we will see in this book, because of the results from the last years (mainly, fMRI), “localization” is replaced with “widely distributed neuronal areas”, and “correlation” remains the main notion of cognitive neuroscience.

The main question that I want to answer throughout this book is: “Can we construct a science on such correlations”? From a classical viewpoint (on which we define the other sciences), using “correlations” as the main notion, it is impossible to claim that cognitive neuroscience is a real science. Obviously, correlations do not presuppose laws, but maybe we can extend the definition of “science” precisely so as to identify cognitive neuroscience as a

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[1] At least, some of the researchers use this notion without clarifying it.

particular science. With such extension, would cognitive neuroscience be a real science?

The knowledge of different sub-domains/experiments of cognitive neuroscience created a strong congestion for young researchers. They have two alternatives: working on the same paradigm that imposes a particular knowledge (from interpreting the empirical data) and instruments of investigation or changing the meta-paradigm of thinking and thus re-thinking the questions for which they search some answers. In cognitive neuroscience, a new meta-framework is necessary more than ever (Friedman 2001)[1]. I investigate in detail many theories, approaches, experiments of cognitive neuroscience from an EDWs perspective only to show that the old meta-paradigm (the unicorn world) created many (hyper)ontological contradictions and paradoxes impossible to be solved. I strongly claim that only by changing the paradigm of thinking, could the researchers in cognitive neuroscience increase their hope of solving some problems of their domain.

In writing this book, my intention is to analyze, from the EDWs perspective, very recent papers that appear in journals of cognitive neuroscience. Without having any criteria for selecting particular articles and books from a huge amalgam of information that belong to this field, working alone for this book (I have never heard somebody working in cognitive neuroscience in Romania), I tried to select what I thought necessary for investigating cognitive neuroscience from my perspective, the EDWs. Obviously, for me it has been impossible to cover the main theories and ideas of this field. Moreover, being a philosopher that works in library, I strongly emphasize that it was not possible for me to understand all technical (empirical) details regarding some experiments (for instance I could not completely understand the function and the structure of an fMRI). Therefore, in these cases, I tried to understand the theoretical consequences of empirical results for the nature of cognition and the relationship between the mind and the brain. Under these

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[1] As we will see in this book, I offer this new perspective, the EDWs perspective.

circumstances, I would therefore like to apologize for some mistakes that may appear in this book. I would like to thank very much to people who sent me their papers when I asked them. Internet saved me to update my knowledge in this extremely dynamic domain, cognitive neuroscience.

With this book, I would like to draw the attention on the wrong framework in which people work in cognitive (neuro)science. Apparently, the old framework, the unicorn world (see chapter 1) does not influence directly quite many empirical experiments and investigations. Nevertheless, at least their conclusions are quite wrong or quite ambiguous from the viewpoint of my perspective. The change this old framework of thinking with a new one could affect not only the answer to some old questions but even the formulation of those questions. The construction of experimental technologies follows particular frameworks of thinking, so the understanding of measurements/observations realized by any instrument or the creation of any experiment has to be included within a paradigm of thinking.[1] Based on the knowledge that I acquired reading articles and books from various fields of cognitive neuroscience, I hope I will be able to construct, in the next book, the ontological status of the "I", the relationship between the "I" and its features (that are the "I"), and the correspondences between the mind-EW (the "I") and the brain-body (that belong to the macro-EW). In my future work, my intention is to construct a completely new image of the "I", more necessary than ever in cognitive neuroscience today.

This book is written for quite young (middle-aged) researchers of cognitive (neuro)science who had accumulated plenty of knowledge from cognitive neuroscience and want to decode the mysteries of the neuronal functions and their relationships with particular mental states. This book is not an introduction to cognitive neuroscience since I investigate mainly papers that were published in the last 3-4 years. My investigation wants to show that the direction

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[1] Related to this point, see Bohr's idea in Vacariu (2008).

of researches of cognitive neuroscience has no future. For my investigation, I selected some of the main topics of cognitive neuroscience, but my bibliography is extremely reduced in comparison to the huge number of papers and books published in the last years on each topic in this area. Nevertheless, in the summer of 2012, I realized that analyzing any paper from my perspective, the results would be the same: every author works within the unicorn world and the consequences are the same, i.e., after many experiments and extremely elaborated approaches, there is no answer to any of the great questions from this field. This is the main reason I stopped analyzing, from my perspective, new articles that belong to cognitive neuroscience.

The reader will be surprised by the fact that I quoted quite many paragraphs from various papers.[1] There are two reasons: I did not have enough time to "translate" them in my words; English is not my mother tongue and I preferred to avoid the possibility of using words that can create misunderstandings. I mention here that I do not have access to papers and many books. Therefore, in my book, I selected papers and books that could be accessed by me. The content of this book is the following. Chapter 1 is about my EDWs perspective. In Chapter 2, I introduce some general notions from cognitive neuroscience. In Chapters 3 and 4, I offer some details about the debates between optimist positions and skepticist framework in this domain. In all the other parts, I investigate various topics (localization, the binding problem, perception and object recognition, the crossmodal interactions, space and the mind, and finally the holism approach or the "widely distributed neuronal patterns" for any mental state) of cognitive neuroscience from the EDWs perspective. Each topic varies regarding the paper that I analyze in this book. For some topics, I read quite many papers and chapters, for other quite few. I emphasize here that it would be useless for me to read more papers for any topic. No important

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[1] The footnotes (many times, just quoted paragraphs from papers or books) are extremely important in this book. These paragraphs reflect exactly the situations that I analyze in that context.

changes would have taken place in my book. Any paper from the last year, mentioned or not in this book, can have the same interpretation under my EDWs perspective. Thus it became useless for me to read more papers so as to write this book.

The order of these topics mirrors their difficulty: if in the past, the researchers were interested in perception and object recognition (or consciousness), nowadays they move their interest on the binding problem (strongly related to perception). After realizing the difficulty of solving these problems, the researchers moved to localization. In the past, it was thought that any mental state activated just a small area of the brain. With the progress of research, almost everybody realized that any mental state has to be correlated with a “wide patterns of neurons”, usually localized in the cortex zone. However, with new tools of the brain images (like diffusion tensor imaging, diffusion spectrum MRI or diffusion-weighted imaging), things become much more complicated. For any mental state it is not only the cortical areas, but also the subcortical zone that are involved. . Finally, the last chapter is about the Fingelkurts’s (2010) approach. Their theory perfectly reflects the state of affair in cognitive neuroscience: extremely elaborated, based on a very large area of knowledge, but unfortunately only some Ptolemaic epicycles within a wrong framework. I hope the young researchers from cognitive neuroscience will be able to understand that they need to change their old -fashioned framework of thinking and working. I believe that if they do not want to change this framework, the results of their works would be quite useless.

Chapter 1

The unexpected: “Epistemologically Different Worlds”[1]

1.1 Introduction

In other works (2005, 2008, 2011, Vacariu and Vacariu 2010), I tried to illustrate that the greatest illusion of human knowledge surviving from the oldest times is the notion of „world”, of „uni-verse” or as I called it, the „unicorn world”. The unicorn world is the greatest illusion because human beings constructed their entire knowledge within this „house” and nobody inquired it. The main mistake that led to the creation of the unicorn world is that we, the human beings, believed (consciously or not) that we were the only observers of the “world”. As a result, Gods, all beings (humans with their mind, brains and bodies, and plants, cells, microbes, animals) and all objects (tables, stones and planets, electrons, waves and fields) have been placed within the same world, the unique world, the uni-verse. The world is all the entities and their relationships inevitably placed within the same spatio-temporal framework. Everybody has thought that all living organisms *observe/perceive*, more or less, the same world. Nobody has ever wondered whether a planet or an electron “observes” (as we will see, “observation” is equivalent to “interaction”, also see Vacariu 2005, 2008, 2011; Vacariu and Vacariu 2010) the same unique world. If we reject the hegemony of the human being that uses certain conditions of observation for observing that “unique world”, then we have to wonder on the conditions of “observation” available for the other entities. As we will see in detail, conditions of observation are equivalent to conditions of interaction. In this context, the question that arises is “Does each entity

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[1] Large parts from this chapter are from Vacariu (2011). However, no other parts from this book appeared in other works of mine.

‘observe’ the same world?” As we will see below, each class of entities represents an EW that is epistemologically different than other EWs. Thus, we have more “worlds”, but these worlds are neither ontological worlds or many-worlds or multiverse (not even possible worlds – a useless philosophical notion), nor the epistemological aspects of the same world, but there are epistemologically different worlds (EDWs) with epistemologically different entities and epistemologically different interactions. Each world consists of epistemologically different entities and their interactions. Since Ancient times, we have been looking in the wrong place: the unicorn-world! Therefore, in the next sections, I will introduce the “unexpected” EDWs, since nobody thought about their existence. From my viewpoint, “to expect the unexpected” means to give up the oldest framework of thinking, the unicorn-world and to understand and concede the DWs perspective. Working within the unicorn-world, within the context created by so many unsolved problems, many researchers from cognitive (neuro)science desire a new framework of thinking in this domain.

1.2 Definitions

I would like to introduce the definitions of the main concepts that are necessary for building the EDWs framework. These definitions overstep certain pseudo-notions of the unicorn world and refer to entities (and their interactions) that represent the EDWs.[1]

(a) “Non-living” entities that *exist* will be called it^s. (The singular is “it”.)[2]
(b) “Living” entities that *exist* will be called It^s. (Singular: “It”)

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[1] If we think of EDWs simultaneously, we get the concept of the „hyperverse”. This word is an abstract notion, since it is necessarily a hyper-entity that is able to observe/interact with entities from all EDWs.

[2] „it” is a neutral pronoun for neutral entities. I need plural for “it” (it does not exist in English) that will be “it^s”. I mention that if there is an “it” at the beginning of a sentence, I will not use the capital letter. For “living” entities, I use “It” with capital letter in any place of a sentence. “Entity” is a general notion that includes it, It and the being (we will see later about the being). This is the reason I do not use “entity” for neutral.

(c) The entity that *corresponds* to an It will be called “being”. The correct statement is “Being is.” The incorrect statement is “Being exists”. “Being” refers to all these notions like the mind, life, the subjectivity or the “I”, but is something beyond them.
(d) “Correspondence” refers to the *conceptual* (not real) relationships between entities that belong to the EDWs.
(e) “Interaction” (notion available for all entities) is equivalent to “observation/perception” (notion available for certain human actions).
(f) “Determinate” refers to certain determinations/ characteristics/traits; “indeterminate” refers to an entity that has determinations in possible states; “non-determinate” refers to an entity that has no determinations, not even in possible states.
(g) “Human being” means the “I”, “human organism” means the intermingle between brain and body.

I would like to emphasize the difference between those three types of entities: it^{s} and It^{s} *exist*, while being *is*. Later, I will introduce 11 propositions available for all types of entities that exist or are that represent the axiomatic-hyperontological framework for known or unknown EDWs. The order of these propositions reflects the chronological appearance of all entities. I should remind you of the fact that when I use “ontology” (that is equivalent to epistemology), I refer to the entities belonging to one EW; when I use “hyperontology”, I refer to at least two EDWs.

Essential is that the notion of “observation” is equivalent to that of “interaction”. Imagine that an individual is a microparticle (electron or photon) or macroparticle (table or planet; cell or multicellular organism). Obviously, an electron does not “observe”, but interacts with something. What is this something? An electron interacts with/observes other microparticles from the same EW. An electron does not interact with a planet!

Many paradoxes, anomalies, and contradictions from science and philosophy appeared just because people had broken this rule. Usually, a notion that is successfully used in a theory that explains correctly certain phenomena belonging to a particular EW is incorporated in other theories with the hope of explaining phenomena belonging to other EDWs. Obviously, this dangerous action was possible because of the unicorn world framework.

1.3 Propositions for it^s

According to the actual physical theories that explain the unicorn world, after the Big Bang, there was the quantum plasma (quarks and gluons) with an extremely hot temperature. As the plasma became less and less hot, the first microparticles (photons) escaped from that plasma. Later, the planets appeared in the "Universe" and much later, life "emerged" on the surface of at least one planet, the Earth. Following this chronological order, I will introduce the first set of propositions for it^s and their interactions.

(1) Epistemologically different interactions constitute epistemologically different it^s, and epistemologically different it^s determine epistemologically different interactions.
(2) Any it exists only at "the surface" because of the interactions that constitute it.
(3) Any it exists in a single EW and interacts only with the it^s from the same EW.
(4) Any EW (a set of it^s – and eventually It^s – and their interactions) appears from and disappears in the hypernothing.
(5) Any EW is, therefore all EDWs have the same objective reality.

The notion of "exist" is used always for an entity that has certain determinations. The determinations of an entity require a (spatio)temporal framework. Each set of it^s exists in *one and only one* EW. It means that each it interacts with the it^s from only one and the same EW. These two notions, "existence" and "interaction", are strongly interrelated. Proposition (1) can be re-written in the following way:

"To exist means to interact". If an it is *constituted* by certain interactions with other it^{s}, what does "constitution" mean? Interactions constitute the "surface" of an it. Through this process, an it accomplishes an ontological reality. An it exists only at the surface, notions like "internal existence", "internal determinations", "essence" are meaningless to characterize an it. Constitution refers to the entire entity, so we have to exclude the idea that there are "parts" of an it. An it exists only as a whole, i.e., the surface has no parts. As we will see, the relationship parts-whole is just a conceptual notion created by the human mind that has nothing to do with the existence of an it. From an ontological viewpoint, the notion of "composition" for an it is meaningless. Constitution proceeds on determinations, determinations act on constitution, so there is a bidirectional relationship between "constitution" and "determination". However, constitution and determination carry out on the "hyper-nothing" (see below). If these functions performed on something else, we would have the constitution of a set of entities from another set of entities and we would have two cases: both sets of entities are from the same EW or from EDWs. In the first case, we have "composition", but not constitution; in the second case, we have a mixture of EDWs. Through constitution, an it acquires existence with certain determinations. These determinations determine the constitution of other it^{s}. We cannot talk of constitution without determination (vice-versa is not possible, either), even if both functions refer to the same it. Because of the bidirectional relationship between these two functions, we can talk of the unity (in Kantian line) of an EW. Obviously, this unity regards the relationship between entities and their interactions, which presupposes a (spatio-) temporal framework. It is not the unity similar to individuality or identity of an entity. An entity from an EW "perceives" (i.e. interacts with) other entities that have certain determinations from the same EW, but this does not mean that a particular entity perceives all determinations of other entities. There are certain *primary* determinations for some it^{s} that belong to an EW, but there are also *secondary* determinations for other it^{s} that belong to the same EW. In this respect, it is possible for a set of it^s to have several sub-sets of it^s. This means that an it and parts of an it or certain determinations of an it interact with epistemologically different entities that belong to EDWs. Nevertheless, for the human being, all the sub-sets belong to the same EW.

Again, I emphasize the fact that the identity of an it is neither given by its “essence” or “inside” (or other metaphysical empty notions), nor by the perceptual-constitutive mechanisms of human being (Kant and quantum mechanics). The conditions of possibility of the existence of an it are given by its interactions with other it^s within the same EW. An it is constituted at the surface by certain interactions, an it cannot interact with it^s belonging to the other EDWs. Finally, an it is not “composed” of other it^s. I have to mention the fact that the notion of “composition” refers to the natural entities, not the human artifacts, like a car. A car means not only its “surface”, but also its internal components. Nevertheless, the car, on one side, and its components, on the other side, cannot exist in the same spatio-temporal framework at the same time. Otherwise, we get a hyperontological contradiction.

The first part of proposition (5) is “any EW is”. An EW does not exist (i.e. it does not exist in a spatio-temporal framework), but “is”. Only certain epistemologically different entities (and their interactions) exist within an epistemological spatio-temporal framework. Nevertheless, all the epistemologically different entities and their epistemologically different interactions have the same objective reality. Therefore, the EDWs have the same objective reality. The human being is no more or less than an entity like all the other entities. Various instruments of observation (measurement) just allow the “I” to perceive the EDWs. The relationship between the brain (body) and the entities that belong to the macro-EW is bidirectional (the body “observes” the macro-entities, these entities “observe” the body). The relationships between the body and the micro-entities do not exist; any microparticle interacts with an amalgam of microparticles belonging to the micro-EW, not with a body that belongs to the macro-EW.

Any EW appears "spontaneously"[1] from *hyper-nothing*. Hyper-nothing is a hyper-ontological element that goes beyond any EW. It presupposes the absence of any spatio-temporal framework and of any entity or interaction. Hyper-nothing has no determination. If any EW is indeterminate, hyper-nothing is non-determinate, i.e. it has no determination (not even potential determination). Hyper-nothing has no dimensions like space and time. The difference between nothing and hypernothing is that nothing presupposes a spatio-temporal framework or an EW, while hypernothing rejects any spatio-temporal framework or any EW. An EW appears from hypernothing because it cannot appear from something that exists (or is). If an entity A appeared from an entity B (that exists), then inevitably the entity B would belong to the same EW, so it would not be about the appearance of a new EW, but only the appearance of new phenomena within the same EW. If an EW appeared from something else, then we would have the interaction of two EDWs, and this phenomenon is not possible.

Hypernothing is a hyperontological notion, correspondence is an epistemological notion. As a hyperontological notion, hypernothing is hyperontologically placed between any two EDWs. We can say no more than "Between two EDWs there is hypernothing". If we do not accept that hypernothing is hypernothing, then we cannot accept the being of EDWs. Again, we can say that there is a correspondence

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[1] Kant wrote that our thoughts appeared "spontaneously" in our mind. (Critique of Pure Reason) In our days, Raichle hints at a special topic in neuroscience: the dark energy of the brain. The question is why does the brain need so much energy? "The brain apparently uses most of its energy for functions unaccounted for – dark energy, in astronomical terms." (Raichle 2006, p. 1249) Raichle writes about the spontaneity of cognition and intrinsic functional activity of neurons, suggesting that further research needs to clarify the spontaneous activity of neurons. (p. 1250) (See section 11.2) As I showed in Vacariu (2008 and 2011), the spontaneous activity of neurons corresponds to the spontaneous cognition (that is the explicit knowledge). The spontaneous cognition is the product of the implicit knowledge. If we recognize that the brain belongs to the macro-EW and the mind is an EW (see below), we will understand why such questions in neuroscience have no answer. Such "dark energy of the brain" could not be explained using notions from neuroscience, but only by means of the *correspondence* with the implicit knowledge (that is the "I").

between two epistemologically different it^s belonging to EDWs. A new EW1 can appear from hyper-nothing and correspond to another EW2, but the EW1 does not appear from the EW2. Alternatively, an entity from the EW2 does not appear from it^s that belong to the EW1. Probably, there is a correspondence between the entity from the EW2 and an amalgam of it^s from the EW1. Correspondence is only the relationship between it^s which belongs to EDWs. I recall that the proposition (4) is "An EW appears from and disappears in hypernothing". The most important reason why we can say, "An EW is" is that an EW appears from hypernothing. In this case, "is" is a verb without any predicate just because the EW *as a whole* is indeterminate. Finally, we cannot even conceive an EW as a whole. Without interacting with other entities, an "EW is" but does not exist. On the contrary, any it^s or It^s exists and has determinations given by the interactions with other it^s and/or It^s. An EW appears from and disappears in hypernothing. In this way, hypernothing attains its hyperontological status.

Within the context of the EDWs perspective, it is important to answer to this question: "What was before the Big Bang?" In general, almost any physicist would tell us that this question is meaningless just because they do not have any plausible (scientific) answer. From my viewpoint, this question has a plausible (philosophical) answer. There was an EDW (or maybe that EW still exists), let me call it the "pre-Big Bang EW". (See also Vacariu 2012) However, the micro-EW (or the macro-EW) didn't "appear" from the "pre-Big Bang EW". There are no causalities between any two EDWs. The idea of any kind of causality between ED entities that belong to EDWs is meaningless. Obviously, there are some *correspondences* but not causalities. Any EW appears from and disappears in the hypernothing. Then, what is the role of that "pre-Big Bang EW"? There are some *correspondences* between ED entities and processes that belong to the pre-Big Bang EW and the micro-EW (it is supposed that this is the EW that that appears firstly after the Big Bang). Again, "what was before the pre-Big Bang EW?" Was it another EW? Then there could be an infinite "chain" of

EDWs! How can we stop this infinite chain? Moreover, how could we avoid the theoretically “small” infinity and “big” infinity? For instance, we can divide a table in infinite parts or we can imagine traveling in infinite space and time.[1] Within the unicorn world, nothing could stop us to think of such infinities! Only using the EDWs, we can rule out all these infinities. Before the pre-Big Bang EW, maybe was (has been) another EW and before this EW was another EW and so on, but we do not have an infinite chain of EDWs. We can stop this infinite chain of EDWs assuming that, in this chain of EDWs, it was (has been) an EW (let me call it the EW0) that had no spatio-temporal framework! This EW0 can exist because there is another EW without space (the mind-EW) and there are some entities without time (the photons) that belong to a particular EW (the micro-EW). So, having an EW without space and time, the question “What was before a particular EW?” is meaningless in that chain of EDWs since there is the EW0 that has no time and space. If we talk about the EW0, the questions referring to the spatio-temporal framework of the entitites that belong to this EW are meaningless. Therefore, we cannot divide a table in infinite parts or we cannot theoretically travel in infinite space and time because at “one moment”[2] we move in the EW0 that has no spatio-temporal framework. Important is that, within the EDWs perspective, we rule out any kind of infinity. The notions of “world”, “infinity”, God and many other notions have been created by the human mind within the unicorn world. It is time now to give up to such invented notions that have always created great problems for the human being.

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[1] These infinities remind us about Kant’s antinomies of space and time, atomism, causality (freedom). From my viewpoint, I think that I have to come with an alternative for all Kant’s antinomies (including the antinomy about God). With the EDWs, we avoid the notion of the “world” and therefore we rule out any kind of infinity (including the existence of God). (Using the EDWs perspective, I showed that the notion of God - like that of “world” and “infinity” - is meaningless. At my webpage, see my presentation "God died long time ago. How can we rule out the infinite?" from the Symposium “Theism versus Atheism”, September 2012, Bucharest University)

[2] This notion is quite improper!

1.4 Propositions for It^s and being

In this part, I intend to introduce the proposition referring to It^s and the corresponding being. An It is a cell or a "living" organism. It^s refer to all living entities like cells and human organisms. As we saw in the previous parts, we have the hyper-framework in which the human entity is not the only observer. Each entity has its own viewpoint of/interaction with other entities that belong to the same EW. Even in the unicorn world, it is more plausible to believe that certain animals have viewpoints more or less different from those of the human being. More exactly, many animals "perceive" their external world quite differently from the human organisms. From animals, we can move to less and less complex "living" beings like bacteria, multicellulars and unicellulars. Besides, if we accept the postulate that the smallest entity that "has" life (life "emerges" from) is the cell, we can wonder how a cell "perceives" its surrounding environment. Somebody may find this statement ridiculous, but we have to remember that within the EDWs even an electron or a planet "perceives" (i.e. interacts with) other entities from the same EW.

Before introducing the proposition about being and It^s, I should add something about the composition of an It, even if I intend to introduce more details later on in this section. An It, as a whole, has no parts – the whole and the parts cannot exist in the same place at the same time. From the viewpoint of the whole (an It), the parts do not exist. The whole is those parts. Any "part" of an It is just a mental construction (if the It is really decomposed, the It will not exist as a whole). Essentially, as we will see below, each It corresponds to an It or an amalgam of it^s. The propositions for being and It^s are the following.

(6) Being corresponds to an It.
(7) Being is an EW. Therefore, being is.
(8) Having certain determinations, from our viewpoint an It is composed of an amalgam of It^s/it^s and their relationships.
(9) Certain states and processes form knowledge that is being.

(10) As an entity, being has unity as indeterminate individuality.

Being needs the existence of a corresponding It. Without this correspondence, being cannot be. Being is an entity and an EW at the same time. It is the only case when we can find this paradoxical situation: something is an entity and an EW at the same time. Obviously, as any EW, being appears from and disappears in hypernothing.

Essential for the correspondence between being and an It is the fact that without this correspondence, the It would not be able to survive in its environment. We cannot stick to the opinion, as we have done so far, that the biological functions (that are the results of evolution) are enough for an It to survive in its environment. Within the unicorn world, the coordination of all the biological functions of an It is thought to be the result of such an evolution. The evolution of an It is explained by such coordination. From the EDWs perspective, the coordination of all biological functions needs a unity *impossible to use* within the mechanisms of an It. Consequently, such a unity does not exist in an It. Even if there is a correspondence between this unity and the mechanisms/functions of an It, this unity is no more or less than being. *This unity corresponds to the development of an It and the evolution of species.* I consider that the scientists from cognitive neuroscience make a major mistake in avoiding to take into account the essential role of development and evolution when they analyze the relationship between mind and brain (especially using brain imaging with fMRI and PET).[1] In reality, using for instance, fMRI in imaging the brain, we could not grasp the consequences of development of an It and the evolution of species. Many mental and

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[1] For instance, Singer introduces some arguments that suggest that some cognitive functions related to consciousness involve higher order cortical areas that appeared during the evolution. (Singer 2009, p. 44) More exactly, due to this evolution, the brain is able to produce meta-representations, the "basis of conscious experience". (*idem*) We have here a clear mixture of notions that belong to EDWs. Moreover, "meta-representation" would need the homunculus!

behavioral functions appear during the development of an It. After a period of training (of weeks, months or years), probably many neural areas reduce their activation for realizing such functions. In psychological terms, the explicit knowledge is transformed into the implicit knowledge so as to perform certain tasks. Therefore, when we scan the brain of an adult, we cannot grasp all these processes. Certain neural patterns (that at the beginning of that task were most activated) seem not to be activated or at least a lot less activated. Most probably, because of their habitation, the neural patterns reduce their activation but not completely, since the task is still accomplished. The same processes are available during the evolution of species. Therefore, in order to achieve a task, there are many parts of the brain involved, but we are unable to observe all of them. However, the major mistake is that we “correlate” some mental functions only with certain neural functions that we observe using fMRI and PET. In reality, if we go back in time (the development of an It and the evolution of species), then we will notice that many other neural areas are involved in fulfilling a certain mental function, in fact the whole brain and body. For instance, if we can scan the brain of a child during the first months after its birth, we would probably observe the activation of numerous parts of the brain even for the basic movement of arms, legs, and even the eyes. After a period of training, many parts of the brain become less active for such actions. Nevertheless, the same tasks are still accomplished. Very possibly, such processes are available even for the “sensation” of the self. In consequence, using fMRI and PET, we can find only certain neural areas (maybe the most activated ones, but not all of them) that are activated in correlation with certain mental functions.

Each mental function is the unity of being. This unity represents the *indeterminate individuality* of being, or better said, being is an indeterminate individuality. Using any condition of observation, we will not be able to identify the individuality of being. Therefore, this individuality is indeterminate (not non-determinate). Trying to reduce the indeterminate individuality to a *complete* determinate individuality means a mixture of EDWs. If we were able to perceive certain determinations (within a spatio-temporal framework), it would mean that we could determinate the individuality of being. As we will see below, it is even impossible for us to construct the instruments of observation/perception of being (or its unity) as a whole. Once more, within an It, we cannot find the corresponding unity of being, we cannot identify (even trying to find certain "correlations"), a notion from cognitive neuroscience that relates mental functions to neural entities. Within the brain, for instance, the indeterminate individuality is meaningless. Any It (or its parts) has certain determinations. Being is an indeterminate individuality but not hyper-nothing. In fact, being only appears from and disappears in hyper-nothing, but the indeterminate individuality is an entity with *potential* (implicit) determinations. (See below the relationship between the implicit-explicit knowledge.)

From my viewpoint, an It is composed of other It^{s} from the same EW (usually, the macro-EW) or of other it^{s} (from the same or other EW). We identify an it through our sensorial mechanisms (and their extensions) within a spatio-temporal framework, so the It has certain determinations. Being cannot be identified through any kind of perception (or its extension) because human perceptions are being. If all entities (except for the being or any other EW as a whole) can be "perceived", then we can imagine the 6th sense for perceiving the being. We can only hope that in the future humans will be able to create certain instruments to perceive the being. Under these circumstances, being would be an entity with certain determinations. Is this situation even theoretically possible? From the EDWs perspective, having the 6th sense for perceiving the being is a hyperontological contradiction. (See below) Therefore, the construction of such an instrument is quite impossible. I reiterate the idea that "being is" or "being is an indeterminate individuality".

I can make a parallel between two pairs of notions: being-an It and a table-the microparticles. From our viewpoint, many It^{s} are composed of other It^{s} (for instance, an organism is composed of many cells). We already know that each It corresponds to the being. Then, the question that arises refers to the nature of the relationship between being that corresponds to It as a whole and being that corresponds to each It as parts. In order to get an answer, we analyze the table-microparticles distinction. The extension of a table is not formed by the extension of its parts. Such decomposition is available only in our mind, but not in reality. The extension of parts does not exist in the same place and at the same time with the extension of table. Within a single EW, the parts-whole relationship leads us to a hyperontological contradiction. Trying to find the relationship between the being (as a whole) and the "beings" (of the parts) is meaningless. Moreover, each It corresponds to an EW exactly as the whole It corresponds to an EW. The composition or the sum of "being" is useless since being is the indeterminate individuality. It would be very strange to use a statement like "Being is composed of many beings". *The notion of "being" has no plural*. Being does not interact, so again, it is meaningless to look for the relationship between the "beings" that correspond to many It^s. Being simply corresponds to an It. If we stated "Being exists" (not as it is correct, "being is"), we would look for such relationships. It is not about the limits of the human thinking (that includes perception), but about the status of the indeterminate individuality of being. In this context, the "composition" of being is a notion that has no meaning.

Within the unicorn-world, we could say that a "biological organism" has certain knowledge. Within the EDWs perspective, we have the correspondence between any It (a human biological organism or cell) and being, but the "knowledge" has nothing to do with an It but (obviously) only with being. In this case, it is wrong to stick to the sentence "A being has knowledge" for at least two reasons. The first reason is that there is not "a being" but only being. The second reason is that we introduce a difference between being and "its" knowledge. This linguistic difference is very wrong, indeed. There is nothing inside or outside of being. The correct sentence is "Knowledge is being". As I said above, there are different types of knowledge (declarative and procedural, implicit and explicit, conscious and non-conscious – see Vacariu 2008), but these types of knowledge do not form being or are not parts of being. Knowledge is being. All knowledge of the human being is not "of" but "is" being. We have to remember the paradoxical status of being: an entity and an EW at the same time.

The space of the macro-EW is always determined by its it^{s}. We do not have a representation of empty space, without any it. The localization of space in some neural areas of the brain is quite impossible. An it has an identity that unifies certain determinations, including, in general, the space. The unity of the "I" cannot be localized in the brain. There are representations of space (that are being) and the corresponding biological mechanism of an It that interacts with a specific external space. Even if the macro-EW has spatial dimension, the space has to be "suspended" (represented) in being. If the mind had a space, the mind would be decomposed. The decomposition of the "I" is not possible, so the mind has no space.

This virtual space is necessary for the corresponding It to survive in its environment, but the "space" is not being, the representations of space are being. Amazingly, nobody claims that a color is in the brain because the brain has no color. We can make an analogy between space and color. Nevertheless, many people argue that space exists in the mind because the brain (as we observe it) has a spatial extension! The "space" is only "represented" exactly as the color is represented in the mind. That is, the space and the color are no more or less than being. There is no direct relationship between the external space or color and the *representations* of space or color. The *representation of space* is something completely different than the real space or the spatial extension of a neural pattern of activation just because such representation is the being, and the brain belongs to the macro-EW, while the mind is an EDW. There is no localization of space in our brain![1] The researchers in cognitive neuroscience try to localize the mental representation of an object in the brain, but only

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[1] Hauskeller (2012) supports the same idea. Analyzing some philosophical concepts like graduality and identity of the mind (Kurzwiel's "Jack", Theseusu' ship, Sorites paradox, leap of sand, etc.), Hauskeller tries to argue that the self is inseparable from the body. Therefore, the philosophical notion "mind-uploading" (the copy of the mind or self) is not possible since the self is not information. (p. 199)

the object is in a spatial (-temporal) framework. Even for the representation of an object, localization is not possible because that representation corresponds not only to the most activated neuronal patterns, but also to the rest of the brain and body. As an EW and an entity, being has no spatial dimension, so looking for the spatial dimension within our mind is meaningless!

1.5 The hyperverse

The hyperverse is the sum of all the EDWs, an abstract notion, from an ontological and epistemological point of view. Ontologically, since the entities from a particular EW do not interact with entities from another EW. Epistemologically, since the human being cannot observe (through correspondence) the entities that belong to two or more EDWs at the same time. In order for the hyperverse to have an ontological status, one needs an entity to interact with (observe) the entities from EDWs (at the same time). Such an entity has to be a hyperentity. Does the hyperentity exist? The human being is not a hyperentity: a human being cannot perceive two EDWs at the same time, because human attention (probably consciousness) is a serial process. If attention were a parallel process, the human being would observe (through correspondence) at least two EDWs. The attention is a feature of the mind. Thus, a hyperentity needs two minds to observe two EDWs. Since the mind is being, a hyperentity would be two beings, clearly a hyperontological contradiction.

In order to observe the entities from a particular EW, as observers, we have to use certain conditions of observation. The observation is a unidirectional process, since certain entities observed by us are not in the same EW with the brain and body (the macro-EW) that correspond to the “I”. For instance, when someone “observes” an electron of the micro-EW with the help of an electronic microscope, the electron does not observe either the brain-body or the mind of that researcher. An electron observes/interacts with some amalgams of microparticles that correspond to the microscope and the brain/body (that corresponds to the mind-EW or the “I”). Our processes of observing entities that belong to the EDWs are always unidirectional processes. The interaction/observation between two entities that belong to the same EW is bidirectional, i.e. the entities "observe" each other. Except for the human organism, no other entities can change their conditions of interaction/observation. For all these entities, the conditions of interaction impose their ontological/epistemological limits.

We can change the conditions of observation (or their parameters) and we still observe the same EW. This movement passes an organizational threshold regarding the organization of what we observe using both kinds of conditions. We can "observe" parts of the whole, but both constituents (the whole and the parts) belong to the same EW (even if these classes of entities could not exist at the same time in the same EW). Nevertheless, a person cannot observe both constituents at the same time. If we change the conditions of observation and we pass an epistemological-ontological threshold, we observe entities that belong to EDWs. We have to be aware of the fact that in order to find a new EW, we have to construct conditions of observation that "interact" with the entities from that EW. In Kantian words, within the EDWs perspective (see Vacariu 2008) the conditions of the possibility of our tools of observation should reflect, at least partially (that is, to grasp certain determinations, if not all) the conditions of the possibility to constitute interactions of a set of It^{s} (and/or It^{s}) that belong to an EW. We can realize there are EDWs only through the hyperontologization of epistemology. The ontologies of EDWs have become epistemologies and vice-versa. Nonetheless, these ontologies are not "different" ontologies, but epistemologically different ontologies that represent the hyperontology of the hyperverse.

What does the expression "*epistemologically different*" actually mean? Obviously, this difference is not ontological. "Ontologically different" means ontologically different substances or kinds of matter. There is no ontological (in fact hyperontological) meaning for this expression. (For instance, for Descartes, mind and body are two different ontological substances.) The difference is neither linguistic, we cannot say "entities linguistically different". The notion "epistemologically different" imposes certain hyperontological limits related to the limits of each entity from any EW. “To exist” or “to be” means to have certain limits. Such limits entail the determinations of the limits that exist. Even being as an indeterminate individuality has limits (it is not infinite, it does not matter what kind of infinity would be involved), more exactly, certain epistemological-ontological limits. The notion of “epistemologically different” assigns to each class of entities the same epistemological abilities as the man has (these are epistemological-ontological abilities within the EDWs perspective), i.e. the “observation”/“interaction”. As we saw above, if I were a planet (an electron), I would interact with another macroparticle (microparticle). If I were a cell, I would interact with the surrounding environment specific to a cell. However, being that corresponds to a cell does not interact with something else, since it is an EW. The expression “epistemologically different” eliminates many speculations (the Ptolemaic epicycles) created by the human being. It eliminates ontological-epistemological contradictions typically available within the unicorn world. The human organism needs to change the conditions of observation, in order for the human being to “observe” certain epistemologically different entities. The status of this change requires an ontological-epistemological threshold - neither an ontological nor an epistemological threshold.

We can clearly understand now the expression “epistemological-ontological”. Changing certain conditions of observation (the difference between them being an epistemological-ontological threshold), we observe the EDWs. In other words, the threshold is an epistemological-ontological one between entities that belong to the EDWs. We think that we possess certain knowledge about the “world”, but many parts of this knowledge have been counterfeits. The distortions have not been our knowledge about certain entities (that really exist or are), but the pseudo-relationships (causalities or not) between them. As the dictator-observer, the human being imposed the domination of the unicorn world. From the viewpoint of the human being, it seems that all the entities are within the same spatio-temporal framework. From the viewpoint of another entity, the it can "observe" only the entities that interact with it. The interactions between certain it^s take place in a spatio-temporal framework. The framework of an it (for instance, a microparticle) is not the same as the spatio-temporal framework of a biological human organism, since the microparticle does not observe the macroparticle. Therefore, the microparticles and the macroparticles are in epistemologically different spatio-temporal frameworks. This is the main reason why we have to reject the idea that all the entities are within the same spatio-temporal framework, i.e. the unicorn world. Obviously, assuming the same spatio-temporal framework can be helpful in our daily life. However, in science the fundamental problems require the EDWs paradigm.

An entity needs to have a unity that represents its identity (even for the indeterminate individuality). In this context, I will introduce the next proposition, the principle of hyperontologization:

(11) Being is, therefore EDWs are.[1]

The notion of spontaneity (essential for Kant) creates the place for being and the representations (that are being). The spontaneity reflects the unity of representation and the unity of the "I". The spontaneity corresponds to some neural activities that pass a certain threshold of activation. The unity is the Kantian synthesis necessary for thinking (that includes perception). If for Kant the synthesis is a transcendental process, for me it is the implicit knowledge, the conditions of possible explicit knowledge. If Kant writes "Even for space as an object, we need the unity of the combination of the

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[1] In "Being and the Hyperverse" (2011) there are 13 propositions. Number 13 is sacred for the Maya civilization. The Mayan calendar starts with the year 3114 B.C. and ends with the 13th baktun, around the date 21st December 2012. Aristotle considered 10 the perfect number, Kant believed in 12. I believe in nothing. "13" is not a "perfect", "magic" or "unlucky" number. All numbers have nothing to do with "perfection". Numbers, like "perfection", are notions created by the human mind and nothing else. Our predictions of natural events require numbers, but all numbers and mathematical equations are only tools created by the human mind that fit, more or less, with some phenomena that belong to EDWs.

manifold of a given intuition", for me space (more exactly, the representation of space) is being. The color (the representation of color) has to be in the same situation. The spontaneity is the determination of being. As a whole, being is an indeterminate individuality, but the spontaneous appearance of an explicit/conscious representation determines the being to be in a certain state. Thus, we have to make another distinction for the "I", the explicit and the implicit states. The spontaneity is indeed "a determination of my existence", but this determination has to be *explicit*, since being is with or without determination. More exactly, these determinations are being. The spontaneity explains the explicit knowledge. The thoughts could not appear from hypernothing; they appear from being, they are being. Only being, as an EW and as an entity, appears from hypernothing. The thoughts appear spontaneously from the implicit knowledge. The indeterminate individuality (of being) would be the premises of the possibility of such spontaneity.

Let me introduce a thought experiment: the subjectivity of a planet. You can imagine you are a planet and you cannot observe yourself. Paradoxically, your perceptual capacities are able to perceive only the microparticles. Consequently, you as a macroscopic object cannot observe any macroscopic object. This situation is similar with being that cannot observe/perceive itself. In such a situation, you cannot observe your extension as a unity or a macro-object having certain determinations. You are a reductionist and empiricist, so you think that only the microparticles exist. However, there are some phenomena (for instance, the gravity) which cannot be explained by the microparticles (and their interactions). The gravitational force is related only to the macro-objects (like yourself), not with the microparticles.

Being is similar with a planet from a thought experiment. We can perceive a planet (or a table) with the corresponding eyes, but we cannot perceive the being because each of us is being. All mental perceptions (that correspond to the functions of certain biological mechanisms) are being. Therefore, being cannot perceive itself. (As we will see below, the notion of "perception" is meaningless.) It is like asking an eye to see itself! In such a situation, we cannot even think of the 6th sense of perceiving being! It will lead us to a hypercontradiction. I will call this inconsistency the *“being-perceiving” contradiction* that leads to this rule: *“Being does not perceive”*. There are two reasons for supporting this rule:

(1) Being does not perceive itself or an entity from any EW, since being would need a biological mechanism to “perceive” something and this would be a mixture of the EDWs (again a hyperontological contradiction). A biological mechanism and its activities correspond to perceptions that are being. The biological mechanism cannot perceive it self, otherwise we have the “being-perceiving” contradiction. Mental perceptions are the being, but there are no mental representations to perceive the being. Therefore, being is an indeterminate individuality. Being cannot observe another being because being is an EW and there are no pluralities of beings.

(2) As an EW, being obviously cannot perceive something else. For instance, mind cannot perceive another mind, just because mind is an EW and we would have a mixture of EDWs. Such idioms like “in my mind” or “what is it in your mind” are just unregimented linguistic slogans created within the unicorn world framework. We can analyze a real experiment that clarifies this contradiction more: “I perceive my hand”. As we already know, the “I” is an EW, the “hand” is “part” of an It that belongs to the macro-EW. What does “I perceive my hand” mean? With the help of light, the eyes (extensions of the brain) interact with the hand, both the eyes and the hands are parts of the body (but only in our mind). The “I” is an EW, the body (brain) belongs to the macro-EW. The conclusion is this one: it is impossible for being to perceive something. It is wrong to assert “The ‘I’ perceives an object of the external world”. The “I” does not perceive anything, since perceptions are being. There are only certain perceptual images that are the “I” and correspond to the real objects. From an EDWs perspective, it is very important to assert that the notion of perception does not exist. If interactions exist, perceptions mean a mixture of EDWs, and therefore they do not exist. Nothing is perceived because it presupposes an entity that “perceives” and an

entity that “is perceived”. Perception is an EW (being) and an EW cannot be perceived! In reality, perceptions are spontaneous states that correspond to certain interactions that belong to another EW. Moreover, being always corresponds to an It. Only within the EDWs framework can we avoid huge errors of our thinking. The conclusion is this: *perceiving is being, that is both an EW and an indeterminate individuality*. Various perceptions (and feelings) are the entities of an EW (being), but their individuality/identity is epistemologically-ontologically different than the individuality/identity of the it^s or the It^s. The main difference is given by the status of being, the indeterminate individuality. All kinds of perception are being and being is an indeterminate individuality. However, a perception has a kind of individuation different from the individuation of any it or an It (their individuation is within a spatio-temporal framework). More exactly, for instance, two perceptions are spontaneously different, but not in relationship with the whole being. Both perceptions are not a kind of “internal perceptions” of being, but are being.

Chapter 2

A general view on cognitive neuroscience

The term "cognitive neuroscience" was coined by Michael Gazzaniga, one of the Godfathers of this discipline, while talking to George Miller in the backseat of a taxi in New York in the late 70s.[1] (D'Esposito 2010, p. 204) He launched the *Journal of Cognitive Neuroscience* in 1989, and created the Cognitive Neuroscience Society in 1993. (*idem*) Almost everybody is aware of the limits of various technical tools in cognitive neuroscience. D'Esposito (2010, p. 210) illustrated the spatial and temporal resolution of some methods in cognitive neuroscience in his book.[2]

In this book, I want to show that cognitive neuroscience is just a new kind of engineering or even worse, a pseudo-science. Therefore, I will introduce some general notions of cognitive neuroscience from a textbook published quite recently, written by Baars and Gage (2010). In my whole book I will introduce details from another textbook (Banich and Compton 2011)[3]. These books can be considered standard and very actual books for students who

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[1] The label "cognitive neuroscience" "was coined in the late 1970s in the backseat of a New York taxi when Mike Gazzaniga was riding with the eminent cognitive psychologist George Miller to a meeting to gather scientists to join forces to study how the brain enables the mind." (D'Esposito 2010, p. 204)

[2] Almost the same image can be found in the works of other people, for instance, Baars and Gage (2010, p. 98)

[3] In this book, I introduce an unusual method: I analyze, from the EDWs perspective, some information about cognitive neuroscience from two textbooks written by Baars and Gage (2010) and Banich and Compton (2011). I am forced to do this just because a single person cannot deal with large knowledge of the entire multidisciplinary field of cognitive neuroscience. I am not specialized in any particular sub-domain or particular topic of cognitive neuroscience. My goal was to grasp a general and very recent view on cognitive neuroscience and then to analyze it from the EDWs perspective.

are interested in cognitive neuroscience. I want to emphasize some elements from these very recent books. The main idea is that regarding many topics, in both books, the authors underline that the results are still controversial in many cases.[1] Three elements can be the causes of this state of affair: firstly, the main subject of research is a very complex entity (the mind/brain); secondly, cognitive neuroscience is at the beginning of research; thirdly, the framework of people working in this "science" is wrong. However, regarding the second point, because there are already 40 years of research in this science and the number of people working in cognitive neuroscience is huge, we can consider that this science has a much longer history (not in time but in its empirical results) than other particular sciences. The first and the third points are strongly related to each other: something can be considered "complex" because of our framework of thinking. Therefore, it is better to consider that the third point is the main cause for the lack of real progress in the theories/approaches in this domain. Working within this wrong framework, I believe that there is no chance for someone to elaborate a general approach accepted by the majority of researchers in the future.

In this chapter, I introduce some quite particular notions from cognitive neuroscience, in which I am interested directly. I want the reader to become somehow familiar with some notions in order

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[1] I give some examples from Banich and Compton's book: the area V4 "has been posited to play a special role in color perception, although that claim has been controversial" (p. 161); "despite the continuing controversy in this area" (p. 163); "the organization of cells across inferotemporal cortex is still not fully understood" (p. 182); "researchers are still attempting to understand exactly what inputs the cells use to engage in this computation and how they transform the information from one reference frame to another" (p. 214). "The functional significance of these feedback connections from the cortex is still under investigation…" (p. 153); "Controversy still exists about whether changes in striate cortex activation actually cause the shift in conscious perception between the rival stimuli…" (p. 159); Does each area—V1, V2, and V3—serve a different function? Do they represent different properties of the visual world? The answer is that we do not really know the functions of all these visual maps." (p. 161). (There are many such paragraphs in Banich and Compton's book from 2010.)

to understand the next chapters. I will start by introducing a few words about the control-automatic actions (related to training and development). It is already well known that voluntary actions can become automatic with practice (Shiffrin and Schneider 1977) or the self loses executive control over them (Langer and Imber 1979). (Baars and Gage p. 52)[1] The title of section 4.1, Chapter 10 of Baars and Gage's book illustrates that the "practice and training may change connections in the brain".[2] (Baars and Gage 2010) I draw the attention upon the fact that we have to introduce the period of development in analyzing what neural areas are activated for certain cognitive, motor or perceptual functions. Moreover, we have to think that these processes take place in the case of any animal during the evolution of its species. I believe that for an ideal understanding of the relationship between the mind and the brain, i.e. to "correlate" exactly a mental state with some distributed neuronal areas, we have to scan the brain of a person the whole life, from the beginning to the end. In this way, it would be possible for us to grasp the effects of development on an individual.

One of the main notions that I analyze in this book is "localization": the main job of researchers working in this domain to localize certain mental functions/states in the brain. Even if, in the last years, more and more people consider that any mental state is widely distributed in the brain, many of them have been working for localizing each mental state on quite few neuronal areas of the brain. Against localization, we have to take into account the notion of "two-way connections" (that involve re-entrant processes) between almost

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[1] For recent presentation of automatic-control information (strongly related to conscious-unconscious knowledge), see Schneider (2009). For the relationship between automatic-control and conscious-unconscious knowledge, see Vacariu (2008).

[2] "When the same finger movement is repeated over and over again, the cortical representation of that finger will decrease, as if the cortex is treating it as a redundant (highly predictable) event. However, subcortical innervation of the finger does not disappear, because the brain is still controlling and monitoring finger movements." (Baars and Gage 2010, p. 542)

all two neural areas.[1] (Baars and Gage 2010, section 3.2) Moreover, different neuronal areas work together many times. (For instance, sensory and motor areas, Baars and Gage, section 3.3):

> while there are very clear anatomical divisions between sensory and motor pathways, they are constantly interacting. When we speak, we also hear ourselves speak. When we walk, an array of visual information streams across our retina. Video games that simulate the flow of optical vistas really give a sense of motion, even though they are only visual. The brain is constantly updating its motor systems by means of sensory input, and telling the sensory systems what to expect by way of motor signals. (Baars and Gage, p. 75)

From the EDWs perspective, when we try to localize certain mental functions that belong to the "I" (better they are the "I"), we could consider that we cannot make a very clear difference between the sensory and the motor pathways. In the brain, there are quite many interactions between these pathways, while the mental states (that correspond to these pathways) are the "I". The "very clear anatomical divisions" between sensory and motor pathways is a methodological separation, or in Kantian terms, a transcendental division. The simulation of motion through the visual games is a consequence of the existence of the "I" as an EW. There are interactions only between the brain-body and the environment, but not between the "I" and the environment. The "sense of motion" is the "I" that corresponds only with large approximations to some neural patterns. Baars and Gage indicate Fuster's "classical diagram" that suggests the "cycling information between input and output channels, to keep the sensory and motor world in synchrony (Fuster, 2004; Kandel et al., 2004)." Fuster points towards the hierarchies of local hierarchies inside the brain and in constant interactions between the brain, the body and the environment. (Baars and Gage 2010, p.

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[1] "Many cortical regions are massively interconnected with each other, so that activity in one part of the cortex quickly spreads to other regions. A number of scientists believe, therefore, that the entire cortex, together with satellite regions like the thalamus, should be considered as a functional unit. This is often called the thalamo-cortical system." (Baars and Gage 2010, p. 81)

76) Moreover, these authors mention Friston's hierarchical maps diagram with the feed-forward and the feed-back channels.[1] From an EDWs perspective, when we talk about the hierarchies of hierarchies inside the brain, localization is excluded automatically! We do not have to forget the fact that localization involves "correlations" between certain neuronal areas brain and particular mental states. What kind of mental states could we "correlate" with such neural hierarchies of hierarchies? Again, we have to be aware of the fact that localization is something very approximate in both *spatial* and *temporal* scales, since we try to correlate phenomena that belong to the EDWs. The temporal and spatial limits impose us some conditions regarding the correlations of these hierarchies of hierarchies with particular mental states.

In our days, the fMRI is the main instrument that helps us localize the mental state. I strongly emphasize that it will be impossible to localize any mental state in the future. Anyway, I quote here one of the most important ideas of Baars and Gage: "(…) *neurons do more than fire spikes.* The input branches of a neuron, the dendrites, also engage in important activity. By recording different parts of a neuron we get somewhat different measures of its activities." (Baars and Gage 2010, p. 96; my italics) With this idea, we return to Bohr's principle of including the measurement apparatus in defining the entities and the processes that we investigate using certain tools of observation: if we use the fMRI, then we have to include the structure of an fMRI in defining the phenomena grasped by this instrument. If we use the EEG apparatus, then we have to do the same thing. Obviously, using certain conditions of observation, we observe certain entities and processes. Using internal "tools" (introspection, consciousness), we "observe" certain mental states. (That is, any mental state is the "I".) Using the fMRI or PET, we observe the activation of some neural patterns. Using an EEG, we observe certain waves. These states are almost complementary. From

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[1] "Hierarchies are not rigid, one-way pathways. They allow signals to flow upward, downward, and laterally." (Baars and Gage 2010, p. 91) These bidirectional pathways are against localization and strongly support the EDWs perspective.

my viewpoint, if we pass an epistemological-ontological threshold by changing certain observational conditions, we observe ED entities/processes. So, we really need to include the conditions of observation in the definitions of entities/processes. The fMRI and PET tools have spatial resolutions (for instance, the response of an fMRI takes 6 seconds necessary for changes in local blood supply), while the EEG and MEG have temporal resolution.[1] Thus, each apparatus has certain limits imposed by its structure in analyzing the activities of the brain. For instance, the EEG grasps information from the cortex but not from subcortical regions (very important). These conditions also illustrate that our tools of observation are *a priori* limited to their structure for grasping phenomena (that also have particular certain structures). In some situations, the results offered to us by a set of observational tools are just partial "aspects" about the phenomena that we investigated. Therefore, it is compulsory for us to combine the results of various tools of observation/investigation. There are researchers that combine the results of fMRI with EEG so as to get both spatial and temporal resolutions. For Layreys, Boly and Tononi, the "multi-modality integration" means the combination of results offered by two apparatuses, for instance, fMRI and EEG. With such combinations, we get a more "complete characterization of the different aspects of the brain activity during cognitive processing". (Layreys, Boly and Tononi 2009, p. 41) I emphasize again that, in some cases, we have to take into account Bohr's principle of complementarity! So, maybe we really cannot combine certain phenomena (firing neurons and oscillations) characterizing the same entity (the brain in this case). Combining data furnished by different tools could lead us to illicit extensions: the mistake is created when we attribute, "illegally", an "aspect", a feature to an entity. In reality, there are ED features that belong to ED entities.

Another important problem for localization is represented not only by the subcortical zones but also by the role of

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[1] For more details about fMRI, PET, EEG, and other functional neuroimaging, see Laureys, Boly and Tononi (2009); for more technical details, see Ramsøy, Balslev, and Paulson (2010).

neurotransmitters and neuromodulators (that are “classes of neurotransmitters that influence synaptic transmission broadly within neural circuits”, Noudoost and Moore 2011, p. 585) for the corresponding cognitive functions. The roles of these elements are essential for cognitive functions, but the fMRI and the EEG could not grasp directly the actions of neurotransmitters/neuromodulators.

> Notice that all of these neuromodulators project axons from small nuclei below the cortex, spreading their neurochemicals to wide regions, both cortical and subcortical. Only a few thousand cell bodies in these nuclei therefore have massive effects in the rest of the brain, controlling sleep and waking, pleasure and pain, alertness and working memory. (Baars and Gage 2010, p. 541)

From an EDWs perspective, inevitably the actions of neurotransmitters and neuromodulators have to be added to the role of neurons (their properties of firing and oscillations). In fact, all these phenomena (the activity of neurotransmitters and neuromodulators, firing neurons and oscillations) *correspond* to particular mental representations and processes.[1] We cannot ignore these elements in explaining the relationships between the neuronal states and the mental states. However, the problem is not yet finished. The researchers of cognitive neuroscience have made an incredible mistake: they correlated a mental state with some particular cortical area, ignoring the role of subcortical regions! In fact, the researchers have completely ignored the idea that, without these elements, the cortical areas would have no “contribution” (correspondence) to the mental processes. That is, while trying to

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[1] Very recently, even if the authors mention that such researches are at the beginning, Noudoost and Moore (2011) emphasize the modulatory role of acetylcholine (Ach) and dopamine (DA) neurotransmitters in neuronal control of selective attention. “Evidence to date suggests, for example, that Ach may serve a more unique role in bottom-up attention than it does in top-down attention, whereas the reverse may be true for DA.” (Noudoost and Moore 2011, p. 589) However, from the work of other people, the authors know that “different neuromodulatory systems interact with one another (…), including within PFC (…), the contributions of Ach and DA could be highly complex.” (p. 589) This sentence reflects that the Ach and DA from one side and bottom-up and top-down attention are processes that belong to EDWs!

explain the process of any mental state through the correspondence to some cortical areas, we cannot ignore that any mental state is the "I" (the correspondence to the entire brain-body). This is the reason why we have to correlate not only the cortical areas but also the subcortical regions, the glia cells, the neuromodulators and neurotransmitters to the cortical areas. Amazingly nobody considers that the neuromodulators have the same important role as the processes of firing and oscillations of neurons for the mental states! Why? My answer is that it was much easier for us to construct the tools of grasping the activity of the firing and oscillating of neurons than the actions of neuromodulators. I really do not understand what the criterion for this separation was!

Baars and Gage illustrate their idea through the experiment made by Quiroga and colleagues at Caltech (Quiroga et al. 2005 in Baars and Gage 2010[1]) Using the axonal firing rate, they show that a single neuron in the medial temporal cortex is activated only by pictures of the actress Jennifer Aniston! Other neurons were activated by pictures of Halle Berry or the Sydney Opera House. Baars and Gage underline that a single neuron knows nothing about Jennifer Aniston. Usually, there is a large and distributed network of neurons that are activated by a particular face. "If this neuron were lost, the person would still be able to recognize Jennifer Aniston. The brain as a whole would not show a detectable change."[2] (Baars and

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[1] Again, I realize something which is not usual when writing a book: I mention the work of a person that is quoted in the work of other person(s) without reading myself that work. I have to do this just because I have no time and access to read so many papers and books.

[2] "While the spiking neuron is a plausible unit of brain activity, there are important alternative views. Some scientists believe that graded dendritic currents in each neuron may do useful information processing; some argue for subcellular processes inside the cell; others point to non-classical cells and synapses, which are known to be much more common than previously thought; others believe that glial cells participate in information processing; and many scientists believe that real brain processes only take place at the level of populations of neurons. Therefore, recording axonal spikes is important, but it may not be the only important thing going on. Obviously, it's a risky business to jump from a single neuron to more than 10 billion in the vast forest of the brain." (Baars and Gage 2010, p. 100)

Gage 2010, p. 96) It is the framework of the unicorn-world that creates this paradoxical problem: the role of that neuron in "producing" the recognition of Jennifer Aniston. From the EDWs perspective, there is only correspondence (*not identity*) between the activity of large neuronal parts that can be grasped using fMRI and PET, but we have to add the activities of glia cells, neuromodulators, neurotransmitters, etc. and the mental states that belong to the EDWs!

Using a diffusion tensor imaging, we can visualize the fiber tracts of white matter that reflect the connectivity across those two hemispheres and four lobes of the brain. Observing the results of a diffusion tractography of white (myelinated) fiber tracts and knowing that the role of the white matter cannot be ignored in explaining cognition, localization becomes very problematic using only the fMRI and PET! Moreover, even if it is accepted that the particular mental functions are localized in the right and/or in the left hemispheres[1], the corpus callosum (100 millions fibers) integrates information from both sides. (Baars and Gage 2010, p. 134) Then we can have a meaningless question: does the integration take place in corpus callosum?[2] On the one hand, we have two hemispheres

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[1] "One very old and difficult to be changed is the dogma that language is localized in the left hemisphere (mainly Broca and Wenicke's areas). You can find this dogma in every textbook of cognitive neuroscience. However, actual "work has expanded and fractionated the traditional language areas, so that the left inferior frontal gyrus (L-IFG) is a more appropriate term for Broca's area, and posterior auditory and speech regions of the parietal and temporal cortex are more accurate than the term 'Wernicke's area'. However, there is constant interplay between frontal and posterior language areas, and a hard-and-fast division is to some extent artificial. In addition, the evidence is strong that the right hemisphere has its own role to play in language perception." (Baars and Gage 2010, p. 395)

[2] It has been considered that prefrontal cortex (PFC) is the neuronal mechanism correlated with the "cognitive control", "the ability of our thoughts and actions to rise above mere reactions to the immediate environment and be proactive: to anticipate possible futures and coordinate and direct thought and action to them." (Miller and Wallis 2008, p. 1199) Even if such cognitive control integrates the activity of many, distributed neuronal areas, the PFC has a central role anyway. The "PFC receives converging information from many brain systems processing external and internal information and it is interconnected with motor system structures

correlated with particular functions (*differentiation or segmentation*), whereas on the other hand, we have *integration* of information (for instance, consciousness or even subjectivity have a unity that requires such integration). From my viewpoint, I believe that this couple of notions, the differentiation and the integration (whole-parts) is a creation of the human mind extrapolated from the macro-EW or micro-EW to the mind-EW in relationship with the brain (that belongs to the macro-EW). Such distinction is meaningless if we analyze the mind (the mind-EW) since this differentiation requires space or distance that does not exists in the mind. (See Chapter 9 of this book) Moreover, even in the brain, such segmentations are realized quite artificially by the human being using particular tools of observation (fMRI, EEG, etc.). I strongly emphasize the fact that this differentiation (segmentation) is an artificial notion created by us, which can be only methodologically, pragmatically (not ontologically) useful, while the integration is the “I” or the mind-EW (with its unity).

Let me analyze, from the EDWs perspective, a particular case of integration of spatial information from multiple senses (touch, hearing and vision) presented in Banich and Compton (2011). It seems that the visual information is represented by the eye-centered representations, while tactile and audible information is represented by the head-centered coordinates. (Banich and Compton 2011, p. 214) It is possible that the integration of both kinds of

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needed for voluntary action.” (*idem*) Talking about another kind of integration, Miller and Wallis write that the “PFC has long been suggested to be the great integrator, a brain region that synthesizes information about the external and internal world for the purpose of producing goal-directed behavior.” (Miller and Wallis 2008, p. 1202) However, “a neural system for cognitive control must have access to information from many brain systems and the ability to encode the goal-relevant relationships between them. The cognitive control system must also have the ability to select which sensory, memory, and motor processes are activated at a given moment.” (p. 1200) The question is how the PFC could realize all such integration? What does the ability to “encode” the goal-relevant relationships between so many neuronal areas mean? Is the PFC a kind of homunculus? From my viewpoint, it means the “I” with its unity and nothing else.

information is made by the parietal cortex. The authors write that the "regions of the parietal lobe manage to align maps constructed from different senses". (*idem*) Mentioning a particular work, Banich and Compton introduce a particular example of such integration (superior parietal area aligns visual and touch information in head-centered coordinates). However, I do not understand (they do not explain) what the expression "to align maps" means. This expression has a meaning only within the EDWs perspective, that is it means that it "corresponds" to a particular mental state. The central sulcus is a landmark in cognitive neuroscience. It separates posterior from anterior parts of the brain.

> Posterior cortex contains the projection regions of the major sense organs – vision, hearing, touch, smell, taste. In contrast, frontal cortex is involved in action control, planning, some working memory functions, language production, and the like. In a sense, the posterior half deals with the perceptual present, while the anterior half tries to predict and control the future[1]. (Baars and Gage 2010, p. 145)

The number of Brodmann areas that increased in the last decades reflects the framework of the unicorn world. If, at the beginning of the last century, the number of Brodmann areas was around 52, today there are more than 100 Brodmann areas acknowledged in cognitive neuroscience. These areas are correlated with different specialized functions of the cortex (visual, auditory, motor, language, cognition). Nevertheless, as we saw above, the correlations of such mental functions with neural areas require not only the neuronal areas but also the activity of white matter and subcortical regions (the role of glia cells, neurotransmitters and neuromodulators).

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[1] "The basal ganglia have been implicated in action planning and unconscious cognitive operations. New evidence, however, has linked the basal ganglia to higher order cognitive functions, such as decoding the grammar, or syntax, of language." (Baars and Gage 2010, p. 151) "Unlike regions in sensory cortex, the frontal lobes do not have a single job to do – they are not specialized for decoding speech sounds or recognizing faces. Rather, the frontal lobes are engaged in almost all aspects of human cognitive function." (*idem*, p. 400) These sentences support directly the EDWs perspective!

> While the cortex is vital for cognitive functions, it interacts constantly with major "satellite" organs[1], notably the thalamus, basal ganglia, cerebellum, hippocampus, and limbic regions, among others. The closest connections are between the cortex and thalamus, which is often called the *thalamo-cortical system* for that reason.[2]

(Baars and Gage 2010, p. 127, their italics)

Having the two-way or the re-entrant connections, the thalamo-cortical system is very interlinked and active. (Baars and Compton 2010, Chapter 8, section 1.5) From an EDWs perspective, the role of the thalamo-cortical system becomes essential in understanding the notion of "correlations". Can we still find "correlations" within the thalamus-cortical system? For any mental state, there are some neuronal areas that are the most activated ones, as well as other neuronal areas working in a more "silent" manner (see Vacariu 2005, 2008), but we have to add neuromodulators, neurotransmitters, white matter and subcortical areas, that is the entire brain (and body, see

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[1] About the "satellites" of the subcortex, see Baars and Gage (2010), Chapter 5, section 3.5.

[2] "Think of the thalamus as a relay station: almost all input stops off at the thalamus on the way to cortex; almost all output also stops off at the thalamus, going out to the muscles and glands. Fibers emanating from cortical cells spread in every direction, flowing horizontally to neighboring cells, hanging in great bundles on their way to distant regions of cortex, and converging downward on the great traffic hub, the thalamus, of each half of the cortex. In addition, hundreds of millions of axons flow crosswise, from one hemisphere to the other, creating white axon bridges called commissures …" (Baars and Gage 2010, p. 149) And we also have to keep in mind that "the thalamus is the major input hub for the cortex, and also the major cortex-to-cortex traffic hub, like a large airport that might serve both domestic and international traffic. However, the basal ganglia operate as a major output hub, for motor control and executive functions. The brain has multiple hubs, just as it has multiple superhighways." (*idem*, p. 250; see also Chapter 8, section 1.7) It seems that the unity of the mind involves automatically such re-entrant connections. Taking into account these re-entrant connections and many hubs, what do we really observe using fMRI, PET or EEG? Do we have any chance to correctly localize any mental function? I add Uttal's words: "As the discussion in this book progresses it will become clear that modularization and localization are no longer tenable interpretations." (Uttal 2011, p. 43) Moreover, we have to take into account the changes regarding the neurons and their interactions during development and evolution of species!

Sporns 2006 or Vacariu 2008). We have here Principle 6 (being corresponds to an It). There is only a huge approximation (the "thalamo-cortical system"), but in reality it is about the entire brain (and the body). Analyzing Edelman, Tononi, and Sporns' works, Baars and Gage conclude that

> Recursive complexity reflects the fact that brains show rich organization at multiple levels, from molecular interactions within individual synapses to reentrant interactions among distinct brain regions. A combination of measures may be needed to adequately characterize the neural dynamics relevant to consciousness.[1] (Baars and Gage 2010, p. 292)

From the EDWs perspective, such complexity and "levels" do not exist in "nature" because "nature" itself does not exist! "Complexity" is the most complex Ptolemaic epicycle in biology and cognitive science created so as to reflect the pseudo-relationship between the mind and the brain.

Any mental state (that is in atemporal framework, the "I") has to be "correlated" not only with the posterior and the frontal brain parts, but also with the entire cortex and subcortical areas (that are within a spatio-temporal framework). However, the "internal" time is also the "I". Using various apparatuses, we institute a spatio-temporal framework for certain neural patterns of activation. So, which are the criteria to establish a correct correlation between a spatio-temporal neural state/function and mental temporal state/ process? For instance, the "time lag between two hemispheres working on the same task may be as short as 10 ms, or one hundred

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[1] "Some theorists suggest that the entire cortex, or the thalamo-cortical system, should be viewed as massive networks for integrating, differentiating, and distributing signals (e.g. Edelman, 1989; Edelman and Tononi, 2000; Freeman, 2004)." (Baars and Gage 2010, p. 394) Recall my analogy between table-microparticles and the unity of mind/consciousness-neural patterns of activation. Again, I add Uttal's words: "There are too many uncertainties, too many neurons, too many idiosyncratic interconnections (e.g., the brain is not neatly organized as is a simple crystalline structure) for us to ever be able to understand its detailed organization and how, specifically, this complex information pattern produces the reality we call mind." (Uttal 2011, p. 29)

of a second (Handy *et al*., 2003)" (Baars and Gage 2010, p. 140) What does 10 ms or 50 ms mean for the "I"? The minimum time for vision is 10ms. Is this limit imposed by this time lag? We have to take into account that there are ED times for the brain-EW (that is the brain that belongs to the macro-EW) and the mind-EW. The "I" is not the sum of 10s brain states, but an indeterminate entity that has its unity that cannot be found within the spatio-temporal frameworks imposed by certain apparatuses. Applying Bohr's principle of including the structure of an apparatus used for observing a phenomenon in the definition of that phenomenon (see Vacariu 2008), we also have to include the structure of an fMRI or EEG in defining the entities/processes observed with these tools. It is believed that "100 ms represent the minimum conscious integration time in perception": two discrete sensory processes are integrated into a single conscious event if they occur in an interval of maximum 100 ms. (Baars and Gage 2010, p. 289) From their experiments, Doesburg and his colleagues consider that around 100 ms gamma phase-locking across large areas of cortex are activated in response to lateralized visual signals. (*idem*) Correlating a particular mental state/function with some neural areas becomes quite impossible.

Another element against localization is the spontaneous activity of the brain or the intrinsic brain processes. (See Baars and Gage 2010, section 3.2; see also Raichle's default network, section 11.2 of this book) If we take into account this intrinsic activity of the brain, then the most activated neural patterns that we grasp using fMRI are only the top of the iceberg, but the entire iceberg corresponds to the "I". Each mental state/process is the "I". We have here again the integration-differentiation problem or the whole-part relationship and we can find this problem in many places in Baars and Gage's book. For instance, the basic visual features are color, orientation, motion, texture, and stereoscopic depth. (Baars and Gage 2010, p. 159) Thus,

> … most neurons in early visual areas of the brain are highly tuned to specific features – some may fire very strongly to a line shown at a particular angle, to a particular color, or to a particular motion direction. These neurons respond to a very

> small region of the visual field (i.e. your current field of view), ranging from just a fraction of a degree to a few degrees of visual angle. … If the activity of each of these neurons represents only a small part of the visual field, such as whether a small patch of the visual field contains vertical or horizontal, red or blue, motion or something stationary, then how is the brain able to combine this information across many neurons? Somehow, the brain is able to organize these basic feature elements into organized perceptual groups. (Baars and Gage 2010, p. 159)

At page 394, they claim that

> Chapters 3 and 6 showed that the visual system appears to have at least one region of integration "where everything comes together", the inferotemporal cortex (area IT) (Sheinberg and Logothetis, 1997). In that area, neurons respond neither to single retinal stimuli, nor to separate features like colors or light edges, but rather to entire visual objects. It is at least possible that language may have a similar region of integration (Hagoort, 2005; Figure 11.28). (Baars and Gage 2010, p. 94)

It seems that we have another "hub", that is a point of integration. Undoubtedly, these "hubs" remind me of the (un)famous homunculus from the philosophy of mind. Baars and Gage bring into discussion the Gestalt principle. In their words, the "German word, Gestalt, is difficult to translate directly, but expresses the idea that *the whole is greater than the sum of the parts*." (*idem,* p. 159, their italics)[1] This paragraph is the best reflection of the wrong framework, the unicorn world, in which the researchers elaborate their empirical experiments and approaches. In reality, we have to talk about the EDWs and nothing else. The neurons that respond to a particular stimulus are the "top of the iceberg", while the "organized perceptual groups" are the "I", so we have here at least two EDWs.[2]

Let me analyze from an EDWs perspective, the relationship between the "I", perception, the brain and the external world. (See

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[1] About this (un)famous principle and the EDWs perspective in cognitive science, biology (Kauffman's principle of complexity, 1995, 2000, 2008) and physics, see Vacariu and Vacariu (2010).

[2] Moreover, we have to take into account that different cognitive functions can access the same neural area (one-to-many) and the same mental function can instantiate at least partially different neural area. (Uttal 2011, p. 55-57)

Vacariu 2011) As I showed in other works, the external world has to be, in Kantian sense, incorporated within the "I".[1] There are several points that I need to emphasize. As I showed in Vacariu (2011), the "perceptions" do not exist, since they belong to the mind-EW (more exactly, perceptions are the "I"). Only the brain interacts with the body and the external world, but, as I emphasized in Vacariu (2011), it is meaningless to talk about interactions between the mind-EW and the external world (the macro-EW) because, in this case, we have two EDWs.

In this context, I would like to analyze two notions. The first notion refers to the "constructive perception" or the "*perceptual filling in view*". I consider the perceptual filling as being one of the most important topics in cognitive neuroscience: our eyes have always a blind spot because they lack certain photoreceptors at the back of retina where the axons of the retinal ganglion are unified to create the optic nerve. (For "constructive perception", see Baars and Gage 2010, section 5.4) The brain "*fills in perception* of the blind spot". (Baars and Gage 2010, p. 186) Moreover, such fillings occur not only for the blind spot, but also for other parts of the visual field. (*idem*) The brain fills color, patterns and motion! We perceive in full color and high resolution only at the center of gaze. (Baars and Gage 2010, p. 158) The fovea "subtends about four degrees of visual arc" (*idem*, p. 48)

> Outside of the fovea, which covers only 2 to 4 degrees of arc, the retina loses resolution and is sensitive only to light and dark edges. (It follows that our normal sense of a rich and colorful visual world is a construction of the visual brain, not a literal record of the input into the retina.) (Baars and Gage 2010, p. 272)

Obviously, this observation is extremely important. How can we draw the line between what "we" really perceive and what is filled by the brain? How could we explain the combinations of information

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[1] On the contrary, in cognitive science, different approaches (Clark's extended mind, the dynamical system approach) promote the extension of the mind into the external environment. (See Vacariu 2008 and Vacariu and Vacariu 2010)

that are really “perceived” by the eye and the brain with the information that is “filled by the “brain” (or by the mind)? From an EDWs perspective, these questions are meaningless: all the information belongs to the mind-EW. It is neither a combination between the “external” and the “”internal worlds (of information), nor an extension of mind outside the body (the embodied cognition, etc.). In Kantian sense, the external world is incorporated into the mind (not into the brain). There are interactions between the brain (that include the actions of the eyes) and the external environment but not interactions between the mind and the environment.

The second point refers to the fact that on the occipital lobe in V1 area, the images have 2 spatial dimensions (2D), while the “I” perceives 3D images. It is then logical to consider that we are not aware of what happens in V1, even if V1 is sensitive to visual features like orientation, direction of motion, colors and color differences. We have 3D visual perceptions, but where does the brain “construct” them? V1 projects feedforward signals toward V2, V3, V4 (important for the perception of color), and MT area (important for motion). (Baars and Gage 2010, p. 166) Moreover, it is quite accepted that these projections are divided in two pathways: ventral pathway (from V1 to temporal lobe - important for representing “what” objects are) and dorsal pathway (from V1 to parietal lobe – important for representing “where” the objects are located).[1] Nevertheless, the authors mention that the dorsal-ventral distinction is not an absolute one, since there are many “cross talks” between them, and the parietal and the temporal lobes send projections to the prefrontal cortex area “where information from each pathway can

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[1] Baars and Gage mention Ungerleider and Mishkin (1982), Goodale and Milner (1992) and others. (Baars and Gage 2010) Ungerleider and Mishkin (1982) showed that “two distinct streams were postulated: a *temporal* or *ventral stream* devoted to object recognition and a *parietal* or *dorsal stream* devoted to action or spatial tasks. Ungerleider and Mishkin termed these the “what” and “where” pathways. The ventral stream, V1 → V2 → V3 → V4 → IT (…)” and the “dorsal stream, V1 → V2 → MT → MST … The dorsal stream is dominated by magnocellular cells and the ventral stream by parvocellular cells, although the segregation is far from strict (Merigan and Maunsell, 1994).” (Reid and Usrey 2008, p. 657)

also be reunited.” (Baars and Gage 2010, p. 169) From my viewpoint, the dorsal and the ventral pathways are very rough approximations that correspond very largely to features of mental representations. The “what” and the “where” features of a perceived object are in the mind-EW and nowhere in the brain.[1] Uttal wrote that it is important “to remember that no matter how complex the analysis, brain images essentially search only for answers to the ‘where’ question. The essence of the mind-brain problem, however, is still the ‘how’ question and it is not yet clear just what the ‘where’ question tells us about the mind-brain problem.”(Uttal 2011, p. 46) From the EDWs perspective, the 3D visual perceptions are the “I” or belong to the mind-EW and therefore it is meaningless to check in the brain where such “constructions” take place. The entire brain and body correspond to the constructions of 3D visual perceptions and all other perceptions that are the mind-EW.

Baars and Gage indicate that, according to Ganis et al (2004), the neural patterns (areas from occipital, temporal, and parietal cortex) are almost the same for visual imagery and visual perception.[2] (Baars and Gage 2010, p. 48) This is another support for the EDWs: visual perception is nothing else than an EDW rather than the macro-EW.[3] Baars and Gage suggest that the right PPC is a possible neural area, from which the “perspective of the self” emerges. (p. 293) Nevertheless, they write that there are “still many unanswered questions about endogenous brain rhythms and how they interact with external inputs.”(Baars and Gage 2010, p. 298)

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[1] Related to “where” and “what”, Weiskrantz’s famous blindsight is another example that supports the EDWs perspective. His patient could point the location of the light source even if he was not able to be conscious about that light. Baars and Gage consider that “These findings suggest that there can be dissociations between visual processing in the brain and a person’s subjective awareness (…). (Baars and Gage 2010, p. 177) Obviously, from an EDWs perspective, it is about two EDWs.

[2] On the same line, we can bring the “mirror neurons system” that allow a person to understand the intentions of other person from simple observation of her act. (Baars and Gage 2010, p. 451)

[3] Baars and Gage point out that exactly as visual imagery corresponds to visual perception, there is an inner speech that corresponds to outer speech. (Baars and Gage 2010, p. 49) Again, this is another argument for the being of the “I”.

Another great problem in cognitive neuroscience is memory.[1] I believe that it is quite impossible to localize parts of the brain that are responsible for a particular type of memory or for memory in general. Baars and Gage consider that the memory storage[2] implies "very widely spread synaptic alterations[3] in many

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[1] Attention is another important problem for cognitive neuroscience. Since we talk about EDWs (mental and neuronal), almost all correlations produce "important" and still unsolved problems in cognitive neuroscience.

[2] "Dingman and Sporn, (1964), for example, in a specific effort to consider how we might confirm that a particular molecule, neuron, or locus in the brain was the locus of the memory engram presciently proposed the following tests: 'We suggest that the following criteria must be satisfied in order to demonstrate that a given molecule, set of molecules, structure, or set of structures is indeed [the site of] a permanent memory trace: (i) It must undergo a change of state in responses to the experience being remembered. (ii) The altered state must persist as long as the memory can be demonstrated. (iii) Specific destruction of the altered state must result in permanent loss of the memory. (p. 26)' Such rigorous tests for cognitive neuroscientific relationships of any kind are rarely, if ever, satisfied. Therefore, Dingman and Sporn concluded that all such suggestions that there is a specific memory storage region or mechanism must be "highly circumstantial" (p. 26). Considering the way data is collected today in many comparable kinds of experiments, we must also agree that many of the reported relationships using imaging techniques also remain "circumstantial." (Uttal 2011, p. 72)

[3] However, "the change in synaptic conductivity that accounts for the changes in the neural network—is the basis of most physiological theories of learning and memory. Synaptic conductivity changes can account for short term memory by invoking reverberating circuits that fade as the temporary synaptic changes lose the transient "potentiation." Long-term memories are accounted for by permanent changes in conductivity so that the information in the synaptic patterns becomes locked in. Martin, Grimwood, and Morris (2000) present a compelling argument that such synaptic changes are necessary but that 'little data currently supports the notion of sufficiency' (p. 649)." (Uttal 2011, p. 15) Mentioning the work of O'Reilly and Munakata (2000) and Miller and Cohen (2001), Miller and Wallis mentioned that the long-term memory based on changing synaptic weights are quite inflexible and have local effects. Moreover, the "information contained in a set of synaptic weights is thus expressed only when the circuit is fired. By contrast, the information needed to guide goal-directed behavior must be expressed in a format that allows it to affect the ongoing processing in other brain systems. Sustained activity is such a format. It is extended over time and information contained in a pattern of activity can be propagated across the brain. Thus, the ability of sustained activity to tonically influence other brain systems is likely important for coordinating diverse processing

parts of the cortex"[1], even if the hippocampus is responsible for the transformation of the experience in memory and map for spatial localization. (p. 306) The medial temporal lobe is another hub with widely spread connections to many areas, like visual, auditory, somato-sensory, emotional, motor, memory, and executive areas.[2] Therefore, this lobe receives, binds, and distributes information for

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around a specific goal. It also affords flexibility; if cognitive control stems from a pattern of information maintained in the PFC, changing behavior is as easy as changing the pattern." (Miller and Wallis 2008, p. 1219)

[1] "All brain regions are involved in learning, memory, and plasticity, which can be considered as different methods for evoking long-lasting adaptive changes in the brain." (Baars and Gage 2010, p. 541) "Learning occurs everywhere in the brain. Memory storage occurs in the same regions that are used in active tasks." (*idem*, p. 542) Lost in localization!

[2] "The PFC is connected directly with every distinct functional unit of the brain (Nauta, 1972). It is connected to the highest levels of perceptual integration, and also with the premotor cortex, basal ganglia, and the cerebellum, all involved in aspects of motor control and movements. PFC also is connected with the dorsomedial thalamic nucleus, often considered to be the highest level of integration within the thalamus; with the hippocampus and medial temporal structures, known to be critical for memory; and with the cingulate cortex, believed to be critical for emotion and dealing with uncertainty. In addition, PFC connects with the amygdale, which regulates most emotions and social cognition, and with the hypothalamus, in charge of control over the vital homeostatic functions of the body. Finally, PFC is also well connected with the brainstem nuclei involved in wakefulness, arousal, and overall alertness, regulation of sleep and REM dreams." (Baars and Gage 2010, p. 404) Or the posteromedial cortex (PMC) is the "conjunction of the posterior cingulated cortex, the retrosplenial cortex, and the precuneus (Brodmann areas 23a/b, 29, 30, 31, and 7 m) and has been shown to possess connections to most all cortical regions (except for primary sensory and primary motor cortices) and to numerous thalamic nuclei (…)". (Damasio and Mayer 2009, p. 9) "The PFC is well positioned for a central role in cognitive control. Collectively, these areas have interconnections with brain areas processing external information (with all sensory systems and with cortical and subcortical motor system structures) as well as internal information (limbic and midbrain structures involved in affect, memory, and reward)." For instance, the "dorsolateral and ventrolateral portions of the PFC receive visual, auditory, and somatosensory information from the occipital, temporal, and parietal cortices, whereas orbitofrontal cortex receives chemo-sensory and visceral information (…)." (Miller and Wallis 2008, p. 1201 and 1202) With so many essential hubs, how could we localize mental states in the brain? We recall that the time of the "I" is epistemologically different than the time of neural states/processes.

the long-term memory. Obviously, there are great debates in cognitive neuroscience about localizing conscious events, working memory, and selective attention. (Baars and Gage 2010, p. 309) Baars and Gage mention that maybe the working memory overlaps with attention, conscious events, and episodic recall. (p. 337) From my viewpoint, we have to be aware of the fact that all these processes are the "I", and therefore their precise localization is quite impossible. Paradoxically, the "progress" of research in cognitive neuroscience (mainly through the creation of various mechanisms of investigation, like fMRI) do not solve any problem. On the contrary, the problems become more complicated and new problems appear! For instance, I give an example of localization: it is believed that various areas of prefrontal cortex (and ventral PFC) realize different jobs.

> PFC is not organized by domain (e.g. spatial versus non-spatial), but by process, with ventral areas of the PFC supporting the passive storage and maintenance of items, while more dorsal areas are called upon when the task demands selection, monitoring, manipulation, or other "mental work" to be performed on these items. This is the so-called "maintenance" versus 'manipulation' processing distinction. While this view seems capable of explaining a wide range of findings, several studies have cast doubt even on the assumption that the VL-PFC contributes to storage in WM (e.g. Rushworth et al., 1997). (Baars and Gage 2010, p. 337)[1]

The localization of any mental state has no chance to be solved since it is a pseudo-problem. Unfortunately, hope never disappears! After in this chapter I introduced some important topics from cognitive neuroscience, in the next two chapters, I will investigate, in detail, the optimism and the skepticism trends for people working in cognitive neuroscience.

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[1] Or, the "lateral PFC is activated by a wide assortment of cognitive tasks. These include tests of inhibitory control (such as the Stroop task), rule switching tasks (such as the WCST), and working memory tasks. A distinction that has emerged from these studies concerns the respective roles of dorsolateral and ventrolateral PFC regions. Ventrolateral PFC is activated predominately by tasks that require holding information in working memory whereas dorsolateral PFC is activated when that information must be manipulated in some way." (Miller and Wallis 2008, p. 1207)

Chapter 3

Optimism for localization and the “mind reading”

3.1 Bechtel’s optimism

I will apply the axiomatic-hyperontological framework for the EDWs to the strong dispute among scientists and some philosophers that work in cognitive neuroscience, regarding the use of fMRI, PET, etc. in localizing the brain activities. There is an optimistic group claiming that the mind can be explained through the localization of the mental states within the brain (Bechtel, a philosopher that was quite optimist until quite recently, as well as many researchers from cognitive neuroscience) and a pessimistic group (Uttal, as leader, Hardcastle and Stewart, Prinz, and others). The outcome of this dispute is quite important: it is about the direction of research in cognitive neuroscience in the future. As a philosopher, I want to show that philosophy can still have a role in this quite new domain.[1] I want to illustrate that the EDWs perspective can have great applications in cognitive (neuro)science. From my perspective, both fractions (optimism and skepticism) are quite wrong or incomplete, since these directions have been elaborated within the unicorn world. In this chapter, regarding the usefulness of the brain imaging (mainly, fMRI and PET) in explaining the mind (through localization), I will investigate Bechtel’s optimism[2]. However, I emphasize that Bechtel made quite major changes in his optimistic position in the last two years becoming less optimistic. Bechtel tries to explain the human mind introducing a new concept: the “mental mechanisms”.

> A mechanism is a structure performing a function in virtue of its component parts, component operations, and their organization. The orchestrated functioning of the

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[1] In the books (Vacariu 2008, Vacariu and Vacariu 2010), I showed that philosophy has an important role in physics, biology and cognitive science.

[2] For a detailed investigation of Bechtel’s mechanisms in cognitive neuroscience (mainly, his work from 2008), see Vacariu and Vacariu (2010). I think that William Bechtel is probable the best philosopher working in cognitive (neuro)science. His work has always indicated me the role of a philosopher in this interdisciplinary domain.

> mechanism is responsible for one or more phenomena. (Bechtel & Abrahamsen, 2005; Bechtel, 2006) (Bechtel 2009, p. 6; 2008, p. 13)

The notion of mechanism is related to the localizations in the brain, i.e. the "correlation" between some mental mechanisms and neuronal areas. Bechtel was convinced that localization (and "decomposition") of the mental states in the brain will be successful in the future even if he mentions that even for perceiving a simple object, more than 30 neuronal areas are correlated.[1] Nevertheless, being quite optimistic for localization (and decomposition), Bechtel pleaded for the *heuristic theory of identity*. (Bechtel 2008, for details see Vacariu and Vacariu 2010)

Interestingly, lately, Bechtel has attempted to adapt his theory to the latest researches in brain imaging. He considers that the notions of "localization" and "brain areas" need to be re-conceptualized. (Bechtel 2012; 2013) His new alternative is a combination of mechanisms with the dynamical system approach, i.e. the dynamical mechanisms. As we emphasized in Vacariu and Vacariu (2010), Bechtel (2008) already tried to combine reductionism with emergence.[2] Mechanistic reductionism is Janus-faced. "As William Wimsatt (1976a) proposes, it is possible to be both a reductionist and an emergentist." (Bechtel 2008, p. 129) Moreover, Bechtel wants to preserve not only decomposition, but also the autonomy of a system introducing Bernard's notion of "internal environment" (Bernard's expression in Bechtel 2009, p. 12 or Bechtel 2008) or Cannon's "homeostasis" and its extended notion, Varela's "autopoiesis".[3] (See Vacariu and Vacariu 2010)

> Autonomous systems are mechanistic (dynamic) systems defined as a unity by their organization. We shall say that autonomous systems are organizationally closed.

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[1] "A vast expanse of cerebral cortex—greater than 50% of the total in many primate species—is involved primarily or exclusively in the processing of visual information." (Reid and Usrey 2008, p. 656)

[2] Powell and Dupre (2009) write a very short paper about reductionism, emergence, mechanisms and networks in biology that perfectly mirror the actual status of the unicorn-world in biology on those topics today. Obviously, this status is reflected in cognitive neuroscience.

[3] Bechtel continues this picture with Ganti's chemoton, the simplest system having the basic features of the living system. (Bechtel 2008, pp. 218-20)

> That is, their organization is characterized by processes such that (1) the processes relate as a network, so that they recursively depend on each other in the generation and realization of the processes themselves, and (2) they constitute the system as a unity recognizable in the space (domain) in which the processes exist (p. 55). (Bechtel 2008, p. 217)

In 2009, Bechtel adds that

> In fact, living systems has typically highly integrated despite the differentiation of operations between different organs and cell types. The mind/brain seems to be no different on this score – it consists of component processing areas that perform different computations which has nonetheless highly integrated with each other. Such a mechanism does not typically include encapsulated modules, and one is not likely to find them in the mind/brain. (Bechtel 2009)

In a paper from 2012, Bechtel continues to support that the mental mechanisms with specific functions could be localized, but he emphasizes the *integrations* of the areas in a larger framework of cortex. In order to support these ideas, Bechtel introduces Sporns and Zwi's (2004) "*dual role of cortical connectivity*":

(1) The *functional specificity* of certain cortical areas that manipulates specific information ("functional specificity of small world network from clustering of units into local subsystems")[1] and

(2) The *integration* of this kind of information in a coherent behavior and cognitive states ("integration into coherent global states through oscillations in thalamic neurons play in producing global states, such as attentive awakeness, drowsiness, and sleep, which modulate processing in many local circuits"). (Bechtel, 2012) From my viewpoint, this "dual role" is a contradictory notion within the

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[1] Let me introduce a recent example regarding neural specialization: LaRock mention that "damage in V4, an area of the ventral system, produces achromatopsia, i.e., color blindness; damage in IT produces associative agnosia, i.e., the inability to identify shapes; and damage in MT produces akinetopsia, i.e., motion blindness. Moreover, specialized neuronal areas have been identified within the dorsal system, which correlate with spatial attention, spatial representation, and the ability to differentiate the spatial parts within an object as well as between objects." (LaRock 2010)

unicorn world. A neuronal area would play both differentiation and integration at the same time. For the human observer, the functional specificity is played by certain neuronal areas but the integration refers only to the "I" and neurons and the "I" belong or are EDWs. Analyzing the functional neuroimaging, Laureys, Boly and Tononi emphasize that, by now

> the view is that the cortical infrastructure supporting a single function (and a fortiori a complex behavior) may involve many specialized areas that combine resources by functional integration between them. Hence, functional integration is mediated by the interactions between functionally segregated areas, and functional segregation is meaningful only in the context of functional integration and vice versa. (Laureys, Boly and Tononi 2009, p. 38)

In Chapter 7 of this book we will see the role played by the oscillations for the binding problem, as well as some more details about the idea that some researchers consider the gamma band as playing the role of integration in the brain. However, even the route for finding a solution to the specialization-integration problem is still unclear. For instance, using the hierarchically arranged letters shape, Flevaris et al. consider that in general the left hemisphere generates the binding shapes to the local level, while the right hemisphere creates the binding for the global level. "More importantly, binding is modulated by attentional selection of higher or lower spatial frequencies."[1] (Flevaris, Bentin, and Lynn 2010, p. 424) Moreover, from Chapter 2, we have to remember that some authors believe that some neuronal areas are responsible for such integrations: the prefrontal cortex (PFC) is the neuronal mechanism correlated with "cognitive control" (Miller and Wallis 2008) or thalamus is a "relay station" (Baars and Gage 2010).

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[1] "The results from the current study open the door for these explorations by showing that attentional selection of spatial-frequency information plays a key role in binding elements of hierarchical displays to the levels at which they occur." (Flevaris, Bentin, and Lynn 2010, p. 430)

From an EDWs perspective, we can find this idea of integration in the part-counterpart principle[1] (Vacariu 2005), but we have to filter Bechtel's ideas through all the 13 propositions. Bechtel works within the identity theory, i.e. the mind is the brain. According to proposition (1), the mind and the brain (body) are EDWs. The functional specificity of certain cortical areas is in a hyperontological contradiction with the integration of the whole information into coherent cognitive states within the unicorn world. The specific areas of the brain (and their functions) correspond to some mental functions/states that are the entities of the mind-EW (or the "I"). These mental functions/states are knowledge (proposition 9). Nevertheless, we cannot identify exactly the neuronal areas that correspond to these mental functions because it is about two EDWs. The integration is nothing else than the unity of the "I", an indeterminate individuality (proposition 10). Again, it is impossible for us to identify this *integration* within the brain. In reality, this integration does not exist within the brain, but there is only a correspondence between this integration (that is the "I") and particular neural entities/ processes.

With the help of fMRI, it has been noticed that the synchronization of neural oscillations requires communication among the independent oscillators (functional connectivity - fcMRI), this communication indicating an integral function of the network of neuronal areas.[2] Using fMRI, some researchers endeavor to show

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[1] That principle is: the mind corresponds to the part-counterpart, the part being the most activated neuronal patterns, the counterpart is the rest of the brain and the body. (Vacariu 2005)

[2] "Cordes, Haughton, Arfanakis, Wendt, Turski, Moritz, Quigley, & Meyerand (2000) found similar oscillations in resting state BOLD signals in networks of areas previously identified as jointly exhibiting increased activitation in sensorimotor, visual, receptive language, or expressive language tasks. Moreover, their *functional connectivity MRI (fcMRI)* analysis—applying correlational statistics to resting state BOLD time series data to determine patterns of synchronization—yielded functional networks very similar to those identified from activity during tasks. That is, areas within the same network had correlated patterns of activity across time (rising and falling in synchrony) regardless of whether overall level of activity was relatively

that the long-distance neuronal areas coordinate their functions through synchronization. In Vacariu and Vacariu (2010), we used the latest scientific knowledge from cognitive neuroscience to indicate that the synchronization is an alternative not even for the binding problem (see section 7.3 of this book), let alone other more complicated functions. If we could not solve the binding problem, Bechtel's synchronization has less chance to be a solution to the integration. Again, I emphasize that checking for the property of integration is like trying to find the unity of a table at the microscopic "level"!

For Bechtel, the specialized regions of the brain remain integrated with other regions creating a "small-world network" ("local clustering with specialized regions but long-range connections with other parts of brain").[1] On the other hand, fcMRI corresponds to being (an entity with a unity). Closer to proposition (6) (the principle of part-counterpart in Vacariu 2008) is the notion of "default network" that Bechtel borrowed from Raichle (2001): certain areas are more active in *absence* of task and deactivated in task conditions. (Raichle et al. 2001 in Bechtel in press)[2] Related to the default network are the "*mind-wandering*"

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high (e.g., the sensorimotor network while moving a hand) or relatively low (e.g., the same network in a resting state condition)." (Bechtel 2013, p. 19)

[1] "Small-world organization is a form of organization that lies between regular lattices and randomly organized networks—as in lattices most connections are between nearby units but a few connect between distant locations. For information processing purposes, lattice structures have the virtue of creating modules of units that function together to perform a particular task whereas random networks exhibit a short path of communication across the network. Small-world network possess both properties and many real-world networks have been found to exhibit small world organization, including the default mode network and task directed networks (Sporns, 2010)." (Bechtel 2013, forthcoming, p. 21) The notion of "small world network" is quite close to the EDWs. From the viewpoint of neuronal patterns that are activated to fulfill the corresponding mental functions, the number of EDWs becomes quite large. (See Vacariu and Vacariu 2010)

[2] The "*default mode network*—one which performs actual functions best carried out when there are no external task demands" (Bechtel 2013, p. 17) is present even in sleeping states or anesthesia (p. 18). "Adopting the mind-wandering hypothesis, Buckner, Andrews-Hanna, & Schacter (2008, p. 2) link mind-wandering to the ability to carry out 'flexible self-relevant mental explorations—simulations—that

("undirected thinking" – Bechtel 2013) and the "*self-relevant*" mental explorations[1] that are not localized in a single brain region, but in a network of regions. In his article from 2013, Bechtel offers us more details about the default network. I quote Buckner, Andrews-Hanna, and Schacter's (2008, pp. 4-5) conclusion from Bechtel's paper: "The default network is a brain system much like the motor system or the visual system. It contains a set of interacting brain areas that are tightly functionally connected and distinct from other systems within the brain." (in Bechtel 2013, p. 20) I also emphasize Fox, Snyder, Zacks, and Raichle's idea (2006) that the variability of recorded signal with fMRI produced by oscillations may be the endogenous oscillations. (*idem*) Based on some research, Bechtel considers that the endogenous activity of the brain influences both the mental states and the behavior. From my viewpoint, both the mind-wandering and the self-relevant mental exploration reflect, without a doubt, the counterpart that corresponds to the "I". Moreover, localization would be realized by the most activated neuronal areas visible using fMRI, PET, etc.[2] In the paper from 2012, Bechtel insists on combining integration with the parallel localization of certain various functions.[3] I would like to emphasize again that Bechtel lacks precisely in the EDWs perspective: integration is being, localization is only a very approximate process that "correlates" the phenomena that belong to EDWs. According to proposition (13), we should not mix the judgments that describe these phenomena. We can use fMRI and

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provide a means to anticipate and evaluate upcoming events before they happen' (p. 2)." (*idem*) About the "default mode network", see section 11.2 of this book.

[1] The function of mind-wandering is „to facilitate flexible self-relevant mental explorations – simulations – that provide a means to anticipate and evaluate upcoming events before they happen". (Bechtel, in press). (About default network and mind-wandering see also Bechtel 2013, forthcoming).

[2] Bechtel underlines that "functional *specificity* of small world network" takes place through "clustering of units into *local subsystems*".

[3] For Bechtel, the "integration into coherent global states" takes place due to the "role oscillations in thalamic neurons play in producing global states such as attentive awakeness, drowsiness, and sleep, which modulate processing in many local circuits." (Bechtel 2013)

PET to identify very approximate localizations, but it is not correct to identify a mental function with some neural patterns of activation. Again, each mental function is the "I" that corresponds to the intermingled brain and body. We cannot isolate parts of the brain in our attempt to find the above mentioned "correlations" (for the identity it is even worse). "Integration" is the "I" and an EW, at the same time. In the future, with the development of imagistic technology, we will be able to localize more and more neuronal areas for certain mental functions, but we have to be aware that these mental functions are being that has a unity impossible to identify within (parts of) the brain. The "correlation" would be a very approximate notion. Accepting the EDWs perspective, Bechtel would be able to provide an ontological support for his mental mechanisms.[1]

In his latest paper (forthcoming 2013), Bechtel radically changed his perspective regarding localization. Bechtel criticizes the traditional view (the "reactive perspective"): cognition starts with representation for a task ("internal planning") or a stimulus ("executing actions"). (p. 1) Such representations are transformed through certain architectural operations. All pioneers like Hubel and Wiesel, the people who worked on EEG or fMRI (like Petersen, Fox, Posner, Mintun, and Raichle 1988), adopted the reactive strategy. "Researchers adopting the reactive perspective have provided a great deal of information about information processing in the brain, especially in areas of sensory and motor processing and increasingly with respect to memory, attention, and emotional responses." (Bechtle 2013, p. 3) According to Bechtel, there were people being quite skeptics regarding this strategy.[2] Against this reactive strategy, Bechtel offers a new approach: the "endogenously active

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[1] As we showed in Vacariu and Vacariu (2010), Bechtel could not offer an ontological status for his mental mechanisms (quite close to functionalism) just because he works within the unicorn world.

[2] Among them, Lorente de Nó (1938) who considered that "there are at least as many, and likely many more backwards and collateral projects than forward ones" and Graham Brown (1911, 1914). (Bechtel 2013)

mechanisms in the brain”. The starting points of this new strategy are certain ideas, such as the biological organisms are the non-equibrum, and the autonomous systems, Maturana and Varela’s autopoesis, oscillations[1], and other notions. Bechtel relates these notions with his notion of “mechanism”, the mechanisms being understood as the “dynamic mechanistic explanations”. (p. 7) Interestingly, Bechtel remarks that Hodgkin and Huxley considered the “action potential” from a reactive perspective, while one of their disciple found the “specialized *pacemaker* neurons that generated their own rhythmic action potentials” (Alving, 1968). The philosopher emphasizes the work of Llinas. Llinas showed

> a variety of functionally important ion currents in neurons of the inferior olive and cerebellum in mammals and birds. Most were spatially distributed and gated by voltage in a different manner than the sodium and potassium channels in the axon, equipping them for functions other than the direct generation of action potentials. Notably, the dendrites were endowed with channels providing high-threshold conductance to calcium ($Ca^{2+)}$ ions, enabling dynamically complex dendritic excitation in contrast to earlier assumptions of passive transmission of signals from synapses. Moreover, the cell bodies of some neurons in the inferior olive had a different kind of calcium channel with a seemingly paradoxical low-threshold conductance that, in interaction with sodium and high-threshold calcium conductances, enabled these neurons to function as single-cell oscillators “capable of self-sustained rhythmic firing independent of synaptic input” (Llinás, 1988, p. 1659). (Becthel p. 8)

According to Bechtel, Llinas proved that the neurons are oscillators that can work either in isolation or in collaboration. Therefore, Bechtel largely analyzes the role of oscillations as being the endogenous activity in the brain. As a conclusion of his paper, the new challenge for Bechtel is to show the role of endogenous activity of the brain in explaining cognition. I emphasize again that his new position lacks precisely in the EDWs perspective! Cognition

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[1] “Sustained oscillators are the simplest endogenously active mechanisms—as long as they can recruit free energy from their environment they are continually active. Neurons are examples of such sustained oscillators. The endogenously nature of neuronal activity, however, is often not appreciated.” (p. 7)

corresponds not only to the most activated neuronal patterns (the part of the brain) but also to the endogenous activity of the brain (the counterpart of the brain). We have to add, obviously, the body of the subject (Sporns 2006) and, in this way, we reach the conclusion that the mind (the “I”) corresponds to the brain and the body.

3.2 The work of Gallant’s laboratory

One of the most optimistic achievements in cognitive neuroscience is represented by the results of some people working in Gallant’s laboratory. Before analyzing the greatest achievement of this laboratory (Nishimotto et al. 2011), I would like to introduce some details about their work from Uttal (2011) who analyses Gallant lab’s previous work (2008 and 2009). Their work showed that it is possible to decode 120 pictures from the results of fMRI in V1, V2 and V3. The first step is examining the fMRI signals to a larger (1,750) library of natural images and measured the fMRI responses produced each by a certain number of voxels. This established a training set. A representation of each picture was then formed based on the Fourier properties of the image in which the spatial frequency and the orientation information were summarized as a “predicted activity pattern” for each of the many voxels that were associated with the presented picture. This provided a quantitative representation of the fMRI responses to each of the images. (Uttal 2011, p. 112) Based on similarities, the voxel pattern of each image (from those 120) was compared with the information from the library, the best fitting image being selected. In thirteen repeated trials for a given picture, Kay and his colleagues (2008) report a correct identification score in the mid-90%, the random performance being 0.8%. When only the fMRI signals from a single presentation were used, the identification performance was reduced to much lower values (51% and 32% for two subjects).

This was an impressive step forward, but it still depended on a training set of stimuli and recognizing pictures on the basis of an fMRI pattern analysis. Furthermore Kay et al.’s (2008) constructions based their identification scores solely on the visual areas of the brain, in which some resemblance of retinotopic mapping was presumably retained. Thus, they wrote that the “problem is analogous to the classic ‘pick a card, any card’ magic trick”. (p. 352) (Uttal 2011, p. 113) Moreover, the images “were made in the Fourier domain of a set of stimuli, and these matched stimuli that shared at least some properties of the training set. The task in psychological parlance is one of recognition or identification.” (*idem*) Another method is the “reverse retinopy”, pioneers of this method of reconstruction of an image from its components being Thiron et al (2006) and Miyawaki et al. (2008). (Uttal 2011, p. 114) The shape of simple geometrical forms is preserved enough in the early retinotopic regions of the visual system to support the inference that “these simple contrast patterns such as squares, × s, +s, and letters of the alphabet can be inferred from the pattern of spatially and topologically constant voxels. (Uttal 2011, p. 113) This method “depends solely on the preservation of the topology of the original stimulus pattern and the spatial resolvability of the spatial pattern” and “examine the spatial pattern of the activated voxels, and infer the shape of the stimulus.” Moreover, the “spatial information is retinotopically persevered in the early portion of the visual system.” (Uttal 2011, p. 113)

Nevertheless, the work of people from Gallant’s laboratory was much better in reconstructing images using not the “reverse retinopy” method but some “complex natural scenes from nonisomorphic fMRI images”. Naselaris et al. mention that under “the Bayesian framework used here, a reconstruction is defined as the image that has the highest posterior probability of having evoked the measured response.” (p. 902 in Uttal, p. 114) Uttal mentions that this method seems to be “a process of recognition, selection, or identification of an image from a known library of alternatives rather than a reconstruction in either the psychological or the neuroscientific sense.” (Uttal 2011, p. 114) Worth mentioning is another observation made by Uttal: the reconstructed images “are not pictures that were directly reconstructed from the fMRI data but pictures produced by combining parts of pictures that were selected from the library of images, that is, the Bayesian priors on which the system was originally trained.” (Uttal 2011, p. 114) Even if Uttal admires Gallant lab’s work, he concludes that mostly they were able to show distinctive fMRI responses from a number of visual cortical areas (V1, V2, V3, V3A, V3B, V4, as well as the lateral and anterior occipital cortex) that could be used to identify images from the training set. They did not take fMRI images and directly plot from them pictures of the original stimuli; once again, they selected pictures from their library, based on the pattern of activations. This is not reconstruction per se; it is selecting from a predetermined “deck of cards”.[1] (Uttal 2011, p. 114) Uttal mentions that these pictures do not grasp the meanings that in general an image has within the human subjectivity. Firstly, not every image has a meaning. Secondly, I believe in the future (decades or in the next century), researchers will be able to re-construct images and parts of their meaning. Nevertheless, in order to grasp the corresponding meaning of an image, it will be necessary to investigate the entire brain (and body). However, it will be quite impossible to grasp the entire “I” that corresponds to the whole brain and body.[2] (See again the perception-thinking contradiction, Vacariu 2011 and Chapter 1 of this book)

I continue by analyzing another work of the researchers from Gallant’s laboratory. Nishimoto et al. published an article in 2011 about a new method for the “mind reading” (this work being considered among the best achievements of cognitive neuroscientists in the last 15 years). With a computer program, a quantitative model of brain activity based on fMRI results is constructed. Using the brain activity measurements, Nishimoto et al. (2011) reconstruct natural movies seen by three human subjects. It is the first study of

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[1] “However, this is not a matter of reconstructing the mental contents but, rather, of using these residual signals as a means of choosing among a set of stimuli in much the same way that a magician can determine which card was selected from a deck.” (Uttal 2011, p. 139)

[2] We do not have to forget that all conscious and unconscious states are the “I”. It will be much easier for the cognitive neuroscientists to understand and explain consciousness than the “I”!

reconstructing dynamic stimuli (natural movies) through the brain activity using fMRI. In the past, such stimuli were reconstructed only from static pictures[1], the main problem being that the blood-oxygen-level-dependent (BOLD) signals measured by the fMRI are much slower than the neuronal activity in relationship with certain dynamic stimuli. This new "motion-energy encoding" model furnishes a mapping between the stimuli and the evoked fMRI signals. That is, it has to fit two components, the visual motion information and the slow hemodynamics mechanisms, (Nishimoto et al. 2011, p. 1641) in order to "recover fine temporal information" from slow BOLD signals. (p. 1644)

> The first stage consists of a large collection of motion-energy filters that span a range of positions, motion directions and speeds as the underlying neurons. This stage models the fast responses in the early visual system. The output from the first stage of the model is fed into a second stage that describes how neural activity affects hemodynamic activity in turn. The two stage processing allows us to model the relationship between the fine temporal information in the movies and the slow brain activity signals measured using fMRI. (https://sites.google.com/site/gallantlabucb/publications/nishimoto-et-al-2011)

The researchers of *Gallantlab* focus on the signals received by the early visual neural areas V1 (the functionality of this neural area being quite well studied), V2 and V3 (all areas being in occipito-temporal cortex lobes).[2] They indicated how the spatial and temporal

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[1] Thirion et al (2006) first reconstructed static pictures in the brain from BOLD signals in early visual areas; Kamitani, Y., and Tong, F. (2005) reconstructed orientation and direction. (in Nishimoto et al. 2011)

[2] "The human visual system consists of several dozen distinct cortical visual areas and sub-cortical nuclei, arranged in a network that is both hierarchical and parallel. Visual information comes into the eye and is there transduced into nerve impulses. These are sent on to the lateral geniculate nucleus and then to primary visual cortex (area V1). Area V1 is the largest single processing module in the human brain. Its function is to represent visual information in a very general form by decomposing visual stimuli into spatially localized elements. Signals leaving V1 are distributed to other visual areas, such as V2 and V3. Although the function of these higher visual areas is not fully understood, it is believed that they extract relatively more complicated information about a scene. For example, area V2 is thought to represent

information is represented in several thousands of voxels of this visual cortex. The brain of each subject who watched several hours of movies is scanned with an fMRI. The measured training data of brain activity (BOLD signals evoked by 7,200 s color natural movies, each movie presented once) are used to fit an encoding model for each voxel from the posterior and the ventral occipitotemporal visual cortex. Then they use a Bayesian decoder to reconstruct the movies from the evoked BOLD signals, i.e., combining the "estimated encoding models with a prior sampled natural movie, in order to produce reconstructions of natural movies from BOLD signals." (Nishimoto et al. 2011, p. 1642) Comparing the fMRI data and the details of each movie, the computer program constructs some "dictionaries" for shape, edge and motion. Each voxel has such a dictionary.[1] The subject watches the second set of movies and new fMRI data are collected. Using the computational models constructed on the first set of movies, the second set of movies is reconstructed only from the second fMRI data.[2] (Gallantlab.org)

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moderately complex features such as angles and curvature, while high-level areas are thought to represent very complex patterns such as faces. The encoding model used in our experiment was designed to describe the function of early visual areas such as V1 and V2, but was not meant to describe higher visual areas." (https://sites.google.com/site/gallantlabucb/publications/nishimoto-et-al-2011)

[1] "Functional MRI records brain activity from small volumes of brain tissue called voxels (here each voxel was 2.0 x 2.0 x 2.5 mm). Each voxel represents the pooled activity of hundreds of thousands of neurons. Therefore, we do not model each voxel as a single motion-energy filter, but rather as a bank of thousands of such filters. In practice fitting the encoding model to each voxel is a straightforward regression problem. First, each movie is processed by a bank of nonlinear motion-energy filters. Next, a set of weights is found that optimally map the filtered movie (now represented as a vector of about 6,000 filter outputs) into measured brain activity." (https://sites.google.com/site/gallantlabucb/publications/nishimoto-et-al-2011)

[2] "We estimated the posterior probability by combining a likelihood function (given by the estimated motion-energy model; (…) and a sampled natural movie prior." (p. 1642) "Build a random library of ~18,000,000 seconds of video downloaded at random from YouTube (that have no overlap with the movies subjects saw in the magnet). Put each of these clips through the dictionaries to generate predictions of brain activity. Select the 100 clips whose predicted activity is most similar to the

As you move through the world or you watch a movie, a dynamic, ever-changing pattern of activity is evoked in the brain. The goal of movie reconstruction is to use the evoked activity to recreate the movie you observed. To do this, we create encoding models that describe how movies are transformed into brain activity, and then we use those models to decode brain activity and reconstruct the stimulus. (https://sites.google.com/site/gallantlabucb/publications/nishimoto-et-al-2011)

Interestingly for the EDWs perspective, the authors acknowledge some limits of this experiment:

(1) The relationship between motion and direction

The motion-energy model three encoding models: a static model (no information about motion), a non-directional model (motion-energy but not direction) and a directional model (motion-energy and direction). (p. 1641) The second model was only slightly better than the first model. This slight difference reflects the limitations of fMRI spatial resolution.[1]

(2) The same relationship holds between color and luminance. The results grasped by a model with luminance are quite close to the results of a model with color. More importantly, “our reconstructions tended to recover color borders (e.g., borders between hair versus face or face versus body), even though the encoding model makes no use of color information.” (Nishimoto et al. 2011, p. 1645)

Acknowledging the limits of their method, Gallant’s observation, according to which decoding strongly depends on the way we think that the brain represents the information, is important. This information determines the construction of the computational model which interprets the fMRI data. Actually, the early visual

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observed brain activity. Average those clips together. This is the reconstruction.” (https://sites.google.com/site/gallantlabucb/publications/nishimoto-et-al-2011)

[1] “Indeed, a recent study reported that hemodynamic signals were sufficient to visualize a columnar organization of motion direction in macaque area V2 (…). Future fMRI experiments at higher spatial or temporal resolution (…) might therefore be able to recover clearer directional signals in human visual cortex.” (Nishimoto et al. 2011, p. 1645)

neural areas are quite well understood by neuroscientists, but the authors consider that the neuroscientists are not able to understand completely the functions of later visual neural areas and the relationship between occipital-temporal areas with the frontal lobe that provides, for instance, the meaning of each image. From an EDWs perspective, these limits show exactly that color, luminance, motion and direction (among many more other features) are *methodological* differentiations (segmentations) created, artificially, by the human researcher. In reality, these differentiations cannot be localized in the brain. Moreover, the mind is the “I” that has a unity and therefore the decomposition of a mental representation cannot be realized. Such decomposition is a human mind creation that does not exist in reality. Each mental representation of an object in a visual scene is that mental visual scene (but does not “compose” that mental visual scene) in a spatio-temporal framework. In the brain, any feature (for instance, color) activates a particular neural area (for instance, V4 for color), but we cannot visualize a color in itself (in a perception, the color to be allocated to a particular object). Again, I think that from the “I” viewpoint, the neurological distinctions V1, V2, IT, or those between color and motion or several objects in a scene are, in Kantian sense, some *methodological differentiations*. In reality, from the “I” viewpoint, these distinctions are meaningless. Even the correspondence between a vertical line and V1, color and V4 or motion and MT is meaningless.

In our days, it seems that the researchers working in cognitive neuroscience accept that any mental state is correlated with widely distributed neuronal areas in the brain. If we take into account the development of each individual and the strong dependence of interactions between brain, body and environment, then the binding problem is a pseudo-problem. Using the “‘pick a card, any card’ magic trick”, the researchers working in Gallantlab do not even try to offer an alternative to the binding problem. If we accept the identity theory (or any alternative except the EDWs), the binding problem is not a pseudo-problem. It requires a solution: for instance, any mental picture of an object has an irrefutable unity, while the correlated neuronal areas are largely distributed in the brain. How then could we explain the binding features of a perceptual object if those features are correlated with the widely distributed neuronal patterns in the brain? If those patterns are widely distributed in the brain, where does the binding process take place? Do we have a kind of projection of the activity of the neurons (that correspond to the traits of an object) in other parts of the brain (Damasio's convergence zone, for instance)? I do not think that such "projections" represent a viable alternative: it would involve the homunculus rejected by the theory of species evolution. Therefore, the notion of "projection" is meaningless. From my viewpoint, the binding problem is a pseudo-problem since any mental feature of an object is the "I" (any particular neural area is the brain). The mind and the brain belong to EDWs. Moreover, the "I" has no spatial or color dimensions. As we will see in Chapter 8 and 9 of this book, the "I" has the *representations* of color and space, something that is completely different than the real color and the real dimensions of space.

Another criticisms against the achievement of Gallant's team is that they do not take into account the oscillations (among many other neural processes) that have an important role for the corresponding mental processes like perception, in particular, and cognition, in general (again, see section 7.3 of this book). A final comment on this article: the authors mention that the reconstructions might be "improved if the number of samples in the prior were much larger" than they used. (p. 1645)

> We found that the quality of reconstruction could be improved by simply averaging around the maximum of the posterior movies. This suggests that reconstructions might be further improved if the number of samples in the prior is much larger than the one used here. Likelihood estimation (and thus reconstruction) would also improve if additional knowledge about the neural representation of movies was used to construct better encoding models (…). (Nishimoto et al. 2011, p. 1645)

Nevertheless, the neural patterns changed continuously during training (that is the development and the entire life until the moment of scanning the brain). Thus, these and other reconstructions are just rough approximate correspondences between mental visual states and neural patterns. The work of Nishimoto et al. is based on statistical similarities between training data and data of the new movie, i. e. the connectivity is consistent regarding the functional responses. For an ideal result, one should record the brain activation throughout the entire development until the day of prediction. Moreover, I am convinced that the dictionary cannot be extended from one human subject to another.

3.3 Other optimistic works

Quite close to Gallant's laboratory work is Sorger's et al. work regarding the "brain reading" research. Using fMRI, the authors identify neuronal activated patterns for each letter of the English alphabet. (Sorger et al. 2012) Using an automated decoding procedure that works in real time, Sorger and collaborators associate each alphabetical letter (and the blank space between them) with distinct neuronal patterns of activation grasped by the single-trial fMRI signals. As the authors emphasize, their research is the "first spelling device based on fMRI". (Sorger et al. 2012, p. 1) "To our knowledge, no previous fMRI study has been published in which brain states were correctly decoded out of 27 alternatives, let alone on a single-trial level, without time-consuming training and in real time." (Sorger et al. 2012, p. 3) Moreover, in order to obtain these results, one did not need a long preceding training phase[1]. Interestingly,

> only intentionally generated brain activation—originating from active mental task performance alone—was employed for letter decoding. The visual input was identical across trials and was only used to provide the letter encoding information. Note that the encoding technique does not necessarily rely on visual input: the same mental operations can be guided by auditory input. (Sorger et al. 2012, pp. 3-4)

Sorger et al. extrapolate their results from seeing or listening a letter to consciousness.

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[1] More exactly, the "voluntarily evoking differential hemodynamic brain activation by using our encoding technique requires almost zero pretraining." (Sorger et al. 2012, p. 3)

> Another possibility offered by our spelling device is that it can serve as a crucial diagnostic tool to assess preserved consciousness in nonresponsive patients—an assessment that is difficult to establish by other means. So far, inferring consciousness from fMRI data has been done offline (…). With our real-time methods, inferring consciousness would become possible online, which would constitute a significant advantage. Importantly, if a patient conveyed a single meaningful message, any potential remaining doubt on a patient's state of consciousness (…) could be definitely excluded. (Sorger et al. 2012, p. 3)

Within the EDWs perspective, the performance of such correlations does not matter. Only if we accept the identity theory, do we have to be content with these results.

Following the same line of research, using the diffusion-weighted imaging (DWI), "an MRI technique that measures the propensity of water to travel along myelinated axons", Saygin et al. (2011) show that only the activation of an individual's pattern of structural connectivity (fusiform face area – FFA) predicts the function of face selectivity. In other words, the structure of the brain (the extrinsic connectivity) determines the function. "Voxels with higher responses to faces had characteristic patterns of connectivity to other brain regions that distinguished them from neighboring voxels with lower responses to faces, or higher responses to scenes." (Saygin et al. 2011, p. 5) Therefore, there is a strong relationship between structural connectivity and function. Interesting for my EDWs is one of the consequences of this experiment, the authors considering that

> spatial information alone is insufficient for predicting functional activity and that connectivity offers information above and beyond the topographic information inherently embedded in it (owing to the posited small-world organization of cortical connectivity). The relationship between function and spatial information was highly variable across participants, whereas the connectivity data were consistent across participants in relationship to the functional responses. (Saygin et al. 2011, p. 5)

It seems that we cannot use the spatial information (that is different from "connectivity") to localize the mental functions. Nevertheless, connectivity is a very complicated notion in neuroscience. The analysis of Saygin et al. (2011) reveals that

> the target brain regions for which connectivity with the fusiform was most predictive of face- or scene-selective activity in the fusiform. Face-selective fusiform voxels were predicted by connectivity with regions that have been previously reported to function in face processing, such as the inferior and superior temporal cortices (…). Scene-selective voxels, by contrast, were best predicted by their connectivity to key brain areas involved in scene recognition, such as the isthmuscingulate (containing the retrosplenial cortex) and the parahippocampal cortex. (Saygin et al. 2011, p. 5)

Again, from my viewpoint, the differentiation between neural areas necessary for face- and scene-selectivity (or between mental processes like face-recognition and scene-selectivity) are certain methodological differentiations but not ontological ones. Taking into account the neural connectivity between any neural area (responsible for a particular mental state) and the surrounded neural areas (and other large-distance areas), these differentiations are not real. Therefore, we can differentiate between such neural areas only with very rough approximations. Moreover, any mental state is the "I", so again the differentiation between the self and one of its states is useless. Within this new framework, the EDWs perspective, we can easily understand the "unexpected" results from the experiment of Saygin et al. (2011). They discovered some unexpected predictors of the face selectivity, i.e. the cerebella cortices and therefore new studies need to expand the components of structural connectivity for particular functions. (Saygin et al. 2011, p. 6) Their final suggestion is that the voxel-to-voxel tractography can offer new information about the relationship between structure and function. If we want to insert information offered by the voxel-to-voxel tractography, we need also to take into account the EEG results (and the data that new apparatuses will give us in the future). In reality, even for the face recognition, we will introduce more and more parts of the brain until we understand that we have to include the whole brain. Obviously, some parts of the brain are more involved when it comes to face recognition, but anyway we need to introduce the activity of the entire brain for any mental process. If, from the dynamical system approach, we were forced to introduce the environment, then we had to accept, from an EDWs perspective, that the "I" corresponds to the brain, body and their interactions with environment.[1]

The work of van Wedeen (2012) perfectly reflects the highly dynamic transformations in cognitive neuroscience. Using the diffusion magnetic resonance imaging, van Wedeen shows that the brain has a geometric structure of the "cerebral fiber pathways". (van Wedeen 2012) Wedeen uses an "interactive software to compute for any path the set of all paths with which it shares one or more voxels, termed its path neighborhood". (van Wedeen 2012, p. 1629) He offers some particular cases of the brain areas as examples (for instance, rhesus monkey superior longitudinal fasciculus-3 (SLF3))[2] that "entirely consists of a single curved two-dimensional (2D) sheet of paths, all mutually parallel, transversely oriented, and all crossing SLF3 at nearly right angles" (p. 1630). This grid structure of the cerebral zone is continuous with those of the limbic system and the basal ganglia (p. 1633). In general, this grid structure can be found at all scales, from "single voxel, to the lobe, to the hemisphere" and in all species! (p. 1633) Thus, the "cerebral path crossings formed well-defined 2D sheets" and all brain pathways have sheet structure. (van Wedeen 2012, p. 1632) The "complex brain" is nothing more than the simple evolution of "simple brain" following this grid structure

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[1] The dynamical system approach is strong related to the "*embodied–embedded cognitive science*" (Wheeler 2005, p. 11 or 2009, p. 320). About this perspective, see Vacariu (2008); about Wheeler's approach, see Vacariu and Vacariu (2010).

[2] Other examples: the occipital lobe (the sagittal stratum) or frontal lobe of the rhesus monkey (left arcuate sulcus, midline callosal region, and right central sulcus) (the "path neighborhood comprises two sets—transverse callosal paths and longitudinal paths of the cingulum and SLF1—that crossed like the warp and weft of a fabric as a near-orthogonal grid. Thus, these paths formed a single biaxial system. This pattern was typical of cerebral white matter." (p. 1630) "Continuity of grid structure between superficial gyral and deep cerebral pathways was demonstrated through analysis of neighborhoods at sequential depths (SOM text and fig. S4). Grid structure in all three orthogonal axes was observed in the centrum semiovale, including the longitudinal and transverse paths and dorso-ventral projection paths." (van Wedeen 2012, p. 1633)

coherent and continuous with the three axes of development.[1] Therefore, the grid structure restricts and simplifies the axonal pathfinding!

> In the brain, fibers growing in any axis would have a choice at each moment of just the four orthogonal directions perpendicular to their course. Grid structure would increase the efficacy of path orientation as a mechanism of axonal pathfinding (…). Simultaneously, this structure supports incremental modification of connectivity by geometric modification within broad continuous families of parallel paths. Thus, the grid organization of cerebral pathways may represent a "default connectivity," on which adaptation of structure and function can both occur incrementally in evolution and development, plasticity, and function. (van Wedeen 2012, p. 1633)

The grid structure has a major impact for the brain mapping because it simplifies the topological structure of the entire brain, its pathways and connectivity, and what we think about white matter. (*idem*) So, in this very recent article, using the diffusion spectrum MRI (DSI), van Wedeen et al. (2012) offers a *completely new image regarding the anatomical structure of the brain*. The unexpected result is that the brain is wired in a rectangular 3D grid structure! The DSI acquires a detailed image of the three-dimensional pattern of water diffusion by measuring the diffusion in dozens to hundreds of directions. "Far from being just a tangle of wires, the brain's white-matter connections turn out to be more like ribbon cables — folding 2D sheets of parallel neuronal fibers that cross paths at right angles, like the warp and weft of a fabric". Essentially, this grid structure "is continuous and consistent at all scales and across humans and other primate species." (van Wedeen 2012) So, the brain is not a mechanism as complex as we have thought until now! On the contrary, as a result of evolution, the brain seems to be a rather simple machine. I think that within this new framework created by van Wedeen, the mind-body problem still remains unsolved. I

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[1] Following the rules of evolution, there are certain "evolutionary emergence of discrete pathways parallels the increasing cerebral complexity in the primate lineage. Functionally, pervasive cerebral organization with parallel paths and similar lengths would naturally support neural coding via spatial and temporal coherence (…)". (van Wedeen 2012, p. 1633)

understand the brain is much simpler than we thought, but we do not get a simpler answer to the mind-brain problem.[1] The brain has a much simpler structure than we thought just because "nature" does not think. As I emphasize several times in this book, when we try to understand the functions of the brain, we have to be aware of this simplicity. Obviously, within the unicorn world, the brain becomes a much more complicated entity!

In this context, it is important for me to analyze Fletcher's remarks on the brain's adaptability (Baars and Gage 2010, pp. 81-82). Learning – such an important event for the survival of animals – means the adaptability of the brain to change in a particular dynamic environment. Until now, the people working with fMRI have focused on the "functional segregation" but the learning processes need a "functional integration". Adaptability needs to be analyzed from two viewpoints: functional and structural. The striking thing is that the adaptability is given not only by the changes in the neural "localized regional activity" (functional), but also by the changes in its structural connectivity (gray matter density and white matter tracts). As an argument, Fletcher introduces an experiment regarding the contingency relationships between auditory and visual stimuli (den Ouden et al. 2009):

> Intriguingly, though experimental participants in this study were largely unaware of these contingency relationships, there was a measurable increase in the degree of connectivity between primary auditory and visual areas as a consequence of experiencing them, even though they had no bearing on the task that was being performed. (in Baars and Gage 2010, pp. 81-81)[2]

The conclusion of this chapter is that optimism in cognitive neuroscience has no real (hyper)ontological support. The results of many experiments seem to be a game with predetermined "deck of cards".

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[1] In Vacariu and Vacariu (2010), we introduced the similarity (or even identity) between two entities/processes: mind and life. Thus, life is an EDW than the organism of an animal or a cell!

[2] We have here the crossmodal interaction that we discuss in chapter 10 of this book.

Chapter 4

Skepticism in cognitive neuroscience

4.1 Hardcastle's skepticism

For Hardcastle, cognitive neuroscience is an area with eight different research areas in neuroscience: "development, perception, action, attention, memory, higher cognitive functions (including language), affect, and plasticity". (Hardcastle 2007, p. 295) Hardcastle raises essential questions regarding cognitive neuroscience today. Even if it seems a real progress in cognitive neuroscience in the last 20 years, Hardcastle emphasizes the main problems of this quite new science. It is not surprising that the researchers become more and more interested in developmental neurobiology (an area that becomes more and more molecular[1]) or in the interactions between genes and environment in their attempt to explain the mysterious cognition. Even at the beginning of her article, Hardcastle writes that the "perceptual systems represent the external environment to us. Through complex computations we do not yet understand our sensory systems derive stable images from the ever-fluctuating raw signals of our transducers." (p. 296) Within the unicorn-world, it is not amazing that Hardcastle uses notions like "transducers" in order to refer to the relations between stable images of sensory systems and the fluctuating signals. In fact, there is the mind-EW where we can find the stable mental representations while the processes that belong to the brain-EW are constantly changing. Obviously, we cannot "yet understand" the relationship between mind and brain within the unicorn-world. Hardcastle asks the same questions posed by many people working in cognitive neuroscience:

> How and where are our sensory signals encoded and stored? How do we separate "figure" from "ground"? How are incoming signals "mixed" with our memories,

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[1] In this direction, see Bickle's approach in Vacariu and Vacariu (2010).

> attention, and our understanding of the world so that we get full-blown representational experiences? How do we combine information from different sensory modalities? How do other brain systems transform and use this information? How do they modulate the representations to meet our behavioral goals and biological needs? How do we use representations to regulate action, planning, and other outputs? (Hardcastle 2007, p. 297)

From the EDWs viewpoint, these pseudo-questions have no answers. The first four questions regard the "I" (its unity) or the mind-EW (the mental representations/processes and their interactions), the next question mixes EDWs (brain and mental information), and the last questions refer to the behavior. I will analyze papers on these topics without definite answers published in the last 3-4 years. The great problem is that the researchers are convinced of their results.[1]

Harcastle inquires about attention, one of the most problematic concepts in cognitive neuroscience.[2] From my viewpoint, attention (and also memory and all other features of the mind) does not exist as a separate feature within the mind-EW. Moreover, no particular neuronal mechanism for attention exists and therefore it is meaningless to check for such mechanism in the brain. Moreover, very problematic are also the relationships between attention and memory[3] or between memory and perception (or action and emotions). Hardcastle is aware that an individual neuron does not reflect memory, even if Kandel et al. (2001) try to show us that changes in synapses are related to memory. It is sure that changes in synapses are strongly "correlated" to memory, but we cannot

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[1] The history of science shows us that such positions are normal: it is quite difficult to change the framework of thinking, even if we have the Internet. The advantage of having the Internet (the rapidity of changing the information) is balanced by the avalanche of this information that congests people working in any science.

[2] "What areas of the brain are involved in coordinating attention across our neural circuitry (the "source" of attention), and how these areas accomplish these tasks (at the "site" of attention) are still matters of investigation." (Hardcastle 2007, p. 297)

[3] "Memory researchers divide memory into (roughly) the following categories: procedural and semantic or cognitive, explicit and implicit, recall and recollection. Each of these divisions might mark a completely separate brain system (or they all might be completely wrong)." (p. 298).

"reduce"[1] memory to such changes! Since the memory is a psychological feature of the "I", or better, the memory is the "I", we can check only for rough correspondences. In this context, obviously, the main question remains "how the brain coordinates itself across neurons to produce global effects." (p. 298) Maybe we have some neuronal global effects like oscillations, but it is not the brain, which "coordinates/produces the mental global effects". The "I" could not perceive such global effects, since these "effects" are the "I". We need indeed to change the unicorn-world framework of thinking with the EDWs framework. We have to be aware that we can find only rough correspondences, but nothing more!

Interestingly, Hardcastle underlines the idea that the lower level processes "support and organize" the higher level abilities. (*idem*) This idea reflects directly the correspondence relationship between the mind-EW and the brain-EW. In fact, we can make only rough, very approximate dissociations between the higher and the lower neuronal levels. Spatially and temporally, it is quite impossible to identify such levels. It is completely wrong to consider high neuronal level the same with cognition! Hardcastle also inquires about the plasticity of the brain: we can find that

> plasticity at multiple levels of organization, from long-term potentiation in molecules on up to (and challenging) question facing cognitive neuroscientists today. (Hardcastle 2007, p. 299)

Moreover, throughout the entire book we investigate the relationship between integration and differentiation (segmentation), the hottest topics in cognitive neuroscience. In reality, these notions are rough methodological exaggerations of people working in cognitive neuroscience. Regarding the methodology in this domain, the author asks

> neuroscientists to worry about what counts as appropriate empirical justification for a theoretical claim, how to determine which level of organization is the correct one for a scientific explanation, what explanations should look like, whether all

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[1] From the EDWs perspective, the notion of "reduction" is meaningless. It has to be replaced with "correspondence".

> explanations will or should reduce to some primitives, and how what we learn about the mind/brain should affect the larger social, economic, and political arenas (…). (Hardcastle 2007, p. 299)

Again, the answers to such questions are indeed only Ptolemaic epicycles within the unicorn-world. The question “Which level of organization fits to a particular scientific explanation?” has to be replaced with a much more complicated question: “What EW embraces certain neuronal patterns of activation?”

Hardcastle also emphasizes one of the main topics in cognitive neuroscience: localization/reduction. For instance, until now, it has been known that the visual area involves more than 30 cortical areas, but I believe that new tools of investigating the brain will indicate more and more neuronal areas that correspond to the process of “vision” or better perception (a mental process, anyway). The neuroscientists can record no more than 150 neurons simultaneously; they can sum LFP from no more than several thousands.

> But brain areas have hundreds of thousands of neurons, several orders of magnitude more than they can access at any given time. And these neurons are of different types, with different response properties and different interconnections with other cells, including other similar neurons, neurons with significantly different response properties, and cells of other types completely. (Hardcastle 2007, p. 304)

Hardcastle enumerates some problems regarding important methods used in cognitive neuroscience: recording the activity of one cell inserting an electrode (the problem is that it is quite impossible to record the activity of a single neuron in isolation); lesions (the plasticity of the brain overpasses its lesions); the feedback projections in the brain; the abilities of the brain imaging mechanisms like fMRI (this instrument has quite good spatio-temporal limits - 0.1 millimeter and half second for each sample); and the subtraction method[1] of functional imaging (we cannot be

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[1] “Experimenters pick two experimental conditions that they believe differ along with respect to the cognitive or perceptual process under investigation. They then compare brain activity recorded under one condition with what happens in the

sure if the difference between those states is related to cognitive processes and not just a simple coincidence).

> Neuroscience is a victim of imprecise instrumentation. If scientists extrapolate from what they might learn with more sensitive measures, it can easily be seen that there will come a time when this whole approach just will not work anymore. Put in the harshest terms, brain imaging seems to support reductionism because the imaging technology is not very good yet. (Hardcastle 2007, p. 306)

Uttal also criticizes the subtraction issue. (Uttal 2011, section 1.5.2)

> Most important of all is the fact that the resulting brain images are themselves the cumulative activity of uncountable numbers of neuronal responses. Thus, the observation that an area may null out and leave no trace in the difference image does not mean that its detailed activity was the same in both the experimental and control conditions. The nature of the underlying neuronal network state may change considerably and still produce zero difference scores. (Uttal 2011, p. 26)

D'Esposito has doubts regarding this method: cognitive subtraction could produce errors in interpreting the functional neuroimaging results.

> Cognitive subtraction relies on two assumptions: "pure insertion" and linearity. Pure insertion implies that a cognitive process can be added to a preexisting set of cognitive processes without affecting them. This assumption is difficult to prove

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second condition, looking for regions whose activity levels differ significantly across the two. These areas, they believe, comprise the neural substrates of the task under scrutiny." (Hardcastle 2007, p. 305-306) Or "The prototypical fMRI experimental design consists of two behavioral tasks presented in blocks of trials alternating over the course of a scanning session, during which the fMRI signal between the two tasks is compared. This is known as a blocked design. For example, a given block might present a series of faces to be viewed passively, which evokes a particular cognitive process, such as face perception. The 'experimental' block alternates with a 'control' block, which is designed to evoke all of the cognitive processes present in the experimental block except for the cognitive process of interest. In this experiment, the control block may be a series of objects. In this way, the stimuli used in experimental and control tasks have similar visual attributes, but differ in the attribute of interest — faces. The inferential framework of 'cognitive subtraction' (Posner, Petersen, Fox, & Raichle, 1988) tributes differences in neural activity between the two tasks to the specific cognitive process, that is, face perception." (D'Esposito 2010, p. 213)

> because one needs an independent measure of the preexisting processes in the absence and presence of the new process. If pure insertion fails as an assumption, a difference in the neuroimaging signal between the two tasks might be observed, not because a specific cognitive process was engaged in one task and not the other but because the added cognitive process and the preexisting cognitive processes interact.[1] (D'Esposito 2010, p. 214)

Again, I am convinced that, even if in the future our tools of investigating will become more and more powerful, the (hyper)ontological relationships between the brain and the mind (EDWs) would still impose us certain limits of research. Therefore, the reductionism view is not even a wrong notion, but a meaningless method! The problem is that not only certain entities/processes belong to the EDWs, but also each neuronal area seems to be involved in many cognitive processes:

> … Brodman area 6 appears significantly and differentially active after subtraction in studies of phonetic speech processing, voluntary hand and arm movements, sight-reading music, spatial working memory, recognizing facial emotions, binocular disparity, sequence learning, idiopathic dystonia, pain, itch, delayed response

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[1] "An example of this point is illustrated in working memory studies using delayed-response tasks. These tasks (for an example, see Jonides et al., 1993) typically present information that the subject must remember (engaging an encoding process, followed by a delay period during which the subject must hold the information in memory over a short period of time (engaging a memory process), followed by a probe that requires the subject to make a decision based on the stored information (engaging a retrieval process). The brain regions engaged by evoking the memory process theoretically are revealed by subtracting the blood oxygenation-level dependent (BOLD) signal measured by fMRI during a block of trials that the subject performs that do not have a delay period (engaging only the encoding and retrieval processes) from a block of trials with a delay period (engaging the encoding, memory, and retrieval processes). In this example, if the addition or "insertion" of a delay period between the encoding and retrieval processes affects these other behavioral processes in the task, the result is failure to meet the assumptions of cognitive subtraction. That is, these "nonmemory" processes may differ in delay trials and no-delay trials, resulting in a failure to cancel each other out in the two types of trials that are being compared. In fact, this has been shown to occur in a fMRI study using a delayed response task (Zarahn, Aguirre, & D 'Esposito, 1997)." (D'Esposito 2010, p. 214) D'Esposito indicates another problem with fMRI imaging: "forward inference" versus "reverse inference".

> alternation, and category-specific knowledge, to list only a subset of activities. (Hardcastle 2007, p. 306)

Moreover, each area depends on the "neural context": its connections with other areas and how these other areas respond to stimulus.[1] Another problem is that the activity of a neuron is not limited to its action potential. There are many other processes within a neuron (the activity of dendrites and axons, the chemical reactions, the waves) essential for explaining cognition. Therefore, we cannot "reduce" mental states to action potential activities or spiking neurons[2]. In Hardcastle's s words:

> Spike shapes can change over time, electrodes can drift during recording session, changing position relative to the cells, which would also alter the spike amplitudes, and the electrical properties of electrodes vary with changes in tip condition or background impedance. Gathering data from single unit activity presents neuroscientists with a serious technical challenge. (Hardcastle 2007, p. 308)

Hardcastle is aware about the gap from the "raw recordings to genuine data" that clearly reflects the mind-body problem in our days. It is worth inserting the entire last paragraph of Hardcastle's article:

> Cognitive neuroscience is an intricate combination of several different research areas, each with their own regions of concern, bent on understanding the processes of an intricate organic machine. But they all work together —or at least in parallel — toward that common goal. Bound by common methodologies and common methodological difficulties, the subdisciplines that comprise cognitive neuroscience are making tremendous headway. It is my sincere hope that the complete story of how a brain thinks will be known in my lifetime. Right now, that hope does not seem unreasonable. (Hardcastle 2007, p. 310)

Without working within the EDWs perspective, using any method and technology, people working in cognitive neuroscience have no

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[1] We can find the same ideas in Uttal's book. (See below, Uttal 2011)

[2] "It is simply an unsolved problem how to decompose coincident action potentials with variable spike shapes." (Hardcastle 2007, p. 308)

chance to explain cognition through neuroscience in the future. The identity between cognitive and neural states has to be replaced with correspondences between phenomena that belong to EDWs. It is a pitiless verdict for cognitive neuroscience just because this science is, from my viewpoint, a pseudo-science. (See the conclusion of this book).

4.2 Uttal's skepticism: *"In effect, we are doing what we can do when we cannot do what we should do."* (Uttal 2011)

Emblematic for the contemporary skepticism regarding the localization of certain mental functions through the imagistic procedures is Uttal (who is not a philosopher, but a researcher in cognitive neuroscience). His main book against localization is from 2001, but in his book from 2011, Uttal pushes further these ideas with the latest research from the field of cognitive neuroscience (Uttal 2011).[1] In this book (Uttal 2011), Uttal investigates the status of cognitive neuroscience, especially the role of brain imaging (fMRI) in grasping the mind-brain relationship. The main notion for the brain imaging (fMRI) area is, obviously, the localization. In the introduction, Uttal writes his main idea (emphasized throughout the whole book): "Unfortunately, the explosive growth of this new mode of research has not been accompanied by a comprehensive and synoptic evaluation of the huge number of studies published in the past two decades."[2] I believe that this is the status for cognitive

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[1] The advantage for me in filtering Uttal's book through the EDWs perspective is that of saving time and overpassing the impossibility of one individual to read so many books/articles that are published in cognitive neuroscience today. Even in the introduction, Uttal highlights that at "the outset I must accept the fact that it is impossible to cover all of the relevant literature. However, by selecting appropriate exemplars, I hope that it will be possible to come to a reasonable conclusion about the current status of what clearly is a time of major developments in cognitive neuroscience." (Uttal 2011, p. xxii) I hope that in my book, I introduced more important literature published in the last 3-4 years in order to grasp the actual status of cognitive neuroscience.

[2] "There is no question that brain imaging devices represent one of the most important diagnostic and scientific developments of all time." (Uttal 2011, p. 1)

neuroscience today. There are more and more experimental researches based on fMRI, but more and more people become aware of the fact that the researchers are “lost in localization”. (See Derrfuss and Mar 2009) Obviously, an analytical cognitive neuroscientist has to be aware of the limits of fMRI studies that offer mostly a “partial” image of the mind. More precisely, the brain imaging cannot grasp all types of activities of the entire brain that have to be correlated with any particular mental state.

Under the umbrella of the identity theory (the mind is identical with or “produced” by the brain), Uttal constructs many arguments against localization. In an ontological postulate, he considers that the mental processes are the results of interactions from the micro-level of the brain. Since the fMRI and PET “localize” the mental functions at the “macro-level” (large neural patterns), the results – and also those of the EEG[1] that are at the macro-macro-level - are completely wrong.[2] (Uttal 2011, p. 11) Moreover, the microelectrodes offer information about the activity of individual neurons but not about the large neural patterns that are involved even in the simplest thoughts. (Uttal, p. 10) From an EDWs perspective, it does not matter if we identify the micro-“level” or the macro-“level” of the brain with the mind: both “levels” belong to the brain (an entity placed in the

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[1] “The EEG and event-related potential, or ERP, have also been used in many studies, but after many years, these global electrical signals do not seem to have contributed much to our understanding of how we learn.” (Uttal, p. 198)

[2] Rolls and Treves also consider that we can explain the brain computation only through information furnished by single neurons and not by hundreds of thousands of neurons (functional neuroimaging). (Rolls and Treves 2011) “Because information is exchanged between the computing elements of the cortex (the neurons) by their spiking activity, which is conveyed by their axon to synapses onto other neurons, the appropriate level of analysis is how single neurons, and populations of single neurons, encode information in their firing. More global measures that reflect the averaged activity of large numbers of neurons (for example, PET (positron emission tomography) and fMRI (functional magnetic resonance imaging), EEG (electroencephalographic recording), and ERPs (event-related potentials) cannot reveal how the information is represented, or how the computation is being performed (---).” (Uttal 2011, p. 457)

macro-EW[1]). Even if Uttal is not content with the actual tools of investigating (scanning) the brain, his approach is under an epistemological umbrella that lacks the ontological grounds. Therefore, it is not surprising that Uttal appeals to postulates in his approach. I believe that the EDWs perspective furnishes Uttal's viewpoint the missing ontological grounds. Therefore, in this section, I will try to re-construct Uttal's epistemological and instrumental attack against the brain image under an (hyper)ontological framework, the EDWs perspective. Uttal uses many times the idea that the mind is "produced" by the brain. If "produce" is similar to Searle's notion (Searle 1992), then this notion is completely wrong. As we showed in Vacariu and Vacariu (2010), Searle constructed his theory within the unicorn world. The brain does not produce anything mental! It seems more plausible that Uttal's framework is the identity theory, but this approach is also wrong (see Vacariu 2005, 2008). Therefore, the notion of "producing" has to be replaced with that of "correspondence". Uttal considers that the brain images are not a direct method of measuring or indicating the cognitive processes. Therefore, the notion of "correlations" is the most important, but also the most debatable notion in cognitive neuroscience.[2] (Uttal 2011, p. 1)

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[1] In reality, if we accept the existence of both levels within the same EW (at the same time), we get ontological contradictions. In order to avoid such perilous contradictions, we have to introduce EDWs even for these "levels". That is, for the entities/processes from the neuronal micro-"level", the entities/processes from the neuronal macro-"level" do not exist and vice-versa. In this way, the number of EDWs increases dramatically. However, I suggest that it is better for a scientist to be lost in EDWs than in localization!

[2] "The ontology of cognitive neuroscience is especially complex for two reasons: first, we have no direct access to or empirical evidence of the mind (Uttal, 2007); we have only indirect evidence from which we must infer its nature and construct hypotheses concerning its function. Second, mental activity is not sufficiently constrained by behavioral observations so that a robust analysis can be made of it into modular elements: in other words, all of our cognitivist-reductionist theories of mind are underdetermined." (Uttal 2011, p. 4) Talking about Koch's "neural correlates of consciousness", Uttal writes that Koch "retreats back to confront the traditional problems faced by all cognitive scientists. First, all of the problems faced

Very important for my approach are two ideas emphasized many times by Uttal in his book: on the one hand, the latest research provides strong arguments against “modular-localization” and promotes the idea that each mental state has to be correlated with a “widespread distribution of brain representations”[1]. On the other hand, there are many arguments for a “more unified view of psychological mechanisms”. (Uttal 2011, p. xxiii)[2] Uttal introduce two postulates as the foundation of his approach. Interestingly, he mentions the framework for elaborating these postulates: the “major ontological assumption” of cognitive neuroscience that the “brain makes the mind”, a monistic framework. (p. 4) Again, “make” is identical to “produce”, so I introduce the same observation: even if it seems that Uttal adopts the identity theory framework, from my viewpoint, “makes” is a wrong notion that has to be replaced with “correspondence”.

> Nevertheless, the assumption of mind-brain equivalence is without any compelling empirical foundation; none of the required tests of necessity and sufficiency have ever been carried out to confirm it generally or specifically. However likely it may seem, there is no evidence other than plausibility and reason to support this foundation assumption.[3]

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by correlation methods are once again brought to our attention; second, the brain measures — the NCCs — to which he alludes are generally drawn from irrelevant levels of analysis such as brain images, EEGs, and other cumulative methods; and, third there is no direct access to the conscious experiences that permits us to directly compare mental and neural events. The details of the neural networks, however gracefully and eloquently expressed, are totally finessed.” (Uttal 2011, p. 8) Obviously, there is “no direct access” because the mind and the brain belong to EDWs.

[1] “It is now increasingly apparent that brain images at the very least reflect the fact that vast regions of the brain, if not all of it, are involved in even the simplest cognitive processes.” (Uttal 2011, p. 45)

[2] On the same page, we can find one of Uttal’s ideas that we can consider a kind of slogan for his book: “This book is a modest effort to resolve some of the present problems generated by mental inaccessibility and neural complexity.” Indeed, these two attributes need the EDWs perspective.

[3] “In summary, these two ideas — the general first part of the ontological postulate stating that the mind is a function of the brain and the second more specific part that

These sentences grasp perfectly the state of affair of cognitive neuroscience. The last years of research in cognitive neuroscience support this framework. Everybody accepts the identity theory, but more and more people inquire about the results of brain imaging.[1] Uttal's main postulates are the following:

The Two Parts of the Basic Ontological Postulate

1. All mental processes are the outcome of neural activity.
2. All mental processes are the outcome of the microscopic interactions and actions of the great neuronal networks of the brain. (Uttal 2011, p. 5)[2]

Again, it seems that for Uttal "the outcome" means "equivalence" or "identity".[3] Uttal claims that the mind is reflected by the microscopic

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it is the detailed pattern of neuronal interactions that represents or encodes mental activities and processes — with all of their uncertainties seem to be our best current answers to the mind-brain problem." (Uttal 2011, p. 10) From my viewpoint, the mind is not a function of the brain but corresponds to the brain (and body) and a mental state is not correlated with more or less neural patterns of activation since any mental state is the "I" that corresponds to the It (brain and body).

[1] Within the philosophy of mind, we can characterize this situation in this way: in cognitive neuroscience, everybody accepts the type-type identity (the mind is identical with the brain), but more and more people inquire about the token-token identity (a mental state is identical with some neuronal patterns of activation).

[2] Interestingly, Uttal wrote that this "philosophical, ontological belief is cornerstone of much of cognitive neuroscience. However, this postulate, this assumption, this axiomatic principle, undeniable though it may be, is still in its infancy in terms of the scientific foundations required to establish its validity." From an EDWs perspective, this "belief" is not even in "its infancy", it is completely wrong!

[3] "Our minds are products of our nervous system, and any idea of the consciousness or mind existing after the deterioration of the brain is without merit. Indeed, without this kind of mind-brain monism the whole cognitive neuroscience enterprise would be meaningless and pointless (…)". (p. 5) As I wrote above, the notion of "product" is very problematic. However, Uttal is perfectly right regarding the second part of the first sentence. My opinion is that if someone accepts that the mind can exist without the brain, that person has to go to church not to work in an academic environment. From an EDWs perspective, the real problem of cognitive neuroscience is the monism framework that creates all its problems, impossible to solve within the unicorn-world. Or "It is this complex and intricate pattern of neuronal activity and interactions that cognitive neuroscientists assert becomes or *is* mind (…)." (Uttal's italics, p. 6) Many expressions from Uttal's language can be

neuronal entities/processes (not macroscopic grasped by fMRI). As I wrote above, from an EDWs perspective, it does not matter if we analyze the microscopic or macroscopic neuronal interactions/ entities in order to explain the mental states, since both kinds of interactions are parts of the brain (parts of the brain that belong to the macro- or even micro-EW, but not to the mind-EW).

There are another two important points against the fMRI data and localization. Firstly, the bidirectionality between any particular mental state and the corresponding *widely distributed neural patterns of activation* ("many different cognitive processes can activate the same area or system of areas of the brain" (Uttal 2011, p. 22) and "many different regions of the brain have activated during any kind of cognitive task"[1] (p. 23)). Secondly, it is about the

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analyzed from an EDWs perspective in this way. The "brain is the organ of mind" (Uttal 2011, p. 11) or "there is no theory or putative explanation that yet explains how mental processes emerge from neural ones." (p. 21) "Having accepted the proposition that the mind and the brain are two parts of the same basic reality (…)." And "… this complex information pattern produces the reality we call mind." (p. 12) "To suggest that mind and brain, in fact, are not causally or otherwise intimately related to the degree of identity or equivalence would invalidate the very essence of cognitive neuroscience." (Uttal 2011, p. 12) In this book, I argue that, from an EDWs perspective, cognitive neuroscience is a pseudo-science just because the identity theory and any other relationship between the mind and the brain (correlation, association, causality, emergence, supervenience, etc.) is wrong. If any relationship between the mind and the brain is meaningless, the essence of cognitive neuroscience is invalidated. Moreover, as we will see in Chapter 7 of this book, the binding problem is indeed a pseudo-problem. Therefore, as I argue in the conclusion of this book, cognitive neuroscience is quite useful engineering, nothing more or less!

[1] "Isomorphism has been used by cognitive neuroscientists for years as an acceptance criterion of a putative relation between neural and mental variables. If there is a similarity in the shape or time course of two functions, then this similarity is taken as evidence that one represents the other. Nevertheless, if there is any single principle we have learned from the study of sensory processes, it is that there is no need to assume that the dimensions used by the stimulus are the same as those used by the neural responses; similarity of functional shape or even of dimensionality is not good evidence of a causal relation." (p. 30) Against this idea, Uttal analyzes "one-to-many" and "many-to-one" issues at 1.4.3 and 1.4.4. It is about "polyfunctionality", i.e., the most "brain areas are now known to participate in

complexity of the brain (its interactions and levels)[1]. In the first corollary, Uttal claims that the brain imaging tools grasp the wrong level of analysis, so the mind-brain problem cannot be solved in this way. In the second corollary of this postulate, Uttal believes that “the neural network approach is computationally intractable” and thus the “mind-body problem cannot be solved.” (Uttal 2011, p. 26) Again, he undertakes the actual general view in cognitive neuroscience that the “brain activity associated with mental activity is broadly distributed on and in the brain”[2] (the first epistemological principle for neuroscience). (Uttal 2011, p. 18) Since the mind is the “I” as an entity and an EW, and the brain exists in the macro-EW, it is indeed impossible to associate any mental state with some neural areas. We

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multiple cognitive processes. No area seems to have a unique function.” (Uttal 2011, p. 375)

[1] Related to this idea is the second epistemological postulate for neuroscience. “Because of their great complexity and number, it is not possible for us to analyze the great neuronal networks of the brain in a way that would permit us to identify the neural equivalent of any kind of mental activity at this microscopic level of analysis.” (Uttal, p. 19) Gallant et al.’s recent work (Nishimoto et al. 2011) is against the idea that complexity is an impediment for the mind reading. (About Gallant et al.’s work, see above) Moreover, as I indicated in the previous chapter, van Wedeen shows that the anatomical structure is much simpler than we thought! (Wedeen 2012) However, Uttal writes that what “the brain imaging techniques do best is to provide an answer to the question of where on the brain activity is observed when a stimulus is presented.” (p. 94) Indeed, as Uttal emphasizes in his book, the “brain image is highly limited in what it can say about the neuroscience of processes such as sensation and perception.” (Uttal 2011, p. 95) From my viewpoint, Nishimoto et al. could not explain the binding problem through widely distributed neural patterns using statistical method. From my viewpoint, the complexity of any kind of brain (human, monkey, cat or Kandel’s *aplysia californica*) does not matter. It is not about Uttal’s point that “cognitive neuroscience, despite considerable ballyhoo, does not yet have the tools with which to deal with an intricately complex system such as the brain” (Uttal 2011, p. 45), but about the EDWs that impede the real progress of cognitive neuroscience.

[2] “To summarize, the main point made here is that a priori no brain imaging or electrical recording activity, no matter how direct they may seem to be in recording the activity of the brain, can in principle provide solutions to the mind-brain problem.” (Uttal 2011, p. 26) It lacks the hyperontological background, the EDWs perspective!

can see now the epistemological-ontological framework that shows us that the neural networks are indeed "computationally intractable". We can find no computations within the brain but only some terrible complicated interactions that correspond, partially, to mental computations. Within the brain, computation is a notion without any meaning, an empty notion. I mention that the mind *corresponds* to the brain and the body and the distinction between micro-level and the macro-level of the brain becomes useless. In order to reject the notion of localization, Uttal needs a new framework of thinking, i.e. the EDWs perspective. Uttal believes that localization through fMRI and PET is the wrong method of identifying the mental states. Interesting here is the movement from the spatial localizations to the processes that are less possible to be localized. This movement seems to be a better alternative since the brain and the mind are EDWs.

Actual tools of scanning the brain (fMRI and PET or EEG) inquire for such question like "where" ("and it is not yet clear just what the "where" question tells us about the mind-brain problem") but these tools do not ask for the "why", the main question for the mind-brain problem. (Uttal 2011, p. 11, p. 28, p. 94) From an EDWs perspective, it is indeed a major problem with the fMRI results: they do not tell anything about the ontological status of either the brain or the mind. The brain imaging is just engineering, nothing more or less! (See the conclusion of this book) Getting quite good results from the fMRI results in reconstructing certain perceptual images, the "mind reading" method is probably the most important realization in cognitive neuroscience of the last 15 years. We can get quite good "correlations" (correspondences) between some mental states (mainly perception) and corresponding widely neural patterns of activation, but *we can never grasp the ontological status either of these neuronal patters of activation or of the correlated mental states!* Just engineering… We have here the being-perceiving contradiction (Vacariu 2011, p. 60 or Chapter 1 of this book): since the being does not perceive anything from the external environment, the "I" cannot perceive itself. Therefore, our endeavors to grasp the correlations between perceptions that are the self and particular neuronal areas are meaningless. The problem is if we consider that any perceptual state is the “I”, then we can analyze these results through three analogies:

(1) The first analogy is between the mind and the computer: long time ago, the computer was associated with the mind, the computationalism dominating 2-3 decades the mentality of people working in cognitive science. (See Vacariu 2008) However, in our days, very few people accept computationalism as an alternative in explaining the function of the mind.

(2) The second analogy is between a table and its microparticles, i.e. between objects that belong to the macro- and micro-levels. We have very good results regarding the macro- and the micro-objects, but from an EDWs perspective, they belong to EDWs. Similarly, we get good fMRI results in reconstructing a perceptual movie but we do not have to forget that the brain and the mind belong to EDWs.

(3) The third analogy is between the wave and the particles in quantum mechanics. Quantum mechanics theory has very good empirical results without any theoretical/ontological background. After almost 100 years, nobody knows exactly the ontological relationship between the wave and the particles. As I showed in other books/articles, (see, for instance, Vacariu 2008, Vacariu and Vacariu 2010), the wave and the particles belong to the EDWs. In cognitive neuroscience the state of affair is the same: without any ontological background, through statistical methods, we get quite good statistical “correlations” between some perceptual states and neural patterns of activation. Using the fMRI, we will never reconstruct consciousness or the ontological status of the “I” because the “I” is an EW!

In his first epistemological postulate for neuroscience, Uttal claims that the “brain activity associated with mental activity is broadly distributed on and in the brain. The idea of “phrenological localization” must be rejected and replaced with a theory of broadly distributed neural systems accounting for our mental activity.” (Uttal 2011, p. 18) Nevertheless, he makes the same mistake as everybody: he lacks any ontological background in supporting his approach.

One of the main topics of Uttal's book is the "seductive attractiveness of brain images" offered by fMRI results. Roskies refers to the brain images as perpetuating an "illusion of inferential proximity" that makes us feel we know something about something that in fact remains inscrutable.[1] (Roskies 2008 in Uttal 2011, p. 21) For Uttal the main reason of this point is that the actual tools operate at the wrong "level of analysis", the mind would be better grasped not at the macroscopic neuronal level but at the microscopic neuronal level. Moreover, after a few pages, he claims that suggesting that the "mind and brain, in fact, are not causally or otherwise intimately related to the degree of identity or equivalence would invalidate the very essence of cognitive neuroscience." (*idem*, p. 28) Supporting the identity theory (or maybe the mind is produced by the brain - a kind of Searle's position from 1992), Uttal proclaims an "intimate" relationship between mind and brain. Again, any kind of relationship between the mind and the brain (except for correspondence) is meaningless! In the first chapter (more exactly 1.5), Uttal investigates the limits of fMRI in general. In the following chapters, Uttal analyzes these limits for particular mental tasks (sensation, perception, learning and memory, attention, consciousness and higher-order thoughts, etc.).[2] The end of each chapter contains some negative conclusions regarding the power of fMRI in reading the mental functions. I selected some of Uttal's conclusions:

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[1] Against fMRI results, there are many people drawing the attention upon the limits (theoretical and empirical) of such tools of observing the activation of neural patterns. Uttal mentions Maier, Wilke, Aura, Zhu, Ye, and Leopold (2008), Sirotin and Das (2009), Bartels, Logothetis, and Moutoussis, 2008, Vul, Harris, Winkielman, and Pashler (2009), etc. I discuss about fMRI in Chapter 5.

[2] "Please understand that in no way am I denigrating the powerful uses of brain imaging (or any of the other earlier neuroelectric techniques that preceded it) in solving problems of anatomy and physiology — that is, of structure and function. The criticism that is expressed throughout this book is with the application of neuroscientific techniques and findings specifically to our high-level mental or cognitive processes — exactly the kind of processes for which we have the most critical clinical and other applied needs." (Uttal 2011, p. 315) This paragraph formidably reflects the EDWs!

- It is very possible that any mental task/function/state (sensation, perception, simple thought) or any simple thought involves the entire brain. From my viewpoint, I bring into discussion an old principle of EDWs perspective, the part-counterpart principle (2008 and 2010): a mental state corresponds to the most activated neural pattern, to other neural patterns less activated, to the entire brain.[1] Through the EDWs perspective, Uttal's epistemological approach gains the missing hyperontological framework.
- Uttal's main critics refer to the subtraction method, the paucity of quantification, indirectness of measurement, the timescale difference, variability, and statistical errors. For instance, he emphasizes Raichle's "default mode network" who claims that "60 to 80% of all energy used by the brain — occurs in circuits unrelated to any external event."[2] (Raichle 2010, p. 47 in Uttal 2011, p. 27) (See Chapter 11 of this book)
- There are no clear definitions for many different mental states. For instance, emotion, attention or consciousness[3] have no unique definition and probably are general properties, not modules of cognition. From my viewpoint, if any mental state is the "I", it is really impossible to define it.

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[1] Related to this principle are Llinas and Pare's "penumbra", Sporns's idea that the brain can never be separated by the body or Raichle's default net. (See Vacariu 2008 or Vacariu and Vacariu 2010)

[2] "If this is so, it raises questions about what the absence of an activation measured with an fMRI machine actually means in terms of the blood oxygen level dependent (BOLD) level itself and the fundamental idea that blood oxygenation varies with neural activity in the way we thought it did. What the concept of resting or default activity further raises is that this ongoing activity is being confounded with the evoked activations! If the subtraction method is thus flawed and BOLD measurements are associated not only with stimulus-evoked neural activity but also with background activity, the whole edifice of this kind of brain imaging could be called into question." (Uttal 2011, p. 27)

[3] For instance, Vimal (2009) "offered a list of 40 different meanings of consciousness and argued that even this list was not exhaustive." (in Uttal 2011, p. 271) The status of consciousness in cognitive neuroscience reflects the status of cognitive neuroscience today!

- Learning and memory are composed of different parts. Again, from my viewpoint, memory or perception is the “I” which means they are not composed of parts, but are the “I” who has its unity. Otherwise, if the “I” *has* memory or perception, we lose its unity and we need to introduce the eternal homunculus.
- It seems that all parts of the brain are involved in attention, consciousness[1] or perception.[2] Moreover, each particular neural state that corresponds to attention or consciousness[3] has been associated to other cognitive process.
- The parts of the brain are all somehow interconnected.[4]

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[1] “This raises, once again, the important point of separability of a cognitive process such as consciousness from the other that were listed in section 7.1. It seems likely that none of the items in this list are activities that can be experimentally isolated from each other; the severability of cognitive modules (i.e., pure insertion) is a chimera rather than a scientific likelihood. Much more likely is that any artificially isolated cognitive activity is actually a part of a much greater system (both psychological and neural), the other parts of which are at least interacting and at the worst do not exist as independent modular entities. Certainly consciousness is so completely integrated into the other processes that considering it a cognitive module or seeking some sign of it as an independent process seems totally inappropriate.” (Uttal 2011, p. 271)

[2] It is about the widely distributed neuronal areas for any mental state, i.e., in Utall’s words, “virtually all of the brain is involved in almost any cognitive process.” (Uttal 2011, p. 375)

[3] “It must be reiterated, however, that there is no way to distinguish between behavior driven by automatic mechanisms and conscious ones.” (Uttal 2011, p. 285) However, Davelaar argues that “control representations” are task specific related to a stable memory trace and can be localized in the brain (distributed neuronal patterns), while “control processes” are task nonspecific and cannot be localized in the brain. (Davelaar 2011)

[4] “Modern diffusion tensor imaging techniques elegantly demonstrate the multiple interconnections that run between and among most of the regions of the brain. These connections make it hard to imagine that signals are not repeatedly and recursively transmitted back and forth among widely dispersed parts of the brain during neural processing. Therefore, it seems unlikely on the basis of this anatomical information, as well as on the accumulation of functional findings, that any area of the brain operates in isolation, independently of the rest.” (Uttal 2011, p. 375) Again I insist on mentioning that the result of diffusion tensor imaging (DTI) and diffusion

- It is not possible to isolate the neural patterns that correspond to any cognitive process. From the EDWs perspective, since any cognitive process is the "I" and the "I" corresponds to the entire brain and body, then there is no isolate neural pattern for a particular mental task.[1]
- Consciousness and all its relatives (thinking, reasoning, decision making, problem solving, and intelligence) are the most problematic notions in cognitive neuroscience. There are no clear differentiations regarding the definitions of all these notions.[2]

Regarding the indirectness of measurements, Uttal mentions, for instance, the work of various authors that illustrate the limits of fMRI.[3] (Uttal 2011) For instance, Sirotin and Das (2009) claim that it is very possible that the hemodynamic activity grasped by the BOLD measurements does not reflect the neural activity, as it was believed. (in Uttal 2011, p. 32) However Bartels, Logothetis, and Moutoussis (2008) show that fMRI measurements do not reflect the "cumulated

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spectrum imaging (DSI) technique are other arguments for the EDWs perspective: any mental state corresponds to the entire brain (and body) and not only to some cortical areas. "Localization" is just a very approximate notion that mirrors the relationships between phenomena that belong (or are) to two EDWs.

[1] "The cytoarchitectonic bases of the Brodmann areas notwithstanding, there are no sharp dividing lines between the putative regions of the brain." (Uttal 2011, p. 161)

[2] "It seems likely that both the mental processes we call conscious thought and the brain mechanisms that instantiate them are aggregates of many components. A major question arises, therefore: can we separate out any of the components? Or, are these features of cognition so thoroughly entangled that they must be treated collectively? Will consciousness evaporate as a result the very effort to dissect it?" (Uttal 2011, p. 310)

[3] Some "neuropsychologists have argued that functional imaging for all its technical sophistication has failed to lead to any increased understanding at the cognitive level of analysis (Coltheart, 2006; Harley, 2004). Thus, Coltheart has posed a challenge to cognitive neuroscientists to provide examples where definitive answers to open theoretical questions have been given by functional imaging evidence. So far, there has been no conclusive response. We believe that intellectually this perspective on functional imaging is too limited." (Cooper and Shallice 2010, p. 402)

spiking activity of neurons".[1] (in Uttal 2011, p. 32) Again, from my viewpoint, any neural process belongs to the brain-EW (the macro-EW), not to the mind-EW (the "I"). The fMRI results and the spike action potentials are different "aspects" of the brain. (See Chapter 5 of this book). These results correspond "partially" (correspond) to some mental states (that are all the "I"), but we do not have any perception or any thought in the brain-EW. Regarding the mind reading, I introduce Uttal's observations on the works of some people. For instance, O'Toole et al. (2007) ask

> "How reliably can patterns of brain activation indicate or predict the task in which the brain is engaged or the stimulus which the experimental subject is processing?" (p. 1736). Poldrack, Halchencko, and Hanson's (2009) formulation of this basic question is conceptually the same: "What task is the subject engaged in given the observed pattern of brain activity?" (p. 8). Curiously, the answer to these questions does not depend on robust knowledge accumulated from the search for localized functions — it is not essential that the location of the salient regions be known before they can be considered. This issue can be resolved on the fly, so to speak, if one takes into account activity widely dispersed around the brain. All that is necessary is that the brain activation pattern varies from one cognitive experience to another. As impressive as this work is most of it depends on a prior set of responses that have been linked to the particular pattern of brain activations. This is a critical point in understanding the work to be described. These results do not mean that the percept is being reconstructed directly from the brain images; instead it allows us to use some unexpected differences in the pattern information to select forms from a "library" in much the same way that the Asian telegraph system used number codes to represent the 5,000 or so characters that could be transmitted. The number code itself contained none of the pictorial or semantic content of characters.[2] (Uttal p. 101)

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[1] Bartels, Logothetis, and Moutoussis's conclusion (2008): "an fMRI image may be the result of cumulating something quite different than the spike action potentials thought to be a key to neural coding of sensory processes. Instead, they argued that: "A key reason for this is that BOLD signal is not primarily driven by principal neuron spiking, but by the input and local processing of the area under investigation and that in some cases the two can be entirely dissociated (p. 451)". (in Uttal 2011, p. 96)

[2] This paragraph is followed by this one: "Although the change from the search for localization to the inference of distinguishable perceptual experience would not be tantamount to 'reading the mind', it would represent a major step forward toward discriminating cognitive processes from each other and open the door at least a little bit to achieving that 'holy grail'." (Uttal, p. 101)

Indeed, it is not here about "classic" localization. Even if there are other parts of the brain involved in every mental function, the "mind reading" can be solved "on the fly". As Uttal emphasizes, there are two main points: the neural areas differ from one mental function to another; the training period recorded by fMRI from a human subject for a particular mental function.[1] During the training period a "library" is formed, and this library is used to decode new input. It is indeed a great achievement (taking into account the great power of a computer to analyze the fMRI results from widely distributed patterns of activated neurons. Nevertheless, this method has almost nothing to do with the mind-EW or the "I". Uttal highlights that the researchers are able to do this job only for simple mental task. I am sure that, in the future, more and more complicated functions will be decoded with more developed fMRI results implemented in a computer. From an EDWs perspective, in order to grasp any mental state (simple vision or thought), it is necessary not only to comprehend the brain areas responsible for consciousness, but also the fact that the entire brain and body correspond to the "I". With new tools of scanning the brain, the progress of the mind reading will be more and more powerful, but these tools will never be similar with the "I".

Emblematic for the statistical errors is Vul, Harris, Winkielman, and Pashler's article (2009), a meta-review of 54 articles on fMRI.[2] Vul et al's conclusion is that the results display "implausibly high correlations between fMRI images and measures of personality and emotion". (Uttal[3], p. 36) Uttal's first conclusion

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[1] "An important next step was made by Kamitani and Tong (2005) when they showed that fMRI images of the early visual areas (V1 and V2) could reliably be associated with a stimulus consisting of a set of eight oriented gratings without training.10" (Uttal 2011, p. 104) Footnote10. "Similar results were obtained in which the fMRI signal was shown to be related to orientated stimuli by Boynton (2005) and by Haynes and Rees (2005) using different classification procedures. All seem to agree that this effect diminishes once one has moved beyond the most peripheral of the brain's visual areas." (Uttal 2011)

[2] About Vul et al. (2009), see also Vacariu and Vacariu (2010).

[3] Uttal mentions the strong debate on Vul et al.'s article after publishing their article. Nevertheless, "Vul and Kanwisher (2010) extended this critique of the statistical

about the fMRI limits is that the “brain images at the very least reflect the fact that vast regions of the brain, if not all of it, are involved in even the simplest cognitive processes.”[1] (Uttal 2011, p. 45) From my viewpoint, the fMRI (and its statistical method) reflects that cognitive neuroscience is a pseudo-science without any kind of laws. There are only *very approximate statistical correlations* between mental and neural states that transform cognitive neuroscience in a new fashionable *engineering*. Emblematic for Uttal’s framework is the following paragraph:

> No longer are the responses, covert that they are, linked only to the physical parameters of the stimulus; no longer are the causal influences restricted to the stimulus alone; no longer are the salient responses localized to well-defined peripheral anatomical structures; no longer do we have well-developed methods that allow us to measure the critical neural activity; and, most important, no longer do we have any means of directly measuring, or, for that matter, adequately controlling the responses of interest — the awarenesses — the experiences themselves. (Uttal 2011, p. 53)

From the EDWs perspective, I can argue for each “no longer” from this paragraph:

- The responses and the stimulus cannot take into account the unity of the “I”.
- The causal influences are not the results of the stimulus alone because of the corresponding unity of the “I”.
- “Localization” is a dead goal, indeed. The “salient responses” would include the entire brain and body.
- The “critical neural activity” does not matter, since the brain and the mind belong to EDWs.
- It is impossible to directly measure the “awareness” or mental “experiences” because the instruments of

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analyses used by many researchers who routinely and somewhat naively use statistical analyses of fMRI data.” (Uttal 2011, p. 38)

[1] “What this all means is that the MRI and the EEG are blunt instruments — epistemological sledge hammers — when it comes to understanding or even representing the detailed neuronal network mechanisms that actually underlie cognitive processes.” (Uttal 2011, p. 46)

> investigation (fMRI, EEG, etc.) grasp neuronal activities that are “correlated” with mental states.

Essential for rejecting the fMRI results (i.e. these results are identical or better “correlated” with particular mental states) is the unity of the “I”: each mental state/process is the “I”. Therefore, when cognitive neuroscientists claim that some widely neural patterns of neurons are correlated with a particular mental task, they do not take into account propositions 6 and 9 (Chapter 1 of this book or Vacariu 2011). We cannot correlate, even in principle, a mental state/process with widely distributed neural patterns just because each mental state is the “I”. The (un)famous philosophical qualia (Uttal mentions it several times) are the “I” and this is the reason we cannot correlate it with any widely distributed neural patterns. Any quale has to be correlated with certain widely distributed neural areas (with different activities), the rest of the brain and the body. Maybe certain neural areas are the most activated parts of the brain for each quale, but we have to be aware of the fact that any scanning tool (or whatever other instrument) grasps only certain neural processes that fit with the structure of that instrument. In other words, in a Kantian/Bohr framework, using fMRI or EEG we measure/observe something that fits with our tools of measurement.[1] (See Vacariu 2008, Vacariu and Vacariu 2010)

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[1] Following Anderson and Oates (personal communication), Uttal claims that “different pattern analyzers may produce different anatomical response patterns. In other words, and this is critically important, *the actual locations activated and neural response patterns may depend as much or more on the analysis method used as on the stimuli or the organization of the brain.*” (Uttal 2011, p. 111, his italics) Moreover, regarding consciousness and other higher-order the “(e)lectroencephalographic and brain imaging studies typically differ in their reports of which brain regions are activated.” (p. 311) (The same idea at p. 139; see also a particular example about alpha band and fMRI relationship at p. 328.) As I wrote several times in this book, using new tools of scanning the brain will offer us new “aspects” of the brain involved in each mental task. In fact, the macro-level grasped by fMRI is not something wrong in representing the mental states. In the future, with a performing EEG instruments we can do the same thing as Gallant et al did with an fMRI, but the EEG mechanism grasp other “aspects” of the brain than fMRI. Maybe

Uttal considers that "*specifically with regard to its application to the study of cognitive processes*, the brain imaging has demonstrated that it is not doing what it is supposed to do — that is, to localize modular cognitive processes in a particular place or a number of particular places on or in the brain."[1] (Uttal 2011, p. 363, his italics) Nevertheless, against the EDWs perspective the next two assumptions can be mentioned:

> Two fundamental assumptions are likely to remain constant as the enterprise goes forward. The first is the basic idea of materialism — that the world is real; that there is only one kind of reality, and that everything else emerges from operations in that domain. The second is that all mental processes (and the behavior that may or may not attend them) are functions of that material reality. (Uttal 2011, p. 364)

Both assumptions are within the unicorn-world and this is the reason Uttal constructs only ontological and epistemological *postulates*. From my viewpoint, we cannot reduce everything to a physical world, i.e., an EDW rather than a mind-EW. In Kant's (and Bohr's) framework, the physical world that we observe is a "creation" of our tools of observation that correspond, partially, to particular ontological interactions. Moreover, the mental processes are not

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we can make an analogy between the wave-particles from quantum mechanics and the fMRI-EEG data: wave and particles belong to EDWs, fMRI and EEG data describe phenomena that belong to EDWs! So, in this case, "aspects" would be a wrong notion.

[1] In the last "final note", Uttal mentions again that the "brain imaging, however successful it may be in anatomical and physiological studies, is the wrong tool for the study of cognitive neuroscience." (Uttal 2011, p. 379) "What they are saying, in general, is that there are patterns that occur over the brain that allow us to distinguish to a limited degree among a few perceptual and cognitive processes. In other words the brain is doing something that is demonstrably different as it processes different percepts or other cognitive processes. The main problem is determining how far we can go in making these fMRI-based discriminations. Whatever the final outcome of this work, it is clear that there is more information in the fMRI images than had previously been thought." (p. 111) But this "is not 'mind reading' in the popular sense. At best, these results suggest that the pattern of responses across the brain is different for different thoughts and percepts." (Uttal 2011, p. 111) Just engineering...

"functions of material reality" even if there is a correspondence between the "I" and the It.

Uttal's final conclusion is that "*In effect, we are doing what we can do when we cannot do what we should do.*"[1] (Uttal 2011, p. 369) However, even if Uttal is partially right claiming that "cognitive neuroscience makes it clear that we still know very little about the way the brain makes the mind" (Uttal 2011, p. 378), he still works in the unicorn-world: the brain does not "make" or is not identical with the mind.

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[1] This is strongly related to the measuring validity of fMRI: "It is all too easy to succumb to the siren call of 'face validity' and to assume that *what is being measured* is *what is intended to be measured* simply because *it can be measured*." (Uttal 2011, p. 29)

Chapter 5

Blood-oxygen-level-dependent (BOLD) of fMRI and local field potentials (LFPs)

In our days, the most important and used method of investigating the brain so as to explain the mind is neuroimaging (mainly non-invasive fMRI, but also PET, MEG, etc. and new tools of investigation like diffusion tensor imaging and diffusion-weighted imaging). The neuroimaging tools offer a new powerful framework of associating cognitive functions with particular neuronal areas. However, these associations are not perfect: we cannot be sure that a cognitive process that we associate with some neuronal areas is totally isolated from other cognitive processes. (D'Esposito 2010, p. 207)

> As a result, observed neural activity may be the result of some confounding neural computation that is not itself necessary for the execution of the cognitive process seemingly under study. In other words, functional neuroimaging is a correlative method (Sarter, Bernston, & Cacioppo, 1996). (D'Esposito 2010, p. 208)

These limitations are available for all physiological methods "including microelectrode recording of neurons, scalp evoked-related potentials, magnetoencephalography, hemodynamic measures, and measures of glucose metabolism". (*idem*) As D'Esposito emphasizes, no method in cognitive neuroscience is perfect! From my viewpoint, D'Esposito's idea lacks the hyperontological background, i.e., the EDWs.

As we will see in section 11.2, Raichle and Mintun underline that the BOLD signal is correlated with the local field potentials (LFPs[1]) and not with the spiking activity of neurons. Related to this

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[1] "LFPs is the electrical fields recorded from microelectrodes in the brain that mirror the weighted average of input signals on the dendrites and cell bodies of neurons." (Raichle and Mintun 2006)

topic, let me present the work of Berens et al. (2010) about the gamma-band of LFP, BOLD and the spiking activity in detail. The cognitive and the motor states/processes are represented in the neural action potentials that are the results of computations performed on inputs, feedforward and feedback information. It has been largely accepted that every pyramidal cortical cell receives approximately 10,000 synaptic inputs (75% are excitatory) and the computational and the dynamical properties of neural patterns are represented by the action potentials of a large number of neurons simultaneously. Worth mentioning, it is believed that "the local field potential (LFP) has been hypothesized to provide an aggregate signature of the synaptic input and dendritic processing within a localized cortical network[1] (Mitzdorf, 1987; Logothetis, 2003)". (Berens et al. 2010) More exactly, the LFPs are produced

> from a weighted average over potential changes in the vicinity of the electrode tip, generated by current sinks and sources in extracellular space (as reviewed by Logothetis, 2003, 2008; Berens et al., 2008a). These are generated, for instance, when synchronous excitatory synaptic input activates the dendrites of a neuron, leading to a current sink at the dendrite and a source at the soma (Figure 1C; Mitzdorf, 1985; Nunez and Srinivasan, 2006). The resulting dipole contributes to the measured LFP depending on the arrangement of the generating cell with respect to the local population.[2] (Berens et al. 2010)

The action potential processes occur at frequencies above 500 Hz and therefore the spikes are not added to the LFP power (but some researchers consider that the low frequencies of spike waves' forms influence the LFP). The local spiking could influence the LFPs.

> While it was originally thought that excitatory postsynaptic potentials are the primary source of LFP generating dipoles (Mitzdorf, 1985, 1987), more recently

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[1] Certain results indicate that "it is likely that in many instances measurements of the local field potentials reflect fairly local processes in the cortex, integrating signal sources from a few hundred micrometers of surrounding tissue." (Berens et al. 2010, pp. 9-10)

[2] Measuring the LFPs, we have to add the spikes and the feedback projections. (Berens et al 2010)

also other sources have been found to contribute significantly to the LFP such as inhibitory synaptic input (Hasenstaub et al., 2005; Trevelyan, 2009; see also below), and integrative soma-dendritic processes including subthreshold membrane oscillations (Kamondi et al., 1998) and after-potentials of somato-dendritic action potentials (Buzsáki, 2002). In addition, simulations have shown that not all synaptic potentials have the same influence on the LFP, but that their impact may vary with the position of the active synapse and the position of the recording electrode (Linden et al., 2010). (Berens et al. 2010)

The gamma-band originates within the microcircuits of pyramidal cells and the interneurons (according to Mann et al., 2005; Fries et al., 2007; Logothetis, 2008; Cardin et al., 2009; Sohal et al., 2009 in Berens et al. 2010), these microcircuits having the property of recurrence. The oscillations appear because of the interplay between pyramidal cells and interneurons. Working on the visual cortex, Berens et al. consider that

primary visual cortex, most MU [multi-unit activity] sites respond with an elevated firing rate to bars or gratings of a certain orientation (Hubel and Wiesel, 1968; Ringach et al., 2002)”, but “the LFP gamma-power increases in a stimulus specific manner during visual stimulation with an oriented grating (Frien et al., 2000; Kayser and König, 2004; Berens et al., 2008b). (Berens et al. 2010)

We have here a clear case that shows us that we cannot reduce any mental activity to the firing rate. Indeed, the “neurons do more than fire spikes”! It is well known that the LFPs integrate information from a larger area, not from spiking a local neural population. However, Berens et al. conclude that the LFP offers information (yet not complete information) about the integration of cortical processing and computation. Therefore we need to use other tools (like fMRI, for instance) investigating the activity of the neurons that corresponds to a mental state.

In the past, it was believed that LFPs and spiking are correlated with the BOLD response. The work of Logothetis and collaborators showed, among the first, that in some cases there are clear and strong LFPs signals but spikes are absent! (Logothetis et al., 2001; Goense and Logothetis, 2008 in Berens et al. 2010, p. 12) The authors indicate the names of many researchers that support this idea. I mention Viswanathan and Freeman’s experiments that show a “strong coupling between LFPs and changes in tissue oxygen concentration in the absence of spikes”. (2007 in Berens et al 2010)

> Given our current knowledge, local field potentials and, thus, to some extent the BOLD signal may instead be thought of as reflecting more the integrative processes instantiated in synaptic and dendritic activity than the spiking activity per se. Note that some aspects of the BOLD signal may not be related to neuronal processes at all: Sirotin and Das identified an anticipatory component of the haemodynamic signal which could not be reliably predicted from either LFP or MU activity (Sirotin and Das, 2008). (Berens et al. 2010)

The final conclusion of their chapter is that LFPs measure the synaptic and the dendritic processes plus the dynamics of cortical computation (not the output of computation).

> While fMRI alone is unlikely to reveal the actual mechanistic aspects of cortical circuit computation, it is an excellent tool for studying the global functional organization of cortical circuits (Logothetis, 2008). In conjunction with microstimulation (Tolias et al., 2005), it may be used to identify functionally connected subregions as has recently been done for the face patch system (Moeller et al., 2008). Subsequently, local field potentials and spiking activity may allow to gain a better understanding of the input –output transformation taking place within the regions, when their complimentary information is combined with the appropriate data analysis tools (Besserve et al., 2010; Panzeri et al., 2008; Magri et al., 2009; Gerwinn et al., 2009; Kelly et al., 2010; Murayama et al., 2010). An integrative approach to population coding in neural circuits makes use of all these signals and tries to put their individual strengths to optimal use. (Berens et al. 2010)

If in Vacariu and Vacariu (2010), we investigate Vul’s verdict about fMRI (2010), let me offer some very important information about fMRI from Logothetis’s paper (2008). Even at the beginning of the paper, Logothetis strongly emphasizes that the “ultimate limitations of fMRI are mainly due to the very fact that it reflects mass action” and not hardware or acquisition methods. (Logothetis 2008, p. 870) Only in a few cases can an fMRI furnish valuable information about the neural patterns that are correlated with some cognitive functions. Nevertheless, Logothetis indicates that in order to get the best features about the brain functions, we need to combine the fMRI results with the information furnished by other tools like EEG mechanisms.[1] As a motto for the analysis of Logothetis' paper, I would like to mention these words:

> a frequently made assumption is that the mind can be subdivided into modules or parts whose activity can then be studied with fMRI. If this assumption is false, then even if the brain's architecture is modular, we would never be able to map mind modules onto brain structures, because a unified mind has no components to speak of. (Logothetis 2008, p. 869)

Obviously, these words fit incredibly perfectly with the EDWs perspective! However, Logothetis accepts the idea that the brain is, at least partially, modular and his aim is to reveal the possibility of fMRI mapping different neural modules and their dynamic inter-relationship. From my viewpoint, the architecture of the brain is not modular and indeed the unified mind is not at all divisible. Without the mind being divisible, we have to become aware that it has no spatial dimension (property), even if the brain is located in a 3D space-temporal framework. (See Chapter 9 of this book) Within this context, the "correlations" between the neural and the mental states are very rough approximations, since the mind and the brain are or belong to EDWs.

In general, the functional activations of the brain are detected with the fMRI (measuring the tissue perfusion, blood-volume changes, or changes in the concentration of oxygen). An fMRI furnishes us mainly the *blood-oxygen-level-dependent* (BOLD) of the brain. (Logothetis 2008, p. 870) The critical factors that characterize the results of fMRI tools are signal specificity (the generated maps that mirror the neural changes), spatial-temporal resolution[2] (determine the entities of the activated networks and the

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[1] Again, in this case, maybe we have to apply Bohr's notion of complementarity.

[2] "Spatiotemporal resolution is likely to increase with the optimization of pulse sequences, the improvement of resonators, the application of high magnetic fields, and the invention of intelligent strategies such as parallel imaging, for example, sensitivity encoding (SENSE) method (…)." (Logothetis 2008, p. 870)

time of neural events) and experiment design used. (p. 870) The main problem of fMRI is the *spatial scale* at which it works in the brain. The optimal conditions for investigating the brain in relationship with cognition seem to be available, i.e. a spatial resolution of 0.7x30.7 mm in slices of 1mm thickness, timing being of a couple of seconds. The spatiotemporal resolution depends on “the optimization of pulse sequences, the improvement of resonators, the application of high magnetic fields, and the invention of intelligent strategies, such as parallel imaging, for example, sensitivity encoding (SENSE) method”. (p. 870) However, the fMRI signal is sensitive to neuromodulation but the neuromodulatory effects (effected by arousal, attention, memory, etc.) are slow and have reduced spatiotemporal resolution and specificity.[1] (*idem*) Obviously, the traditional “input-elaboration-output” scheme (corresponding to the perception-cognition-action model”) is “probably a misleading oversimplification”.

> Research shows that the subcortical input to cortex is weak; the feedback is massive, the local connectivity reveals strong excitatory and inhibitory recurrence, and the output reflects changes in the balance between excitation and inhibition, rather than simple feedforward integration of subcortical inputs. (Logothetis 2008, p. 872)

Moreover, the neuronal connections (bottom-up, top-down, etc.) are bidirectional. (*idem*) Taking as example the sensory systems and the thalamic region, Logothetis considers that the

> primary thalamic input innervates both excitatory and inhibitory neurons, and communication between all cell types includes horizontal and vertical connections within and between cortical layers. Such connections are divergent and convergent, so that the final response of each neuron is determined by all feedforward, feedback and modulatory synapses to some extent define feedforward and feedback pathways. (p. 872)

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[1] Important for me is Logothetis’ affirmation that repetition of an identical stimulus produces a reduction in the fMRI signal. It is about Hume’s “habituation”, Baars’s training period and involves Llinas’ and Frith’s “prediction”. For these notions, see Vacariu (2008), Vacariu and Vacariu (2010).

Again, reading Logothetis' ideas, we have to become aware of the limits of fMRI. Moreover, these or other limits are available for any (actual or potential) instrument of the brain imaging. These inevitable limits (that depend on the structure of any tool) have to be included in the definitions of entities that we observe with their help! We "observe" the activation of widely distributed activated patterns of neurons or "large-scale systems" and their relationships for any mental state. But in order to understand how large-scale systems work, we need to know the "architectural units that organize neural populations of similar properties and their interconnections" (Logothetis 2008).[1]

Again, from the EDWs perspective, I consider that the disputes between the micro- and the macro-neuronal areas (or between the large neural areas and the cell/molecules – see Bickle's approach or many other people trying to explain consciousness at quantum level, for instance) and their correlations with particular mental states are meaningless. These alternatives are mixture of notions that describe the phenomena that belong to the EDWs. We use various observational conditions to grasp different scales of neural states, but we have to be aware of the fact that the mental states have no spatial dimensions. (See Chapter 9) These states are not "observed" by an external observer that uses special tools within a spatio-temporal framework. Again, the mental states are the "I" and therefore such correlations are just rough approximations between states/entities/processes belonging to EDWs. Obviously, some "neural patterns of action potentials" (with properties of frequency and timing) seem to be much more responsible for particular mental states, but we have to take into account that (1) we use specific instruments of investigation that grasp some "aspects" of the brain, (2) these neuronal areas do not work in isolation within the brain and

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[1] I mention again Uttal's skepticism about the results of neuroimaging in explaining the cognitive functions: in order to grasp the real correlations between the neural states and mental states, we need mechanisms that offer neuroimaging at the micro-scale and not macro-scale (the actual neuroimaging apparatus). (See section 4.2 of this book)

(3) the “I” has a unity that has to correspond to the entire brain (and body). It is absolutely clear that the “I” uses certain tools of “investigation” (for instance, introspection that is the ‘I”) and the structure of these mental “tools” is totally different than the structure of fMRI and EEG! This is the framework that forces me to strongly emphasize, many times in this book, that the mental/conscious unity could not be identified or correlated with either the neural functions, or the quantum phenomena.

Logothetis introduces the notion of exhibition-inhibition networks (EINs) to understand the function of fMRI. What are the properties of these EINs? The magnitude and timing of any *local activation* arise as properties of the microcircuits. The excitation–inhibition balance means that the micro-circuits are capable of “large changes in activity while maintaining proportionality in their excitatory and inhibitory synaptic conductances”. The properties of microcircuits are

> (1) the final response of each neuron is determined by all feedforward, feedback and modulatory synapses; (2) transient excitatory responses may result from leading excitation, for example, due to small synaptic delays or differences in signal propagation speed, whereupon inhibition is rapidly engaged, followed by balanced activity; (3) net excitation or inhibition might occur when the afferents drive the overall excitation–inhibition balance in opposite directions; and (4) responses to large sustained input changes may occur while maintaining a well balanced excitation–inhibition. (Logothetis 2008, p. 872)

Reading this paragraph any researcher working in cognitive neuroscience has to become aware of the fact that localization is indeed a very ambiguous concept! Each neuron is involved in many phenomena (in space and time) and it is quite impossible to localize a mental state within the brain. Using computational modeling, these EIN microcircuits can reflect sensory input, gain control, modulation for excitability with attention, persisting activity during the delay periods of working memory tasks, etc. The microcircuits, “depending on their mode of operation—can, in principle, act either as drivers, faithfully transmitting stimulus-related information, or as modulators, adjusting the overall sensitivity and context-specificity of the responses”. (Logothetis, p. 872)

What is the relationship between EIN and fMRI? Changes in the excitation–inhibition balance (net excitation, inhibition, or simple sensitivity adjustment) influence the signals recorded by the fMRI (that is the regulation of cerebral blood flow). Logothetis underlines that in some cases, the increase in BOLD signals is produced by the spiking neurons, but there are other phenomena responsible ("of balanced proportional increases in the excitatory and inhibitory conductances, potential concomitant increases in spontaneous spiking, but still without a net excitatory activity in stimulus-related cortical output") for this event. (p. 873) Moreover,

> an increase in recurrent inhibition with concomitant decreases in excitation may result in reduction of an area's net spiking output, but would the latter decrease the fMRI signal? The answer to this question seems to depend on the brain region that is inhibited, as well as on experimental conditions. (Logothetis 2008, p. 873)

The fMRI signal can be influenced by an "increase in recurrent inhibition with concomitant decreases in excitation, [which] may result in reduction of an area's net spiking output". In animals, the metabolism increases with the increase of inhibition or the reduction of the spikes rate. (*idem*) In contrast, there is deactivation of fMRI signal with neural inhibition. (p. 874) Therefore, it is necessary to understand the relationship between the inhibitory activity and the changes in energy metabolism. "Unfortunately, the few published theoretical estimates of energy budget have not considered the metabolic costs of spikes in interneurons and of the inhibitory postsynaptic potentials (IPSPs) they produce." (p. 874) Modeling inhibition is difficult: "the density of cortical inhibitory neurons is 10–15 times lower than excitatory neurons" and the "inhibitory interneurons are fast spiking" (2-3 times faster than pyramidal neurons). Logothetis adds that the activity of the neurons affects directly the microvessels. So, the problem is that, in fact it is difficult to understand clearly the relationship between the inhibitory activity and the changes of metabolism! His conclusion is that "the nature of the EIN suggests that mass action and its surrogate haemodynamics are ambiguous signals, the interpretation of which must be constrained by the concurrent use of other methodologies." (*idem*) Do we need more arguments to understand the limits of fMRI in "reading the mind"?

Logothetis continues his article comparing EIN, EEG and fMRI results.

> The linear superposition of currents from all sinks [membrane of a discharging neuron] and sources [the inactive neurons] forms the extracellular field potential measured by microelectrodes. The extracellular field potential captures at least three different types of EIN activity: single-unit activity representing the action potentials of well isolated neurons next to the electrode tip, multiple unit activity reflecting the spiking of small neural populations in a sphere of 100–300 mm radius, and perisynaptic activity of a neural population within 0.5–3 mm of the electrode tip, which is reflected in the variation of the low-frequency components of the extracellular field potential. Multiple unit activity and local field potentials (LFPs) can be reliably segregated by frequency band separation. (p. 874)

The local field potentials (LFPs) are not reliably segregated by the frequency band separation, even if, indeed, Logothetis is right in claiming that the LFPs are the only signals of "integrative EIN processes". The problem is that the LFP signals are produced not only by the postsynaptic potentials but also by the "integrative soma-dendritic processes—including voltage-dependent membrane oscillations and after-potentials following soma–dendritic spikes—that all together represent the local (perisynaptic) activity in a region". Logothetis is aware that the status of LFP signals is their ambiguity, changes in the power of any LFP occurring "in any mode of operation of EIN".[1] Therefore,

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[1] "As most of the excitatory input into an area is local, LFPs will also indirectly reflect some of the postsynaptic effects of pyramidal cell activity. In addition, LFPs have a certain neural-class bias, which in this case is determined by geometry and regional architecture. The arrangement of the pyramidal and Purkinje cells will give rise to large LFP modulations; in contrast, interneurons will contribute only weakly because of their star-shaped dendrites and their geometrical disorder. Finally, inhibitory synapses may occasionally act as 'shunts' for the excitatory currents through low-resistance channels, in which case large synaptic conductance changes may produce little effect in the membrane potential, and result in weak and hard-to-measure multiple unit activity and LFPs." (Logothetis 2008, p. 874)

> Electrophysiological studies examining the individual contributions of different LFP frequency bands, multiple unit activity, and spiking of individual neurons are probably our only realistic chance of gaining insights into the neural mechanisms of haemodynamic responses and their meaning in the context of different cognitive tasks. (p. 874)

The studies referring to the relationships between the LFPs and the spiking activity to the BOLD furnish the information that the BOLD responses mirror the input and the intracortical processing, not the pyramidal cell output activity. Even if, at the beginning of using fMRI, people thought that both the LFPs and the spiking were correlated with the BOLD response, the alternative was that the "undiminished haemodynamic responses in cases where spiking was entirely absent despite a clear and strong stimulus-induced modulation of the field potentials." (pp. 874-875) In this context, we can understand that

> regional glucose utilization is directly related to neuronal synaptic activity. For example, the greatest 2-DG uptake occurs in the neuropil (that is, in areas rich in synapses, dendrites and axons, rather than in cell bodies). During orthodromic and antidromic electrical microstimulation, only orthodromic microstimulation, which involves presynaptic terminals, increases glucose consumption. Similarly, the highest density of cytochrome oxidase (an enzyme of the respiratory chain) is found in somato-dendritic regions that are adjacent to axon terminals. Finally, as mentioned earlier, presynaptic activity increases metabolism even if the output is inhibited (that is, the spiking activity is abolished).[1] (Logothetis 2008, p. 875)

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[1] A few words about Magistretti's paper related to the energy of the brain: the title of the first section of this paper is "Energy metabolism of the brain as a whole organ" with the subtitle "Glucose Is the Main Energy Substrate for the Brain". Glucose is the energy (metabolism) of the brain. (Magistretti 2008, p. 271) The title of another section is "Tight coupling of neuronal activity, blood flow, and energy metabolism". The title of the last section is "The astrocyte-neuron metabolic unit". Only reading these titles, we can understand that, from the energy viewpoint, the brain is analyzed only as a whole organ! Obviously, for any mental task the energy of the brain is involved. Therefore, the entire brain corresponds to any mental task! In this context, we cannot separate the neurons from glia, For instance, "in response to a neuronal signal (glutamate), astrocytes release a glucose-derived metabolic substrate for neurons (lactate). Glucose also provides the carbon backbone for regeneration of the neuronal pool of glutamate." (Magistretti 2008, p. 292) From my viewpoint, the

Interestingly, Logothetis underlines that

> many different types of electrical and optical measurements provide evidence that a substantial proportion of neurons, including the cortical pyramidal cells, might be silent. Their silence might reflect unusually high input selectivity or the existence of decoding schemes relying on infrequent co-spiking of neuronal subsets. Most important for the comparison of neuroimaging and electrophysiology results is the fact that lack of measurable neuronal spiking may not necessarily imply lack of input and subthreshold processing. A direct analogy between neuronal spiking as measured in animal experiments and the fMRI signal obtained in human recording is thus simply unrealistic and might often lead to incorrect conclusions. It is hardly surprising that most studies so far relying purely on BOLD fMRI have failed to reveal the actual neural properties of the studied area, at least those properties (for example, selectivity to various visual features) that were previously established in electrophysiological studies.[1] (Logothetis 2008, p. 875)

The "saliency" of neurons is strongly related to Raichle's "default network" (see section 11.2 of this book) or Merzenich and deCharms's penumbra (1996) and has to be correlated with the unconscious processes that produce the conscious states (Baars's global workspace theory). Therefore, I would like to extend Logothetis's observation to the measurements made by any kind of apparatus. Returning to Bohr's idea (who follows an extended Kant's

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question is why the researchers consider that, for the neuronal computations (that are correlated with the mental functions), the signals among the neurons are more important than the relationships between neurons and glia? Analyzing the relationship between the brain and the mind, since the "I" has its indestructible unity, we have to conceive that even the brain has a unity at least regarding its energy. Moreover, we have to relate the brain with the body. (see Sporns 2006 in Vacariu 2008) In this context and within the frame of EDWs perspective, we have to accept that the mind (the "I") corresponds to the unification of the brain and the body.

[1] I add an important paragraph: "Yet, as I have indicated above, the BOLD signal is primarily affected by changes in excitation–inhibition balance, and this balance may be controlled by neuromodulation more than by the changes in spiking rate of a small set of neurons. In fact, the BOLD signal is strongly modulated by attention, and the results of the motion after-effect experiments could, in principle, be due to the fact that a stimulus with illusory motion automatically draws the attention of a subject more compared to a situation in which there is no motion after-effect." (Logothetis 2008, p. 876)

approach, i.e., we have to include the conditions of our tools/instruments of observation in defining the entities and processes that we observed), my main question refers to the status of the (in)famous notion of “localization”. Obviously, it is not possible to find an intrinsic link between localization (segmentation) and the “neural integration” on the one hand and mental states/tasks and the unity of the mind, on the other hand, since it is about EDWs. Logothetis offers more arguments regarding the limits of fMRI, but his conclusion is the following:

> The fMRI signal cannot easily differentiate between function-specific processing and neuromodulation, between bottom-up and top-down signals, and it may potentially confuse excitation and inhibition. The magnitude of the fMRI signal cannot be quantified to reflect accurately differences between brain regions, or between tasks within the same region. The origin of the latter problem is not due to our current inability to estimate accurately cerebral metabolic rate of oxygen (CMRO) from the BOLD signal, but to the fact that haemodynamic responses are sensitive to the size of the activated population, which may change as the sparsity of neural representations varies spatially and temporally. In cortical regions in which stimulus- or task-related perceptual or cognitive capacities are sparsely represented (for example, instantiated in the activity of a very small number of neurons), volume transmission (…)—which probably underlies the altered states of motivation, attention, learning and memory—may dominate haemodynamic responses and make it impossible to deduce the exact role of the area in the task at hand. Neuromodulation is also likely to affect the ultimate spatiotemporal resolution of the signal. (Logothetis 2008, p. 876)

Therefore, the multimodal approach for studying the brain’s function is necessary more than ever. Essentially, the

> computational methods and non-invasive neuroimaging (that is, excluding animal experimentation) should be sufficient to understand brain function and disorders [which] are, in my opinion, naïve and utterly incorrect. (p. 876)

I investigated in detail Logothetis’s article just because fMRI seems to be the main tool for localizations and “correlations” in our days. The people who read this article would become aware of the limits of neuroimaging. Obviously, with the EDWs, I offer the *hyperontological limits* of neuroimaging and therefore I push much further the limits illustrated by Logothetis. Being aware of the fact that localization and the binding problem can be realized under *very rough approximations* (“rough correlations”), we will be able, in the future, to get beyond the classical or any other contemporary accepted paradigm (or sub-paradigms) of thinking/working within cognitive neuroscience. I am convinced that, in the next two decades, working within the unicorn-world, the researchers from this field will be very startled either by the unsolved problems or by the “weird” discoveries.

Rolls and Treves (2011) emphasize the fundamental difference between neurons and voxels of an fMRI: based on input, output, and spike process, each neuron “uses a code” to transmit information independently from the other neurons. We need only to decode such information from populations of single neurons in order to get good prediction. (p. 483-484) A voxel is composed from hundreds of thousands of neurons.[1]

> Instead of the average activation (a single scalar quantity), it is the direction of the vector comprised by the firing of a population of neurons where the activity of each neuron is one element of the vector that transmits the information (Rolls, 2008). It is a vector of this type that each neuron receives, with the length of the vector, set by the number of synapses onto each neuron, typically of the order 10,000 for cortical pyramidal cells. (Rolls and Treves 2011, p. 484)

There is no important information in the “stimulus-dependent cross-correlations between voxels.” (*idem*) We cannot compare the code furnished by the firing rate of single neurons and the code provided by the average process across many neurons grasped with fMRI, EEG, etc.) (Rolls and Treves 2011, p. 484) Probably, we can also find here two EDWs! Moreover,

> because it is a major principle of brain function that information is carried by the spiking of individual neurons each built to carry as independent information as

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[1] “(If the neuronal density is taken at say 30,000 neurons/mm (Abeles, 1991; Rolls, 2008), then a 3 X 3 X 3 mm･ 3 voxel would contain 810,000 neurons.)” (Rolls and Treves 2011, p. 484)

> possible from the other neurons, and because brain computation relies on distributed representations for generalization, completion, maintaining a memory, etc. (Rolls, 2008), methods that average across many let alone hundreds of thousands of neurons will never reveal how information is actually encoded in the brain, the subject of this paper. It is this independence of the information transmitted by individual neurons that enables a population of neurons to encode which individual face (Rolls et al., 1997b), which particular object (Booth and Rolls, 1998), which particular spatial view (Rolls et al., 1998), which particular head direction (Robertson et al., 1999) etc. has been shown.[1] (Rolls and Treves 2011, p. 484)

In his paper from 2010, Poldrack specifies other problems of the fMRI studies. The changes during developmental, maturation and learning are quite difficult to grasp by means of the fMRI. (Poldrack 2010) Moreover, the "imaging signals cannot determine whether a region is necessary for task performance". (Poldrack 2010, p. 873) He talks about certain interesting notions like efficiency, scaffolding, process-switching, and focalization of activation in cognitive neuroscience. For instance, efficiency means that the "developmental changes (reflecting a combination of maturational processes and experience-dependent plasticity) could in principle reflect sparsification of neural codes and thus more efficient neural processing". (p. 874) Anyway, all these notions are related to the "difficulty [which] arises from knowing how to map gross changes in blood oxygenation into changes in the functions being performed by the brain". (p. 876) In the future, we have to analyze in detail the relationships between fMRI results, performance-differences and structure-function under the framework of computational neuroscience and developmental neurobiology. It seems that the data furnished by the fMRI become more and more difficult to interpret!

In a very recent article, Poldrack (2011) points out the future of fMRI in cognitive neuroscience. Initially skeptic regarding the

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[1] "Of course, functional neuroimaging cannot address the details of the representation of information in the brain (Rolls et al., 2009) in the way that is essential for understanding how neuronal networks in the brain could operate, for this level of understanding (in terms of all the properties and working hypotheses described above) comes only from an understanding of how single neurons and populations of neurons encode information." (Rolls and Treves, p. 487)

role of fMRI in explaining cognition, and mentioning the work of Kriegeskorte et al. (in press) and Vul et al. (2009), Poldrack pleads for an absolute necessary methodological rigor in using the fMRI in cognitive neuroscience. Following this rigorous method, the researcher has to avoid the uncorrected statistical results and to check for more robust methods of statistical inference ("analyses of correlations between activation and behavior across subjects are highly susceptible to the influence of outlier subjects, especially with small sample sizes"), and to pay attention to the problematic use of "small volume corrections". (Poldrack 2011, p. 2) Against "blobology" (localization of function in some particular blobs), Poldrack notices a new direction: the connectivity in relationship with a function.[1] One major problem of using fMRI in cognitive neuroscience in mapping the structure of the brain onto functions seems to be that very different functions can be correlated with the same structure.[2] (p. 3) The solution for Poldrack is the identification of "selective association" between structures and functions:

> we ask not simply whether we can find a region that is engaged by a particular mental process, but whether one can find a region that is engaged *selectively*, such that activation of the region is actually predictive of the mental process. (Poldrack 2011, p. 3)

As Uttal emphasizes, more and more researchers in cognitive neuroscience become aware of the correlation between wide distribution of neuronal areas and any mental state. For Poldrack, if we want to use the brain imaging in understanding the functions and the organization of the mind, it is necessary to have certain projects of collecting fMRI data from the entire world by means of some special computers and computational models for mapping mental functions on neural structure[3]. This work needs an ontology

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[1] Obviously, it is about Edelman's degeneracy strongly supporting Uttal's kepticism.

[2] Again, one of Uttal's postulates!

[3] "The availability of large databases of neuroimaging data, particularly as the Brainmap.org database (Laird et al., 2005), has enabled powerful meta-analyses. However, the ability to perform metaanalysis is limited by the metadata that are

framework of mental functions.[1] I believe that the EDWs perspective offers the general hyperontological framework for this new kind of "engineering", cognitive neuroscience. In the paper written in 2011, in the abstract Poldrack et al. inform us that cognitive neuroscience

> aims to map mental processes onto brain function, which begs the question of what "mental processes" exist and how they relate to the tasks that are used to manipulate and measure them. This topic has been addressed informally in prior work, but we propose that cumulative progress in cognitive neuroscience requires a more systematic approach to representing the mental entities that are being mapped to brain function and the tasks used to manipulate and measure mental processes. (Poldrack et al. 2011, p. 1)[2]

Poldrack et al. draw the attention upon the fact that people working in cognitive neuroscience use quite many terms with ambiguous meanings.[3] Interesting for my perspective is a section from Poldrack's paper, called "Toward the ontology of cognition" that refers to the ontology of cognitive neuroscience. Biology is taken as example of information with a specific kind of ontology. Poldrack et al. want to apply this kind of ontology to cognitive neuroscience. The authors of this paper indicate that models like Anderson's ACT-R or Newell's SOAR grasp the computational principles but not other properties of the mind. In a program that continuously develops and

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associated with each data set; in order to assess which brain systems are associated with particular mental processes, the data need to be annotated using an ontology of mental processes. The Brainmap database currently uses a relatively coarse ontology of mental processes, which limits the ability to make finer assessments about structure– function associations (Poldrack, 2006)." (Poldrack et al. 2011, p. 8)

[1] "The precision and recall of literature searches can be greatly improved by the use of ontological knowledge to guide the expansion of search queries." (Poldrack et al. 2011, p. 7)

[2] The first question is how "can we integrate knowledge from an exploding number of studies across multiple methodologies in order to characterize how mental processes are implemented in the brain? The creation of neuroimaging databases containing data from large numbers of studies has provided the basis for powerful metaanalyses (Laird et al., 2005)." (Poldrack et al. 2011, p. 1)

[3] As example, they introduce the notion of "working memory" that has several meanings.

changes (the “Cognitive Atlas”, cognitiveatlas.org), Poldrack et al. make the distinction between mental tasks (manipulate and measure) and mental processes (not directly accessible).[1] Essentially for the EDWs perspective is the following paragraph:

> The ontological status of psychological tasks is not in question (i.e., nearly everyone will agree on what the “Stroop task” is), but the relation of those tasks to the latent mental constructs is at the center of many debates in cognitive science. For this reason, we propose that it is essential to make a clear distinction between mental processes and psychological tasks, and to develop separate ontologies for those two domains (resulting in two separate but interlinked ontologies that form a bipartite graph). (Poldrack et al. 2011, p. 3)

Mental concept is a “latent unobservable construct” (not physical instantiated since it is quite difficult to instantiate at the neuronal level). Related to mental concepts there are mental representations and mental processes, and Poldrack et al. write that mental representations are

> mental entities that stand in relation to some physical entity (e.g., a mental image of a visual scene stands in relation to, or is isomorphic with, some arrangement of objects in the physical world) or abstract concept (which could be another mental entity). Mental processes are entities that transform or operate on mental representations (e.g., a process that searches a mental representation of the visual scene for a particular object). (*idem*)

A mental task presupposes the manipulation of mental functions in order to understand mental processes.[2] Even more interesting for my

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[1] Obviously, this distinction is strongly related to procedural-declarative, implicit-explicit or unconscious-conscious knowledge.

[2] “The structure of the representation of mental tasks in the CA [Cognitive Atlas] builds upon the cognitive paradigm ontology (CogPO [www.cogpo.org]; Turner and Laird, 2011), which has a basic class of Behavioral Experimental Paradigm that describes mental tasks.” (Poldrack et al. 2011, p. 3) More details about Cog PO, see Turner and Laird (2012): “CogPO represents a single building block in the description of experiments in a structured framework, which should ultimately facilitate the representation of the actual experimental process leading to the published results, and the assertions that the published results claim to support.” (Turner and Laird 2012, p. 65)

perspective, Poldrack et al. write about the ontological relations across *different ontologies*:

- is-a (e.g., “declarative memory is a kind of memory”) • part-of (e.g., “memory retrieval is a part of declarative memory”)
- transformation-of (e.g., “consolidated memory is a transformation of encoded memory”)
- preceded-by (e.g., “memory consolidation is preceded by memory encoding”) (Poldrack et al. 2011, p. 5)[1]

The authors indicate other notions necessary for their future work: the relations between processes and tasks, the relations among tasks, the technical infrastructure, the utility of CA (like clearing the vocabulary!), etc. I think that even if apparently Poldrack et al.’s “ontologies” seem to be quite close to the “epistemologically different ontologies” of EDWs, these notions are quite distinct. The ontology of cognition (of the mind-EW or the self) is not a formal ontology because the content of the mind is not only “information” but all kind of knowledge (procedural-declarative, implicit-explicit, conscious-unconscious, etc.). Poldrack’s ontology is quite abstract and therefore it may be quite confusing. The reason is that these ontologies are constructed within the unicorn world. The mind neither supervenes on the brain, nor is identical with the brain, since the mind and the brain are EDWs. The main idea to grasp the EDWs perspective is the rejection of the unicorn world! Unfortunately, Poldrack has no idea of rejecting the existence of the unicorn world and he is unaware of certain hyperontological contradictions produced by his approach.

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[1] I would like to emphasize that I hope to deal with this complicated problem in my next work.

Chapter 6

The localization problem (segmentation vs. integration)

The fMRIs are used for brain scanning when a human subject has a particular mental state. Thus, people using the fMRI try to localize those neuronal patterns responsible for a particular mental state. Related to localization (especially in the last 3-4 years), is the notion of integration: the identification of some neuronal processes that are correlated with the unity of consciousness or the binding processes. Quite many experiments in cognitive neuroscience have been lately created under the localization (segmentation or differentiation)-integration umbrella. Nevertheless, localization remains the main topic of cognitive neuroscience. In this chapter, I will analyze the main ideas about the segmentation/localization in visual perception (one of the most important topic in cognitive neuroscience). The researchers try to convince us of the power of localization offered by the neuroimaging instruments (fMRI, PET, etc.). Nevertheless, I want to show that, from an EDWs perspective, these tools can give us only very approximate information about the correspondences between particular neural areas and mental states.

I would like to start this chapter with a few words on the distinction segmentation-integration from Baars and Gage's book. They discuss about the "hierarchical theories" of Crick and Koch (1995) and Rees et al. (2002), and the "interactive perspective" of Bullier (2001) (Baars and Gage 2010l, Chapter 6, section 3.1). For the hierarchical theory, the specification of certain visual features takes place at the early visual levels, while the integration of these features happens at the higher visual areas. The main question is how are we aware of specific visual features that are represented in the early visual areas like V1?[1] (Baars and Gage 2009, p. 173) Even if,

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[1] "The fact that signals in higher but not lower visual areas match conscious perception of objects during rivalry has long been taken as evidence that

in the past, there was a classical answer to this question (that is, V1 and V2 is the early visual level while V2, V3, V4, etc. are the later visual field), today there are some doubts about this position. For instance, the interactive theory presupposes many feedback and feedforward projections between early and higher visual areas. In this situation, could we identify a clear differentiation between the early and the later (or lower and higher) levels when we try to correlate such neuronal processes with particular mental states?

> Why might this combination of feedforward-feedback signals be important for awareness? This may be because higher areas need to check the signals in early areas and confirm if they are getting the right message, or perhaps to link neural representations of an object to the specific features that make up the object. (Baars and Gage, p. 173)

Baars and Gage specify that both theories have problems especially in the context in which many people accept the distributed neural patterns for any conscious experience. (*idem*) I may under these circumstances raise the question: what does it mean “to check” or “to link neural representations of an object to the specific features that make up the object”? “Checking” requires the eternal homunculus, while “linking” implies a kind of hierarchical structure. Indeed, both alternatives are wrong but only from the EDWs perspective. I believe that, within the unicorn-world, the disputes regarding segmentation-integration distinction will be endless.

Baars and Gage mention the work of Tong (2003) regarding the hierarchy of visual processing. (Baars and Gage 2010) Small dots are present at lateral geniculate nucleus (LGN), orientation, disparity and some color at V1, color, basic 2D and 3D shape, and curvature at V4, complex features and objects at ventral temporal cortex. V1 neurons are important for orientation, contours and shapes of objects, particular direction of motion, particular colors (even if some basic

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consciousness occurs late in the visual system (…). However, this neglects the multi-level nature of consciousness that includes not only the high-level object category but also the fine-grained spatial layout of shades of brightness and colours of which an object is composed.” (Haynes 2009, p. 200) types of color-sensitive neurons are in retina and LGN), and visual features in fine level of detail. (Baars and Gage 2010, p. 165-166) V1 neurons send feedforward signals to V2, V3, V4 (V4 being responsible for perception of color, according to Zeki 1977) and motion-sensitive area MT/V5[1]. (Baars and Gage 2010, p. 166) For Tong (2003), in general, the early visual cortex is responsible for any visual feature, while the higher visual areas are specialized in perceiving certain visual features or objects.[2] (Baars and Gage 2010, p. 172) I emphasize again the fact that this is the "classical view" regarding the correlations between V1, V2, etc. and the features of any mental perception. I add another classical distinction made by Ungerleider and Mishkin (1982) and later by Goodale and Milner (for instance, 1995): *ventral* (V4, lateral occipital complex and IT) and *dorsal* (middle temporal area and parietal lobe) pathways are responsible for "what" objects are and respectively "where" objects are located.[3] (Baars and Gage 2010, p. 167) Thus, we have to add to the "classical view" the famous ventral-dorsal distinction. From my viewpoint, such correlations are very approximate since the features of these phenomena belong to EDWs.

I believe that it will be quite difficult to change this "classical view" in this period even if there are more and more experimental results that throw doubt upon it. Many people are still convinced about segmentation with the help of fMRI or other brain imaging tools. For instance, in a very recent paper, Cavina-Pratesi et

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[1] The lesions to MT/V5 produce akinetopsia (motion blindness). Someone can sustain that MT/V5 is the core neural correlates of consciousness. However, Haynes draws the attention upon the fact that lesions to MT/V5 affect fast (but not slow) motion percepts. (Haynes 2009, p. 196) Therefore, MT/V5 is not the only area for NCC for all kinds of motion. Moreover, "content-specific brain regions that are modulated by consciousness can also be activated by unattended and even unconscious, invisible contents (…). This would indicate that the encoding of signals in a content selective region does not always lead to conscious experience of the corresponding content." (Haynes 2009, p. 200)

[2] In contrast, see below Seymour et al. (2009).

[3] Identifying specific neural areas (for instance, fusiform area) for a particular mental activity (for instance, a person sees a face) is not enough to find the "neural correlates of consciousness" (NCC). (Haynes 2009, p. 200)

al. (2010a) try to show that various properties of a perceptual thing (object shape, size and orientation), on the one hand, and (texture and color), on the other hand, can be precisely localized in the brain. As an example, these authors mention that, in different works and a few years earlier, Cant and Goodale indicated that the "geometric properties of meaningless objects activated the lateral occipital cortex (LOC), surface properties of the same objects activated more medial areas near the collateral sulcus (CoS)". (Cavina-Pratesi et al. 2010a, p. 2319) Cavina-Pratesi et al.'s experiments (realized with 2 patients having visual agnosia for texture-shape discrimination) confirmed these segmentations. Moreover, Cavina-Pratesi et al. found that

> the medial occipitotemporal cortex contains separate foci for processing different surface features of a given object. In particular, although color-related activity was localized anteriorly within the CoS and the LG, texture-related activity lay more caudally within the CoS (…).We also showed that areas selective for shape, texture, and color were quite distinct from those areas that respond to all of these features (shape and texture and color) together. The latter were found to correspond closely with some of those associated with the perception of more complex stimuli such as faces and places. (Cavina-Pratesi et al. 2010a, p. 2328)

In more details, shape was identified with LO (a subdivision of lateral occipital cortex, the neuronal "object area"), texture with posterior collateral sulcus bilaterally, and color with left lingual gyrus and anterior collateral sulcus bilaterally. The neuronal areas that are activated by all these features are fusiform gyrus and anterior and the posterior portions of the gyrus. (p. 2329) Their conclusion is that, indeed, the ventral stream is responsible for the perception of objects, but their work indicates an intermediate level of visual mapping (depending on the visual feature that is processed). This intermediate level is between the low level (retinotopic) and the high level (stimulus category mapping[1]). (Cavina-Pratesi et al. 2010a, p. 2330)

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[1] In another paper, Cavina-Pratesi et al. (2010b) identify the neuronal patterns responsible for "transporting the arm to the cup" ("transport component"), the

Contrary (at least partially) to the classical view regarding the localization of vision perception, I investigate some very recent papers. Bartels **(**2009) analyzes exactly the segmentation-binding relationship in visual perception. In a perceptual scene, the human observer can detect various objects in a specific surrounding (segmentation, in Bartels' terms). The properties of each perceptual object are its boundaries, color, motion, direction and distance to the observer. The question is what neural mechanisms create the links among segmentation, feature binding and attentional selection. (Bartels 2009, p. 300) Interestingly, based on recent empirical evidence, Bartels claims that even at the early visual cortex (V1 and V2) such connectivity takes place! Subsets of neurons from V1 and V2 are responsible for the border-ownership of edges[1] and the same

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superior parieto-occipital cortex and the left rostral superior parietal lobule (probably parietal area 5L) (Cavina-Pratesi et al. (2010b, p. 10320), and "preshaping the hand to grasp the handle" (the grasp component"), the bilateral anterior intraparietal sulcus and left ventral premotor cortex (even "no arm transport occur"!). Interestingly, they found an integration of the two components in left dorsal premotor cortex and supplementary motor areas and somator area S1, S2, and M1. (*idem*) The authors are aware of the limits of fMRI: "fMRI measures the BOLD signal, which appears to be influenced by many subtypes of neurons (large and small, excitatory and inhibitory) and by postsynaptic potentials (PSPs) (Logothetis, 2008) and anticipatory hemodynamics (Sirotin and Das, 2009)." (p. 10321) Moreover, even if they try to identify some specialized functions for particular neuronal areas, they are aware of the "crosstalk between dorsomedial and dorsolateral streams". (Cavina-Pratesi et al. 2010b, p. 10321)

[1] "In the 1930s and 1940s, Hartline developed the concept of the receptive field with studies of the axons of individual neurons that project from the lateral eye of the horseshoe crab (*Limulus*) and from the frog's eye (Ratliff, 1974). The lateral eye of the *Limulus* is a compound eye made up of about 300 *ommatidia* arranged in a roughly hexagonal array. Each ommatidium contains optical elements, photoreceptors, and a single neuron whose axon joins the optic nerve. Hartline found that when an isolated ommatidium was illuminated, the firing rate of its axon increased. More surprisingly, the firing of the same axon was decreased by a light stimulus in any adjacent ommatidium. This form of antagonistic behavior, known as *lateral inhibition*, serves to enhance responses to edges while reducing responses to constant surfaces. Without it, visual neurons would be just as sensitive to a featureless stimulus, such as a clean white wall, as to stimuli defined by edges, such

subsets are directly modulated by the top-down attention.[1] (Bartels 2009, p. 300) However, the neurons from V2 are also responsible for color and motion.[2] Bartels introduces some experiments that indicate that visual illusions like Rubin's face-vase or Escher's pictures, which can be solved by accepting one alternative and excluding the other one. This decision takes place not only at V4 but also at V1 and V2!

> Surprisingly, a neural substrate for this holistic property of figure–ground segmentation resides not only in neurons in V4, which have large receptive fields, but also in those of the primary visual cortices V1 and V2, where the neurons have tiny receptive fields (covering just 0.2 to 1 visual degrees). In addition to their selectivity for position, orientation, colour, depth or motion, neurons in these areas are additionally modulated by border-ownership: some superficial V1 neurons and most edge-responsive V2 neurons are modulated by the side of the edge 'owner' (…). (Bartels 2009, p. 300)

Bartels indicates that objects properties that far exceed the small field of view of V2 neurons through feedback are mediated by myelinated (fast conducting fibers of neurons with much larger receptive fields[3], similar with the neurons from V4). Important is that this feedback mediated not only spatial binding in V2, but also color and motion ("features that are processed within V2's anatomically segregated

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as a white square on a black wall. Similar spatially antagonistic visual responses were found in mammals (…). (Reid and Usrey 2008, p. 638)

[1] About attention, see Greenberg et al. (2012) in Chapter 8 of this book.

[2] Haynes mentions that "even if V1 does not encode colour sensations, it could still encode other, simple features of conscious experience, such as brightness or contrast sensations." (Haynes 2009, p. 198)

[3] "As defined by H. K. Hartline in 1938 (Ratliff, 1974, p. 167), a visual receptive field is the "region of the retina which must be illuminated in order to obtain a response in any given fiber." In this case, "fiber" refers to the axon of a retinal neuron, but any visual neuron, from a photoreceptor to a visual cortical neuron, has a receptive field. The definition was later extended to include not only the region of the retina that excited a neuron, but also the specific properties of the stimulus that evoked the strongest response. Visual neurons can respond preferentially to the turning on or turning off of a light stimulus—termed *on-and-off* responses—or to more complex features, such as color or the direction of motion. Any of these preferences can be expressed as attributes of the receptive field." (Reid and Usrey 2008, pp. 637-8)

thin and thick stripes, respectively”). (Bartels 2009) Again, we cannot locate (spatially or temporally) the feedward and feedback projections that are correlated with a mental state at one moment. Mentioning various experiments, Bartels writes that V2 neurons

> mediate not only cross-feature attentional selection of objects (object-based binding), consistent with the integrated competition model […], but also cross-feature binding […]. Recent fMRI evidence indeed demonstrates the explicit conjunction coding of colour and motion as early as V1 […]. Interestingly, voxels coding for conjunctions were separate from those coding for colour or motion, consistent with the anatomical segregation of ‘bridging’ neurons […].[1] (Bartels 2009, p. 301)

Moreover, other experiments suggest that the same neurons (mainly V2) mediate the border ownership and the basic visual features.

> What is the neural code mediating border-ownership? No evidence has been found that synchronous firing ‘tags’ same-border neurons, as classic theories on the binding problem have proposed […]; instead, this seems to be mediated by a plain enhancement of the neural firing rate [1]. Nevertheless, select neurons that coding for border-ownership the distinct hallmark synchronous firing indicate same/ different coding, but that are part of a network connectivity (…). (Bartels 2009, p. 301)

Bartels’ conclusion is that the experiments show that the early visual cortex mediate border-ownership, feature binding and object-based attentional selection.

Following the same line of research, let me introduce the very interesting experiment realized by Seymour et al. (2009, Bartels also signed this article). This work refers to localizations of color, motion and *conjunction* between color and motion. At the beginning of their paper, they mention that both features are processed by distinct (even if connected) neural areas: color with blobs of V1, thin strips of V2, and V4, while motion layer 4B of V1, in the thick stripes of V2, and in the V5/MT.[2] Thus, motion and color seem to be

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[1] About this work, see below Seymour et al. (2009) and Whitney (2009).

[2] According to Albright, “neurons in MT (and, to a greater extent, those in MST) appear to be sensitive to more complex aspects of visual motion, such as the motion

segregated at the cellular level, lesions studies (lesions in V4 impair color perception but spare motion perception, lesions to the V5/MT impair motion perception but spare color perception) confirming this segregation. (Seymour et al. 2009, p. 177) Obviously, if there is such functional segregation, how and where does the binding of such features take place?[1] Seymour et al. realized an interesting visual experiment. The human subjects perceive two transparent motion stimuli, each stimulus having the same two circle-colors and two motions, the difference being the direction of movement of circles-color (clockwise and counterclockwise). The brains of human subjects are scanned with fMRI. The authors specify that "the double-conjunction stimuli would be indistinguishable without conjunction-specific responses, as all four feature-specific units are active in both conditions". (Seymour et al. 2009, p. 178) I introduce Whitney's words about Seymour et al.'s paper:

> There were two double conjunction stimuli, both of which contained the same feature information (red, green, clockwise, and counterclockwise). The only conjunction stimuli were the pairings of color and motion: in one, red was paired with clockwise motion and green was paired with counterclockwise motion; in the other, red was paired with counterclockwise motion and green was paired with clockwise motion. (Whitney 2009, p. R251)

The main conclusion of their experiment shows that the primary visual cortex includes information not only about motion direction and color hue but also about *conjunction* of these two features. (Seymour et al. 2009, p. 180) "Whereas some areas showed better performance as well as biases for decoding one feature over the other (e.g., V5/MT+ for motion; V4 for color), information about both features and their conjunction was present in nearly every visual cortical region." (Seymour et al. 2009, p. 180) More exactly,

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of extended objects rather than isolated features (Albright, 1993)." (Reid and Usrey 2008, p. 657)

[1] Seymour et al wrote that it "remains a matter of debate whether visual-feature binding is mediated by a temporal code (…), by communication between visual areas (…), by feedback connections to early visual areas (…), or by representations at higher, cognitive stages (…)." (Seymour et al. 2009, p. 117) Eternal questions!

> We found that information related to a specific pairing of color and motion direction could be decoded from BOLD responses in V1, V2, V3, V3A/B, V4, and V5/MT+. This constitutes the first direct functional evidence of conjunction coding of color and motion in the human visual cortex. Because each double conjunction stimulus contained the same basic color and motion information, a classifier could not rely on independent color and motion ‘‘feature maps’’ to distinguish the two double-conjunction stimuli. In such a case of joint selectivity, both stimuli would evoke the same activation. The only factor distinguishing our two double-conjunction stimuli was the unique pairing of features. Therefore, our data show evidence for specific feature-conjunction information throughout the visual cortex. Because the voxels most informative about color-motion conjunctions were largely distinct from those informative about color or motion alone, it is possible that separate functional units code for motion, color, and conjunctions of these features.[1] (Seymour et al. 2009, p. 181)

The authors of this work also emphasize the limits of spatial-temporal resolution of fMRI. Moreover, Whitney emphasizes some problems with Seymour et al.’s “clever technique”: beside lesions, we have to take into account the psychological and physiological models of binding based on higher-level mechanisms; also, the feedbacks from fronto-parietal attentional region to create the conjunctions are possible; under the illusions’ framework, it is possible for the mechanism of feature binding not be recruited for unambiguous visual stimuli. (Whitney 2009, pp. R252-R253)

Let me analyze the viewpoint of Seygmouret al’s from an EDWs perspective. My intention is to bring further critical viewpoints to this work. As I wrote above, Seymour et al. are aware of the limits of fMRI and PET. If we add the role of neurotransmitters, the feedbacks from other neural areas, Baars’s global workspace, Edelman’s re-entrant processes, Raichle’s default network, Libet’s CMF or synchronized oscillations, could we really precisely localize particular visual features at V1, V2, V3, V4 or V5? How can we integrate localization/segmentation and integration in

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[1] “If the neural responses that underlie the fMRI BOLD response were generated by the individual features (color and motion independently), the response to the two double conjunction stimuli should have been equivalent. Surprisingly, however, this was not the case; the results demonstrate that feature conjunctions are represented as early as V1.” (Whitney 2009, p. R251)

such conditions? Again, we have to recall Bohr's method of introducing the conditions of observation in defining neural and mental entities/processes. So, it is very clear that using the fMRI and PET, we grasp certain neural features of the brain available for such neuroimage tools. The question is what the criteria to attribute color, motion and conjunctions of these features to V1 or V2 are. Could we correlate certain perceptual features only with the firing of some neurons? But the "neurons do more than fire spikes"![1] (Baars and Gage 2010, p. 96) From the EDWs perspective, we have to be aware of the fact that the brain and the mind (that include perception) are EDWs and therefore we cannot assume that only V1 or V2 are "correlated" with color, motion and their conjunction. Introspection, consciousness or the "I" are also involved in such experiments so we also have to find the neuronal activities that correspond to such entities! Through the neuroimage, we get just rough approximations of localizations. These localized neural patterns correspond, with large approximations, to particular mental states, but these mental states are not "observed" by the "I", they are the "I" (not parts of the "I"). The occipital lobe is dedicated, indeed, to vision but this lobe also corresponds to the "I" and thus the localization of the exact visual mechanism becomes very problematic. Again, I believe that the development of new tools will facilitate more and more details about the localization of visual features in the brain. However, we are already "lost in localization" (Derrfuss and Mar 2009). Using new tools of observation, we realized that the links (re-entrants or "conjunctions") between local or general neural areas are present everywhere. We will need "God's eyes" for a precise localization of the human being who perceives a visual object/scene.

Watanabe et al. (2011) indicate as well that we have to reconsider the functional role of V1 in visual awareness. Even if

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[1] In "primary visual cortex, most MU [multi-unit activity] sites respond with an elevated firing rate to bars or gratings of a certain orientation (Hubel and Wiesel, 1968; Ringach et al., 2002)" but the "LFP gamma-power increases in a stimulus specific manner during visual stimulation with an oriented grating (Frien et al., 2000; Kayser and König, 2004; Berens et al., 2008b)". (Berens et al. 2010, p. 6) About Berens et al's paper, see Chapter 5 of this book.

there are psychophysical factors that suggest that the visual attention and the visual awareness are two dissociated functions in the visual system, they claim that they show for the first time the differential neural correlates for these mental functions.

> We separately examined the effects of top-down attention and visual awareness on the blood oxygenation level–dependent (BOLD) signal in the human primary visual cortex (V1). We focused on V1 because measurements from neuroimaging and electrophysiology are incongruent for both attention (---) and awareness (---), and hence the lower limit of neural modulation has become a key question for both subjects. (Watanabe et al. 2011, p. 829)

In accordance with the previous experiments, their experiments based on the BOLD effects reveal that the neural processes of top-down attention act upon the lower level of visual mechanism. However, they found that visibility and invisibility of visual target produce nonsignificant BOLD effects in primary visual cortex (V1).

> The increase of the BOLD signal with attention in V1 agrees with the previous literature (---). However, the results regarding awareness in our study challenge the currently established view that the BOLD signal in V1 correlates robustly with the contents of percept. (Watanabe et al. 2011, p. 831)

These authors consider that the previous studies showed the awareness modulation on the BOLD signal in V1 just because attention was not correctly controlled during experiments. (*idem*) In this respect, awareness and attention could not be identified. Nevertheless, typically in the research context of our days in this field, Watanage et al. draw the attention upon the fact that their experiments do not exclude the role of V1 in visual awareness, more experiments being necessary (for example, those on synchronization). Anyway, from my viewpoint, trying to find the correspondences between entities and processes that belong to EDWs, especially when the human brain and the "I" are in this equation, the results will always be uncertain. More exactly, visual awareness and attention are the "I" that corresponds to the brain and body, so it is practically impossible to identify precisely the difference between the corresponding neuronal patterns of activation.

Regading the visual consciousness, Panagiotaropoulos et al. (2012) realized some experiments of the binocular flash suppression on macaque's brain illustrating that there are at least two areas responsible for the visual awarenss and not only one: the first area is the traditional one, i.e., the temporal lobe, the new one is the lateral prefrontal cortex. The previous experiments showed that the "perceptual modulation in the temporal cortex was proposed to reflect a stage of cortical processing where visual ambiguity has already been resolved and neural activity reflects phenomenal perception rather than the retinal, sensory input." (Panagiotaropoulos et al. 2012, p. 932) Their experiments illustrate that the "high-frequency (>50 Hz) LFPs in the LPFC reflect subjective visual perception, while power in the beta frequency band (15–30 Hz) exhibited a tendency to decrease during the phenomenal perception of a preferred stimulus." (p. 933) The authors conclude that it is for the first time when particular experiments indicate that the "high-frequency oscillations reflect conscious perception in the macaque cortex." (*idem*) These results support the ''frontal lobe hypothesis'' of conscious visual perception (Crick and Koch, 1998) and the "global networks of neuronal populations" (Blake and Logothetis, 2002).[1] (p. 933)

The same kind of problem is illustrated by D'Esposito: what are the neurons responsible for the delay between the presentation of information and its later use in behavior? Some quite early investigations (1971 or 1989) showed that the lateral prefrontal cortex is involved in this delay and (based on other studies) in working memory. (D'Esposito 2010, p. 208) The problem appeared when other studies illustrated that hippocampus (usually considered responsible for long-term memory) contains delay-specific neurons (working memory). Other recent studies show that hippocampus has a role in working memory. However, "the hippocampus may only be engaged during working-memory tasks that require someone to subsequently remember novel information." (D'Esposito 2010, p. 209)

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[1] Obviously, the authors should have mentioned Baars's work.

Chapter 7

The binding problem

7.1 Introduction

One of the most important problem in cognitive (neuro)science is the binding problem.[1] Some authors claim that we need to solve this problem in order to understand the function of the mind and the relationship between mind and brain.[2] There are various definitions of binding, but the classical one (perceptual binding) refers to the relationship between certain activated neural patterns of neurons posit in different parts of the brain that are correlated with various features/properties of an object (color, size, motion, orientation) and the unity of mental representation for that object. It is about the segmentation-integration distinction (partially, related to consciousness).[3]

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[1] In fact, all problems of cognitive neuroscience are very strongly related (all are very "important") just because many of them are pseudo-problems constructed within the unicorn world!

[2] Roskies (1999) considers the binding problem to be ‘‘one of the most puzzling and fascinating issues that the brain and cognitive sciences have ever faced’’. Triesch and von der Malsburg (1996) regard the binding problem as one of today's key questions about brain function. Treisman (1996) indicates that a "solution to the binding problem may also throw light on the problem of the nature of conscious awareness." (Velik 2010, p. 994) Also, Schmidt mentions that some authors believe that solving the binding problem would offer an alternative to consciousness. (Schmidt 2009, p. 157)

[3] "Roskies (1999) regards the problem of consciousness as the most mystifying binding problem of all. She raises the question how something as simple and mechanistic as neural firing can add up to subjectivity, raw feelings, and self. She asks whether the mechanisms that allow us to attribute the correct color and shape to an object are the same ones that lead to "the unity of phenomenal experience and if the solution to the binding problem will be the solution to the mystery of consciousness." (Velik 2010, p. 995)

Different authors like Velik (2010 - who mentions many other authors), Treisman (1996, 1998, 1999) Plate (2007), Robertson (2003, 2005), Feldman (2010), Flevaris, Shlomo Bentin, and Lynn C. (2010), Glyn W. Humphreys and M. Jane Riddoch, Gudrun Nys, Dietmar Heinke (2002), and Schmidt (2009) offer various types of binding:

- Spatial (location[1]) and temporal binding
- Part binding (the segregation of parts of an object from the background, these parts being bound together) (Treisman 1996, p. 171)
- Conscious and unconscious binding
- Perceptual (unifying aspects of percepts), visual binding (linking together color, form, motion, size, and location of a perceptual object or binding various perceptual objects), auditory binding
- Range (binding "particular values on a dimension (e.g. purple on the color dimension, or tilted 20 for orientation) are signaled by ratios of activity in a few distinct populations of neurons (e.g. those sensitive to blue and to red so as to signal purple). Any system using the "coarse coding" with just a few distinct populations of broadly tuned detectors to represent fine distinctions along a full range of properties must combine, and therefore bind, different levels of firing in cells with overlapping sensitivities to represent particular points on the dimension in question". (Treisman 1996, p. 171)
- Cognitive (relating a concept to a percept): binding in language understanding; binding in reasoning
- Sensory-motor binding, crossmodal identification, and memory reconstruction

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[1] Treisman specifies that objects and location seem to be separately coded in dorsal and ventral pathways "raising what may be the most basic binding problem: linking 'what' to 'where'". (Treisman 1995)

- Within a single modality, across modalities like sensory-motor integration; cross-modal binding; in action control or across perception and action[1]
- Hierarchical binding ("the features of shape-defining boundaries (e.g. orientation, curvature and closure) are bound to the surface-defining properties that carry them (e.g. luminance, color, texture, motion, and stereoscopic depth)" (Treisman 1996)
- Memory binding
- Binding in connection with consciousness (a unified experience)[2]
- Conditional binding ("the interpretation of one property (e.g. direction of motion) often depends on another (e.g. depth, occlusion or transparency)", Treisman 1996)

In this chapter, I will analyze the perceptual visual binding process, the most popular case of binding. The binding problem clearly reflects the relationship between parts (different parts of the brain) and whole (the unity of mind or consciousness or experiential subjectivity). (See Chapter 11 of this book) Obviously, it is strongly related to the framework created by the mind-brain problem and the problem of representation.[3] Inevitably, in order to solve the binding

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[1] In this case, there is for instance "Simon effect", a case of "compatibility phenomenon": "responding with a left keypress to a square and with a right keypress to a circle is easier when the square is presented on the left-hand side of the display while the circle is presented on the right-hand side". (Schmidt 2009, p. 152)

[2] Obviously, there are other forms of binding or other notions that refer to the same thing. For instance Feldman classifies the binding problem in this way: feature binding (associating the visual features with objects), variable binding (natural language and other abstract thought), and the subjective unity of perception. (Feldman 2010) Garson makes the distinction between functional and phenomenal binding. (in Plate 2007, pp. 781-2)

[3] Jackendoff (2002) considers "four challenges" for cognitive neuroscience: "the massiveness of the binding problem that occurs in language, the problem of multiple instances (or the 'problem of 2'), the problem of variables, and the relation between binding in working memory and binding in long-term memory." (in van der Velde

problem we need a framework for the mind-brain problem. Even if we accept the identity theory, we cannot solve the binding problem: we cannot identify a mental state with one or more neural patterns of activation. The binding problem is the hardest job for people working in cognitive neuroscience just because it is a pseudo-problem. Using modern technology (fMRI, PET, MEG, etc.), the main task for cognitive neuroscience is to solve this problem. Essential is the fact that binding is "almost everywhere in the brain and in all processing levels." (Velik, p. 994) Nevertheless, if the identity theory was not correct, if we changed this framework, the solution to the binding problem will arise immediately. I claim that the binding problem is a pseudo-problem in any framework of thinking.

The binding problem is strongly related to mental representation, another very problematic notion in cognitive science and philosophy of mind. From my viewpoint, we have to accept that mental representations really exist, otherwise psychology and cognitive (neuro)science would lose their status of science. There have been strong disputes on the status of representations that inevitably involves the status of mental functions. (See Vacariu et al 2001 or Vacariu 2008)[1] The process of binding refers to certain mental attributes that represent the properties of, for instance, a visual object. An object is mentally represented through a visual mental representation with certain characteristics. The arguments for the existence of binding processes are, for instance, synesthesia (most common is the case of grapheme-color, i.e. adding color to black letters), Balint syndrome ("difficulty localizing different objects or object parts, changing their direction of gaze, or shifting their focus of attention from one aspect of the scene to another" and simultanagnosia - inability to perceive more than one object at a

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and de Kamps 2006, p. 38) (see also Marcus 2001) (For the problem of representation in cognitive science, see Vacariu 2008).

[1] In Vacariu et al (2001), three main approaches are analyzed: computationalism, connectionism and dynamical system in relationship to the notion of mental representation.

time). (Schmidt 2009) There are some people who consider the binding problem a pseudo-problem or a problem that can be avoided. For instance,

> If we consider entire cortical regions as a single network system acting as one resonating unit, then a vehicle for uniting disparate feature-bits would be unnecessary. Instead, the higher level statistical aggregate of firing neurons would unite sets of feature primitives. (Hardcastle 1996, p. 262)

or

> Arguably the most radical critics are O’Regan and Noe (2001) “who suggest that the binding problem (of which they never distinguish different versions) can be dismissed ‘‘as, in essence, a pseudo-problem’’ (p. 967). On their view, attempts to solve the problem are in part motivated by the mistaken belief that ‘‘the fact that object attributes seem perceptually to be part of a single object’’ requires these attributes to be represented in some ‘‘unified kind of way, for example, at a single location in the brain, or by a single process’’ (p. 967). This criticism is put forward in the context of a general attack on the importance of internal representations for perception. (Plate 2007, p. 782)[1]

and

> Riesenhuber and Poggio (1999) report that the binding problem may be only a problem in the eye of the beholder, but is not necessarily a problem for all object recognition devices and perhaps may not be one for the brain. (Velik 2010, p. 994)

Plate notices that the binding problem is not just an aspect of perceptual experience but more important is “how subjects represent

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[1] On O’Regan and Noe’s position, Plate makes one of the most important observations about the binding problem for us: “This may well give rise (as it apparently did in the case of O’Regan and Noe) to the impression that the belief in the binding problem is rooted in the naïve assumption that experiential ‘unity’ must require some form of neurophysiological unity, presumably in analogy to the at least equally naive idea that an experience of something green requires there also to be something green in the head.” (Plate 2007, p. 783) See comments on this paragraph, in Chapter 7.

the world and its objects".[1] (p. 785) Moreover, LaRock mentions van der Velde who emphasizes that the visual awareness cannot be solved "inside the brain":

> … from the perspective of a neuron buried deep within the cortex, the situation is different. It has only an intrinsic perspective, which does not allow it to "look beyond its horizon"' (p. 793). Van der Velde concludes that solving the object feature binding problem is akin to solving a global information problem, and thus a solution to the former problem would involve a processing approach that extends 'beyond the local information obtainable within each of the different brain areas involved'. (Van der Velde p. 793 in La Rock 2010, p. 252)

This idea also reflects the relationship between *specialization* (differentiation or segmentation) and *integration*[2] of neural patterns of the brain that mirrors the binding problem.[3] (See Bechtel and Abrahansem 2011) Livingstone and David Hubel introduced a model in 1988 that strongly influenced people working in cognitive science:

> different visual features (specifically, color, motion, orientation, and retinal disparity) were analyzed in anatomically separate processing streams. These streams would originate in different types of ganglion cells in the retina, run through different types of layers in the visual part of the thalamus, and enter different layers of the primary visual cortex (V1). (Schimdt 2009, p. 151)

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[1] The binding problem and the relationship between subject and objects of external world, see LaRock (2010).

[2] "Obviously, the brain must balance the degree of pacing and coordination against the need for local neurons and their neighbors to work on local functions. There must be a balance between integration and differentiation (Edelman and Tononi, 2000)." (Baars and Gage 2010, p. 89) From an EDWs perspective, integration is the "I", while "differentiation" is *almost* a pseudo-notion in cognitive neuroscience. I used "almost" because differentiation is a methodological process with useful, pragmatic results but without any ontological status! See Chapter 6 of this book.

[3] "If each nerve cell or neuronal set represents a feature of visual awareness, then each nerve cell or neuronal set is aware only of part and not of the whole. The individual nerve cells may be aware of distinct features of visual information, but this fails to explain the unitary character of visual awareness. (…) The partial awareness of individual nerve cells in distinct neural clusters does not constitute, or add up to, the person's globally unified awareness." (LaRock, 2002, p. 252)

Recent research strongly contradicts this model. In this context, Schmidt indicates that

> neurons in V1 and V2 should not be regarded as simple feature detectors at all: It is unlikely that simple visual features are ever encoded completely independently of each other in early visual processing. Instead, cells are typically broadly tuned to more than one feature without being neatly segregated into different cortical compartments, which raises doubts about the disassembly metaphor in its strong form. (Schimdt 2009, p. 151)

This observation supports the EDWs perspective. However, on the contrary, Schmidt believes that different sensory modalities (vision, audition and touch) are processed by the specialized anatomical parts of the brain and the problem is created by the "crossmodal binding" (see Chapter 10 of this book). From my viewpoint, I really do not understand how we can find the differences regarding the correspondences between information that refers to particular features furnished by a single sensory modality and information provided by the entire sensory modalities. Again, the difference between features and representation is just a methodological distinction without any ontological status realized by the human researcher.[1] As a philosopher, I am really interested only in the entities/processes that really exist/are (have the ontological status) and belong to the EDWs. In this context, let me try to answer Schmidt who considers that three sub-problems create the binding problem:

> First, there is the "establishment problem", which is essentially the binding problem proper: How does the system determine which features belong together and should be bound into a single object? Second, there is the problem how binding is signaled in the brain: How does the representation of bound stimulus features differ from that of unbound features? Third, it must be explained how this information is read out by the rest of the system: How does the brain recognize and retrieve an integrated stimulus representation where features have been bound together? In addition, a convincing theory of binding should be able to explain grouping and object

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[1] About segmentation and integration, see Chapter 6 of this book.

constancy in addition to the binding of stimulus features at a single location (…). (Schmidt 2009, p. 152-153)

From an EDWs viewpoint, regarding the first question, I ask why do we need to consider the features of an object as being separated and where are they separated? If the mind has no spatial dimension (see Chapter 9 of this book), this question becomes a pseudo-question. Our mistake is that we attribute certain features (color, spatial dimensions, movement, etc.) that belong to the external objects to our mental representations. However, the mental representation of an object is not an object *per se*, so it is very possible that the mental representations do not have similar features with those of the external objects. Regarding the second question, if binding is a pseudo-problem, we can find, with very rough approximation, the correspondence between some wide neuronal patterns and the features that construct a mental representation, but the binding processes do not exist in the brain. The other particular problems (recognition, retrieval, grouping and object constancy) have a viable alternative only through postulating the being of the "I", but these processes are the "I". The object constancy, for instance, is possible only if we consider that any mental representation/process is the "I", an EW without spatial dimension, indeterminate EW! Obviously, there are some parts of the brain that are more active for the stimuli received from a particular sensory system, but we can isolate/"segmentate" them only from a methodological viewpoint. From the "I" viewpoint, such segmentations are meaningless.[1]

I will analyze in the next section the two main approaches for the binding problem: the feature-integration theory (FIT, e.g., Treisman, 1991; Treisman & Gelade, 1980; Treisman & Schmidt, 1982) and the synchrony or temporal binding "formulated independently by C. Legendy in 1970, P. Milner in 1974, and C. von

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[1] These segmentations remind me of Einstein's special and general theories of relativity that showed that segmentation like space and time or gravity and acceleration are just methodological but wrong notions used by physicists along centuries! (See Vacariu 2008; Vacariu and Vacariu 2010)

der Malsburg in 1981” (von der Malsburg 1999, Velik 2010) (but I do not investigate more problematic alternatives like binding by “convergence” or by “population coding”[1]).[2]

7.2 The “Feature-Integration Theory” (FIT)

One of the most acknowledged alternatives for the binding problem is the feature-integration theory (FIT) of attention elaborated by Anne Treisman.[3] (Treisman and Gelade 1980, Treisman 1996, 1999) The main ideas are the following:

- The features of a perceived object (color, size, motion, etc.) are registered automatically and in parallel at early stage and represented in certain “feature maps”.[4] (Schmidt 2009, p. 155) “These feature maps are connected to a ‘master map of locations,’ which encodes the exact

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[1] For these approaches, see for instance, Velik (2010) and Schmidt (2009). Related to these approaches, see the “convergent hierarchical coding” or the “combination coding” (Velik 2010). Another alternative is the binding by “recurrent processing” elaborated by Lamme and Roelfsema. (Schmidt 2009)

[2] Treisman points out several mechanisms that may be responsible for the binding processes: the “grandmother cells”, the local cell assemblies, the detection of temporal contiguity, the synchronized firing (1996, p. 171). For me, Treisman’s idea is very important (in at least two articles) that these mechanisms are not mutually exclusive. Considering the mechanisms are complementary, some researchers try to combine different alternatives in creating new models of binding but the framework is still the unicorn world.

[3] Interestingly, for the “experimental psychology researchers, two papers on binding by Anne Treisman in the 1980s set the course for nearly two decades (Treisman & Gelade 1980; Treisman & Schmidt 1982). Treisman’s ‘feature integration theory’ (FIT) became not only the most influential theory of binding, but also the most influential theory of attention.” (Holcombe 2009)

[4] “1) Features like color and shape are represented separately in the brain, but for each feature (such as red) there is a feature map indicating the location of each instance of the feature in the visual field. By virtue of the position of the units that represent the feature relative to the others in the map, a location tag is implicitly included and activity of a unit signals both feature identity and location. 2) The objects of a visual scene initially cause representations of the various features of all the objects to become active. The system does not yet represent which features belong to the same object.” (Holcombe 2009, preprint)

positions of objects in visual space". (Schmidt 2009, p. 155)

- Later, with the help of focus attention (spotlight or zoom lens that work in a serial manner) certain features (presented in the same "fixation" of attention) are combined to form a single unitary object. (Treisman and Gelade 1980, p. 97) Conjunctions of various features need focal attention that acts serially to each location.[1] (Schmidt 2009, p. 132) More exactly, the "window of attention" scans a "master map" of locations.[2]
- Selecting the features currently active in corresponding locations of various specialized feature maps, and suppressing those in other locations to prevent erroneous binding. The selected features are assembled to form an "object token" and are compared to the stored representations to identify the object. (Treisman 1996, p. 172)[3]

In other words, the process of binding is realized by a common location ("common location tags") of different features.[4] One of the

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[1] I emphasize that the FIT refers to the spatial attention, while the "synchronized oscillations" approach refers to the temporal binding. (Robertson 2003)

[2] "3) Binding happens when attention is directed to a particular location. The neurons corresponding to this location in each feature map become active to the exclusion of those in other locations, and the features occupying the location are bound." (Holcombe 2009, preprint) (See also L. Robertson 2003 or Schmidt 2009, p. 155)

[3] "Extensive evidence suggests that the binding of visual features into unified objects requires focused attention (see, e.g., Cohan & Rafal, 1991; Eglin, Robertson, & Knight, 1989; Friedman-Hill, Robertson, & Treisman, 1995; Humphreys, 2001; Treisman, 1999; Treisman & Gelade, 1980; Treisman & Schmidt, 1982)." (Delvenne, et al. 2010, p. 108) However, there are many critics against this theory. For instance, there are models "without any role for attention in binding, can also explain visual search performance (Rolls & Deco 2002; Eckstein 1998). These alternative models imply that the nature of the binding process cannot be determined from visual search results alone. Visual search results are affected by many factors such as image segmentation mechanisms, local salience processing, and crowding, making it difficult to isolate the binding process." (Delvenne, et al. 2010, p. 108)

[4] Many experiments try to prove that the location tags support the binding process. (Delvenne et all indicate, for instance, Steven Shevell et al. 2008) On the contrary,

most important arguments for the formation of "illusory conjunctions" is that, without attention, the conjunctions could take place accidentally, creating such illusory conjunctions since the features of unattended objects are "free floating" with respect to one another. (Treisman and Gelade 1980, p. 100) "Illusory conjunction may also occur if attention is diverted or overloaded."[1] (Velik 2010, p. 998)

After its first appearance, this theory was changed by Treisman or other researchers.[2] In the main article (1980), Treisman and Gelade mention that the binding problem is solved by focal attention and top-down processing.[3] (p. 134) Top-down processes are involved in different mental processes like knowledge, expectation, and memory. Important for me is Velik's remark:

> Treisman and Gelade (1980) suggest that, besides focused attention, contextual information and past experience play a role in binding of features. Even when attention is directed elsewhere, subjects are unlikely to see a blue sun in a yellow sky. Hommel (1998) points out that we experience object constancy despite changes over time in some of the features. This cannot be explained by a merely temporal integration through attending.[4] (Velik 2010, p. 998)

Delvenne et al. suggest that the location tags could not support the binding processes. (Delvenne, et al. 2010)

[1] "Evidence for such 'free-floating' features comes from experiments where observers view brief displays of various objects under conditions of diverted or reduced attention." (Schmidt 2009, p. 149)

[2] "More recent theories extending Treisman's work (e.g., Jeremy Wolfe's 'guided search theory') view the master map as a map of object 'salience,' that is, the degree to which an object differs in its features from the remaining objects. They stress the possibility of controlled preactivation of feature maps, which allows searching for single features as well as feature conjunctions." (Schimdt 2009, p. 155)

[3] "Frith and Dolan (1997) as well as Miller and Cohen (2001) identify the parietal and the prefrontal cortex as sources of these top-down influences." (Velik 2010, p. 998) As we see below, Treisman offers empirical data to support the idea that the parietal zone has a major role in the binding processes.

[4] Zmigrod and Hommel suggest that the "spatiotemporal continuity is crucial for object persistency (Gao & Scholl, in press; Mitroff & Alvarez, 2007; Yi et al., 2008) and that the impression of a continuously existing object begins to fade if visual objects disappear for more than half a second (Burke, 1952), at least in the absence of bridging events (…)." (Zmigrod and Hommel 2011, p. 150)

Obviously, the role of spotlight attention is to preserve the feature bindings in the visual short-term memory. Without focus attention, the representation of object disappears from memory, only its features are preserved. Nevertheless, it seems that the long-term memory is also implicated in the construction of a perceptual scene.[1] Memory is necessary to preserve the constancy of a perceptual object even if some parameters of the visual scene are changed. Knowledge for expectation and prediction seems to be involved in the binding processes for perceptual objects (events) about which the subject already has some knowledge that is acquired during training (habituation) processes.[2] From my viewpoint (but Uttal's skepticism supports this idea), we cannot make any distinction (not even methodologically) between the binding processes, attention and memory. The same verdict is true for the distinction between high and low levels or between top-down and bottom-up interactions.

In 1988 and 1990, Treisman added to her theory the notion of "feature-selection process" for the cases "where highly discriminable features appear to group and allow rapid or parallel conjunction search." (Treisman 1999, p. 106) It is about the inhibition of locations from the feature maps that contain some unwanted features. Treisman appeals to Edelman's reentrant connections[3] and Damasio's convergence zone[4] so as to mirror the

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[1] Even if Treisman quoted Wolfe ("Vision exists in the present tense. It remembers nothing."), the relation between vision (features and their binding) and memory is under a strong debate.

[2] "Through top-down processing, in a familiar context, likely objects can be predicted. In misleading context, this route to object recognition can give rise to errors." (Velik 2010, p. 998) Or "frequent exposure [habituation] to a conjunction stimulus (for example, colour and shape) can produce binding that does not require attention." (L. Robertson 2003, p. 95)

[3] "One possible mechanism of feature binding, according to feature integration theory, is reentrant processing (Treisman, 1996)." (Bouvier and Anne Treisman 2010, p. 424)

[4] McNorgan, et al. (2011) develop Damasio's "convergence zone": the "multimodal semantic integration occurs in multiple convergence zones organized in a deep integration hierarchy". (p. 227) As we will see below, McNorgan et al's alternative for the binding problem is "a deep integration hierarchy in which modally

neural implementations of such mechanisms. (Treisman 1996, p. 175 or 1999, p. 105) Anyway, Treisman is aware of the fact that her model needs improvements. This adoption of such position is common for someone working on a pseudo-problem and being aware that the approach needs more “improvements” (or, as I call them, Ptolemaic epicycles)! Based on the research from the 90s (fMRI, PET, event-related potential), Treisman concludes that the parietal zone has a major role in binding the mental features of mental representation that represents an external object. (1996; 1999; Treisman and Kanwisher 1998) Supporting this idea, there are cases of damage to the parietal lobes that produces the illusory conjunctions (Reynolds and Desimone 1999 in Velik 2010, p. 998). Balint’s syndrome is also an example of brain damage related to the binding problem: it is about the inability to localize objects or the inability to see more than one object at the same time (simultanagnosia). (Treisman 1996, 1998, L. Roberston 2003)

Against FIT, there were various critics. For instance, if the binding process is solved through top-down process, there would be a problem between the speed of such processes and the speed with which an object is recognized by the subject. Moreover, if attention is a serial process and vision is a parallel process, there is no time for attention to search for all possible feature combinations. (Velik 2010, p. 998) If location tags support the binding process, there are some experiments that illustrate some temporal problems between the identification of constituent features and the binding process. Important is that

> no chronotopically-organized visual areas have been found, raising the issue of how features might be tagged temporally. Temporal tagging would be unnecessary if all features were processed in the same amount of time. But features have different sensory latencies and processing times (Schmolesky et al. 1998). Perhaps the perceptual systems have a scheme for tagging the time that features actually

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distributed information is first integrated in single-modality convergence zones, which then feed into cross-modal convergence zones.” (p. 219) From an EDWs perspective, convergence zone is among the worst alternatives against the evolution of the brain.

occurred in the world, as opposed to when they are identified by the brain (Nishida & Johnston, in press), but this is not yet understood. (Delvenne et al. 2010)

As we will see throughout the following chapters, the times of the mind-EW and the time of the brain processes are epistemologically different times. So, trying to “correlate” various mental and neuronal processes represents a mixture of EDWs!

Mentioning the work of Riesenhuber and Poggio (1999), Velik introduces another critic against FIT: in some situations, the object recognition does not depend on some top-down processes. Gray claims that, in such cases, some “mechanisms that act prior to attention and also serve to attract it (Gray, 1999)” would be necessary. (Velik 2010, p. 998) What happens with the knowledge acquired through the attentional spotlight when it moves from one location to another? In this case, memory is necessary to preserve this information, so we have to combine the binding processes with memory and attention! The neuronal correspondence for these processes is obviously the entire brain.

The results of some experiments contradict that idea that attention has any role in the binding processes. Thus, the features remain bound in the visual-short-term-memory without the need of attention.[1] Kihara and Yakada (2010) consider that “when we view a natural scene, we are consistently aware of a single intact image, not separate multiple images depending on each spatial frequency channel. This indicates that information from these channels must be integrated prior to awareness.” (Kihara and Yakada 2010, p. 2158) From this statement, we can deduce that attention is not necessary for the integration of an image. Making some experiments on the delay recall task, Gajewski and Brockmole (2006) try to clarify the relationship between attention and visual working memory. Following Treisman’s idea, attention is indeed necessary for the binding object features and has a role for the information that is accounted within the visual working memory. Also, without attention, there are illusory conjunctions. (Gajewski and Brockmole

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[1] Different authors are mentioned by Delvenne et al. 2010, p. 108.

2006, p. 585) Nevertheless, without attention, we do not remember the features independently but "integrated objects are stored in visual working memory without need for continued attention". (Gajewski and Brockmole 2006, p. 581) In the visual working memory, a human subject memorizes an object as a whole or it is deleted from memory. (Gajewski and Brockmole 2006, p. 586) Vul and Rich indicate that there have been certain recent debates on the role of attention for the binding process.[1] Nevertheless, Vul and Rich's experiments show that the conjunction of two features is just *statistically equivalent* to "two independent samples from a probability distribution (attentionally selected region) in both space and time."[2] So, crucially, their conclusion is that the binding process does not need a special mechanism of selective attention.[3] (Vul and Rich 2010, p. 1173)

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[1] "Although psychophysical and physiological evidence suggests that conjunctions are represented in primary visual cortex (Sincich & Horton, 2005) and are formed without attention (Humphrey & Goodale, 1998) or consciousness (Vul & MacLeod, 2006), conscious perception of objects seems to require feature binding by attention (Treisman, 2006)." (Vul and Rich 2010)

[2] VanRullen et al. consider that the illusory conjunctions are created just from *local* "features of the neighboring objects". (VanRuellen 2005, p. 3142) They show that the binding process does not need attention. Nevertheless, Hollingworth and Franconeri claim that the visual system gets information from different sources for establishing continuity across perceptual interruption, that is for solving the "correspondence problem". (Hollingworth and Franconeri 2009) ("Correspondence problem": perceptual interruption (ex. brief occlusion) produces gaps in perceptual input. However, the visual system establishes correspondence between objects visible before and after the disruption.) "Neither spatiotemporal nor surface feature information will always provide a reliable solution to the correspondence problem, however. Both are potentially prone to error." (Hollingworth and Franconeri 2009, p. 165) For me, it is clear that for the correspondence problem the brain needs to interact with the external environment, but the mind has to be an EW. (The correspondence problem is strongly related to the "filling" gap process.)

[3] In other words, the visual attention is a "sampling process in selecting visual features for conscious perception, and that there is no additional 'binding' process: Veridical binding is just the limiting case of this sampling process, when the spatiotemporal window from which features are independently sampled is narrow enough to contain only one object." (Vul and Rich 2010, p. 1174)

7.3 The synchrony or temporal coding theory (temporal binding)

7.3.1 Oscillations – a general framework

An alternative to the superposition problem of population coding and the combinatorial problem of convergent hierarchical coding is the temporal binding hypothesis initiated by C. Legendy (1970), P. Milner (1974), and C. von der (Malsburg 1981). (Von der Malsburg 1999) The binding processes are realized through the synchronous neuronal oscillations under different frequencies. Using EEG[1] or MEG, the electrophysiological signals are obtained at the scalp level, signals that mirror the "synchronization of weak synaptic currents across a large number of neurons: scalp signals therefore necessarily reflect *synchronized* neural activity" (Tallon-Baudry 2009, p. 322) or "rhythmic modulation of discharge activity (neuronal oscillations)". The coupling of neurons through synchronization depends on adjusting the phase relationship or the frequency of cells from that neuronal group. The phase of an oscillation furnishes the window for processing information. The inputs in "good phase" of the ongoing oscillation are selected, whereas the inputs in "bad phase" are suppressed. (Moser et al. 2010, p. 199) There is the hypothesis that the synchronization between different areas is achieved through zero-phase lag between the same frequent-oscillatory activities.

> When two brain regions fire in synchrony with a lag time, the term phase locking is more accurate than synchrony. Sound waves echoing in a canyon are phase locked but not synchronous, because they echo back and forth with a brief lag time. Because neurons also take time to send their axonal spikes, there is a lag time in echoing among related brain regions, leading to phase locking rather than synchrony. Both synchrony and phase locking are commonly observed in the brain.[2] (Baars and Gage 2010, p. 252)

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[1] "Intracranial EEG (iEEG) has a far better signal-to-noise ratio than scalp EEG, since it is recorded from the brain itself. iEEG voltages typically are measured in millivolts; scalp EEG is measured in microvolts." (Baars and Gage 2010, p. 262)

[2] "Sometimes perfect synchrony is not attainable, so that there is a brief time lag between the peak of the wave in one place (like the hippocampus) and another place (like the frontal lobe). In those cases, the better term is phase locking or phase

The results of certain experiments showed that the zero-phase lag synchronization can occur over local brain areas or large distances (between hemispheres, Engel, König, Kreiter et al. 1991), even if there are great conduction delays of pathways that connect the synchronized neural groups. (Moser et al. 2010, p. 205)

> A power increase in a given frequency band at an electrode or MEG sensor is thus considered as measure of local oscillatory synchrony, probably generated through local, within-area neural interactions. Long-range oscillatory synchrony, thought to arise from between-area recurrent feed-forward/feed-back loops, is best characterized by phase synchronization (…), although some care has to be taken when using this measure at the scalp level (…).[1] (Tallon-Baudry 2009, p. 322)

According to Baars and Gage (2010, p. 107), the main frequency bands and their features are the following:

- Delta wave (less than 4 Hz) - the slowest wave with the greatest amplitude, typically for deep sleep (unconscious) states. If our awareness about the external world decreases, delta wave increases.
- Theta wave (3.5 to 7.5 Hz) – available for sleep states and meditation or, creating communications between hippocampus and cortex, is involved in short-term memory and memory retrieval tasks.
- Alpha wave (7.5 to 13 Hz) – discovered by Berger in the 19th century, arises in relaxation moments (the eyes are closed; if the eyes are open, alpha wave is attenuated).

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coherence, a little bit like a syncopated ‘off-beat’ rhythm in music. It is synchrony with a time lag.”(Baars and Gage 2010, p. 261)

[1] For Singer, “it is not too unexpected, that local gamma oscillations had the same power in the conscious and unconscious condition. What distinguished these two conditions was the global synchronization of local gamma oscillations. This suggests that conscious processing requires a particular dynamical state of cortical networks that is characterized by a brief episode of very precise phase locking of high frequency oscillatory activity. We propose that this particular state, because of its short latency and because of its global coherence, serves as trigger event for the access to conscious processing.” (Singer 2009, p. 49)

- Beta wave (13-26 Hz) – irregular, low voltage available for waking conscious states, symmetrically distributed in both hemispheres (most evident in the frontal area).
- Gamma wave (26-70 Hz[1], centered around 40 Hz) – available for conscious states (conscious perceptions and other cognitive states) and in REM dreams (rapid eyes movement sleep) leading to communication between the cortex and the subcortical areas.

Importantly, the EEG results grasp only the surface of waves; underneath the visible EEG, there are various kinds of interactions among waves (locked in synchrony with each other, phase-locked, transiently coordinated, cross-frequency coupling) with different ranges, (recent discoveries indicate ranges from 0.01 to 1000 Hz). (Baars and Gage 2010, p. 254, Chapter 8) Nevertheless, Baars and Gage emphasize the idea: *"Keep in mind that brain rhythms are a moving target, as new evidence appears with remarkable rapidity."* (Baars and Gage 2010, p. 261)

Segmentation up to 90 Hz, for large distances, is beta and gamma oscillations between 30-60 Hz, consciousness is associated with phase locking of gamma oscillations across widely distributed cortical areas, while unconscious processes are associated with local gamma oscillations. (Singer 2010, p. 165 or 2009, p. 49) Singer (as well as many other people) mentions that the firing rate (discharge rate) is for some particular features, while synchronization correlates these features. (Singer 2010, p. 164) (See also Singer 2009) Moser et al. indicate that the phase of oscillations (relative timing) is used for coding. (Moser et al. 2010) The responses of synchronized cell populations to the strong excitatory inputs on the rising phase of oscillation are earlier comparing with the responses to weak inputs. Therefore, the "intensity can be encoded during spiking in relation to the oscillation phase. This is a convenient way of coding, since the

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[1] As we will see below, the actual taxonomy of gamma band is low band (30-60 Hz) and high band (60-120 Hz).

latency of first spikes already contains all information about the amplitude of the driving input.” (Moser et al. 2010, p. 199) Oscillations are necessary to synchronize the spikes so as to propagate them in sparse networks and the spikes timing “has to be adjusted with high precision for the definition of relations in learning processes such as spike timing-dependent plasticity”. (*idem*) The information about the input amplitude or the relationships between distributed processes is to be found in the timing relations between spikes or between spikes and the phase of a population oscillation. (Moser et al. 2010, p. 200)

> An oscillatory modulation of membrane potential, such as occurs in oscillating cell assemblies, confines spiking to the rising slope of the depolarizing phase. Thus, spikes emitted by networks engaged in synchronous oscillations become synchronized. The temporal precision of this synchronization increases with oscillation frequency. In the case of gamma oscillations, output spikes can be synchronized with a precision in the range of a few milliseconds. Because of the coincidence sensitivity of neurons, this synchronization greatly increases the impact that the output of synchronized cell assemblies has on subsequent target neurons. (Moser et al. 2010, p. 199)

As we already know, the very recent topic of cognitive neuroscience is the integration of different neural patterns of activation that are correlated with particular mental functions (in the visual binding problem it is about the features of perceived scene/object). The activity of certain neural patterns is responsible for the presence of a particular mental (perceptual) feature, while grouping all such features in one (perceived) entity is due to the synchronization processes. Such integration is correlated with the unity of consciousness/mind/ subjectivity (the binding problem is the unity of perceptual scene/object).

In a very recent book (Philips, von der Malsburg and Singer, 2010, are the editors) the main topic is the dynamic coordination in the brain/mind.[1] Mainly, it is about the same thing: “coordinating

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[1] I am interested in introducing in a footnote the abstract of von der Malsburg’s paper from 2010: “Trying to apply our everyday concept of coordination to the brain

interactions are those that produce coherent and relevant overall patterns of activity, while preserving the essential individual identities and functions of the activities coordinated”.[1] (Philips, von der Malsburg and Singer 2010, p. 1) So, the main problem is how the brain combines local with global information (“relational Gestalt organization”) (information that is correlated with local and global mental functions/states).[2] There are two main mechanisms to get the coordination in the brain: by the gain modulation (synaptic gain changes, activity-dependent gating - “when dendritic segments are switched off by shunting inhibition” - the activation of synapses along a dendrite is change, etc.) or by the synchronization of oscillation patterns. (Moser et al. 2010, pp. 198-9) However the gain does not fit quite well with the speed and flexibility of cognitive processes. Therefore, the oscillatory synchrony approach is a better alternative and this is the main reason why quite many people

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raises a number of fundamental questions: What is the nature and meaning of local brain states that are to be brought together? On what grounds are they to be coactivated and connected? What is the nature of meaningful structural relationships, and how does the brain learn them? What is the role of focal attention? How does the brain assess its current level of coordination? How do brain states address goals? What is the nature of our environment’s statistics, and how is it captured by the brain? What mechanisms endow brain dynamics with a tendency to fall into coordinated states? Some of these questions seem to be difficult to address within the current experimental paradigm.” (von de Malsburg 2010, p. 149) This abstract reflects directly the situation of cognitive neuroscience in our days! In fact, we already saw other authors that ask the same or quite related questions. Thus, it seems that the progress of local knowledge (mainly in neuroscience) does not offer any general direction of research (or framework of working) in cognitive neuroscience.

[1] Coordination is quite similar with the binding processes. For von der Malsburg, coordination “is the ability to create internal scenes that capture the reality of environment.” (von der Malsburg 2010, p. 155) In the terms of the book edited by Philips, von der Malsburg and Singer (2010), the neural synchrony oscillations and the vector coding are two processes that are distinct and complementary processes that can be correlated with various cognitive processes.

[2] “… synchronization probability appeared to depend on the Gestalt criteria that the visual system applies in order to accomplish scene segmentation and perceptual grouping (Gray and Singer, 1989; Gray et al., 1989)” (Singer 2007)

accepted it in our days. Among the groups of neurons, frequency and phase adjustments are necessary for the selective routing activity and the dynamic gating of interactions between neural areas. Moreover, through the same mechanisms, the groups of neurons can be connected into coupled assemblies or segregated into functional subgroups. The oscillations with these mechanisms "could serve three complementary functions: gain control, selective and flexible routing of information between neuronal groups, and formation of coherent representations." (Melloni and Singer 2010, p. 20) Neural oscillations establish the relationships ("coordination") among distributed neurons through synchronization. Nevertheless, it is certain that the oscillatory synchrony is not the only mechanism for coordination in the brain and all these mechanisms are complementary.[1]

The features of a perceptual object are encoded at the subcortical levels, while the object as a whole, the relationships among these features, the relationships between the representation of this object and the representations of other objects from the same external perceptual environment are encoded by intracortical neuronal connections and "iterative recombination of feed-forward connections from lower- to higher-order neurons".[2] (Singer 2010, p. 159) Obviously, the brain has a hierarchical structure with systems and subsystems, neural codes and oscillations, feedforward and feedback signals and other entities and processes, but all these elements have to be correlated with mental functions and the unity of human subject. The problem is that the neural patterns (modalities or subsystems) have to be *reliable* ("neural codes must code for the same thing when used at different times and in different contexts") and *flexible* (codes must be used in different ways at different times

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[1] I return again to Bohr's principle of complementarity. These "mechanisms" are not complementary of a "thing-in-itself" (we have to remember Bohr embraced Kantian noumen-phenomen distinction, see Vacariu 2008), but it is possible to be phenomena that belong to the EDWs!

[2] We have to recall that "other entities and processes" are neuromodulators, the role of glia cells, in fact all the activities of the entire brain. In this context, it is quite impossible to identify the exact correlations between a mental state and "some" neuronal processes.

and in different contexts".[1] (Philips, von der Malsburg and Singer 2010, p. 2) The relational information encoded by different neural areas under the dynamic coordination framework has to change in a context-, task, and goal-dependent way. (Moser et al. 2010, p. 194) We have here the strong dynamic of parts of the brain-environment interactions and the stability of the "I" but also the plasticity of mental states. We cannot correlate the exact stability with rapid changes since these processes belong to the EDWs.

Notions like "coding" and "coordinating interactions" are applied at each level of neuronal processing from the single-unit to the population coding that form the hierarchical structure of the brain. The frequency bands are the most attractive tool to grasp the neural "integration". Von der Malsburg is among the first who introduced the binding-by-synchrony hypothesis. However, we have to integrate the frequency bands before talking about the binding problem. For any perceptual scene, we do not need some "vectors of activity" able to grasp all the entities and their relations from that scene, but the "dynamical graphs" that change more rapidly. (Moser et al. 2010, p. 204) Any researcher from cognitive neuroscience tries to explain which neural states are correlated with each perceptual feature (segmentation/localization) and the integration of all these features in one perceptual scene (the binding problem). In order to get a mental representation for a perceived object among those neural patterns, there is a temporal correlation or a synchronization of neurons firing. It seems that we cannot talk of the binding problem without taking into account the segmentation/localization problem.[2]

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[1] These notions are strongly related to notions like segmentation/localization and integration (see Chapter 6). In philosophical terms, it is about the combination of localism with holism (whole-parts relationship). Many authors from the book (2010 Philips, von der Malsburg and Singer eds.), from which I insert many ideas in this presentation, are the result of a conference on the "dynamic coordination", the whole-parts relationship being the central notion.

[2] In the past, the segmentation processes was not a problem in cognitive neuroscience. Only after the results offered by new apparatuses (fMRI, PET) in the last 10 years, we can talk about the segmentation problem/the localization problem.

With the actual technologies or inventing new apparatuses, could we solve this problem in the future?

7.3.2 More details about frequency bands, activated neural areas and cognitive functions

Tallon-Baudry draws the attention upon the fact that, in the past, each frequency band was associated with a cognitive function or state: delta waves were associated with sleep, theta[1] band with memory, alpha wave with vigilance fluctuations (more recently, with mental imagery and other mental processes – Baars and Gage 2010, p. 270), beta and gamma ranges with active awake stages and later with feature binding, attention, and memory. (Tallon-Baudry 2010, p. 239 or 2009) Quoting different authors, she offers other examples of actual associations: gamma range (plus alpha range) for the binding perceptual features, from theta to gamma frequency bands (but also alpha frequency) for various attentional tasks or for episodic memory encoding and retrieval[2], gamma and beta range for visual short-term memory.[3] (pp. 239-40 or 2009, p. 326) In an article published in the

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[1] Theta (also alpha) seems "to 'carry' gamma oscillations in much the way an AM radio frequency carries a voice signal." It plays a role in episodic memory being involved in actions of frontal lobe and hippocampus.

[2] Enumerating the work of some researchers, Tallon-Baudry indicates that the process of repeating the presentation of the same visual stimulus has in impact on gamma band scalp EEG oscillations […] and gamma-band oscillatory synchrony in hippocampus and medial temporal areas. "Interestingly, depending on whether the repeated object is meaningful or meaningless, gamma oscillations either decrease or increase […]." (Tallon-Baudry 2009, p. 325)

[3] Apparently in opposition with these correlations, in their experiments, Nicolaev et al. found no association between perception and duration of synchronized oscillations in other frequency bands (including gamma band), except beta band. (Nikolaev et al. 2009, p. 15) Nikolaev et al. try to offer a support for this discrepancy, i.e., the size of n sizes of synchronized networks and the frequency band: the higher the frequency, the smaller the size. "Gamma-band synchronization is generally responsible for local communication across short cortical distances, whereas beta frequencies can synchronize over longer conduction delays, that is, between more distant brain structures (Kopell et al. 2000). Thus, it is plausible that the significance of beta band in our results is a consequence of the spatial scale of

same book (2010), Singer indicates some cognitive functions (binding, attention stimulus selection, and consciousness) associated with various bands of synchronization:[1] Following the results of the last ten years of research, it is already accepted that more precisely the subdivisions of some frequency bands (for instance, gamma sub-bands) correspond to particular cognitive functions and vice-versa.[2]

Various researchers try to prove that the interactions within large-scale cortical areas (i.e., communication among various cortical areas) are produced by some long-range synchronization of oscillatory signals.[3] Singer specifies that the synchronization among distant neuronal areas occurs at oscillations in theta or beta frequency range; synchronization among local groups of neurons is produced by gamma oscillations.[4] As I mentioned above, the oscillations in different frequency bands can coexist and exhibit complex phase

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our measurements (about 8 cm).” (Nikolaev et al. 2009, p. 15) Nevertheless, the gamma band is responsible for both local and global distances.

[1] It seems that the conscious processed stimuli are associated with global, widely distributed cortical areas phase locking of gamma while unconscious processed stimuli with local gamma oscillations (Melloni et al. 2007). (in Singer 2010, p. 165; or Le Beau 2010, p. 32) However, gamma-band also appears during REM phase of sleep and hallucinations. (LeBeau 2010, p. 32) About consciousness and neural synchronization, see Singer (2009). About synchrony and perception, attention and memory, see Jensen et al. (2007).

[2] For instance, “… the same fronto-parietal network (Buschman and Miller 2007) or the same visual (Wyart and Tallon-Baudry 2009), olfactory (Cenier et al. 2009), or audio-visual (Chandrasekaran and Ghazanfar 2009) region can engage into oscillatory synchrony at distinct frequencies, involved in distinct cognitive functions.” (Tallon-Baudry 2010, p. 24)

[3] “Long-range oscillatory synchronization has been suggested to dynamically establish such task-dependent networks of cortical regions (Engel et al., 2001; Fries, 2005; Salinas and Sejnowski, 2001; Varela et al., 2001).” Hipp et al. 2011, p. 387)

[4] “Task-induced changes in synchronization or coherence have been reported at the level of individual regions during sensory integration (Roelfsema et al. 1997), selective attention (Fries, Reynolds et al. 2001), working memory (Pesaran et al. 2002; Howard et al. 2003), and motor control (Crone et al. 1998). Between distant cortical regions they have been reported during object recognition (Varela et al. 2001), working memory (Jones and Wilson 2005), long-term memory encoding (Fell et al. 2001), visual attention (Gregoriou et al. 2009), and sensorimotor integration (Roelfsema et al. 1997).” (Moser et al. 2010, p. 200)

relations (Roopun, Kramer et al. 2008 in Singer 2010, p. 162).[1] In this context, we have the "nested relations" hypothesis (Singer 2010, Moser et al. 2010) necessary to encode the compositionality (for instance, the representation of composite perceptual objects and movement trajectories).[2]

Very recently, Hipp et al. **(**2011) argue that beta-band synchronization (20 Hz) works in fronto-parieto-occipital areas, while gamma-band synchronization (80 Hz) in centro-temporal areas.[3] Hipp and colleagues analyze the results of EEG recordings in the human subjects that report the alternation of a perceptual ambiguity (audiovisual stimulus).[4] Regarding beta-band synchronization they show that the

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[1] Engel et al. (2001) introduce the hypothesis that different frequency bands mediate both the bottom-up and the top-down interaction through synchronization. (Velik 2010, p. 999) It is quite clear that different classes of interneuron have different roles in producing different types of oscillatory activity. (Somogyi and Klausberger, 2005; Grillner et al., 2005 in LeBeau 2010, p. 31)

[2] "So-called nested oscillations attracted a great deal of interest because of an influential model of memory storage that would account for the limits of human memory capacity by an interplay between theta and gamma oscillations (Lisman and Idiart 1995), and there is growing evidence in humans for such theta/gamma relationships (Canolty et al. 2006; Sauseng et al. 2008)." (Tallon-Baudry 2010, p. 243)

[3] "The authors developed a new analysis method based on a combination of beam forming procedures and cluster permutation statistics that allows an unbiased search for synchronized networks across the entire human brain. The subjects' task was to judge the configuration of an ambiguous audiovisual stimulus consisting of two approaching bars that crossed over and then continued to move apart from each other. At the moment of contact a click sound was played. Perception of this stimulus spontaneously alternates between two bars bouncing off each other or passing one another, the addition of the click increasing the relative frequency of the bouncing percept, which indicates polymodal integration." (Singer 2011, p. 192)

[4] "To avoid the encoding of false relations (conjunctions), these ambiguities need to be resolved before signals can be subject to grouping in the respective convergent pathways. This sorting of appropriately groupable responses must occur in a context-dependent way at each level of processing. At low levels, it is indispensable for scene segmentation; at high levels, it is required for the disambiguation of simultaneously configured distributed presentations (assemblies) (Wang 2005)." (Singer 2010, p. 160)

> intrinsic fluctuations of synchrony may predict[1] the subjects' alternating perception of the constant physical stimulus. Indeed, we found that beta-synchrony was not only enhanced during stimulus processing but also predicted the subjects' percept of the stimulus. (Hipp et al. 2011, p. 389)

So, some experiments show that the temporal structure of activity patterns indicates the states of "expectancy" or "anticipation" before the appearance of stimuli. (Engel et al., 2001 in Velik 2010, p. 999) It seems that the fluctuations of large-scale beta-synchrony determine the perceptual interpretation of stimulus. (p. 389) Hipp et al. propose that beta-band synchronization is the mechanism that mediates large-scale interactions among frontal, parietal and extrastriate areas. Gamma-band synchronization is involved in the subjects' percept of the ambiguous stimulus[2] and is directly linked to the cross-modal

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[1] I add this footnote: the "role of oscillatory synchrony in top-down attention appears also before stimulus onset, when subjects anticipate the appearance of the stimulus: pre-stimulus gamma oscillations successfully predict the speed of reaction times (55-57), are modulated by the degree of predictability of the stimulus (57-60) or the information content of the warning cue (61, 62). Oscillatory synchrony in the gamma range thus appears as an efficient mechanism to establish a neural state facilitating the processing of forthcoming stimuli – in other words, anticipatory attention." (Tallon-Baudry 2009, p. 324)

[2] Experimental results indicate that during the binocular rivalry, the rate of individual neurons in V1 cannot be predicted if a neuron from V1 belongs to the processes that produce conscious experience. On the contrary, we can predict that some neurons participate to the processes correlated with conscious experience measuring the synchrony of periodic activity of gamma frequency band. (Moser et al. 2010, p. 196) According to Doesburg et al. (2009), it seems that these perceptual switches are related to the theta and gamma synchronization. (in Melloni and Singer 2010, p. 23) Gamma-band is responsible for discrete moments of perceptions, while theta-band involves their succession in time. (Doesburg et al. 2009) Using MEG recording of visual stimuli, they "found approximately 100 ms momentary gamma phase-locking across large regions of cortex in response to lateralized visual signals." (Doesburg et al 2008 in Baars and Gage 2010, p. 289) "We propose that discrete moments of perceptual experience are implemented by transient gamma-band synchronization of relevant cortical regions, and that disintegration and reintegration of these assemblies is time-locked to ongoing theta oscillations." (Doesburg et al 2009 in Baars and Gage 2010, p. 290) About binocular rivalry and synchronization, see also Singer (2009).

integration of auditory and visual information.” (Hipp et al. 2011, p. 389, 390) Gamma-band synchronization includes central (sensorimotor and premotor regions) and temporal areas involved in multisensory processing. Premotor regions are involved in auditory, visual, and somato-sensory stimuli, while temporal regions in cross-modal integration of audiovisual stimuli.[1] (Hipp et al. 2011, p. 392)

Quoting the work of some authors, Tallon-Baudry indicates disparate results regarding these correlations: occipital, temporal, parietal and frontal regions or a focal activation, confined to the occipital pole. The problem is that MEG and EEG offer us different images about the visually induced oscillations: “while EEG data reveal a short-lived burst of oscillatory synchrony between 30 and 60 Hz and 200 and 300 ms, MEG studies consistently report sustained oscillations at higher frequencies.”[2] (Tallon-Baudry 2009, pp. 322-3) The results show that visual stimuli produce gamma oscillations at different areas and different frequencies. (p. 324)

Enumerating the works on synchronized oscillations of many authors, Fries emphasizes three main reasons why gamma-band synchronization is so important in the cortical computation: this frequency band (30–100 Hz) is involved in many brain regions

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[1] Interesting for Hipp is that the experiments indicate a “surprising dissociation between local oscillatory activity and long-range synchronization”. (Hipp et al. 2011, p. 392) Important for the main topic of this work, like many others, these authors indicate that the large-scale cortical synchronization is strongly related to the perceptual organization of sensory information. (p. 392) For Singer, the results “provide further evidence for the functional relevance of phase-locking across large-scale cortical networks in that they establish direct relations between the magnitude of synchronization and the outcome of a bistable perceptual task. As perceiving the bounce requires more cross-modal integration than perceiving the pass, the increase in phase-locking both in the beta and in the gamma network is compatible with the hypothesis that synchronization serves dynamic coordination of interactions.” (Singer 2011, p. 192)

[2] “Because scalp EEG electrodes integrate brain activity over larger areas than MEG sensors do, the signals from neighboring sources could be combined to generate the short-lived burst of gamma oscillations seen in EEG data. The better spatial resolution of MEG would reveal sustained activities from neighboring sources at distinct frequencies and foci.” (Tallon-Baudry 2009, p. 324)

(visual, auditory, somatosensory, motor, parietal cortex and outside the neocortex, the hippocampus); we can identify it at various species (from insects to humans); it is correlated to many human cognitive activities (sensory stimulation, attentional selection, working memory maintenance, etc. (Fries et al. 2007, p. 309). Some experiments show that visual attention is correlated to increases in coherence between local field potentials from the frontal and parietal cortex. (Buschman and Miller 2007, 2009 in Moser et al. 2010, p. 200) Theta oscillations seem to have a role in local hippocampal[1] functions and in long-range coordination between hippocampus and neocortex. (Baars and Gage 2010, p. 259)

Tallon-Baudry strongly emphasizes that there is no strict correspondence between a frequency band and a cognitive process.[2] (p. 239 or 2009, p. 325) After at least two decades of extensive research on synchronized oscillations, nobody can claim that a frequency band is responsible for (correlated to) a particular cognitive function. Moreover,

> the functional role of oscillatory synchrony in distinct frequency bands may simply depend on the functional specialization of the area that generates these oscillations

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[1] Hippocampal areas seem to be involved in changing the conscious experience in memories. (Baars and Gage 2010, p. 259)

[2] Essentially, there is “no doubt that gamma-band oscillations are influenced by stimulus low-level features in sensory regions (Hall et al. 2005; Adjamian et al. 2008), but whether this still holds true for higher-level areas remains an open issue.” (Tallon-Baudry 2010, p. 241) “There is growing evidence that distinct cognitive functions elicit oscillations at different frequencies within the gamma range (Chaumon, Schwartz, & Tallon-Baudry, 2009; Vidal, Chaumon, O’Regan, & Tallon-Baudry, 2006). However, there is no simple one-to-one relationship between a frequency range and a cognitive function! (Tallon-Baudry, 2009) For instance, depending on the experimental paradigm, the neural correlates of attention can be found in the high or low gamma-range (Vidal et al., 2006).” (Sperduti et al. 2011, p. 16) Moreover, we have to take into account that “the visible EEG waves are just the waves on top of the oscillatory lake. Underneath the irregular scalp EEG there are known to be synchronized rhythms.” (Baars and Gage 2010, 270)

(Tallon-Baudry et al. 2005), much as the functional significance of ERPs depends on the areas that generate them.[1] (Tallon-Baudry 2010, p. 240)

The correlation between a cognitive function and a frequency band depend on two sets of features: physiological needs (network's size and geometry, time, coding precision required, and metabolic costs for oscillations) and cognitive constraints (time, "chunks of processing", the number of cognitive function can be multiplexed). (Tallon-Baudry 2010, p. 241-2) In an article from 2011, Scheeringa et al. push further certain results regarding the relationships between BOLD signals and different frequency bands (alpha, beta and gamma powers).[2] The main conclusion of their empirical results (simultaneously recorded EEG and BOLD while subjects were engaged in a visual attention task) is that low-frequency (alpha and beta bands) neuronal synchronization correlates negatively with BOLD signal changes, while high-frequency (high-gamma band)

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[1] Related to this idea: "For instance the dependence of visual ERPs on the phase of pre-stimulus alpha rhythms (---) or ongoing gamma local field potentials (---) suggests an interaction between ongoing rhythms and transient evoked responses, although the exact nature of the relationship is a matter of current debate (---)". (Tallon-Baudry 2009, p. 327) Moreover, "… the nature and strength of the interaction could depend on the resting state frequency characteristics of each subject (Koch et al. 2008)." (Tallon-Baudry 2010, p. 239) "Obviously a full understanding of how a given function – here attention – operates at the neural level calls for an integration of the findings in ERPs and oscillatory synchrony in a more comprehensive schema." And in any case "oscillatory synchrony in a given frequency band should not be considered as a single phenomenon, functionally and anatomically homogenous (Tallon-Baudry 2010)." (p. 241) "Nevertheless, it appears that gamma oscillations and ERPs are not systematically co-localized (---), nor do they necessarily display the same functional modulations (---). Besides, the BOLD signal seems to correlate better with local field potentials than with spiking activity (---), but whether it corresponds better to ERPs (119) or oscillatory synchrony (---) remains unclear." (Tallon-Baudry 2009, p. 327)

[2] Mentioning the work of other researchers, Tallon-Baudry emphasizes that there is no event-related potential element correlated with gamma range for perceiving an object. Therefore, the neural properties reflected by induced gamma power synchronization and ERPs are different! (Tallon-Baudry 2009, p. 322)

neuronal synchronization correlates positively with BOLD signal changes.[1] (Scheeringa et al. 2011)

Having presented above various opinions on *segmentation*, let us see the results about the *integration* of different areas or different frequency bands. Following different criteria, there are various alternatives for cross-frequency coupling, but three main interactions are co-variations in amplitude (the power of one frequency that increases can determine the increase or decrease of the power of another frequency), phase coupling between frequencies (coupling an oscillation with n cycles to another with m cycles, i.e., n:m phase synchrony)[2], or phase-amplitude coupling. The phase of an oscillation could influence the amplitude of another oscillation. (Tallon-Baudry 2009, p. 326)

There is the hypothesis according to which faster waves (for instance, gamma range) may “multiplex” on slower waves (theta or alpha range). (VanRullen and Koch in Baars and Gage 2010, p. 255) In other words, theta oscillations (or even alpha), for instance, can group gamma band.[3] Alpha band can group gamma oscillations in

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[1] Mainly, “the BOLD-EEG coherence analysis further strengthens the notion that alpha and beta on the one hand, and high gamma on the other hand, independently contribute to explaining BOLD variance: the BOLD-gamma coupling is modulated by very slow oscillations (<0.02 Hz), while the BOLD-alpha and BOLD-beta coupling are not.” (Scheeringa et al. 2011, p. 575) Interestingly, from their experiments, Scheeringa et al. consider that “trial-by-trial fluctuations in alpha and beta power on the one hand and in high-gamma power on the other hand, are uncorrelated, though both contribute to the BOLD response. This strongly suggests that these contributions are independent from each other.”(*idem*)

[2] “Cross-frequency phase coupling links alpha, beta and gamma oscillations in humans during mental calculation and in a working memory task.” (Palva, J. M., S. Palva & K. Kaila 2005 in Tallon-Baudry 2009, p. 326). For a review regarding the role of gamma-band for attention and memory, see Jensen et al. (2007).

[3] “In the hippocampus [62], and more recently also in the neocortex, slow oscillations in the theta range have been found to be coupled to the coexisting beta- and gamma-oscillations. This suggests the hypothesis, that local coordination of computations within specific cortical areas is achieved by fast ticking clocks, such as beta- and gamma oscillations while global and sustained integration of local results is achieved at a slower pace by low frequency oscillations. This would allow the brain to represent the results of the numerous parallel computations at different

working memory. (Palva and Palva 2007 in Baars and Gage 2010, p. 270) “Steriade (2006) has suggested that slow oscillations may generally work to group faster ones. Even the newly discovered ‘slow oscillations’ that range from 0.1 to the delta range may serve to group theta, alpha, beta, and gamma.” (Baars and Gage 2010, p. 269) There is the hypothesis that the cross-frequency phase synchrony between alpha, beta, and gamma oscillations “coordinates the selection and maintenance of neuronal object representations during working memory, perception, and consciousness”.[1] (Palva and Palva 2007 in Baars and Gage 2010, p. 270) But “we now have a number of separate sources of brain evidence showing coherent gamma bursts in association with conscious perceptual moments, paced by rhythms near theta or alpha.” (Baars and Gage 2010, p. 290)

7.3.3 Gamma range in visual cognition

Since the main topic of this work is the binding problem, I would like to offer more detail about the role of gamma range in visual cognition. Gamma band is between 30-120 Hz, being low range (30-60) and high range (60-120) correlated with various cognitive functions. In the late 1980s and early 1990s, von Malsburg, Singer, Engel and Gray[2] were the first who showed that gamma band

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temporal and spatial scales, whereby the two dimensions would be intimately related.”(Singer 2009, p. 50)

[1] A figure from “Cantero et al. (2005) shows that long-distance gamma phase-locking, which reflects fast information transmission, is distinctively associated with the waking state, but not SWS or REM.” (Baars and Gage 2010, p. 289) “However, it is important to bear in mind that nature may not always go along with our conventions. Different subbands of gamma routinely seem to do different tasks, for example.” (*idem*, p. 270)

[2] “In 1989, the seminal paper of Gray and colleagues (22) showed that anaesthetized cats' neurons synchronized their firing on an oscillatory mode in the gamma range when the stimulus was perceived as coherent by a human observer, without significant effects on their mean firing rate.” (Talloon-Baundry 2009, p. 322) In many cases (for instance, attention and stimulus selection), synchronized oscillations are not necessarily associated with major changes in firing activity of neurons. Therefore, Singer considers that it is possible synchronization and rate of discharge “can be adjusted independently, and that precise synchronization can be used to raise

frequency is related to visual binding. (Tallon-Baudry 2009 or Fries 2005) Later, it has been discovered that this range is involved in many other cognitive functions like attention, memory or awareness.

> Induced gamma oscillations are thus not related to a single cognitive function, and are probably better understood in terms of a population mechanism taking advantage of the neuron's fine temporal tuning: the 10-30 ms time precision imposed by gamma-band rhythms could favor the selective transmission of synchronized information (attention) and foster synaptic plasticity (memory). Besides, gamma oscillatory synchrony also seems related to the emergence of visual awareness. The recent discovery that gamma oscillations could appear simultaneously in distinct areas at distinct frequencies and with different functional correlates further suggests the existence of a flexible multiplexing schema, integrating frequency bands within the gamma range but also at lower frequency bands. (Tallon-Baudry 2009, p. 321; also p. 326)

The best solution to the perceptual binding problem seems to be the synchronized oscillations alternative, a process that is involved probably in all visual levels (from retina to the highest cortical area) solving both segmentation and integration processes. (Singer 2010, p. 163; about gamma-band and conscious perception, see also Singer 2009)

> In all cases, synchronization probability reflects some of the Gestalt criteria that are used for scene segmentation and perceptual grouping. In the retina, ganglion cell responses synchronize with millisecond precision if evoked by continuous contours (Neuenschwander and Singer 1996). This synchronization is associated with high frequency oscillations (up to 90 Hz) and is based on horizontal interactions within the network of coupled amacrine cells. In the visual cortex, synchrony is often associated, especially when it is observed over larger distances, with an oscillatory pattern of spike discharges in the beta and gamma frequency range (30–60 Hz).[1] (Singer 2010, p. 163)

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the saliency of responses independently of discharge rate (Fries, Neuenschwander et al. 2001; Fries et al. 2007).” (Singer 2010, p. 165)

[1] Against Treisman’s theory, Singer sustains that for familiar object, for instance, grouping operations can occur pre-attentively without the attention to be involved. These binding operations are based on binding by convergence in feedforward structures and synchronization. (Singer 2010, p. 164) About grouping processes and neural synchronization, see Singer (2009).

The perception of a meaningful object is correlated with a burst of induced gamma oscillatory synchrony over occipital electrodes between 200 and 300 ms. With new methods of investigation, segmentation and object identification take place within less than 200 ms, grouping operations happening in 10 to 20 ms (Thorpe et al. 1996; VanRullen and Thorpe 2001 in Singer 2010, p. 163) “When the perceived object spans the vertical meridian, gamma oscillations in both hemispheres become phase-locked (33). Interestingly, the latency of this burst of oscillations correlates with object recognition delays (34).” (Tallon-Baudry 2009, p. 322) Among binding features, gamma oscillations are involved in spatial, feature-based and object-based attention.[1] (Tallon-Baudry 2009, p. 324)

Tognoli and Kelso (2009) offer a theoretical model of cortical coordination dynamics (“non-linearly coupled non-linear oscillators” with self-organization, multi-functionality, metastability and switching for the “short- and long-range connectivity in the cortex”) in order to mirror the functional specificity (segregation) and the integration in the brain. They use the framework of coordination dynamics to illustrate the role of “integrative mechanisms responsible for coordinating local processes into a functional whole” and for “expressing” the relationship between parts of the brain and their interactions with the external world. (Tognoli and Kelso 2009, p. 32) The “true” synchronized oscillations are responsible for integration. With coordination dynamics it is possible to

> (a) Identify key coordination or collective variables for complex coordination patterns at several levels of analysis; and (b) explain in mathematical terms how patterns of collective behavior emerge in a self-organized fashion from the nonlinear coupling among interacting components. (Tognoli and Kelso 2009, p. 32)

They combined their theoretical model for characterizing the EEG signals during:

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[1] Sperduti et al. indicate that it is quite possible that gamma oscillations could have a role in the anticipatory attention to duration. (Sperduti et al. 2011 p. 16)

> (1) Episodes of stationary coupling between brain oscillations; (2) transient patterns of phase synchrony between neural populations which we propose to be characteristic of metastable brain dynamics; and (3) abrupt phase transitions ('switches') between successive cortical patterns." (Tognoli and Kelso 2009, p. 32)

These authors want to show the difference between true and false synchronization. Essentially, the "dynamically stable states are reached when a key order parameter or collective variable (the relative phase between local oscillations) ceases to change over time, i.e. when brain areas engage in a synchronous assembly". (p. 32) In their dynamical framework, Tognoli and Kelso introduce the attractors that "bind local oscillations into phase-locked states". (*idem*) In order to solve the combination of different frequency bands, Tognoli and Kelso introduce the "metastability" as a form of coordination.

> The dynamics of this region is called metastability. The metastable regime bears only remnants of the attractors and is a fluent way to bind local areas with different intrinsic oscillatory properties (Fig. 1A, green), for instance, two local neural assemblies that need to interact, yet tend to oscillate at different frequencies. Metastability refers to a form of partial coordination that does not lock the dynamics of local areas into synchronized states. Rather, patterns of quasi phase-locking (dwelling tendencies) are created that dynamically summon and release brain areas without requiring costly disengagement mechanisms. Metastability thus enables the concurrent expression of both large-scale integrative activity and local autonomous activity (…). (Kelso, 1995; Kelso and Tognoli, 2007; Bressler and Kelso, 2001) (Tognoli and Kelso 2009, p. 32)

In their model, there are two sources of spontaneous oscillations "(1) local post-synaptic activity, self-organized and/or entrained by pacemaker cells; and (2) recurring network activity that engages local areas and remote sites into recurrent patterns of inhibition and re-excitation". (p. 33) Three categories of phase relationships are studied: pure inphase (zero-lag synchronization); antiphase (synchronization with a lag of half a cycle, oscillatory elements have identical intrinsic frequency); and near inphase or near antiphase (the symmetry of the dynamics is broken). (*idem*) I avoid giving more details about this work but their effort is to decipher real from spurious synchronies. They show that authentic "dwellings in the metastable regime are different from spurious dwellings that arise due to volume conduction. Metastability is the inherent result of broken symmetry in the coordination dynamics (e.g. frequency differences between coordinating brain areas).[1] (p. 38) The conclusion of this article is that the brain "uses multiple phases and metastable regimes to integrate the activity of diverse and heterogeneously connected parts into a functional dynamics, or in other words, to encode and communicate information". (p. 39)

From an EDWs perspective, we already know that within the definitions of oscillations we have to include the parameters of observational tools (usually an EEG). As we saw above, the progress of technology increases our ability to identify better the frequency ranges in the brain. Therefore, we cannot limit our judgments about oscillations to actual tools of observations. Moreover, Raichle's "default network", Baars's "global workspace" or Edelman's "dynamic core" force us to extend the identification of "metastable regimes" that integrate "the activity of diverse and heterogeneously connected parts" to the unity of the self or consciousness. There are too many states/processes within the brain and thus it is quite impossible for us to identify which states are particularly responsible for this unity. The "metastable" states are only rough approximations even if Tognoli and Kelso try to illustrate the difference between real and spurious synchrony. In fact, the unity of the self is the "I" and we cannot find this unity within the processes of the brain. Therefore, the "metastable" is a pseudo-notion incorrectly introduced within very dynamical continuous processes of the brain.[2] In fact, we have to move from certain epistemological conditions (the use of EEG) to

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[1] "A main obstacle to the goal of reading coordination from brain signals (especially in the case of EEG) concerns volume conduction and the spurious synchrony it gives rise to. With the help of a correlation model, we provided predictions that allow investigators to recognize both true and false patterns of synchronization." (Tognoli and Kelso 2009, p. 39)

[2] Again the analogy with table-microparticles: where is the stability of the table (or its color or surface) at the microparticles level?

certain ontological conditions (the being of the "I" or introspections as parts of the "I"). If we do not take into account this movement, we mix two EDWs.

Le van Quyen tries to combine "levels of organization" (that presuppose multiple temporal and spatial scales) with multiple-frequency ranges arguing for upward and downward causations within the framework of "brainweb of cross-scale interactions". (2011) The spatial scales are the microscopic scale (small clusters of neurons at approximately 100 mm), the mesoscopic scale (groups around 10000 connected neurons, approximately 0.4–0.5 mm in diameter) and the macroscopic scales (the division of the brain according to functional and anatomical criteria). The temporal scales corresponding to spatial scales are: couple of ms for spike, order of 10 ms for local synchronization of small networks, and several hundreds of ms for large-scale integration. (p. 58)

> In accordance with these different time and spatial scales, multiple neuronal oscillations (i.e. rhythmic or repetitive neural activity) are recorded, covering a remarkably wide frequency range and ranging from very fast oscillations with frequencies exceeding 400 Hz to very slow oscillations with periods of tens of seconds (Buzsaki, 2006). Fast oscillations reflect the local synchrony of small neuronal ensembles, whereas slow oscillations can recruit neuronal populations of several brain structures (Penttonen and Buzsáki, 2003).[1] (le van Quyen 2011, p. 58)

Le van Quyen makes a major double-mistake. He considers that the macroscopic properties "emerge" from microscopic properties, and global patterns modulate the microscopic properties.[2] We have here

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[1] "Through the relationship between oscillation phase and neuronal excitability, these slow waves modulate the emergence of multiple mesocopic oscillations in high-frequency range (40–200 Hz) and determine whether these oscillations are attenuated or amplified on the large-scale level." (Le van Quyen 2011, p. 61)

[2] In his words, a "crude formulation, the software is acting on the hardware." (p. 59) Totally wrong! It reminds me of Searle's approach (the mind is produced by the brain), another major mistake. (About my critics against Searle's view, see Vacariu 2008)

upward and downward causations.[1] Obviously, almost everybody rejects downward causation (see, for instance, Craver and Bechtel 2007). From my viewpoint, downward causation is really meaningless. Nevertheless, another notion is quite useful: the "type of cross-frequency coupling" that is called "phase-amplitude modulation".

> All oscillations are state-dependent but numerous oscillation bands are simultaneously present in the different states of the wake–sleep cycle and can modulate each other. In this context, I explore and advance the proposition that these multiple neuronal oscillations that run at various frequencies and on multiple spatial scales serve as crucial instruments for scaling up or down in brain dynamics (…). Specifically, oscillatory variations in neuronal excitability generate (non-local) constraints that lock the many degrees of freedom of a smaller scale together (see examples above). Following this general rule, the macro-, meso- and micro-scopic scales can be braided together by co-occurring oscillations at successively faster frequencies that modulate each other by variations of the underlying neuronal excitability. (Le van Quyen 2011, p. 60-61)

This paragraph reflects directly the unicorn world view. From an EDWs perspective, I want to draw the attention upon the fact that a mental state at one moment is not identical with particular widely distributed activated neuronal patterns and/or oscillation bands. Firstly, an activated neuron (or an oscillatory frequency) does not exist in the same EW as a large activated neuronal pattern (or another frequency band): there are many EDWs at one moment that correspond to the brain. Secondly, I emphasize again the main point of this book: it is the relationships between each entity and other entities (not the human observer) that furnish the ontological-epistemological[2] background. The image of the "world" becomes,

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[1] "In common discourse, this causation simply refers to higher levels exercising causal effects over lower. For example, mind–brain interaction: 'I felt like moving my arm, so I did.' Here the mental realm of feelings and volitions is expressed as exercising causal efficacy over flesh." (p. 59) and "This bridge between phase-amplitude modulations of slow oscillations and flow of consciousness remains to be further investigated by empirical testing." (le van Quyen 2011, p. 62) No comments!

[2] The distinction between ontology and epistemology is totally wrong. (See Vacariu 2005, 2008, 2011)

indeed, quite strange and complicated, but this is the “world”, the EDWs! Otherwise, it is much worse working within the unicorn world. Nevertheless, integration is created not by a super-entity/process (a neuronal pattern or particular frequency band), but belongs to another EW, or more exactly, integration is the “I”. Again, exactly as we do not check for color within the brain or the mind (but only for representation of color that is the “I”, see Chapters 8 and 9), we do not check for the “integration” within the brain-EW or for space within the mind-EW! Interestingly, le van Quyen ends this article with the following idea: “Neuroscientists focus on one or two levels of the nervous system at a time, however, and there has been very little success in integrating their observations so as to create a unified understanding of brain dynamics.” (p. 62) He recalls his answer to this problem: a “model of multi-level interactions is based on a tight phase-amplitude coupling of neuronal oscillations that operate at multiple frequencies and on different spatial scales”. (*idem*) Moreover, le van Quyen reminds me of Varela’s “neurophenomenolgy” based on downward causation: conscious experiences have causal effects on large-scale neuronal patterns: slow cortical oscillations could be “physiological signatures” of these downward influences. (p. 62) He insists that the alternance between low and high excitability neuronal states is “consistent” with the “temporal flow of conscious experience” (as example, the binocular rivalry by the first-person reports). In this sentence, we can find a problematic notion: what does “consistence” mean? The flow of conscious experience is continuously without the “I” feeling any alternance! Again, his major mistake is the insertion of downward causation that produces a terrible mixture of EDWs.

Very important for my approach is the analysis made by Frégnac et al (2010) about the notion of dynamic coordination applied to certain neural processes correlated with non-attentional perception. Analyzing the whole-parts or segmentation-integration (binding) relationships regarding the sensory stimulus correlated with some neural processes/states, the authors concluded that

> to a certain extent, both in invertebrate ganglia and the vertebrate brain, the dogma of separability between intrinsic and extrinsic factors in the control of cellular excitability is doomed to fail. Thus, the "whole" cannot be the sum of the "parts," and segmentation does not always coexist with perceptual binding. (Frégnac et al. 2010, p. 172)

This paragraph seems to be written by somebody working under the EDWs framework! Using the results of some perceptual experiments (visual illusions), Frégnac and colleagues try to show that the Gestalt rule is correct: the whole precedes the detection of parts in time. Within the dynamic coordination, a "dynamic agent" could be an internal supervisor embedded in the network, sensory drive or an external prior. Using the binocular rivalry in cat, Engel and Singer explore the role of gamma oscillations in comparing conscious versus unconscious stimulus processing in the visual cortex with identical physical input to both eyes. In more detail, "in the cat's cortex, the dominant (conscious) eye demonstrated gamma synchrony locked to the 'conscious eye', whereas the nondominant (unconscious) eye showed no synchrony."[1] (in Baars and Gage 2010, p. 265) Interestingly, Singer claims that in the case of binocular rivalry, those two patterns that are perceived in alternation need a mechanism "which selects in alternation the signals arriving from the two eyes for access to conscious processing."(Singer 2009, p. 48)

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[1] "Direct evidence for an attention related facilitation of synchronization has been obtained from cats that had been trained to perform a visually triggered motor response (…). Simultaneous recordings from visual, association, somatosensory and motor areas revealed that the cortical areas involved in the execution of the task synchronized their activity, predominantly with zero phase-lag, as soon as the animals prepared themselves for the task and focused their attention on the relevant stimulus. Immediately after the appearance of the visual stimulus, synchronization increased further over the recorded areas, and these coordinated activation patterns were maintained until the task was completed. However, once the reward was available and the animals engaged in consummatory behaviour, these coherent patterns collapsed and gave way to low frequency oscillatory activity that did not exhibit any consistent phase relations. This close correspondence between the execution of an attention demanding visuo-motor performance and the occurrence of zero phase-lag synchrony suggests a functional role of the temporal patterning in the large scale coordination of cortical activity."(Singer 2009, p. 47)

From the EDWs perspective, I believe that this mechanism would be something quite similar to the eternal homunculus. Therefore, we have to reject the idea of any such mechanism.

7.3.4 Communication among neural areas through synchronized oscillations

Let me analyze the main ideas of Fries' approach on gamma-band frequency, the band that has been considered as having a fundamental role in cortical computation. Fries' main concept is the *neural connectivity* (strongly related to cortical computation). When we talk about the neural connectivity we have to solve the problem of selectivity and the invariance of neural outputs. Fries' new approach regarding the communication among different parts of the brain is *"communication-through-coherence"* (CTC) hypothesis. He considers that the interactions among rhythmical active neuronal groups depend on the neuronal synchronization.[1] (Fries 2005, or 2009, p. 214) Such communication is essential for many important correlated cognitive tasks. In general, the researchers from cognitive neuroscience consider that the neurons communicate either through action potential rate or action potential synchronization. For Fries, the *coherence* represents the communication messages between two neuronal groups. (Fries 2005, p. 474) The inhibitory interneuron networks are associated with the rhythmic inhibition of pyramidal cells.[2] (Fries 2005, Fries et al 2007) Within the gamma cycle,

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[1] The main difference the binding-by-synchronization (von der Malsburg, etc.) and Fries's approach is that the first is psychophysiological hypothesis (a correlation between brain and psychological states), the second is physiophysiological hypothesis, ("the relation between two physiological phenomena, namely neuronal synchronization and neuronal interactions", Fries 2009, p. 210). The synchronization of action potentials of a group of neurons is responsible for binding them in a neural state that is correlated with a cognitive function (for instance mental perception. The binding-by-synchronization is a "representational code", while "the CTC hypothesis considers the mechanistic consequences of neuronal oscillations for neuronal communication". (Fries 2005, p. 475)

[2] It is supposed on some empirical results that gamma oscillations are caused by interactions between pyramidal cells and interneuron (basket) cells. (Scheeringa et al. 2011, p. 579) "Pyramidal cells are excitatory, using glutamate as their major

> the excitatory input to a pyramidal cell is converted into a temporal code whereby the amplitude of excitation is recorded in the time of occurrence of output spikes relative to the gamma cycle, stronger inputs leading to earlier responses. Thus, amplitude values are converted into phase values that indicate by how much a discharge precedes the peak of a gamma cycle.[1] (Fries et al. 2007, p. 309)

So, the rhythmic synchronization of interneurons induces synchronized rhythmic inhibition onto the pyramidal cells, which discharges in rhythmic synchronization. Within the gamma-band synchronization, between the discharges of interneurons and pyramidal cells a phase relation[2] is established, the interneurons firing a few milliseconds after the pyramidal cells. (Fries et al. 2009, p. 310) The property of long-range interneurons is that

> their axon caliber is nearly twice as large as that of parallel conduits from pyramidal cells connecting the same regions and the diameter of the surrounding myelin is

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neurotransmitter, but they are surrounded by small inhibitory interneurons that use GABA as their neurotransmitter. Excitatory and inhibitory neurons work together in the same local patch of cortex."(Baars and Gage 2010, p. 244) Excitatory neurons synchronize their firing if they are driven by a common inhibitory cell. (*idem*, 252) "… gamma-band oscillations would critically depend on GABA interneurons in upper layers." (Tallon-Baudry 2011, p. 241) "Cortical interneurons using the inhibitory neurotransmitter gamma-aminobutyric actid (GABA) have been shown, in both in vitro (Whittington et al., 1995; Fisahn et al., 1998) and in vivo (Klausberger et al., 2003) studies, to be essential for the generation of gamma frequency oscillations." (LeBeau 2010, p. 31) More details about "long-range" interneurons (for instance, GABAergic interneurons), see Moser et al. 2010, pp. 208-9. Moreover, it seems that "parvalbumin-containing interneurons in particular have been shown to be critical for the generation of gamma frequency activity." (LeBeau 2010, p. 31)

[1] "Transforming an amplitude (rate) code into a temporal code could have a crucial role in object recognition: spike latency coding or spike rank order coding has been the core component in a class of computational models that perform object recognition with remarkable speed and computational efficiency." (Fries et al. 2007, p. 312)

[2] "Oscillatory inhibitory inputs to pyramidal cells veto the latter's discharges during the inhibitory troughs and favor discharges at the depolarizing peaks, thus causing synchrony in firing. Surprisingly, these locally synchronized oscillatory responses can become phase-locked, with zero delay over large distances, despite considerable conduction delays in the reciprocal excitatory corticocortical connections that mediate long-range synchrony (Engel, König, Kreiter et al. 1991)." (Singer 2010, p. 162)

three times thicker (Jinno et al. 2007). The estimated volume of the total axon arbor of a long-range interneuron is several times larger than the volume occupied by the axon tree of pyramidal cells, suggesting that only few such neurons may be needed to establish coherence between regions. There was consensus in the group about the need for further investigation of the potential role of long-range fast-transmitting inhibitory interneurons in fast inter-area cortical synchronization. (Moser et al. 2010, p. 209)

Singer mentions several alternatives to establish the zero-phase lag synchronization despite conduction delays: the interneurons discharge with spike doublets when the networks engage in beta and gamma oscillations[1] (Kopell et al. 2000); the special topology of coupling connections and the nonlinear properties of networks of coupled oscillators (Vicente et al. 2008); finally, the "precision with which spike timing can be adjusted increases with oscillation frequency (Volgushev et al. 1998) and, often, one observes a relation between oscillation frequency and the distance over which synchronization is maintained." (Singer 2010, p. 162) However, there are researchers considering that the zero-phase lags are improper for the synchronization over long distances. Other alternatives would be (a) the phase shifts "to coordinate convergence of distributed information from different sources or to enforce timing relationships that would establish specific patterns of dynamic routing"[2] (b) a neural population has different phase lags to different subsets of population (c) the role of ascending neuromodulatory systems. (Moser et al. 2010, p. 207-10)

Gamma cycle represents a temporal framework for the latency of neuronal spikes[3] but the timing of each pyramidal cell's spikes is furnished by its level of excitation that depends on the

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[1] For more details, see Moser (2010), p. 206.

[2] For an example of time-shifted synchronization across brain areas in a study of frontal eyes field and attention, see Gregoriou et al. (2009) in Moser et al. (2010), pp. 207-8.

[3] Fries et al. indicate that "neuronal response onset latencies in this case should be determined not only by stimulus onset, but also by the phase of ongoing rhythmic activity". (Fries et al. 2009, p. 314)

relationship between the properties of the stimulus and the functional architecture in which the pyramidal cells are embedded. (Fries et al. 2007, p. 314)

> If a given neuronal processing stage does encode information in the precise spike timing during its gamma cycle, then the next processing stage can decode this information best when it receives a copy of the temporal frame; that is, the gamma cycle. Long-range gamma-band synchronization has been described […] and probably synchronizes rhythmic inhibition across separate local networks, thereby enabling distributed spike-phase based computations to operate on the same reference frame. (Fries et al. 2007, p. 314)

This relative timing of spikes is important for the binding problem: the binding features are coded by columns that oscillate with zero phase lag.

> This has the effect that the latencies of the first spikes of cells responding to groupable features co-vary and are similar. Hence, these discharges are synchronized from the beginning. Following the indications that synchronous firing serves to establish relations among distributed responses […], it has been proposed that this rapid synchronization of first spikes supports rapid feature binding and perceptual grouping. (Fries et al. 2007, p. 314)

Through oscillations of different neuronal groups, the rhythmic modulations are created in neuronal excitability that influences the spike output and the sensitivity to synaptic input. More exactly,

> rhythmic excitability peaks constitute rhythmically reoccurring temporal windows for communication. Only coherently oscillating (or phase-locked) neuronal groups can communicate effectively, because their communication windows for input and for output are open at the same times.[1] (Fries 2005, p. 474 and 475)

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[1] Similar processes are necessary for attention that needs gamma-band frequency when a subject searches for a visual shape in a noise visual input: “In addition to bottom-up amplification, oscillatory synchrony could also play a role as an attentional top-down filter: if high-order areas are in a preset oscillatory mode, with neurons' membrane potentials alternating between peaks and troughs, only those inputs falling at the peaks of an oscillatory cycle will have an impact. In other

Obviously, the communication through coherence requires the "precise timing of events"[1]: "the frequency of the coherent oscillations, the relative phase between them and the conduction delay need to match."[2] There is unidirectional and bidirectional communication. For bidirectional communication, the coherence between two groups of neurons happens at zero-phase (that means they are synchronized) when the "conduction delays were on the same order as the cycle length of the oscillation" and the "spike output generated in one cycle would always arrive at the respective receiving group at the peak of the next cycle." (Fries 2005, p. 476)

The strength of interactions is measured by "correlations among rhythm strengths across all epochs with a certain phase relation". (Fries 2009, p. 214) The interaction strength between these rhythmic activities is determined by the phase relation between two local rhythms. (2009, p. 214-5) There are, for instance, two neuronal groups (A and B) that furnish the converging synaptic input to a target group (C). (Fries 2009, p. 215) If there are two stimuli, one attended and the other unattended, the neural difference is that the "spikes from the sending neurons driven by the attended stimulus are

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words, only those inputs matching with top-down expectancies will be transmitted." (Tallon-Baudry 2009, p. 324)

[1] "Around the time when monkeys find and shift attention to a visual target, there is an increase in coherence in two different frequency bands: an upper frequency band (35–55 Hz) for bottom-up attention (pop-out), and a lower frequency band (22–34 Hz) for top-down attention (conjunction search). During search for conjunctions, the monkeys shift the location of their attention every 40 ms. The attention-related shifts in frontal eye field spiking activity were correlated with increased power in the lower frequency band, suggesting that the oscillations act as a "clocking" signal that controls when attention is shifted (Fries 2009). The study suggests that serial covert shifts of attention are directed by the frontal eye field and that synchronization between cortical systems may regulate the timing of cognitive processing." (Moser et al 2010, p. 200)

[2] Related to these ideas: "the impact that an EPSP [excitatory postsynaptic potential] has on an oscillating target cell will depend on the time of arrival relative to the gamma cycle (…). This time depends essentially on three variables: (i) the time of spike generation in the sending cell relative to its oscillation cycle; (ii) the conduction delay between the sending and receiving cell; and (iii) the phase relation between the oscillations of the sending and receiving network." (Fries et al. 2009, p. 315)

more precisely gamma-band synchronized than the spikes driven by the unattended stimulus" (Fries 2005, p. 478) and there will be a phase-lock to the attended input. Fries analyzes the conditions in which a group of neurons C communicates exclusively with another group of neurons A (but not with B). What are the mechanisms necessary for such exclusive communication link? These mechanisms are the coincidence detection and the rhythmic gain modulation.[1] (Fries 2009, p. 215) In order for gamma-band synchronization to bring about exclusive communication link, two conditions are necessary:

(1) The "inputs driven by a given stimulus need to be rhythmically synchronized to each other, but not to inputs driven by other stimuli" and this is realized through the binding-by-synchronization (von Malsburg)

(2) One of "the input segments must be given a competitive advantage over the other by enhancing its gamma-band synchronization". We have here biased competition through enhanced synchronization (Fries 2005). (in Fries 2009, p. 216)[2]

Neural connectivity involves directly the idea of convergence of inputs in specific patterns onto targets which create the neuronal selectivity and the invariance of neuronal responses. Selectivity is realized by higher neuronal level through learning

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[1] "The presence of synchronization is equivalent to a consistent phase relation between the rhythms of inputs and gain changes." (Fries 2009, p. 213) "The reason behind the winner-takes-all mechanism is the inhibition-mediated rhythmic input gain modulation in C, which lends high gain to the input that is coherent with C but low gain to the input that is not coherent with C. Which input actually achieves coherence with C is likely determined by the coincidence detection mechanism. The coincidence detection mechanism renders C sensitive to the synchronization among the neurons in group A, for example. If those neurons in group A are precisely gamma-band synchronized to each other, then they will trigger many spikes in C and thereby entrain the interneuron network of C to the phase of the rhythm in A. Once this entrainment is achieved, the input gain effect will exert the winner-takes-all mechanism: It will reduce the impact of B and further amplify the impact of A in their competition for control over C. " (Fries 2009, p. 215)

[2] For a summary of the relationships among A, B, C neural groups and these two conditions, see also Moser et al. (2010), p. 201.

mechanisms: when certain inputs pattern occurs frequently, the synapses of those neurons strengthen.

> The outputs of those neurons feedback roughly to the neurons that provide the learned input patterns (Lund et al. 2003). Thus, feedback from them will contain the learned input structure. This feedback will provide a sort of prediction on the basis of prior experiences and will thereby refine the segmentation of an actual given input pattern. Thus, segmentation and selection may evolve together whenever an input is processed. This coevolution could be likened to a fitting procedure in which a model that is distributed over several levels of the cortical hierarchy is fitted to the input. I propose that this fitting process is a fundamental cortical computation and is mechanistically subserved by gamma-band synchronization. (Fries 2009, p. 217)

Invariance can produce confusion that is surmounted by segmenting the input and selecting one segment at a time. The role of gamma-band synchronization is exactly this segmentation and selection. Regarding the relationships between different frequency-bands, Fries emphasizes the fact that the strength of gamma-band synchronization is modulated with phase of theta and alpha rhythms. For instance, “if each theta cycle first makes and then breaks a gamma-synchronized network, then this theta rhythm probably makes and breaks selections of the input segments.” (Fries 2009, p. 219) Nevertheless, the relationship between different frequency bands is very unclear, so more empirical research is necessary in the future.

In a very recent paper, Womelsdorf and Fries (2011) insist on the idea of selective attention through “selective neuronal synchronization of rhythmic gamma band activity within and between neuronal groups”. The authors also analyze the relationship between the “selective attention” and synchronization. Attentional selection modulates interactions at different levels (among single neurons[1] or interactions among local[2] and long-range[1] (long

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[1] “At the level of microcircuits, inhibitory interneuron networks have been shown to impose rhythmic synchronization capable of effectively controlling the gain of the neuronal spiking output (…).” (p. 110)

[2] “At the level of local neuronal groups, attention selectively synchronizes the responses of those neurons conveying information about the attended feature or location (Womelsdorf and Fries 2007).” (p. 110)

distances) groups). At these levels, the “selective modulation of interactions” is based on “selective synchronizations” at various frequency bands.[2] Both temporal and spatial selective attentions depend on selective synchronization. Based on some quite recent research, it is believed that the interneuron networks, through their excitatory drive and rhythmic inhibition, produce gamma-band synchronization. (Womelsdorf and Fries, p. 114) Two neuronal groups interact through rhythmic synchronization. The strength of their interaction is given by the phase of synchronization.[3] If their synchronizations are out of phase, the groups do not interact. Various experiments show that synchronizations determine neuronal interaction in time, space and frequency. The authors are convinced that the interneurons are attentionally modulated. The experiments on macaque visual cortical area V4 (Womelsdorf, Fries, etc.) illustrate that gamma-band synchronization regulates the spatial attention.

Another important role of gamma-band synchronization is that “the speed of change detection could be partly predicted by the strength of gamma-band synchronization shortly before the stimulus change actually occurred (Womelsdorf et al. 2006).” (p. 118)

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[1] “And the coherent output from these local neuronal groups has been shown to selectively synchronize over long-range connections with task-relevant neuronal groups in distant brain regions (…).” (p. 110)

[2] “Neuronal synchronization is typically of an oscillatory nature, i.e., neurons fire and pause together in a common rhythm. When synchronization is rhythmic, it is often addressed as coherence, and we will use these terms interchangeably.” (Womelsdorf and Fries 2011, p. 110)

[3] Singer remarks that “when engaged in oscillatory activity, neuronal responsiveness to excitatory input varies periodically, being maximal around the depolarizing peak and minimal when the membrane is subsequently shunted by the massive synchronized inhibitory volley. As a consequence, oscillating cells are able to listen to the messages sent by other cells only during a narrow window of opportunity (Fries, 2005; Fries et al., 2007). The duration of this window is inversely proportional to the oscillation frequency and at high gamma frequencies may be as short as a few milliseconds. Hence, the information flow between cell groups oscillating at the same frequency can be gated very effectively by shifting the phase relations (Womelsdorf et al., 2007).” (Singer 2011, p. 191)

Supporting the EDWs is the idea that "attention modulates gamma-band synchronization beyond sensory visual cortex." (p. 119) For instance, the tactile perception is reflected with dynamic oscillations beyond somatosensory cortex; attention to a painful tactile simulation requires oscillations across somatosensory cortex, medial prefrontal and insular regions. (p. 119) More important, the spatial and temporal expectation states need particular bands synchronization, in general lower than gamma band. Moreover, "attention enhanced synchronization of the responses of those neurons sharing a preference for the attended target feature, irrespective of the spatial location of attention (Bichot et al. 2005)." (p. 123) Quoting the name of different authors, Womelsdorf and Fries considers that the strength of neuronal synchronization in gamma-frequency band determine neuronal stimulus preference (for instance, orientation and spatial frequency, the speed and direction of visual motion, spatial motor intention and movement directions. This shows that rhythmic synchronization carries "feature-selective" information. (pp. 123-124)

Attentional processes require not only local synchronization but also inter-areal (distant cortical regions) synchronization in gamma and beta bands. For instance, quite recent studies in macaque monkey show that

> fronto-parietal and intra-parietal interactions between areas are accompanied by synchronization at beta frequencies (15–35 Hz) during task epochs, requiring searching for and selecting behaviorally relevant visual stimuli (Buschman and Miller 2007; Saalmann et al. 2007; Pesaran et al. 2008). (p. 124)

Beta band synchronization furnishes the sensorimotor integration (Brovelli et al. 2004 in Womelsdorf and Fries, p. 126); or "perception of coherent objects from fragmented visual scenes goes along with transiently enhanced beta-band synchronization of the LFP among prefrontal, hippocampal and lateral occipital sites (Sehatpour et al. 2008)". (Womelsdorf and Fries, p. 126)

Kinsey et al. (2011) are still convinced that the best alternative for binding the features of an object and its segregation from background (and other objects) is the synchronized oscillations approach. Because of the existence of feedback projections the authors reject the hierarchical model (the number of neurons activated for an object would be “unacceptably large”, p. 392) and plead for oscillations.[1] Using MEG and fMRI retinotopic mapping, Kinsey et al. observed alpha, beta and gamma bands frequencies in certain early visual areas (ventral cortex at the border of V1 and V2). MEG results of other experiments indicate (a) changes in gamma frequency band in contralateral hemisphere for spatial location and therefore for processing visual target (V1/V2 border, “gamma is modulated by the emergence of the figure against the patterned background”) (b) power changes in alpha and beta take place in contralateral and ispsilateral hemispheres being independent in location maybe related to attentional mechanisms. Their experiments support these results and also show that gamma rhythms in figure-ground segregation as a results of labeling (related to increase of

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[1] They mention that the gamma activity “has been studied in both animals (Fries et al., 1997; Gail et al., 2000; Logothetis et al., 2001; Rols et al., 2001; Siegel and Konig, 2003) and humans (Keil et al., 1999; Tallon-Baudry, 2003), and may play a defining role in feature integration (Gray and McCormick, 1996), object recognition (Tallon-Baudry and Bertrand, 1999) and selective attention (Fell et al., 2003). Numerous studies have suggested that alpha rhythms (8–13 Hz) may also play a key role in object processing and visual attention (Thut et al., 2006; Vanni et al., 1996; Worden et al., 2000; Yamagishi et al., 2008, 2003, 2005). Beta rhythms (13–30 Hz) may be important for visuo-motor processing, including both real (Maratos et al., 2007) and imagined (Neuper et al., 2009) interactions with objects. Recent evidence also provides strong support for the role of beta rhythms in modulating general visual attention (Kinsey et al., 2009; Maratos et al., 2007).” (Kinsey et al. 2011, p. 393) Against the synchronized oscillations: “synchronized firing in a pair of neurons is not related to feature binding (Dong et al., 2008) or the perceptual organization of a scene (Lamme and Spekreijse, 1998). Others suggest that the synchronized activity may be minimal or absent altogether for processes related to both figure–ground patterns (Craft et al., 2007) and drifting coherent plaid patterns (Thiele and Stoner, 2003). Finally, an electroencephalographic study on humans demonstrated that the striking perceptual differences between Gestalt and nonGestalt images were not accompanied by marked changes in gamma activity (Heinrich et al., 2002).” (*idem*) I quoted these two paragraphs just to illustrate that nothing is certain regarding the synchronized oscillations for the binding problem.

gamma) and border ownership segregation (related to decrease of gamma).[1] (pp. p. 397-398) Moreover, power increases in high frequency gamma are correlated with attentional changes as a consequence of global motion onset and “the late occurrence of gamma changes (~250 ms after target onset) in the V1/V2 region supports the notion that feedback from higher cortical areas is important for figure–ground segregation”. (p. 398)

7.3.5 The main critics against temporal coding hypothesis

Quite difficult to observe synchrony oscillations in detail, their role in binding processes is unclear and still controversial. Important to notice is that this hypothesis is about how binding is signaled and not how binding is computed. (Velik 2010, p. 997) Moreover, synchronization cannot be an alternative to the *enduring* trait of representation of an object (LaRock 2010, p. 455 or 457). The synchrony oscillatory hypothesis is flexible regarding the long-term memory, but the problem is that “even features that are very likely to co-occur would need to be bound anew every time they are encountered. Thus this kind of binding would be economical in terms of cognitive structure but wasteful in terms of processing time.” (Hommel and Colzato 2009 in Veliko 2010, p. 998)

The synchrony oscillatory does not explain the spatial structure necessary for binding the features.[2] (LaRock 2007, p. 801) Frank van der Velde and Marc de Kamps emphasize that synchronization does not solve the productivity in case of binding. (Frank van der Velde and Marc de Kamps 2006, p. 41) They indicate that for the binding constituents in combinatorial structures, synchrony detectors will be missing for the novel structures. (van der Velde and Kamps 2006, p. 41) Also, very recent experiments on the visual mechanism of monkeys show that synchronization does not

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[1] The authors insist on their results regarding the difference between gamma (high frequency) activity and alpha and beta low frequencies: the “power changes in alpha and beta were independent of the spatial location of the target” against on a black background. (Kinsey et al. 2011, p. 398)

[2] It is believed that parietal lobes are necessary for spatial feature. (Robertson 2003)

depend on the binding problem but only on the selectivity of finding the „border-ownership" of an object. (Dong et al. 2008) In other words, synchronization process takes place for the detection of an object's border and not for the binding of the object's features. Robertson emphasizes some empirical evidence from neuropsychology that indicates that the preattentive binding can influence the performance. (Robertson 2003, 2005) Humphreys et al. suggest that the perceptual performance is facilitated by the unconscious binding.[1] (Humphreys et al. 2002, p. 363) Under Kant's framework, LaRock mention Zeki who

> points out that becoming aware of temporally segregated feature representations of an object over time is not the same as being aware of a bound percept: "subjects become conscious of the bound percept only after they become conscious of the attributes that are bound, again suggesting a temporal hierarchy in perception". It is worth mentioning that at a very early stage of visual information processing, the law of global dominance prevails; that is to say, the form (or Gestalt) of an object is automatically and pre-attentively established, and only afterwards are local features represented. (Zeki in LaRock 2010, p. 461)

and

> In a similar Kantian vein, Zeki ultimately concludes that the only entity that counts as truly unitary "sits at the apex" of the processing hierarchy, and this entity is the **self**. (LaRock 2010, p. 462)

LaRock works under the Kantian framework: the persisting character of the cognizing human subject is the necessary condition for the binding problem. (LaRock, p. 462) Nevertheless, even if LaRock is quite close to the EDWs perspective, he fails when he introduces the notion of emergence, i.e., the self emerges from the brain. (*idem*) Finally, Nicolaev et al. mention that there is more and more evidence that ongoing activity affects the response of animals and humans to sensory stimulation. (About "ongoing activity, see Raichle's default network in section 11.2) Moreover, the ongoing activity is related to

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[1] For other critics against oscillations, see Velick (2010).

learning knowledge (habituation, see below) of stimulation and therefore may mirror the anticipation of stimuli (prediction, see below). (Nicolaev 2009, p. 1)

Rolls and Treves (2011) strongly criticize oscillations as an alternative for the binding problem (vision).[1] From some experiments realized by Rolls and other people, the authors consider that information for the binding problem in vision is furnished by the firing rate of neurons, while oscillations bring no more than 5-6% information. Even the spatial information of the features of an object or for the spatial position of an object in a scene is furnished by the firing rate and not by oscillations. Interestingly, the authors believe that oscillations are important for grouping but not for spatial information. Important for fMRI's capacities is that

> information from different voxels was not independent, and there was considerable redundancy across voxels. This redundancy was present even when the voxels were from different brain areas. The pairwise stimulus-dependent correlations between voxels, reflecting higher order interactions, did not encode significant information. (Rolls and Treves 2011, p. 483)

Essentially, the number of stimuli and speed of information in a short period of time (20 ms) that can be encoded by the firing rate is much greater than the number and speed of information encoded by oscillations. (Rolls and Treves 2011, p. 485) The information of firing rate across a population of neurons can be decoded using the dot product (a plausible biological method useful for generalization and graceful degradation, for instance).

I end this chapter with Uttal's view about the binding problem. In a manuscript (section 1.2.4)[2], Uttal argues that the binding problem is a "non-problem". The binding problem appears in different contexts and at different levels, mainly at the psychological

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[1] The title of section 3.3.7 is this one: "Stimulus-dependent neuronal synchrony is not used for binding even with natural vision and attention." (Rolls and Treves 2011, p. 475)

[2] I would like to thank very much to Bill Uttal for having sent me some chapters from his forthcoming book.

level. Uttal offers a list of eight points that can be divided in these major groups: neurological vs. psychological and psychological. In the first group, we have the “discrepancy” between the individual (micro) and the global (macro) properties of neurons in relationship with a unified psychological experience, and the conditions of transmitting neuronal signals. In the second group, the perceptual scene can be separated in sub-elements, the signals of different sensory mechanisms have to be integrated in the unified psychological experience, and semantic and syntax of language have to be combined in order to get the coherent speech.

> … it is clear that there are actually two distinguishable aspects of the binding problem. The first is apparent need to combine the activity of neurophysiological entities in order to produce a unified psychological experience. The second is the apparent need to combine what are perceived as separable parameters of experience into a unified psychological experience. (Uttal, manuscript)

From an EDWs perspective, the first group reflects the pseudo-relationship between the neuronal processes and the mental states that belong to EDWs, the second group mirrors the relationship between each mental state and the “I”. For Uttal, the main question is “how is it possible that *one* **unified experience can come from a collection of separated components?**” (his bolds) From my viewpoint, some separated components exist in the neuronal states, but the corresponding mental components are the “I”, so we do not have a real differentiation within the mind-EW. Nevertheless, Uttal strongly emphasizes the difference between “the neurophysiological aspects of the binding problem and the perceptual or cognitive aspects”. (Uttal, manuscript) Again, I emphasize that Uttal lacks the EDWs. He believes that the binding problem is a bad problem. “The kinds of discrepancies that appear to exist between the different levels of analysis are largely illusions that elude explanation for reasons I shall refer to repeatedly in this book—system complexity (information overload) and single neuronal insufficiency (information poverty).” (Uttal, forthcoming) For me, the “theory of complexity” (see the Santa Fe Institute, etc.) is also a pseudo-theory.

Nature does not think (in fact it does not exist), therefore it is not so complex as scientists thought! If we replace “nature” (that is the “world”, “universe”) with EDWs, the complexity vanishes. Complexity has the same status as cognitive neuroscience: a pseudo-ontological status. For Uttal, the “system is complex” means “the combinatorics of the brain’s neuronal networks of neurons exceeds any conceivable means of analysis, probably in ultimate principle, certainly in current practice. This is simply because the necessary information is too large to be handled and is thus unavailable.” Many people from cognitive neuroscience would reply to Uttal putting a computer on the table. The very complicated results of fMRI for the human eye are analyzed now with a computer. In the future, other much more complicated tools will be invented to scan the brain. Surely, the scientists will create what we think now is necessary to grasp the mind: new tools, apparatuses for investigating the micro-neuronal level of the brain. From Uttal’s viewpoint, such apparatuses would be enough to understand the relationship between the neuronal processes and the mind. We can imagine cognitive neuroscience after 100 years or even 300 years. Such apparatuses will be able to read, literally, our mind. Paradoxically, I am convinced myself of this achievement in the future. However, from my viewpoint (the EDWs perspective), such methods will not mirror the “I” but only the *correspondences* between certain mental states and neuronal patterns of activation (phenomena belong to EDWs). Uttal’s vision is within an epistemological framework and this is not enough to prove that the brain imaging would not offer us a viable answer to the mind-brain problem. By the “single neuronal insufficiency”, Uttal means that “no single neuron is capable of representing the full range of cognitive activity. Here the missing information is due to our limited perspective of the available technology.” (Uttal, manuscript) Uttal’s rejection of fMRI and PET’s results is based on such an epistemological approach, but I think that this is not enough to point out the strongest weakness of cognitive neuroscience in general: the ontological framework is wrong, therefore, this “science” is a pseudo-science. Many researchers project their work in the future considering that their work pushes the “mind reading” research in the right direction. Maybe they can accept partially Uttal’s criticism, but they claim that in the future his criticism will be overstated by the new tools of investigation. From my viewpoint, it is not about tools of investigation, but about a hyperontological problem: the mixture of EDWs.

Uttal believes that the binding problem is a “false assumption of separate components” because these components are “different for the different levels at which the binding problem is posed”. From my perspective, “levels of analysis” has no meaning. (See Vacariu 2008) Embracing the identity theory, Uttal’s answer is that the mind and the brain (mental and neuronal) are these levels (with many other sub-levels). The identity theory is meaningless since it mixes two EDWs. Therefore, Uttal’s approach is just on epistemological roof without an ontological ground. The EDWs perspective offers this ontological ground to Uttal’s skepticism. The “binding problem is already solved by the existing **organizational properties of the brain**. **It is the overall state of the aggregate of neurons that make up the brain that makes up the mind**.” (Uttal’s bold words) Since Uttal’s position is just an epistemological one, it will be very easy for cognitive neuroscientists to decompose his holism in the “distributed neural patterns” across many parts of the brain. Again, in the future, new tools of scanning the brain will appear, the computer will analyze all data information received from fMRI, therefore the mind will be entirely “read”. Moreover, from a neuroscientist’s viewpoint, an “overall state” can be decomposed and “organizational properties” can be localized. In this context, I recall the last results of Gallant’s lab (Nishimoto et al. 2011, see Chapter 3): nothing can stop researchers working in cognitive neuroscience to continue searching for decomposition and localization using fMRI, PET, etc. and powerful computers. As we will see in the following chapters, many people already accept that each mental state is distributed in the brain. Everybody knows that even to perceive a simple object, more than 30 neuronal areas are activated and probably in the future more and more areas will be discovered. Nevertheless, this “brutal” distribution will be analyzed by combining the fMRI, EEG and computers. The last researchers combine already the fMRI data with EEG results in order to get the segmentation and the integration in the brain. For instance, the fMRI results indicate the features of an object, the oscillations grasp the integration of these features. So, if the mind is identical with the brain, nothing (but really nothing) can stop researchers to hope for the perfect the "mind reading". The only argument against decomposition and localization could be a new ontological framework, that is the EDWs framework.

Again, Uttal claims that the "overall state of the aggregate of neurons [that] make up the brain that makes up the mind". And "what they are doing collectively is the **equivalent** of mind". (Uttal's bold word) Moreover, "the main reason for not pursuing the binding problem is that it is not necessary to synchronize, synthesize, add, or pool the individual component responses to produce a cumulative 'singular unified response'. The state of the system, pari passu, is all that is needed." (Uttal manuscript) All these statements are no more than epistemological propositions that cannot convince people working in cognitive neuroscience to change their direction of work.

Finally, about oscillations, I introduce Sherrington's conjecture: *"Pure conjunction in time without necessarily cerebral conjunction in space lies at the root of the solution of the problem of the unity of mind"*. (in Singer 2009) With this conjecture, I need to return to Kant's a priori intuitions of time and space. The questions are: Why do we need to impose the space and time dimensions to everything we want to prove that exists? Is it, anyway, the same space and time, ontologically different, epistemologically different or in any other way?

Chapter 8

Perception and object recognition

This chapter is about perception and object recognition. Probably, these topics are the most common subjects in cognitive neuroscience but I read only a few papers on this topic. The problem is that even if I were reading ten times more papers the result would be the same: we cannot completely isolate any particular ability of the mind and ignore that all these faculties are the “I”. In the final section of this chapter, I will introduce a few words about consciousness just because perception and object recognition are strongly related to consciousness.

8.1 Perception and object recognition

Strongly related to visual binding are perception and object recognition. As we saw in the previous chapters, within the EDWs framework, we can talk, only from a methodological viewpoint, about different notions like segregation (the identification of particular features of a perceptual representation), binding these features, the perception of an object and recognizing it, the relationship of that object with other objects and the spatio-temporal framework of that scene.

Uttal is very skeptic regarding the results of people working on vision. For him, perception includes some processes like object recognition, face recognition, space and motion perception, illusions, change blindness and mirror neurons. (Uttal 2011, p. 92) Uttal emphasizes the main problem for perception: it is quite difficult to differentiate between the low level and the high level of perception. Essentially, the brain imaging tools give us “an answer to the question of where on the brain activity is it observed when a stimulus is presented” but even for simple stimuli there are wide distributions of brain activations. (Uttal 2011, p. 94) Uttal introduces Poldrack’s

(2006) and Van Horn and Poldrack's (2009) ideas: "we cannot reverse engineer the brain to determine what thought is being processed when a particular area of the brain is highlighted (...). The best we can do is to use patterns of activity to select among a prior set of alternatives." (Uttal 2011, p. 94) Therefore, the "brain image is highly limited in what it can say about the neuroscience of processes such as sensation and perception." (Uttal 2011, p. 95) and the results of fMRI grasp only the macro-level, not enough for identifying cognition. Again, from an EDWs perspective, it does not matter if the results are from macro- or micro-level, high- or low-level; it is about EDWs and not "levels" or "complexity" of the mind.

Against the traditional view (the occipital lobe is responsible for vision), Uttal specifies that for vision other brain regions are activated, ranging from cerebellum to cingulated and frontal lobe.

> From these findings, they concluded that the imagined stimuli did not utilize the same regions of the visual system but, instead, invoked activity in regions devoted to higher-level cognitive skills. The suggestion in their findings, therefore, is that the differential fMRI responses they measured were following the *real physical stimulus* but not the *perceived experience*.[1] One implication of this difference between real and imagined stimuli is that the early responses may not encode perception as much as transmission. (Uttal 2011, p. 102, his italics)[2]

Moreover, Uttal mentions Thirion and colleagues' work (2006): the bidimensional spatial framework of stimuli is replicated on the early brain areas in a topological manner that preserves the spatial relations. (Uttal 2011, p. 105) An important step is made by Shinkareva et al. (2008): using fMRI, it is possible for a small set of objects[3] to be determined by any individual person without training.

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[1] I add this footnote: See again the perception-thinking contradiction in Vacariu (2011 or Chapter 1 of this book)

[2] "Again, there was no explicit inference of what the subject perceived, just a distinction drawn between the neural signals associated with classes of objects." (Uttal 2011, p. 103)

[3] Poldrack et al. (2009) use of the fMRI for identifying eight higher-order cognitive tasks with probability of classifying them running from 90% to 61%. (in Uttal 2011, p. 110)

Uttal draws some conclusions about these experiments. The most important is that these results

> are theoretically neutral. That is, they do not provide any more detailed explanation of how the mind emerges from the brain than any other neuroscientific method. What they have done is find cumulative components of the fMRI signal that correlate with perceptual and cognitive processes. (…) What they are saying, in general, is that there are patterns that occur over the brain that allow us to distinguish to a limited degree among a few perceptual and cognitive processes. In other words the brain is doing something that is demonstrably different as it processes different percepts or other cognitive processes. (Uttal 2011, p. 111)

Again, from the EDWs perspective, any perception or thought corresponds to the most activated neural patterns, the rest of the brain and the body. The differences between any two perceptions/thoughts correspond to the differences between those two widely distributed neural patterns of activation, the differences among the wave bands (their frequency, intensity, etc.) and their values, the status of the entire brain and body in those two moments.[1]

Let us suppose that a human being observes a scene with 3-4 objects in a spatio-temporal framework. How does the mind represent this scene? Are mental representations for each object in our mind? How are space and time represented in our mind? How do we localize these representations in the brain? I consider these questions are totally wrong! There is only one mental representation that contains all objects and the spatiotemporal framework and this mental representation is the “I”. Otherwise, we would not be able to explain, for instance, the spatial or the temporal dimension of a scene. Therefore, localization, the binding problem, perception and object recognition, spatio-temporal framework of a scene are just methodological problems created by many researchers in cognitive neuroscience!

Let me analyze the continuity of representation of an object (the “endurance” problem). O’Herron and von der Heydt (2011)

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[1] Obviously, there are other “aspects” of the brain that will be “discovered” in the future.

investigate the representation of object continuity in the visual cortex in spite of continual fluctuations of retinal image. The authors recognize that the neuronal processes responsible for the continuity of human perceptual representations are unknown! In fact, we have here not only the binding problem but also the "endurance" problem of mental representations and both problems have no answers yet. As we saw in Chapter 7, the binding problem is a pseudo-problem. The enduring problem is a more difficult problem! Interesting for the EDWs perspective is the idea regarding the relationship between the "local" and "global" processing neuronal "information":

> While most neurons in areas V1 and V2 respond to local contrast borders[1] and are orientation selective, about half of the neurons in V2 are also selective for the side on which a border is "owned" by a figure (border ownership, Zhou et al., 2000). The left-hand side of a square, for example, produces high firing rates in neurons of figure-right preference and low firing rates in neurons of figure-left preference. Although these neurons can see only a small segment of border through their classical receptive field, they seem to "know" that this segment is part of the contour of a larger object. They integrate global shape information with various local cues, such as stereoscopic depth and occlusion cues, to infer which side is foreground and which side is background (…). (O'Herron and von der Heydt 2011, p. 1)

Working within the unicorn-world, it seems obvious for the authors to introduce quite strange ideas and notions like the "neurons seem to 'know'" or "they integrate global shape". Only if we talk about the correspondences between parts of the brain and the "I" as an entity with particular unity, can we understand these ideas. Within the mind-EW, the unity of a mental representation of an object is nowhere in the brain. Those neurons have "no idea" about the fact that the segment is "part of the contour of a larger object"![2] I return

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[1] "(…) contrast sensitivity can take on at least three forms: sensitivity to spatial variations in a stimulus (spatial contrast), sensitivity to changes over time (temporal contrast), and sensitivity to changes in both space and time (…)." (Reid and Usrey 2008, p. 638)

[2] The same problem is in quantum mechanics regarding the non-locality problem: a mixture of EDWs, the wave and the particle. (See Vacariu 2008 and Vacariu and Vacariu 2010)

again to the analogy table-microparticles: the electrons, for instance, do not "seem to 'know'" anything about the (unity of) a table! The microparticles "compose" the table only for the human observer, but this "composition" is a methodological distinction that has *no ontological status*. Only mixing the EDWs, could we produce such weird ideas.

The authors indicate the main characteristics of a mental image of an object: the identification of objects in depth and the meaning of mental representations. (O'Herron and von der Heydt 2011, p. 2) The continuity of an object representation requires the short-term memory.[1] The authors propose that the mechanisms that are involved in the "border ownership selectivity" could produce the object continuity. From their experiments, they conclude that the cognitive system does not use information from the long-term memory to create mental representations. Moreover, attention is not necessary for the continuity of representation. It seems that the object representations are created automatically without the need of attention. The conclusion of this article is that the "border ownership signals reflect the cortical representation of object continuity. Presumably, this representation plays a role in maintaining object identity across eye movements and object movements." (O'Herron

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[1] Nevertheless, if we take into account the meaning of mental representation, we have to also add the process of categorization. As we will see below, McNorgan et al.'s (2011) semantic integration is "accomplished across multiple brain regions". (p. 215) Very recently, based on their research using transcranial direct current stimulation Lupyan et al. (2012) illustrate that an important component of categorization (selection of properties essential for certain task) requires the activity of prefrontal cortex (left inferior frontal gyrus). (p. 37) Moreover, other experiments show that the same neuronal area is activated by classic "cognitive control" ("paradigms (e.g., Stroop, go/no-go, and working memory tasks) and by classic language tasks (e.g., word generation, resolution of syntactic or lexical ambiguities (…)"). (p. 47) Their conclusion is that the left inferior frontal gyrus is involved in both categorization of familiar items and language. (*idem*) Even if the authors specify that their research refers only to the specific component of categorization, and moreover, language is also involved, then surely large parts of the brain are also activated. Obviously, it is not only the left inferior frontal gyrus activated for such processes.

and von der Heydt 2011, p. 9) Again the analogy: Where is the color or surface of that table at the "level" of microparticles or which macro-phenomenon is responsible for the movement of microparticles? Meaningless questions!

If the viewer changes his/her position in relationship with a perceived object, the images on the retina can change dramatically regarding position, view angle, illumination, etc. Despite such changes our mind recognizes many objects. "This means that the visual system is able to extract a reasonably constant 'representation' for the shapes and identities of meaningful objects despite such transformations." (Pessoa et al. 2008) Obviously, within the unicorn world, there are different "levels" of visual processing: low-level, intermediate-level and high-level. (*idem*) At the low-level, parts of the brain extract the information regarding edges, brightness, color and motion of object. Here there are so-called "bottom-up" processes (information from the bottom level "moves" to the upper level). The intermediate level combines information of the previous level so as to get the global properties like object shape and orientation. The last level, the high-level, associates a meaning to that mental image to produce recognition and classification (a top-down process). (*idem*) I have never understood such expressions like "parts of the brain extract information"! Is this part of the brain a kind of homunculus able to extract and observe something? I emphasize again that segmentation-integration is a totally wrong distinction. For instance, maybe we can hypothese that a static visual picture is segmentated in different features (V1, V2, V3, V4, V5, for edges, color, motion and other features) and then integrated in a unified picture (unknown parts of the brain). However, I really cannot understand the segementation and the integration of any visual picture that contains two-three objects in motion in different directions for a human subject that is in motion and changes continuously the angle of perceiving those objects! The subject is aware of the movement of those two-three objects in motion. The segmentation and the integration for a visual image with objects in motion entail quite long period of time, but the brain realizes these processes almost instantly! We would not be able to see an object in motion if the visual process requires the low-level and the high-level processes (or segmentation and integration). From my viewpoint, I believe that all the neuronal parts (V1 to V9, parietal and temporal, etc.) are directly involved in creating those pictures in motion and therefore there is no segmentation and integration of visual images. In fact, we completely misunderstand the correlations between vision and perception with neuronal patterns of activation, and therefore we need to rethink these correlations.

Essential for vision is the famous dorsal-ventral streams distinction. Let me analyze Banich and Compton's investigation regarding the ventral pathway ("what" - related to the object recognition) and the dorsal stream ("where" - related to the spatial representation) pathway (Chapter 7 and 8 from their book). The ventral stream consists of neuronal areas from the occipital, occipitotemporal and temporal zones. In that classical view, V2 is responsible for color, texture, length, width, orientation, direction of motion, etc., while the inferotemporal cortex is involved in much more complex visual stimuli (faces, hands).[1] (p. 180) The ventral stream preserves certain spatial information. However, there is "much more to learn about how objects are actually represented in the neural tissue of the ventral stream".[2] (p. 187) Quite many people

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[1] "The different cortical areas in the occipitotemporal pathway share a number of physiological characteristics. Consistent with a role in object recognition, all areas in the pathway contain populations of cells sensitive to the shape, color, and/or texture of visual stimuli. However, at progressively higher levels, cells have larger receptive fields and their stimulus selectivity is more complex to characterize. Thus, higher order properties (consistent with invariant representation of objects) usually are attributed to cells in higher tier areas. For instance, many V1 neurons function as local spatial filters, signaling the presence of contours at particular positions and orientations in the visual field. In contrast, an increasingly higher proportion of cells in higher tier areas (e.g., V2 and beyond) apparently respond to *illusory* contours (i.e., contours implied by stimulus context and higher-order properties, not due to simple light-dark contrast), across increasingly larger regions of the visual field." (Passoa et al. 2008, p. 1074)

[2] "First, how is a specific object represented within the visual stream: is a single object represented by the activity of only a few cells, or is a larger swath of the neural tissue involved in representing any given object? Second, how does the

in cognitive neuroscience use such expressions like "there is much more to learn". Within the unicorn world, we will constantly find such expressions! Even the classical distinction dorsal-ventral streams ("where-what") is somehow supported by certain neuroimaging studies, it seems better to characterize the dorsal pathway as "how" (instead of "where") because it is related to the motor neuronal areas. (Barich and Compton 2010, p. 165) Moreover, there are the limitations regarding the dorsal-ventral streams dichotomy (Husain and Nachev 2007 in Banich and Compton 2011, p. 228). For instance, the parietal lobe is not the only neuronal area involved in spatial cognition (but also, at least, hippocampus[1] and parahipocampal regions).[2]

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ventral stream achieve perceptual invariance (the ability to recognize objects regardless of their orientation, position, or size)? Third, is object perception based on understanding the individual parts of an object and then fitting those parts together, or is it based on a more holistic representation? Finally, we address the controversial issue of category specificity, the question of whether there are segments of the ventral stream that are dedicated to and specialized for processing certain kinds of stimuli, such as faces." (Banich and Compton 2011, p. 187)

[1] It has been considered that hippocampus is clearly involved in spatial cognition. However, in their experiments with mice (they "generated mice (…) in which NMDARs are also lacking in dorsal and, to a lesser extent, ventral hippocampal CA1 pyramidal cells), Bannerman et al. (2012) showed that hippocampal NMDAR receptors (particularly those from dorsal CA1) are not essential for associative, long-term spatial memory. Their results show that "NMDARs on dentate gyrus and dorsal CA1 principal cells are not essential neuronal underpinnings of hippocampus-dependent, associative, spatial reference memory acquisition or storage. Instead they may be critical for using spatial information to guide selection between alternative responses." (Bannerman et al. 2012, p. 5) Bannerman et al. speculate that "these results suggest that NMDARs, either elsewhere in the extended hippocampal formation, such as entorhinal cortex or subiculum, or across the wider cortical mantle, could underlie associative spatial memory performance in the water maze." (*idem*, p. 6)

[2] For an investigation regarding the dorsal and the ventral processing streams (the occipitotemporal and the occipitoparietal pathways, see Pessoa et al. (2008). The ventral stream includes V1, V2, V4, and inferior temporal areas TEO and TE that are activated for color, shape, and texture. The dorsal stream includes V1, V2, V3, V3A, middle temporal area MT, medial superior temporal area MST, and additional areas in inferior parietal cortex that respond to spatial stimuli (the direction and

Interesting for my perspective is the dispute regarding the neuronal areas that code the object perception/recognition: do we have the sparse coding (the extreme of this alternative being "one grandmother cell") or the population coding (the extreme being the entire brain)? (Banich and Compton 2011, p. 188) Today, nobody accepts either of these extreme alternatives[1], so the best answer seems to be that some neuronal areas are involved in the process of object recognition. From an EDWs perspective, the question is meaningless: any mental perception is the "I" that corresponds to some particular neuronal areas that are the most activated, the

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speed of stimulus motion). (Pessoa et al. 2008, p. 1071) Important is that Goodale and Milner (1992) "have proposed a modification of this model, emphasizing 'perception' vs. 'action' for ventral and dorsal processing (…)". (*idem*)

[1] For instance, for the first extreme: the results of an experiment on a subject shows that a cell had "strong preference for the face of the actress Jennifer Aniston, when seen from several different viewpoints, but did not respond to pictures of other actresses nor to pictures of Aniston together with actor Brad Pitt (…). Maybe this is not a 'grandmother cell', but is it the 'Jennifer Aniston cell'?" (Banich and Compton 2011, p. 189) If that cell dies, will the subject not be able to recognize that actress? For the second extreme: the image of an apple is associated with the meaning of apple and its features and this is not possible if the entire brain is involved for perceiving that apple. (*idem*) Rolls and Treves (2011) also show that the representation of a particular object or face is correlated with the distributed neuronal patterns but not a grandmother cell, even if each neuron responds better to some particular stimuli than other neurons (i.e., it is "tuned to some stimuli", p. 460). Regarding the information of a single cell (the element of computation), the authors consider that "most of the information is encoded in the spike count; that large parts of this information are available in short temporal epochs of, e.g. 20 ms or 50 ms; and that any additional information which appears to be temporally encoded is related to the latency of the neuronal response, and reflects sudden changes in the visual stimuli. Therefore a neuron in the next cortical area would obtain considerable information within 20–50 ms by measuring the firing rate of a single neuron." (p. 470) (Rolls and Treves 2011, mainly section 3) Pessoa et al. also reject the "grandmother cell" but embrace the "population code" (the last alternative is necessary for the robustness vs. changes of input and precision of representation. "Although the image of an object projected on the retina changes in response to variations in illumination and viewing angle, the pattern of activity in IT cortex will be largely maintained, insofar as the clustering of cells with overlapping but slightly different selectivity serve as a buffer to absorb such changes." (Pessoa et al. 2008, p. 1074)

counterpart of the brain and the entire body. We have to return to Uttal's skepticism to understand that this problem and many other problems are meaningless.

For object recognition process, some elements are involved: the form-cue invariance (we recognize a familiar object regardless of the form of the cue that represents the object) and the perceptual constancy[1] (we recognize an object in many different conditions of perception like different angles or illuminations). "The ability to recognize objects across so many varying conditions implies that at some level, our mental representation of objects is fairly abstract, in the sense of being removed from or independent of the original stimulus conditions."[2] (Banich and Compton 2011, p. 190) The abstract level of Banich and Compton is available in any perceptual state, but from my viewpoint this is possible only because any mental state is the "I", an EDW than the brain and body. Without the difference between the mind-EW and the macro-EW (that includes the brain and the body), the form-cue invariance and the perceptual constancy would not be possible! The brain and body are constantly in movement, so the existence of form-cue invariance and perceptual constancy would not be possible without the existence of this *abstract* level, i.e., the mind-EW. The original stimuli are some external inputs that activate certain parts of our body and related neuronal areas that belong to the macro-EW. However, any sensation and perception is part of the mind-EW.

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[1] "Additional higher-order, object-related properties are also seen at higher tier cortical levels. One of these properties is increasing stimulus invariance, namely, similar shape selectivity despite variations in the type of lower-order cues used to generate the shape (such as luminance, color, motion, etc)." (Pessoa et al. 2008, p. 1074) Perceptual constancy is possible only because of the unity of the "I". We have to take into account that the perceptual input is continuously in movement and therefore the unity of the "I" has to be responsible for this constancy.

[2] "Neurons at lower levels in the visual system are sensitive to isolated and specific features in visual scenes. Higher visual areas respond to very specific attributes, but these attributes are increasingly remote from the physical stimulus. Instead, they represent increasingly complex concepts, such the motion of an extended object or the identity of a face." (Reid and Usrey 2008, pp. 657-8)

For a monkey, the occipitotemporal pathways, the invariant features of an object and neurons from the anterior inferior temporal cortex are responsible for the form-cue invariance. (Pessoa et al. 2008, p. 1076) For humans, the early visual areas and the lateral occipital cortex are necessary but not sufficient for object recognition. (*idem*, p. 1080) More exactly, Pessoa et al. underline that the lateral occipital cortex is a "stage" (*idem*) or "an intermediate link" (p. 1081) in object processing. These authors close their chapter about object recognition introducing some results that indicate that the various features of a perceptual object are not stored in a particular neuronal area but in distributed areas. (p. 1087) In this context, we can assume there are quite many intermediate links within the unicorn world! I strongly emphasize that it is not possible to explain certain notions like "form-cue invariance" and "perceptual constancy" using information available in the brain since there are continuous neuronal transformations that do not fit with the "mental constancy".[1] The notion of "fit" rejects the identity or any dependence between "perceptual constancy", for instance, and "widely distributed neuronal patterns of activation". Also, the notion of "correlations" (which has no ontological status) is not enough to mirror this relationship. Therefore, we have to introduce the "correspondence" between states that belong to the EDWs. Again, we return to the analogy microparticles-table and neuronal processes-the "I": there is no constancy but only interactions/movements among microparticles, but our perception of the table is very static

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[1] "Neuroimaging studies using the adaptation method have shown that a particular region within the ventral stream seems to display perceptual constancy and form-cue invariance. This region, the lateral occipital complex (LOC), is located at the posterior portion of the fusiform gyrus, directly anterior to Brodmann area 19, and it shows evidence of perceptual constancy across variations in size, location, viewpoint, and illumination (Grill-Spector, Kushnir, Edelman, Avidan, Itzchak, & Malach, 1999; Mazer & Gallant, 2000)." (Banich and Compton 2011, p. 191) I am convinced that other neuronal areas will be added to LOC region (if this area is not be replaced with other areas) in the next several years. The problem is that the majority of people working in neuroimaging ignore the results furnished by other tools of investigation of the brain, for instance, the EEG.

and discrete.[1] A table is not identical with/does not depend on, but corresponds to some microparticles.

I analyze another related problem: "In ways that are not fully understood, position-invariant recognition arises from ventral stream cells that have position preferences." (Banich and Compton 2011, p. 192) The "position-invariant recognition" will never be "fully understood" within the brain-EW. In reality, this position-invariant recognition corresponds to the activation of the entire brain and body: the brain is part of the body that occupies a place in relationship with an external object, and the body has strong neuronal links with the brain that cannot be avoided in explaining such recognitions. The same authors discuss about the object recognition in relationship with the viewpoint-invariant or the viewpoint-dependent: what is the relationship between the neuronal patterns and the viewpoint from which the object is perceived and how does the brain create a 3D representation of an object (recognizable from any viewpoint) from the 2D information received from retina? One classical answer " may be that the brain first extracts viewpoint-specific information, and then uses that representation to build a more abstract three-dimensional representation that is independent of viewpoint" , after which the authors introduce Marr's computational model. (Banich and Compton, p. 192) "May it be"? We will need this expression for almost all the empirical results of cognitive neuroscience forever!

Another alternative would be the viewer-centered representations that require the comparison of a visual representation with some stored knowledge in the brain. We have again the very dubious notion of "abstract" and the totally inexplicable process of

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[1] A reductionist can claim that any table is just an "appearance" that does not exist in reality and only the microparticles really exist. There are many reductionists in physics and philosophy of mind. Nevertheless, the gravitational force cannot be reduced to the micro-forces (we have not discovered the quantum gravity yet). (About the relationship between Einstein's general theory of relativity and quantum mechanics, i.e., the relationship between macroparticles and microparticle, see Vacariu 2008 and Vacariu and Vacariu 2010) From my viewpoint, such reductions are meaningless.

transformations from 2D to 3D spatial representation. (See Chapter 9 of this book) If the eyes are the extension of the brain (due to evolution), how and why are such complicated stages with 2D and 3D frameworks necessary? Species evolution would not allow such "complex" movement! We see the 3D and the depth vision only with one open eye, so the existence of two eyes (the binocular disparity indicates the depth dimension in visual image, Banich and Compton 2011, p. 212) does not fully explain the movement from 2D to 3D. Within the unicorn world, inevitably the researchers in cognitive neuroscience fight to find the neuronal areas activated by the process of object recognition.[1] The huge mistake imposed by the unicorn world is that the researchers attribute the spatial dimension to visual perception and they check for the neuronal area that unifies all other neuronal areas associated with the different perceptual features of a perceived object. Within the identity theory, we can ask two questions from contradictory viewpoints. From one viewpoint, if these perceptual features activate different neuronal areas, why do we need a single neuronal area (the "convergence zone" of Damasio, for instance) that unifies the activity of all the other neuronal areas? From the other viewpoint, how could distributed neuronal areas (correlated with various perceptual features) be correlated with a single perceptual object? Again, within the framework of EDWs, these questions are meaningless! The identity theory is wrong regarding at least this problem: the mind has no spatial dimension, only the brain being placed within the space of the macro-EW.

Using fMRI and multivoxel pattern classification, Cichy et al. (2011) realized certain experiments so as to localize the identity and the location of objects in the brain. In the past, it was argued that localization for the identity of an object was the lateral occipital complex (LOC). One of the main notions in Cichy et al.'s paper is the "location-tolerant object representation", i.e., in the process of recognizing an object: we need a representation that is "tolerant to changing the viewing conditions". (Cichy et al 2011, p. 2297) The goal of their research is to investigate the role of LOC for location-

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[1] As we saw in Chapter 7, the same trouble is with the binding problem.

tolerant object information and object-tolerant location information for representations of exemplars and categories. The subjects visualize 12 objects (4 categories×3 exemplars) in the left or right hemifield. The authors emphasize that, if Ungerleider and Mishkin (1982) introduced the classical distinction between the ventral pathway (identity of objects, no location) and the dorsal pathway (location), other researchers (Milner and Goodale 2006, 2008, etc.) argue that the ventral stream is responsible for location (for instance retinotopic information or eccentricity bias). The titles of some paragraphs of this paper reflect the content of the paper: "LOC contains location-tolerant object information at the levels of exemplars within a category" (p. 2303); "LOC contains more location-dependent than location-tolerant object information within than across locations" (2304); the activity patterns in LOC "generalize across different exemplars"[1] (p. 2305). Finally, because tolerance encodes both location and object information, tolerance is more important than invariance regarding the object representation. The authors claim that, in this way, the binding problem is avoided! (Cichy et al. 2011, p. 2305) As usual, without offering more details, I analyze their results:

> LOC contained location-tolerant object information both at the level of categories and at the level of exemplars within a category. Moreover, location-tolerant information of objects at the level of exemplars within a category was general enough for categorization of other exemplars. LOC also contained location-dependent object information. Interestingly, there was more location-dependent than location-tolerant object information in LOC. Finally, we found that LOC also contained object-tolerant location information. These findings extend our knowledge of the link between object representation and LOC in several important ways. (Cichy et al. 2011, p. 2303)

From an EDWs perspective, I emphasize that these localizations are just huge approximations that require "correlations" between

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[1] Interestingly for me, the "object information in LOC may underlie automatic classification of object exemplars into categories (Rosch et al., 1976; Mervis and Rosch, 1981)." (Cichy et al. 2011, p. 2305) From my viewpoint, the process of categorization (automatic or controlled) involves the implicit knowledge.

entities/processes that belong to EDWs. Moreover, important "aspects" of the brain activity are lacking such equations (just one example, the synchronized oscillations). Using fMRI and other tools, it is indeed quite difficult to get complete knowledge about (all "aspects" of) the brain. However, people working in cognitive neuroscience continue working with high hopes for feasible results in the future.

Jordan et al.'s paper (2010) is one of the most interesting papers written in the last years. The first sentence is emblematic for the "great debates" in the unicorn world: "Perception is a complicated process with impressive feats seemingly accomplished with ease." (p. 492) And then,

> immense amounts of undifferentiated information are smoothly transformed into meaningful units; photons of light become recognizable faces, sound waves are parsed into familiar voices, and wafts of odour are identified as individuated smells. Moreover, discrete units that are parsed out of the morass of perceptual input are then tracked over time and motion as the same, persisting entities. An important goal of cognitive science is to understand such processes. (p. 493)

Within the unicorn world, perception is indeed a very complicated process![1] From the EDWs perspective, perception is the "I" or any perceptual state belongs to the mind-EW. Jordan et al. analyze visual perception in relationship with cognition under the framework of object-file theory (Kahneman, Treisman, and Gibbs, 1992). They try to explain the binding process and the persistence of a mental representation over time and motion. An ‘‘object file’’ is an "episodic representation that stores (and updates) information about an object's properties and tracks the object via spatiotemporal

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[1] "The visual system detects single photons in the dark but can also see clearly in bright sunlight, when the retina is bombarded with over 10^{14} photons per second. At a much higher level of complexity, ensembles of neurons in the cerebral cortex are able to solve extremely difficult problems, such as extracting the three-dimensional motion of an object from two-dimensional retinal images." (Reid and Usrey 2008, p. 637) Those two-dimensional retinal images correspond to perceptual elements that are the "I". The cerebral cortex is not a computer solving some "extremely difficult problems" like the "extraction of 3D motion of an object from 2D retinal images"!

information (Kahneman et al., 1992).” (p. 493) Making certain experiments, the authors investigate the multimodal integration (visual and auditory modalities).[1] Interesting for my perspective is their entire general discussion on the results of their experiments. It is quite amazing to observe the interpretations of such results, the conclusions and finally the questions that arise from such experiments (the cross-modal interactions) under the unicorn world! The main question is where the *integration* of features from multiple sensory modalities into a coherent object file takes place. Based on their experiments, the authors suggest that the object-file representations are *abstract amodal* representations (“how object-file correspondence can be decoupled from specific sensory modalities”). (Jordan et al. 2010, p. 501) As we saw above, they are not the only authors that use the notion of “abstract” in explaining some mental states! Their conclusion is quite close to my EDWs perspective. However, such “abstract amodal representations” belong to the mind-EW (not to the mind)! Moreover, the perceptual and amodal representations are the “I”.

For Jordan et al., it is completely unknown *how and where* (neuronal) different sensorial mechanisms (video and audio) and working memory *integrate* their information! We already know that within the EDWs perspective, these questions are meaningless. Important for the EDWs perspective is their observation that the natural environments “often contain many potential pairings of visual and auditory sources, and it would likely be challenging to establish crossmodal object correspondences based on purely perceptual information alone if there are any competing sounds and sights.” (p. 501) Moreover these “data offer clear evidence for crossmodal object-file processing, but much remains unknown about the role of sensory modality information in the calculation of persisting object representations.”[2] (*idem*) Within the unicorn world, nobody will find

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[1] For the crossmodal interactions, see Chapter 10 of this book.

[2] “For example, can object files transcend sensory modality in any situation, or is auditory information only incorporated into object files in the absence of competing visual information?” (Jordan et al. 2010, p. 501) Eternal questions within the unicorn world!

an answer to this problem. Introducing other problematic topics like top-down knowledge, the problematic localization (the neuronal spatial-temporal frameworks) of vision and especially audition, the authors proclaim that the topic of cross-modal interactions is a “ripe area for future research”![1] Eternal verdict: “Such questions are meaningless!”

8.2 A few words about other notions in cognitive neuroscience

Perception and object recognition are strongly related to other processes, like attention and consciousness, the most difficult notions in cognitive neuroscience. The relationship between this mental process and the neuronal substrate is completely unknown. Nevertheless, using simultaneously the results of diffusion spectrum imaging (DSI) and fMRI, Greenberg et al. (2012) showed a “direct topographic white-matter connections between IPS and visual cortex that may subserve the control of visuospatial selective attention in humans.” (Greenberg et al. 2012, p. 2780) The biased completion model of visual attention presupposes some axonal connections between areas responsible for attention control and visual cortex.[2] From their experiments, Greenberg et al. conclude that the particular white-matter fibers mediate biased competition exactly through the direct topographic white-matter connections between the IPS and the visual cortex. “The correlation between contralateral attention BOLD activation and connectedness suggests that these fibers carry visuotopic attention signals.”[3] (p. 2773) Attention presupposes

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[1] About the crossmodal interactions, see Chapter 10 of this book.

[2] “Neuroimaging and neurophysiological evidence supports a biased competition model (Desimone and Duncan, 1995) of visual attention in which stimuli compete for neural representation in retinotopically organized visual cortex. This competition is resolved by directing attention to the target, resulting in enhanced neural activity to attended stimuli and, simultaneously, decreased activity in neurons representing distracters.” (Greenberg et al 2012, p. 2773)

[3] For more details: “We found that attention modulations in visual cortex were correlated with connectedness to pIPS; however, attention modulations in aIPS were only weakly correlated with connectedness.” (p. 2781, pIPS is posterior IPS; aIPS is anterior IPS) However, the authors specify that aIPS has other roles, for instance, modulating nonspatial dimensions like color and motion. Interestingly,

categorization of an entity (for instance, a target object in a natural scene among distractor images). Such visual categorization requires the integration of multiple frequency scales, integration that has to be prior to awareness. (Kihara and Takeda 2010) It seems that the integration of such multiple frequency scales for rapid categorization of a natural scene has to be between 83-100 ms after the image onset.[1] (Kihara and Takeda 2010, p. 2161) Very shortly, attention is the "I" and we can find it nowhere in the brain. I believe attention is even more difficult than consciousness, so "Do not check for attention in the brain"!

Another very problematic notion in cognitive neuroscience is consciousness (one of the most enigmatic phenomena debated in philosophy of mind but actually the scientist's try offer a scientific explanation). I analyze only Damasio's very recent paper on consciousness (Damasio 2011, the short version). At the beginning of his article, we can find a very interesting paragraph:

> I suggest that a plain mind process devoid of self elements is not likely to provide "experience". Experience requires an experiencer, the provider of subjectivity, and that is what the self process, even if at the simplest levels, confers upon a plain mind. (Damasio 2011, p. 47)

We see here a distinction between the mind, self, "experience" and their integration. Obviously, we cannot talk about experience, in general, without a particular experience, but anyway this distinction

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"connectedness between pIPS and visual cortex increases from V1 through V3. By contrast, the systematicity of visuotopy in these fiber tracts decreases from V1 through V3. However, one must consider the different roles that V1, V2, and V3/VP play in the visual hierarchy." (*idem*)

[1] Making the distinction between "higher spatial frequencies" ("fine information of image details and/or object boundaries"), and "lower frequencies" ("coarse blobs representing the general framework of object shape and layout"), the authors introduce a supposition that cannot be totally verified: "coarse information is processed faster than fine information. However, this does not guarantee that all types of scenes would be processed in a coarse-to-fine manner. We do not make the general claim that this coarse-to-fine processing dominates natural scene perception." (Kihara and Takeda 2010, p. 2161)

is methodological, i.e., it has no ontological grounds (neither in the mind-EW, nor in the brain). Indeed, the relationships between experience, mind, the self, and their integration have been created by the human thinking. The experience and all other mental states are the "I". Such methodological differentiations are created by us when we investigate vision and other sensorial abilities. Again, the efforts to try and grasp the neural correlations of mind, consciousness or the self are useless. From an EDWs perspective, I draw the attention upon the fact that the researchers from cognitive (neuro)science have to be very careful in constructing and using their language. In reality, from an EDWs perspective, they have to reconstruct the entire language.

In the next page of Damasio's paper, I noticed the idea that the "body signals" are represented in the brain as "maps", the basis for sensory images that "we experience in the mind". (Damasio 2011, p. 48) These mental images of the body represent the "protoself", the first, the "lowest level of the self process". Personally, I could not understand what kind of mental representation these mental images are. The protoself structures (these mental images) are "felt": "Body feeling is the key to subjectivity, to experience." (*idem*) My question is the following: "Is the 'I' who has these feelings"? Then, if we impose the existence of the self and its feelings, we have to grasp the relationships between these entities, something that cannot be realized (the first-person or third-person viewpoints do not matter). In order to understand comprehending these relations, we would need again the homunculus (rejected by everybody, including Damasio). From an EDWs perspective, this protoself is necessary for the survival of any organism that corresponds to the being, but these undefined feelings ("*primordial feelings*", emotions being "variations of these feelings) are the "I", nothing more or less. Rejecting the homunculus, the self does not have feeling of its body. Damasio believes that, from an evolutionist viewpoint, these feelings are "correlated" with the brainstem and not with the cerebral cortex. We can accept such differentiations only from a methodological viewpoint[1]. Within the brain-EW, even if the brainstem is the most involved part of the brain, we cannot make an *ontological differentiation* between this part and the rest of the brain and body. *I strongly emphasize that the people working in cognitive neuroscience have to ask questions and make experiments regarding only entities and processes that have an ontological status!* Within the mind-EW, all these feelings are the "I", so they do not have an ontological status. If Damasio informs us that these primordial feelings are "generated as a result of an ever-present body–brain interaction", we could translate this statement in the following way: "The primordial feelings are the 'I' that corresponds to the body-brain interactions".[2]

The second "step" is the "self core" that reflects the interaction between an organism and the objects in the environment. (p. 49) Again, as usual in cognitive (neuro)science, we have notions like "levels" (or even much stranger notion like "steps"), "emergence", etc. As I wrote above, we can accept these notions only from a transcendental (methodological) viewpoint. The last "step" is the "autobiographical self" constructed on memories and predictions about future events/processes. The properties of the first step are available for the last two steps. For Damasio, consciousness is correlated with the upper brainstem, thalamus and wide parts of cortex. (p. 49) I do not analyze in detail which parts of the brainstem, thalamus and cortex are associated with some aspects of consciousness, but the conclusion is the following: many parts of the brain (actually the entire brain) are correlated with consciousness. Damasio tries to show that some parts of the brainstem are involved in a particular mental function related to consciousness but he concludes that the

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[1] In this context, I recall that Kant's distinction between pure and empirical intuitions of space and time is a methodological, transcendental distinction. (See Vacariu 2008) Moreover, if a person perceives a table, the distinction between its legs and its surface is just a methodological segmentation!

[2] These primordial feelings are strongly related to the ambiguous notion of life. (See Vacariu and Vacariu 2010)

> classical reticular nuclei and the ascending activating systems are indeed associated with wakefulness and sleep cycles, but the remaining brain stem nuclei participate in other important functions relevant to consciousness. These include (1) representation of standards for biological value, (2) representation of the organism's interior on the basis of which the protoself can be assembled and primordial feeling states generated, and (3) the first stages in the construction of the core self, which has consequences for the governance of attention. (Damasio 2011, p. 50)

From an EDWs perspective, I point out that the "representation of the organism's interior" (that leads to the protoself) has no ontological status. As a "way-station of inputs received from the body (and from sensorial mechanism of the external world) that are sent to the cortex, the thalamus plays an important role on integration: coordinator of cortical functions, (interconnecting local or large areas of the cortex)". (Damasio 2011, p. 51) Nevertheless, the cortex and the thalamus work together and can never be studied separately. Finally, together with brainstem and thalamus, the cerebral cortex constitutes the mind, the core self and our autobiography. (Damasio, p. 51-52)

> There is suggestive evidence that the early sensory cortices hold such explicit patterns. In typical multisensory experiences there are such simultaneous patterns, held in several separate regions whose ensemble can be appropriately designated as the brain's "image space". The imaged space is controlled functionally by the "dispositional space" (Meyer et al. 2010, 2011). (Damasio 2011, p. 52)

Evolutionary, thalamus solves an apparent "bottleneck" between cerebral cortex (imaginations, reasoning, memory, language) and brainstem (necessary for the life and feelings of body). The bidirectional connections between these parts of the brain can be found in the thalamus. It is very clear that Damasio's notions of differentiations, integrations and correlations require the unicorn-world framework. From an EDWs perspective, they are just *methodologically* possible but, within the unicorn-world, produce compelling ontological contradictions.

> The problem is that, notwithstanding the anatomical and functional expansion of the cerebral cortex, *the functions of the brainstem were never duplicated in the cortical*

> *structures*. The result is a convenient division of labor whose consequence is a complete interdependence of brainstem and cortex. Brainstem and cortex are forced into mutual cooperation. (Damasio's 2011, p. 52, his italics)

This paragraph also supports only the methodological differentiations and integration without any ontological background. Memory, reasoning and visual representations have no ontological background and therefore can never be differentiated within the mind. The "mutual cooperation" excludes a real existence of dichotomy differentiations-integration. Moreover, the unicellular living entities (bacterial cell or amoeba) have the homeostasis or "life regulation", an adaptive behavior. In Vacariu and Vacariu (2010) and Vacariu (2011), we analyze the similarity, or better, the identity between life and cognition. Any it (a cell or an organism) corresponds to an "I" (or to life) that becomes, due to evolution, more and more complicated. But life has no "components"! Why do we consider that cognitions have so many components? For the process of species evolution, there are no ontological differences between cognition and life.

Even more complicated is McNorgan et al.'s approach (2011) that pushes further Damasio's "convergence zone". The authors analyze only the semantic integration that is "accomplished across multiple brain regions". (p. 215) Obviously, there are "widely distributed patterns of activations". However, when we talk about semantic, we need to include the species evolution into equation. The authors introduce the difference between "hierarchically shallow models" (all semantic integration occurs in the same location) and "hierarchically deep models" (connective distance differs). (McNorgan et al. 2011, p. 213) The advantages for the deep-hierarchy is that these "models predict a within-modal advantage for feature inference, they predict a cross-modal advantage for activating a concept from partial information". (p. 223) Moreover, the "multimodal semantic integration occurs in multiple convergence zones organized in a deep integration hierarchy" and the "deep-hierarchy models, higher-level multimodal convergence zones receive input from lower-level within-modal convergence zones that are proximal to the sensorimotor representational regions that they integrate". (*idem*, p. 227) Interesting for me is that the "information from multiple representational modalities is integrated within distal multimodal convergence zones which take as their inputs the output of earlier within-modal convergence zones, passing information across modalities takes longer than within modalities".[1] (p. 228) The authors consider that synchronization is complementary with their deep integration hierarchy in conceptual binding. (McNorgan et al. 2011, p. 229) There is an analogy between the conceptual and the perceptual binding problem: at least the same brain areas responsible for the perceptual binding are necessary for the semantic binding, the difference being the inputs that produce those two different binding processes (external environment and their corresponding neuronal reactions versus internal representations). (McNorgan et al. 2011, p. 230) Everybody who reads this article would remark the coherent "imagination" of the people who wrote it. From the EDWs perspective, I strongly claim that the "convergence zone" is nothing more than a useless Ptolemaic epicycle constructed within the unicorn-world! With such convergence zones, the human brain would be an error on the line of evolution. In order to mirror better this idea, we can make again the eternal analogy with the table-microparticles: we need a strong imagination to imagine that the microparticles create the surface of a table in a "convergence zone"! I think with this analogy, any statement about the convergence zone (pro or con) becomes meaningless.

A neuroscientist, Edmund T. Rolls, tries to explain the relationship between mental and brain states and some philosophical notions like "determinism", "free will" and the "phenomenal aspects of consciousness". At the beginning of his paper (2013, forthcoming), Rolls indicates that he works under a kind of computationalism framework: the relationship between mental and neuronal states is reflected by the relationship between a software and hardware in a computer. The mental states and the neuronal

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[1] "Our studies provide clear evidence for the existence of a deep hierarchy in a multimodal distributed semantic memory system." (p. 230)

states are at different “levels of explanation”: the mechanistic level of neuronal firings, the computational level, the cognitive and the behavioral level. (Rolls 2013, forthcoming) Rolls also emphasizes that, even if we have to correlate some mental functions with certain neuronal areas, it is quite difficult to correlate phenomenal aspects of consciousness and qualia with neuronal blobs (Chalmers’ distinction between soft and had problems).[1] I believe that is would be quite difficult to explain free will and phenomenological aspects of consciousness in any language, being philosophical or scientific languages. Moreover, at the end of 20th century and at the beginning of new millennium, the computationalism approach was strongly attacked by the dynamical system approach (and its related approaches). Finally, qualia are nothing more than the “I”.

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[1] Related to these topics is the notion of representation in cognitive science and philosophy of mind. Rolls points out that “if we know the average firing rate of each cell in a population to each stimulus, then on any single trial we can guess the stimulus that was present by taking into account the response of all the cells”. (Rolls 2001, p. 157) Georgopolous shows that we can predict the direction of a monkey’s arm movement just before grasping an object by observing the neural patterns activated at that moment. Each neuron “votes” for certain direction and the resulting vector of the neuronal population determines the direction of the arm’s movement.[1] (Georgopolous 1988) (See Vacariu 2005, 2008)

Chapter 9

Space and the mind

As I mentioned many times in this book, the “I” (the mind-EW) does not have any spatial feature. (See also Vacariu 2011) Firstly, I claim that if the mind had spatial dimensions, the corresponding organism would not be able to survive in any environment. We have to remember that Descartes claimed that the mind could not be decomposed in parts! Essentially, we have to make a clear distinction between the spatial feature of the mind and the possibility of the mind to *represent* the external space. Only making the difference between the real spatial dimensions and the *representation of space,* will we be able to understand that the mind has no spatial dimensions. Secondly, there are no mental representations of space (and time) at all! In reality, the mind represents different objects within a scene, but the space is not represented at all. More exactly, the space does not exist as an entity in the external environment, so there are no corresponding elements of the mental representations for space. In our mind, there are, for instance, the representations of two objects and the distance between them, but we do not have those real objects, real space and space represented in any way! Moreover, taking into account the serial process of consciousness, we cannot be conscious of two objects at the same moment. When we perceive two objects in a single scene, there are conscious and unconscious processes involved in this process. Many parts of the brain are activated only in order to perceive two objects and the distance between them. But that distance (space) is not particularly represented in the mind. In other words, there is no spatial dimension for the distance between those two objects just because the mind does not have any spatial dimension. Then how does the mind represent the space? This is probably the most difficult question in cognitive neuroscience and philosophy! Many parts of the brain (in fact, the whole brain) are involved in creating, through correspondence, the visual spatial representation. People from cognitive neuroscience claim that the ventral stream (temporal lobe included) is involved in object recognition (see above), while the dorsal stream (parietal lobe included) activates the spatial cognition. I quoted a paragraph from Colby and Olson (2008)

> Dorsal stream areas have at least two distinctive functional characteristics: (1) they contain a comparatively extensive representation of the peripheral visual field and (2) they appear to be specialized for the detection and analysis of moving visual images. (Colby and Olson 2008, p. 1091)

Introducing the process of movement in relationship with space, a viable answer for this equation becomes much more difficult! There are the following elements: the object(s) and their features (color, texture, etc.), the space, the movement, the organism that interacts with that environment and the corresponding mind-EW (conscious and unconscious states, the human subjectivity, the "position-invariant recognition", the continuity of human perceptual representations, the form-cue invariance and perceptual constancy and many other features, more or less identical or different than those already mentioned). Could you find the localization for any element from this equation? The task of any cognitive neuroscientist is to answer this question. The "comparatively extensive representation" is related to my observation that the mind does not have a spatial dimension. In order to support this idea, let me analyze point (2) from Colby and Olson's paragraph. In my interpretation, the fact that "the mind represents a moving object in its visual field" does not mean that there is a mental image moving in our mind (or brain)! So as to support this very important statement, I introduce another essential statement: the mind represents a color, but color does not exist in the mind or the brain. Everybody agrees that there are no colors in our mind/brain but paradoxically some researchers believe the mind has spatial dimensions. Again, *representing* space and color, the mind is an EW without such properties! Otherwise, having a spatial dimension, the mind would not be able to represent space. On the contrary, if the mind had spatial dimensions, would the spatial mental representation have the infinitesimal points or not? Related to this problem is that there is not only the perceptual constancy but also the continuity of representation of an object (the "endurance" problem) (see O'Herron and von der Heydt 2011 in Chapter 8 of this book). How then would the "I" achieve these properties if the mind had spatial dimension? A mental representation of an object "has" these properties (even under the dramatic changes of the corresponding visual inputs in the retina) just because the "I" has its unity (that has no spatial dimension). Only within this framework can we interpret correctly the next paragraph:

> Areas of the ventral stream play a critical role in the recognition of visual patterns, including faces, whereas areas within the dorsal stream contribute selectively to conscious spatial awareness and to the spatial guidance of actions, such as reaching and grasping. (…) Although visual input is important for spatial operations, awareness of space is more than just a visual function. It is possible to apprehend the shape of an object and know where it is, regardless of whether it is seen or sensed through touch. Accordingly, spatial awareness, considered as a general phenomenon, depends not simply on visual areas of the dorsal stream but rather on the higher order cortical areas to which they send their output. (Colby and Olson 2008, p. 1091)

Obviously, the "awareness of space" is not the "visual function" or any representation having spatial dimension, but the "awareness of space" is an "abstract" notion that belongs to the mind-EW. This property corresponds to the activation not only of the dorsal stream but also of the "higher order cortical areas" (in reality the entire brain and body). Finally, let me analyze the last paragraph from Colby and Olson (2008):

> Spatial cognition is a function of many brain areas. No one area is uniquely responsible for the ability to carry out spatial tasks. Nevertheless, some generalizations can be made about the part of the problem that is solved in each brain region. The parietal lobe plays a crucial role in many aspects of spatial awareness, including spatially focused attention. (…) In contrast to the parietal cortex, the frontal lobe transforms spatial awareness into actions. The motor cortex uses a spatial framework to encode intended actions. The premotor cortex contains a

> set of separate spatial representations to generate eye, hand, and arm movements. The SEF[1] contains neurons with very high order, abstract spatial representations. Prefrontal cortex mediates spatial working memory. Finally, the hippocampus mediates spatial declarative memories, including those that underlie spatial navigation. Beneath the unity of our spatial perception lies a diversity of specific representations. The distributed nature of spatial cognition and the many purposes it serves means that we construct internal representations of space not once but many times in parallel. A challenge for the future is to understand how these many representations function together so seamlessly. (Colby and Olson 2008, p. 1110)

In our days, working within the unicorn world, everybody is forced to assert that the spatial cognition presupposes the activation of "many brain areas": the parietal lobe for spatial awareness, the frontal lobe (motor, premotor, prefrontal cortex) for spatial actions (movement of parts of the body), the hippocampus for "spatial declarative memories" and the neurons from SEF for "abstract spatial representations". Just reading this paragraph, we have to realize that something is wrong with the framework in which people have been working. Obviously, it is quite difficult to identify this flawed framework, but it is the unicorn world. The last paragraph of this paper (like the majority of papers that appeared in cognitive neuroscience in the last 20 years) generates great anomalies (ontological contradictions). What is the meaning of "unity of our spatial perception" vs. the "diversity of specific representations" or the "distributed nature of spatial cognition" or the "internal representations of space"? In order to answer such questions, someone has to introduce some complicated Ptolemaic epicycles.

In chapter 4, Banich and Compton offer many empirical arguments for the hemispheric specialization (split-brain syndrome, lateralized lesions, fMRI studies). It is quite broadly accepted that the left hemisphere processes local information in quite analytical

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[1] "A particularly interesting form of allocentric spatial representation is found in the supplementary eye field (SEF). The SEF is a division of the premotor cortex with attentional and oculomotor functions. Neurons here fire before and during the execution of saccadic eye movements." (Colby and Olson 2008, p. 1104)

manner (mainly regarding the temporal relationships, for instance, language), while the right hemisphere processes information in a holistic, Gestalt way (mainly, spatial relationships). Nevertheless, in several places, the authors emphasize that the "hemispheres take complementary role in processing" (Banich and Compton 2011, p. 98) and both hemispheres contribute to any function (even for language and spatial relationships). Then, there has to be some processes of integration of all this information within the unity of the mind/self/consciousness. Mainly, corpus callosum plays this role (but nevertheless oscillations and neurotransmitters have to be inserted in this equation, as well). As we noticed in the previous chapters, the "integration" (without any viable alternative in cognitive neuroscience) is much better explained within the EDWs perspective: integration is the "I" that just corresponds to "widely distributed neuronal processes". Moreover, we do not have to forget that all neuronal entities and processes require certain tools of observation for the human observer. Thus, we have to avoid the presupposition (unconsciously accepted by every researcher) that we see with our eyes (or fMRI, EEG, etc.) what "really" exist. Following Bohr's principle, defining the neurons and the waves, we have to include the tools that we use for observing such entities/process (or any other entity/process). More exactly, the "I" is an EDW rather than the empirical data furnished by the fMRI, EEG or by our eyes. The "I" does not use any tool of observation to perceive mental representations and the brain and body are within the same EW as fMRI and EEG, the macro-EW. The activities of corpus callosum (and the rest of the brain and body) correspond to the unity of the "I", since the "I" and these processes belong to the EDWs. The visual information is also segregated: from retina through LGN until primary visual cortex (V1). (About this "classical" segregation, see Chapter 6 of this book) In the traditional view, the integration of this information takes place at the higher visual levels (V3, V4, etc.).

The segregation-integration distinction is applied even at neuronal "level": each neuron processes certain information, but where can we find a unified image of a visual representation of a car moving in front of us on the street (with its features like colors, size, parts of the car, its motion, etc.) integrated and projected against a background (the street with other cars, houses, etc.) everything being situated in a spatiotemporal framework? How can we explain the unity of any mental state in correlation with the transmissions between neurons (from electrical to chemical and back to electrical signals) and all the other neuronal processes like oscillations and neuromodulators? The neuronal processes and the unity of any perceptual image belong to EDWs, so using any kind of instrument we cannot perceive this unity in the brain because it does not exist in the brain.

Let me analyze in detail a particular mechanism of the neuronal vision: the retinotopic maps. There are two pathways from retina to the brain, i.e., the tectopulvinar path (fast-acting sensitive to motions and novel objects in the visual periphery, inputs from M ganglion cells) and the geniculostriate pathway (for our conscious experience of seeing - perceiving color and all the fine-grained features). The layers from the lateral geniculate nucleus (LGN) receive different inputs only from one eye. Interestingly, most inputs to the LGN come from the cortex not from the retina![1] So, regarding the relationships between retina and the primary visual cortex, we have to take into account the feedforward and feedback projections (bottom-up and top-down processes). It is well known that the projections from retina to the LGN and from LGN to the primary visual cortex (V1) preserve a kind of spatial organization (retinotopic maps[2]). The retina of each eye sends 2D image to the LGN

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[1] Reid and Usrey write that “the inputs that the LGN receives from the cortex also seem to be segregated, such that different populations of cortical cells send input to different layers of the LGN” (Reid & Usrey 2008) The authors add that the “functional significance of these feedback connections from the cortex is still under investigation (…)”.

[2] “For any cortical column, receptive fields are all located at roughly the same position on the retina. Nearbycolumns represent nearby points in visual space in a precise and orderly arrangement. The position of a stimulus on the retina is termed its *retinotopy*; thus a region of the brain (such as the superior colliculus, LGN, or the visual cortex) that maintains the relations between adjacent retinal regions is said to have a *retinotopic map*.” (Reid and Usrey 2008, p. 653)

(retinotopic map) which projects to V1 (also retinotopic maps). Amazingly, the projections of retinotopic maps continue to V2, V3 and V4. Binocular disparity constructs the depth perception in the brain[1]. Banich and Compton (2010) continue their investigation on the primary visual cortex with "contextual modulation", "blind spot", "blindsight", "binocular rivalry" and they conclude that V1 is not coding "for what appears on the retina (…) rather, it is coding for the features that are consciously perceived" and the "brain is actively constructing a representation of the visual world." (Banich and Compton 2011, p. 159) For a clear and complete explanation of this phenomenon, it is lacking the EDWs framework. The processes of the brain that "constructs" the representations of the visual world cannot be explained since we mix EDWs. Moreover, any perceptual visual images (that correspond to the eyes and the entire brain) is the "I". At the end of Banich and Compton's section dedicated to V1, we find this paragraph:

> A more philosophical question is why some kinds of visual processing, such as those supported by the striate cortex, seem to give rise to conscious experience while others do not. This question is much harder, and perhaps impossible, to address with scientific methods. (pp. 160-161)

We may find two scientists who acknowledge that, scientifically, it is impossible to find the relationship between perceptual conscious experience and cortex (that is localization)! The last sentence of this paragraph would force us to think that something is wrong with the framework in which this problem is elaborated! On the same page Banich and Compton write some questions about the retinotopic maps in the brain:

> What is the point of having all of these retinotopic maps? (And there are known to be many more than these three!) Does each area—V1, V2, and V3—serve a different function? Do they represent different properties of the visual world? The

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[1] "Binocular disparity refers to the fact that the image that falls on each retina is slightly different, because the eyes are positioned in different locations." (Banich and Compton (2010, p. 157) This disparity information is first computed in V1.

answer is that we do not really know the functions of all these visual maps. (p. 161)[1]

I believe that the notion of “retinotopic maps” reflects perfectly the mind-brain problem in our days. This is the reason I would like to analyze it in detail.

Quite many years ago, the neuroscientists knew quite many things about the retinotopic maps. For instance, in their book, Bear et al. (1996) depict exactly the relationships between the retinotopic maps that appear on the retina, the superior colliculus, the LGN and the primary visual cortex (V1). However, they indicate that the map is already distorted at the superior colliculus (“more tissue devoted to analysis of the central visual field”).[2] (p. 248) There is a strong segregation of information from retina to the LGN: the parvocellular ganglion cells project exclusively to the parvocellular LGN (dorsal layers), and the magnocellular ganglion cells project only to the magnocellular LGN (ventral layers).[3] Moreover, the right LGN receives information from the left visual field, while left LGN from the right visual field. (Bear et al. 1996, p. 249) Surprisingly, “the visual receptive fields of LGN neurons are almost identical to those of the ganglion cells that feed them.” (p. 250) However, the visual cortex sends 80% of inputs of the excitatory synapses to LGN.[4] (p.

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[1] The answers to these questions are similar with those for the form-cue invariance and the perceptual constancy.

[2] A “discrete point of light can activate many cells in the retina, and often many more cells in the target structure, due to the overlap of receptive fields. Thus, the image of a point of light on the retina actually activates a large population of superior colliculus neurons; every neuron that contains that point in its receptive field would be activated.” (Bear et al. 1996, p. 246)

[3] There is also the koniocellular pathway that project to the konioncellular layers of the LGN.

[4] “This system of descending connections is truly impressive, as the number of descending corticothalamic axons greatly exceeds the number of ascending thalamocortical axons. These connections permit a particular sensory cortex to control the activity of the very neurons that relay information to it. One role for descending control of thalamic and brain stem centers is likely to be the focusing of activity so that relay neurons most activated by a sensory stimulus are more strongly

251) This feedback pathway is essential for our visual cognition (i.e., for the mind) and we cannot ignore it! The LGN projects information to the primary visual cortex (different layers but mainly layer IVC). (p. 253) We find here the retinotopic projections (similar to those from retina to LGN). There is also the segregation of information: "magnocellular LGN neurons project to layer IVα and parvocellular LGN neurons project to layer IVCβ." (p. 254) Layer IVC neurons project information (through axons) to layers IVB and III and here, for the first time, information from the left eye and the right eye is mixed even if the information from each eye remains still segregated: each blob receives input mainly from one eye! (Bear et al 1996, p. 256-8)

From my viewpoint, I underline that the binding process takes place for each eye separately. Thus, it does not matter that the information of each eye is segregated until it reaches layers IVB and III of the primary visual cortex, since the binding processes already happen. Bear et al. (1996) continue their investigation inquiring about the correlations regarding perception and neurons. Even in that period of time, the authors were aware of the fact that the perception of external objects required many "cortical modules" but also some crosstalk interactions. (p. 264-5) This is the reason why they consider that "beyond V1", the processes are much more complicated. (Again we have here one of that expressions that project us within the realm of the unicorn world!) From my viewpoint, this is a clear example that the perceptual visual inputs belong to the mind-EW and not to the subcortical parts of the brain and the primary visual cortex. The eyes, the subcortical and the cortical blobs are parts of the brain (and body), but from their viewpoints (i.e. points of interactions) all these parts have nothing to do with the perceptual cognition (that is the "I"). Even if there are some retinotopic maps from the eyes to parts of the brain (retina-LGN-V1), beyond V1 there are the dorsal pathway and the ventral pathway that have particular functions and

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driven and those in surrounding less well activated regions are further suppressed." (Hendry et al. 2008, p. 547) also strong interactions.[1] Color, space, and all other perceptual features are "widely distributed in the brain". Otherwise, working within the unicorn world, we would need to introduce a homunculus to observe the retinotopic maps in the brain, and we would collapse into a regression *ad infinitum*.

Banich and Compton analyze the role of V4 for coding color. They consider that area V4 is the most activated one for coding color, but there are other neuronal areas involved in this task. Therefore, it is "far too simplistic" to believe that V4 is the area for coding color (and nothing else)[2]. (Banich and Compton 2011, p. 163) Moreover, we already know that the most difficult problem to solve is the integration of signals received by different modalities (for instance visual and auditory inputs)[3] and "there is still much to be

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[1] "In the visual system, separate "streams" involved in visuosensory and eventually visuomotor functions have been described; one is responsible for using visual cues to drive appropriate eye movements and the other for dealing with

The tasks of visual perception (Gallant and Van Essen, 1994). In the somatosensory system, separate motor and limbic paths exist to perform much the same functions for the entire body, supplying sensory input to coordinate and adjust motor output and using complex input from many receptor types to match the shape of a tactual stimulus with one already stored in memory (Johnson and Hsiao, 1992). In the association pathways of the human auditory system, a specialized area of cortex, Wernicke's area, plays a fundamental role in processing speech and language information and in communicating with Broca's area to form a speech motor response. These streams are not separate, as traditionally viewed "motor" areas such as Broca's are now known to become activated in comprehension tasks. Apparent from this pattern in association areas of the cortex is the continued pressure for a division of labor within each sensory system; not one that produces separate paths for analyzing elemental features of a stimulus but one that combines those features either to elicit appropriate movements or to match a stimulus with an internal representation of the world." (Hendry et al. 2008, pp. 547-8)

[2] The authors write that "(cells in V4 of the monkey are also responsive to properties other than color, such as line orientation, depth, and spatial frequency)" and "cells in areas V2 and V3 are sensitive to color" and finally "but the exact nature of the association—how to define different subregions, and what unique contribution each one makes to color perception—is still subject to debate among vision scientists". (Banich and Compton 2011, p. 163)

[3] The alternatives are: convergent model ("auditory and visual inputs are first processed in their separate cortical areas, and then those areas converge upon higher-

learned about how the sensory modalities interact" (p. 173).[1] Within the unicorn-world, many such pseudo-problems that cannot be "solved" by any science/method/apparatus in the future will be discovered![2]

Clearly, following Descartes and from the EDWs viewpoint, we cannot talk about space within the mind: it is really meaningless. I repeat that possessing any spatial dimension, the mind (the "I") would not be able to accomplish its mental functions and the corresponding organism would not be able to survive in its environment. The unity of any perceptual scene is possible only because such mental images do not have any spatial dimension. As I emphasized several times, the "I" has a representation of space but it has no spatial dimension exactly as it has the representation of color but not the color itself. Moreover, time as well is not a property of the mind, but the representation of time is the "I". I strongly draw the attention upon the fact that believing that space and time are dimensions of the human mind is one of the main errors in explaining the functions of the mind!

Let me investigate Chapter 8 from Banich and Compton's book (2011) dedicated to "spatial cognition". In the first paragraph, they specify that the "spatial processing" represents different "abilities" not just a simple "cognitive function". (p. 209) Moreover, the authors are convinced that the retinotopic maps of space (analyzed in Chapter 6) can be found in the visual cortex. (*idem*) Nevertheless, four points support the idea that the retinotopic maps are not enough to explain the space around us:

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level association areas") and interactive model ("processing in one sensory modality (e.g., vision) can influence the information that is being simultaneously processed in another modality (e.g., audition)". (Banich and Compton 2011, p. 173)

[1] It is about the "crossmodal interactions", so see Chapter 10.

[2] In this book, I interpreted within the EDWs quite many paragraphs that refer to different topics. Many times, my comments on these various topics are quite the same. So, someone could assert that these comments, being the same statements, are quite useless to repeat for each paragraph. I analyzed so many paragraphs using the same comments just because I am aware how difficult (almost impossible) it is to change a paradigm of thinking in any domain, especially when this paradigm is the largest from the history of human thinking!

(1) For object recognition, it seems that the retina furnishes only 2D information about a tridimensional object, therefore the “mind has to translate 2D in 3D”[1].

(2) The “mental map of space” is constant, even if you move your eyes (head, body) and therefore the information on retina changes dramatically.

(3) The mental representation of space fills the unobserved space.

(4) We often use spatial maps much larger than our field of view[2]. (Banich and Compton 2011)

Here are the same points that I analyze in my entire book! All these points can be explained only within the EDWs perspective: there is no passing from 2D to 3D, the constancy of an image is the “I”, the brain does not fill the perceptual image, the mental imagery is not spatial. The “I” is an EDW rather than the brain (that is indeed situated within the space of the macro-EW). Since the “I” has no spatial dimension and the brain has spatial features, there is an illicit extension of some features that belong to the external entities to the mind. Exactly because of illicit extension, all the problems related to the spatial dimension (either neuronal, that is localization, or mental) are pseudo-problems generating great anomalies. In reality, we need to check only for the correspondences between mental states and neuronal states, but we have to take into account that the mind-EW and the brain have epistemologically different properties.

Banich and Compton are aware of the fact that the spatial functions (involved in many other functions – for instance, motion) depend not only on the dorsal visual stream (mainly, in parietal lobe), but also on other brain regions. This is the reason why they believe that the “situation is, as always, more complex”.[3] (Banich

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[1] In other chapters, we saw some authors using “extract” instead of “translate”. (For instance, Reid and Usrey 2008)

[2] The last point is strongly related to the notion of “mental imagery”. (See below)

[3] “Directionally selective retinal neurons do not project to the LGN so directional neurons found in the visual cortex (Hubel and Wiesel, 1962) create their selectivity independently and with a different mechanism.” (Reid and Usrey 2008, p. 646) The retinotopic maps are not available in the case of motion. Why then we insist on the

and Compton 2011, p. 210) This expression is typical for somebody trying to solve a pseudo-problem within the unicorn world! From an EDWs perspective, the situation is not complex but totally wrong. Again, I insist in writing that the representation of space is the most difficult problem in cognitive neuroscience just because all people illegally extended a feature of the macro- or micro-EWs (reflected by the relationships among different objects that belong to EDWs) to the mind-EW. We return once more to the main idea of this book: if there are different neuronal areas responsible for certain characteristics like color, space and motion, how are they related to the mind (the binding problem)?[1]

Banich and Compton offer several reasons in arguing that the posterior parietal cortex processes spatial relations. These cells respond to the relationship between retinal location of visual stimuli and position of head/eyes, specific direction of motion, information about the speed of external objects, planned movements (reaching and grasping), visual and tactile stimuli. Where then is the error? Many people (including the authors of the last paper mentioned) believe that the "binocular disparity" is a cue to the depth. Nevertheless, the binocular disparity appears to our eyes when we investigate the brain of another person, but this process does not exist for the mind's eyes.

Let me take an example: Banich and Comptom inform us that the binocular disparity is a cue to depth and this process is not

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retinotopic maps regarding other spatial features? Discussing about the "aperture problem" (seeing through an aperture, two objects moving in different directions can appear to have the same direction of motion), Reid considers that unlike the "neurons in V1, many neurons in MT responded to the pattern direction rather than to the components. This would imply that these MT neurons combine their inputs in a complex manner to achieve a selectivity for the motion of extended objects rather than primitive features." (Reid and Usrey 2008, p. 646) Wonderful questions within the unicorn world!

[1] The error of this question was observed by Ryle (even if he also worked within the unicorn world): there are different frameworks (or different languages, for Carnap) and one notion from a (linguistic) framework cannot be extended to phenomena that belong to another framework. (About Carnap's linguistic frameworks, see Vacariu 2008)

represented by the primary visual cortex (the retinotopic map is 2D) which sends information to the dorsal parts. The inferior parietal lobe, area 7a, lateral intraparietal area and M5/MT are sensible to the perception of depth. (Banich and Compton 2011, p. 212) The main problem is that the space in which the cells are situated does not represent the mental space. If the dorsal part receives information from the primary visual cortex (and other neuronal areas, 2D), we have no idea how 2D images are transformed into 3D representations. In reality, even the image of the external environment is the "I": all the properties of such images (that can change very fast) are incredibly difficult to realize by the specific neuronal areas. Again, we do not have to forget that these images also have many other properties (among these properties, some of them are conscious states). Therefore, we can identify only the correspondences between these properties and parts of the brain (the most activated neuronal regions for space). We cannot identify the "space" itself whatever instruments we use and whatever experiments we realize. The activities of neuronal cells where we can find the retinotopic maps correspond to the *representations* of space in the mind. The major mistake is that, using particular tools of investigation, we take into account only some parts ("aspects") of the brain (maybe these "aspects" belong to EDWs!), when in reality the entire brain is involved in the correspondence of particular mental functions. Even at the beginning of the last century, it was known that the parietal damages can impair depth perception, but it does not mean that only this neuronal area is responsible for this mental process.[1] Probably, from the fMRI results and the brain damage

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[1] "Evidence from humans suggests that although damage to the parietal cortex in humans can impair depth perception (e.g., Holmes & Horax, 1919), there does not seem to be any syndrome in which perception of spatial depth is disrupted but all other spatial functions are intact. This finding tells us that coding for depth probably does not rely upon a single dedicated brain region whose function is to compute depth and nothing else. Rather, processing of depth probably occurs throughout various dorsal stream areas that represent space for a variety of purposes, such as providing a spatial framework for reaching and grasping motions and for understanding motion in the plane of depth." (Banich and Compton 2011, p. 213) I

investigations, we can consider that the parietal area is most sensitive to depth perception, but other tools of inquiring the brain process will suggest us that other areas or processes are responsible for the same mental process.

Analyzing the relationship between object-centered and eye-centered frames of reference, Banich and Compton consider that, among many problems, one essential question is how the brain "creates" *integrated* "multisensory representations of space", using information, for instance, from touch, hearing, and vision? The answer is relevant for somebody working within the unicorn world: "As you can see, researchers are still far from understanding exactly how multiple reference frames from various senses are integrated." (Banich and Compton 2011, p. 214) In many papers and books on cognitive neuroscience, I have found such meaningless positions. The existence of crossmodal interactions is another argument for the rejection of space as mental dimension. The crossmodal interactions (the integration of different sensorial elements) do not exist in the brain or the mind. So, it is meaningless to check for the existence of space in the mind. The authors consider that the left hemisphere is specialized in processing the *categorical spatial relations* ("which specifies the position of one location relative to another in dichotomous categorical terms (e.g., above vs. below, top vs. bottom, front vs. back, left vs. right)") and the right hemisphere in the *metric spatial relationships* ("the distance between two locations"). (Banich and Compton 2011, p. 216) Again, we have representation of space exactly as we have representation of color even if nobody claims we have color in the mind or brain. In other words, nobody claims that the mind/brain has color! Exactly as life (or mind) is an EDW than an organism (brain), space is not a dimension (property) of mind or life. We have to be aware of the fact that nobody claims that life has spatial dimension, but many people argue that mind has a spatial dimension even if it was argued that mind and life were quite similar (or even identical) processes.

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believe we have to apply this rule for any mental state! For instance, the "I" is involved in any mental state/process so we cannot identify some particular neuronal areas that have to be correlated with the "I".

The leader that claims that the mind/brain has spatial dimension is Kosslyn. I will investigate one of his quite recent papers. (Kosslyn 2010) The question Kosslyn tries to answer is "Where is the 'spatial' hemisphere?". Even at the beginning of his article, Kosslyn specifies that this question is meaningless because the brain "represents spatial information" at least in two different ways, each modality being lateralized in each hemisphere. The brain encodes the "categorical" and the "coordinate" spatial relations representations. The categorical spatial relations representations are more abstract (related to language) and assign relative positions to each categorization (such as above or left of). The coordinate spatial relations representations are useful for navigation and reaching, and specify the "location in metric coordinates relative to an origin". (Kosslyn 2010, p. 42 and p. 55) Kosslyn offers results from some empirical experiments, neuroimages studies, brain damages cases, visual mental imagery cases, and computational modeling results so as to prove that each class of these representations is lateralized in different hemispheres. The "categorical spatial relations representations" is lateralized in the left hemisphere, while the "coordinate spatial relations representations" is lateralized in the right hemisphere.[1] Interestingly, there is no hemisphere specialized in the mental visual imagery. Kosslyn considers that there is "no single 'spatial' hemisphere. This was the wrong question to ask. We had better ask about the specific ways in which each hemisphere deals with spatial information." (Kosslyn 2010, p. 55) From my viewpoint, the logical consequence of this answer is that there is no localization of space in

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[1] Kosslyn and his colleagues (Laeng and Shah) (1999) showed pictures of common objects either in standard or contorted configurations to their subjects. One part of results indicates that the participants "evaluated contorted pictures more accurately when they were presented in the right visual field, and hence the input was delivered directly to the left hemisphere." (p. 42) Standard configurations presented in the left visual field activated the right hemisphere. "Coordinate spatial relations may be associated with single exemplars; the metric distance to an object often is only useful for a specific object (for example, a table with a certain shape). If so, then ease of encoding coordinate spatial relations may be associated with ease of encoding specific exemplars (…)." (Kosslyn 2010, p. 46)

the brain, therefore there is no space but only the representations of space in the mind-EW. From the viewpoint of a researcher, the external objects and the brain (its parts) belong to the EW, but from the "viewpoint" of a neuronal pattern of activation or a neuron, the space is different because we have epistemologically different interactions. Moreover, the latest "viewpoint" is epistemologically different than the "viewpoint" of a mental state that corresponds to that neuronal pattern. More exactly, it is not correct to claim that a mental representation has a spatial "viewpoint" (that it, a mental representation interacts with something), since any mental state is the "I" that is an EW without spatial dimension. Essentially, Kosslyn's distinction between the "categorical spatial relations representations" and the "coordinate spatial relations representations" has to be considered a methodological and not an ontological one.

Similar to localization, from my viewpoint, lateralization is also an incorrect notion. Again, some parts of the brain are most active for a particular mental task, but we cannot "lateralize" any mental task, even if we talk of the spatial dimension. As I wrote above, we cannot isolate the spatial dimension in the external world, i.e., space does not exist in the world. The relationships between the external entities forced us to think of space.[1] I recall that scene with some objects represented in our mind. There is no space in our representation of that scene but only the representation of the space of that scene.[2] We already know that even if we can very approximately localize some features of an object (color, movement, edges, etc.), the binding problem is a pseudo-problem. Following the same route, trying to localize space in the brain is a pseudo-problem. Using for instance fMRI (a particular tool of observation with certain structure), we can find, with rough approximations, only certain neuronal patterns that are most activated, but according to the EDWs

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[1] We have to recall the dispute between Newton (absolute space and time) and Leibniz (relative space and time to the relationships between objects).

[2] This problem is strongly related to the properties of a scene on a cinema screen (or TV screen). We have the illusion that we see a tridimensional space (illusion created within the mind) but there is only a bidimensional space on a screen.

perspective, the features of an object are that object, the objects of a scene are that scene. The crossmodal neuronal interactions do not "put together" or "link" the features of an object (for instance, an object - having some colors and a noise - that moves in front of us), those neuronal interactions correspond to that object. The same statement is valid for the objects and their relationships that create any scene. Obviously, the color red, for instance, may appear in two objects in the same perceptual scene. Are different neuronal patterns activated for that red color that is the same pattern? Obviously, it is believed that the same pattern is activated for the color of both objects. But what happens if those two objects have quite different shapes? There are other parts of the brain that are activated for those shapes. But the objects are in different spatial places. How is this difference localized in the brain? We had to impose a spatial dimension for the spatial mental representation. The binding process takes place not only for the features of an object but also for the space in which any object is situated. Even if the light reflects only that object (we do not perceive its background or its space), knowledge accumulated and transformed in habituation (which corresponds to the brain-body in their everyday spatial experiences) imposes to the "I" an implicit space, since any object – in normal conditions - is external to the body. The apparent problem seems to be the relationship between the mind-EW and the brain and body situated in macro-EW. How does the "I" interpret the corresponding space since any scene is the "I"? Is something similar with the brain/respectively the mind interpreting a bidimensional photo? I do not think we can make an analogy. In a bidimensional photo, the habituation plays an important role. Moreover, the photo has to be situated in a spatial framework and this element helps the "I" interpret correctly that photo. (If this spatial framework is absent, can we believe the scene represented in a photo is a real scene?) Probably, because of the habituation during the development of each individual (and the evolution of species), the external space of any object does not require the activation of specific neuronal patterns (as for any explicit object) but for any scene the activation of the brain as a whole is necessary. Similar to the external space are the implicit (unconscious) objects in a scene. Almost exactly as space, such objects do not strongly activate some neuronal patterns. However, we perceive (even implicitly, unconsciously) those objects situated in a space, thus a scene. Importantly, the cognitive scientists need to replace the statement “A subject perceives an object” with “A subject perceives a scene”! The perception of an object does not really exist (even if, I repeat, because of the light, we perceive only that object and not its spatial framework). Also, we do not have a mental scene in our head! Moreover, for a scene, we have to add the position of brain and body (this position has also some correspondence elements that are the “I”) and many other elements. It is not about a holistic view of perception (in opposition to the atomistic view), it is about the “I” who is an EW that includes the corresponding images of the body and the external objects.

The development (imposed by development and evolution) plays an important role also for the corresponding images of the body. In the first months after being born, the “I” becomes aware (explicit, conscious knowledge) and then unaware (implicit, unconscious) of the corresponding body and some external objects. In this period, the “I” acquires knowledge referring to the relationship between the corresponding body and external framework of body. This relationship is “inserted” in the “I” that “perceives” the external space (of the body) inside it. “Perceive” means that the relationships between body and the external objects create some neuronal patterns of activation that correspond to a space that belongs to a scene! Any representation of a scene is the “I”. Again, exactly as the color of an external object is represented in the mind (so there is a representation of color), in the same way, the external space does not exist in the mind-EW, but only a representation of space is the “I”. We have to recall the perceiving-thinking contradiction: the “I” cannot “perceive” something external to it (within the unicorn world, everybody thought of the existence of a contact between the self and the external environment). (Vacariu 2011) This is the reason why we cannot localize the color and much less the space within the brain: both the color of an object and the space in which it is located do not exist either in the mind (but there are the representations of color and space that are the "I") or in the brain (the brain has properties like color and space but these properties are not the qualities of any external object). We can introduce more questions and the state of affair becomes more and more complicated. These questions reflect the illegal extensions made by the human researchers.[1]

Bourlon et al. (2011) investigate the relationship between visual mental imagery and visual perception related to "correlated" neuronal part and movement of the eyes. They quote Bartolomeo (2002) who indicates some patients with occipital damage and some perceptual deficits that have no problem regarding their visual mental imagery. The consequence of these cases is that visual mental imagery is not directly related to the primary visual cortex but to higher levels of integration.[2] (Bourlon 2011, pp. 287-288) Obviously, from my viewpoint, our visual mental imagery is not "correlated" only to the occipital lobe. The human subject is directly involved in such visual mental imagery processes, so we have to introduce into the equation the neuronal patterns correlated with the human subjectivity, the self, and many other elements. The same thing is valid for visual perception. In the past, some researchers believed that the movements of the eyes were quite similar in both processes

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[1] I emphasize that space and color are just two attributes of any perceptual scene or properties of any object and we have to add all the other sensorial qualities. In order to clarify better the idea that mind has no space, it is clear that mind does not have smell, for instance. In other words, mind has no color or space and does not smell! There are some mental states and processes that correspond to some neuronal processes, but these mental representations do not have the similar properties/qualities to various objects. All such qualities are "represented" by the mind and correspond to some properties of entities that belong to EDWs. Therefore, do not check for space in the mind or the brain!

[2] Participants have to imagine a map of France. They heard the name of various towns/regions and had to indicate whether each town/region is on the left or right of Paris. Their vocal response and eyes' movement were recorded. In the second experiment, the subjects see the contour of a France's map (visual mental imagery with map). (Bourlon et al. 2011, p. 288)

of visual mental imagery and visual perception.[1] Bourlon et al. (2011) point out Spivey and Geng's (2001) results which specify a "link between eye movements and mental image exploration, rather than with decision or response stages" (Bourlon et al. 2011, p. 293) Bourlon et al.'s experiments add that saccades of the eyes mirror the direction and the side of exploration. Their conclusion is that there is a "spontaneous eye movement coherent with the location of imagined stimuli". (*idem*) From the EDWs perspective, we return to the virtual space of the mind. (See Vacariu 2001) The movements of the eyes are quite similar in those processes mentioned because of the correspondences between real space and virtual space (the represented space) and between entities that exist in EDWs. Nevertheless, the "mind's eyes" do not exist just because there is not the "I" somehow separated by the external visual "scenes". On the contrary, any visual scene is the "I".

Quoting various authors, Wu et al. (2012) start their paper with the following paragraph: "While visual object recognition may seem effortless, it is actually a highly constructive process, involving a stream of processing that begins with the retinal image, advances through a sequence of computational stages, and culminates in a match to representations in memory (…). (Wu et al. 2011, p. 33) From my viewpoint, this paragraph reflects the framework of the unicorn world that obviously dominates cognitive neuroscience. As I tried to show in the whole book, perception is not, as many people have thought, a process that is constructed in a hierarchical structure from the retina to the low-level inputs and then the high-level inputs (from retina to the LGN and V1 and V2-V5 and then to parietal and temporal lobes and even further to frontal lobe, etc.). What kind of "hierarchical structure" can we talk of if there are so many feedforward and feedback projections between the low-level and the

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[1] Bourlon et al. indicate previous results of previous experiments. For instance, two "previous studies (Brandt and Stark, 1997; Laeng and Teodorescu, 2002) produced evidence consistent with this proposal, by showing that normal participants tend to produce similar eye movements when exploring a visual display and when subsequently imagining it." (Bourlon et al. 2011, p. 288)

high levels (between all parts of the brain for any corresponding cognitive perception) and we cannot identify the localization of neuronal parts that bind such information? We noticed above that some researchers believe that the retina signals and the low-level inputs are quite empirical, while the information at the high level is quite *abstract*. From my viewpoint, even the inputs from the retina *correspond* to elements that belong to the mind-EW. Otherwise, we would have to integrate different kinds of information (even ontologically different matters) and this is not possible. The high level and the abstract level cannot be something ontologically different than the retina signals and the low-level. We return thus to Baars and Gage's idea that the brain "*fills in perception* of the blind spot". (Baars and Gage 2010, p. 186) As I showed throughout the entire book, the brain cannot "fill in perception" of the blind spot or of color, patterns, motion or other parts of the visual field. We would get some ontological contradictions impossible to solve.

For Wu et al (2012), visual object recognition is a "highly constructive process, involving a stream of processing that begins with the retinal image, advances through a sequence of computational stages, and culminates in a match to representations in memory". (Wu et al 2012, p. 33) This construction is necessary to view large objects, the

> necessity for construction is particularly apparent in the situation where information constituting an object is progressively unveiled from spatially distributed exposures. For example, viewing large objects may require integration across saccades, each with its own retinal projection (Irwin, 1991; Melcher & Morrone, 2003; Rayner, 1978), or people may rotate an object to view it from multiple perspectives (Harman, Humphrey, & Goodale, 1999). Under such conditions the ability to integrate information over time and space is critical to the formation of object representations. (Wu et al. 2012, p. 33)

From my viewpoint, such integration would require the mixture of different information (sensorial, perceptual, and conceptual information) that corresponds to the activity of the entire brain. Anyway, it is meaningless to draw a line between external inputs (retina + V1) (or low-level) and internal information (V2-V6 + short term memory, parietal and temporal lobes) (the high-level). Otherwise, we would mix information that produces some hyperontological contradictions. Again, we can ask where the neuronal parts associated with other elements like the self, space and time, conscious and unconscious states, implicit and explicit knowledge (and all other kinds of knowledge) are. In order to avoid such questions, in a Kantian sense, the external world is incorporated into the mind (but not into the brain since there are many interactions between the brain and the external environment).

Wu et al. also interrogate about the relationship between the spatiotemporal framework and the recognition of an object in a particular context: "Observers use a sequence of 2D cross sections, taken from a virtual object in 3D space, to obtain a representation of its 3D structure." (*idem*) For them, the construction of an object representation is a spatiotemporal process.[1]

> For example, participants in Stone's studies (1998, 1999) saw videos of amoeba-like objects that rotated in one direction in the learning phase but in the reversed direction in the subsequent recognition phase. The rotation-reversal produced a significant reduction in recognition performance, suggesting that spatiotemporal information had been incorporated in object representations. Naming familiar objects is also found to be easier when participants viewed structured sequences compared to random sequences of object views (…). (Wu et al. 2012, p. 34)

Within the EDWs framework, the mind has no space. There are other mental processes that have to replace the spatial dimension. The spatiotemporal information is indeed "incorporated in object representations", but this incorporation is better understood as "correspondence" with a *virtual* spatiotemporal framework that is completely different than a real spatiotemporal framework. It is the mental representational space that does not correspond to a space in the brain! Wu et al. made some experiments with the anorthoscopic viewing: a large figure is exposed by passing a small aperture over it.

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[1] "Previous research has shown that such spatiotemporal information can aid in interpreting biological motion (Johansson, 1973), categorizing familiar objects (Lawson et al., 1994), identifying faces (Wallis & Bülthoff, 2001), and recognizing novel objects (Stone, 1998, 1999)." (Wu et al. 2012, p. 34)

> Although the mechanisms underlying anorthoscopic perception are still not fully understood, it is commonly accepted that the necessary processes include segmentation of portions of the underlying figure as garnered through occluding aperture, storage of piecemeal information acquired over time, localizing the pieces within a common spatial framework, and finally, assembling the pieces into an integrated form. Of particular interest in this study are the last two processes, namely, localizing the piecemeal views and integrating across views according to their spatial relationships. Together these processes constitute a form of visualization (McGee, 1979). (Wu et al. 2012, p. 34)

I think that we can make an analogy between the anorthoscopic perception and the processes from the mind-EW that correspond to the interactions between an external object, retina, and the entire brain. If all these processes exist, they are within the mind-EW. The authors indicate two alternatives to this problem: the "retinal painting" hypothesis (Helmholtz) ("a representation is constructed by projecting the successive views onto adjacent retinal loci, thereby resulting in an integrated percept", but there are experiments that contradict this alternative) and the "post-retinal storage" alternative ("information available through the aperture is stored in a working memory and then combined into a whole figure") (Girgus, Gellman, & Hochberg, 1980; Hochberg, 1968; Parks, 1965; Rock, 1981). (p. 34) For the second alternative, it is necessary to localize each visible aperture by mapping it into a common spatial frame of reference. (p. 35) From my viewpoint, this requirement needs a spatiotemporal framework. The combination of the information available through the aperture with that stored in the working memory and the formation of a whole figure takes place within the "I" that has its unity. Otherwise, being would not be able to realize such constructions. In their experiment, they need to establish a "correspondence" between the slices of 2D images (cross-sectional images) observed by the human person and the 3D structure of that real object. These cross-sectional images have to be integrated within a single image (of that real object), an integration realized with the help of a common "frame of reference" that acts as a "glue". (Wu et al. 2012, p. 35) If the mind-EW has no spatial dimension, how does the "integration" of this information in a whole figure happen? (I will try to offer an answer to this question in my future work.) Anyway, integration is given by the unity of the "I", so we have to describe this unity in detail. The authors consider that integration has two steps: "a two-level integration process – constructing individual segments from regions within the cross sections, and constructing a representation of the whole multi-segment object". (p. 37) Moreover,

> the computational mechanism for visualization, which demands post-perceptual working memory for its implementation, transcends the visual system. It is likely to involve higher-level amodal mechanisms (Loomis et al., 1991; Shimojo, Sasaki, Parsons, & Torii, 1989). In this regard, we note that similar integrative processes are demanded in haptic spatial and object perception where information is sequentially sampled. (Wu et al. 2012, p.47)

Again, we have here an illegal mixture of modal and amodal information (perceptual and conceptual inputs or low- and high levels).

Sperduti et al (2011) suggest that many experiments realized in the past indicated that right frontal and parietal areas are essential for time processing and for attention and memory. (p. 16) On the contrary, their experiments reveal that the oscillations in these regions "could appear at odds with intrinsic models." In their view, "duration is not equivalent to a simple stimulus feature and encompasses supramodal properties." (p. 16) Their conclusion is that

> directing attention in a top-down manner to process the duration of a visual stimulus recruits gamma-band oscillations in a right fronto-parietal network. Based on results by N'Diaye et al. (2004) we propose that this activity could reflect supramodal processing of duration, complementary to sensory features processing. The functional role of this activity would be to support the supramodal properties of a time dimension that goes beyond purely perceptive features. (Sperduti et al 2011, p. 17)

We have to remember that, according to Einstein's special theory of relativity, space cannot be separated by time. Why do we try to localize separately space and time in our brain? Do we have a mental spatial representation that is separated from the time representation?

I believe that it is quite impossible to separate the mental representation of space from the mental representation of time. When an EW has spatio-temporal dimensions (not the mind-EW), these spatiotemporal frameworks (like all other features) are epistemologically different properties. In other words, each EW has its own spatiotemporal framework (if that EW has spatio-temporal dimensions) reflected by the epistemologically different interactions between epistemologically different entities. If we can measure the time of some neuronal processes, we cannot measure the time of mental processes. In fact, since the EDWs each have their time, I indicate that the segmentation of mental states is incorrect. Time is the “I”, any mental state is the “I”, so we cannot really make any difference between a mental process and the time necessary for the process of that mental task. Without any comments, I end this chapter with Robertson’s words:

> In an elegant overview of the spatial functions of the parietal lobes, Stein (1992) made a similar argument but concluded that the parietal lobes act to convert signals from one reference frame to another by accessing a set of distributed information processing rules. In his language, no “real” map of space exists in the parietal lobes. Although this is surely true, just as no real yellow exists in the brain, the question becomes how visual systems interact to represent the perception of a unified space. Just as the experience of bound features suggests an integration between such features as colour and shape, so too the experience of a unified space suggests an integration as well. This integration of spatial maps in turn appears fundamental for proper feature binding. An explicit spatial map related to parietal function has more to do than simply direct movement or action (although this is clearly one of its critical jobs). It also appears to be the basis for proper feature integration, a perceptual process.

Chapter 10

Crossmodal interactions

One of the most difficult problems in cognitive neuroscience (another one!) is the crossmodal interactions (a particular case of the binding problem). For instance, someone perceives an object that has a color and a particular shape being in motion within a particular spatiotemporal framework. If these properties (and other features) are processed independently (not completely), the classical question is what mechanism offers the unity of a coherent conscious experience of this visual scene. Even if, from my viewpoint, the question is meaningless, I would prefer to investigate it in detail. The notions of "cross-modal interactions" and the "multimodal integration" have been used quite frequently in cognitive neuroscience lately. These are the main reasons why I dedicate a chapter to this notion.

The traditional view classifies vision as a modular system, self-contained and independent from other senses. Even if different sensory modalities are realized through different pathways and we do not know yet exactly how these "modules" communicate, the human subject has a unified perception of the world. Therefore, it has to be some higher levels of processing that produce this unification. (Shams and Kim 2010, p. 12) Contrary to this classical view, Shams and Kim try to show that vision is altered by sound and touch even at the primary visual cortex! (Shams and Kim 2010, p. 1) The authors mention that, in the past, the influences of the visual signals on other modalities were acknowledged, but only recently have the influences of other senses on the visual perception been shown. (p. 2) "Visual processing can be modulated by non-visual sensory signals even at the earliest stage of cortical processing, primary visual cortex (…), and with a very short latency (…)."[1] (Shams and Kim 2010, p. 13)

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[1] Essential for the EDWs perspective is the following observation: "The electrophysiological and neuroimaging findings may even underestimate the degree

Based on other research, Shams and Kim present cases in which sound and touch increase the “perceived brightness, aid detection, improve temporal resolution, guide attention, and affect motion perception in visual processing”. (p. 2) For instance, experiments made by various people showed that “the crossmodal enhancement of contrast detection largely results from cognitive rather than sensory integration effects”, “decisional and a sensory effect of sound on visual perception”, spatially and temporally coincident sound improved visual detection of degraded stimuli; signal detection analysis revealed a change both in the decision-making criterion and in perceptual sensitivity (…) caused by sound”; “sound can also aid visual perception independent of such temporal cueing effects”, “grouping or saliency in the auditory modality can affect saliency or grouping in the visual modality”, “brief sound presented simultaneously with a color change of a visual target can also decrease detection time when searching for a visual target (e.g., a vertical or horizontal line, changing colors at random times) in a complex, dynamic scene consisting of an array of visual distracters (e.g., oblique lines at various orientations, changing colors randomly and at random times)”[1]; sounds “can especially affect vision in the temporal domain”, tactile stimuli “have also been demonstrated to

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of integration in the brain, given that each method has its own technical limitations. For example, a relatively small proportion of neurons may exhibit superadditivity (which has often been used as a measure of crossmodal interactions in EEG and MEG studies); therefore, physiological recording studies may fail to find such effects due to sampling and signal to noise issues. Additionally, multisensory neurons may be organized in patches amongst unisensory neurons (…), making it difficult to find multisensory effects with the relatively coarse resolution of human brain imaging studies. As research techniques develop, more and more evidence of multisensory integration effects in unexpected regions may become uncovered.” (Shams and Kim 2010, p. 13)

[1] “This is a surprising effect, given that the sound contains no information about the location or identity of the visual object. One may suspect that observers perhaps pay more attention to the visual stimuli when they are accompanied by sound. This top–down control of attention is called endogenous attention.” (Shams and Kim 2010, p. 3) (The “automatic exogenous attentional cueing effect” is the bottom–up stimulus driven.)

affect visual temporal perception" (p. 3-4), the "perceived trajectory of visual motion can be altered by sound", etc. (Shams and Kim 2010, p. 5) Moreover, the crossmodal signals can "affect sensory processing by directing attention" or visual motion perception. (p. 4) Essentially, the authors mention that "although typical vision dominates over auditory or tactile motion perception (…), several studies have reported that visual motion perception itself can also be influenced by other modalities (…). However, these results could be explained by a response bias effect rather than a sensory integration effect." (Shams and Kim 2010, p. 4)

Another argument for such crossmodal activities is the neural correlates of crossmodal modulation of vision. (Section 4 in their article) Recent research experiments show that the neuronal areas correlated only with vision in the past are influenced by the multisensorial stimuli: "visual areas functionally specialized in processing certain features can be modulated by crossmodal stimuli conveying analogous features."[1] (Shams and Kim 2010, p. 6) Against the traditional, classical view, some experiments illustrate that the primary visual cortex (V1, V2, V3) is affected by certain crossmodal stimulation (auditory or even tactile stimuli).

> Retrograde tracers injected in peripheral V1 and V2 in monkeys indicated input from both the superior temporal polysensory area and the auditory core and belt and caudal parabelt areas [Cappe C, Rouiller EM, Barone P. 2009]. Using anterograde tracers, Rockland and Ojima [2003] found direct connections from auditory cortex as well as parietal association cortex to V1 and V2. Hirokawa et al. [2008] recently investigated the functional importance of such lower-order sensory cortices in multisensory integration in rats. (Shams and Kim 2010, p. 8)

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[1] For instance "an fMRI study of haptic object identification (vs. haptic texture identification) found consistent activation of the lateral occipital complex (LOC), a visual object-related region (…). The LOC area has also been demonstrated to be modulated by auditory experience. An electrical neuroimaging study of visual episodic memory discussed below (…) revealed that differences between audiovisually encoded stimuli and visually encoded stimuli were apparent as early as 60 ms post-stimulus, with changes occurring through generators in the right lateral occipital complex areas, suggesting that multisensory experiences affect unisensory processing at early stages and within "visual" object recognition areas." (p. 6)

I emphasize an important aspect: we saw in Chapter 6 that, using fMRI, the spatial localization of a particular feature is very difficult to grasp at the "neuronal level". In Chapter 7, we saw that, using EEG, the temporal binding does not have an accepted solution. Reading the paragraphs quoted above, I may wonder how someone could imagine that it is possible to localize space and time or crossmodal interactions in the brain. If we try to answer these questions, automatically, we would need to introduce an avalanche of homunculi or "hierarchies of networks"! We can make only methodologically the difference between localizing a particular feature and the crossmodal interactions. It does not exist in the human mind and we cannot identify what mechanisms correspond to these processes. More interestingly, Shams and Kim inform us that Cappe et al. (2009) suppose that the integration occurs before the primary visual cortex within the thalamus. "Cortico-thalamo-cortical routing could provide a fast feed-forward pathway by which information from remote cortical areas responsive to different sensory modalities could interact." (Shams and Kim 2010, p. 9) There is some experimental research that indicates that the crossmodal signals "enhance visual episodic memory and perceptual learning. The visual recognition of objects can benefit from a multisensory encoding." (p. 9) All these experiments illustrate the *problem of multisensory integration*! (Shams and Kim 2010, p. 11) The traditional answer to this problem is that the same object causes all the sensory inputs that have to be fused together with the help of a special mechanism:

> Behavioral studies show, however, that while the sensory signals often get fused when they are largely consistent, the signals that are grossly inconsistent do not interact and are often treated independently of each other by the nervous system (…). Moreover, a moderate degree of conflict between signals sometimes results in a partial integration, i.e., the two percepts get shifted towards each other but do not converge to a single percept (…).The traditional model of cue combination does not account for the phenomena of partial integration and segregation. (Shams and Kim 2010, p. 11-12)

From the EDWs perspective, the influence of other sensory modalities on vision is meaningless. There would be some strong hyperontological contradictions impossible to avoid within the unicorn world. Such influences happen at the unconscious "level" but the conscious and unconscious phenomena are the "I". Evans and Treisman (2010) plead for the crossmodal integration (visual and auditory features): auditory pitch and visual dimensions of position, size and spatial frequency. Such integrations are correlated with activations of neuronal areas in the multisensory convergence zone of the temporal-parietal-occipital zones. (Evans and Treisman 2010, p. 10) Kubovy and Schutz offer details about the audio-visual objects (the cross-modal objects) that require some crossmodal interactions between vision and audio modalities. (Kubovy and Schutz 2010) They talk of two "linkages" between vision and audition. First linkage is about the duality of visual system that receives information from surfaces (essential are the properties like lightness and constancy) and audition mechanism that receives information from sources (important is the timbral constancy – i. e. the perceptual constancy of a source).

The second linkage refers to the cross-modal interactions between vision and audition. Their "theory of indispensable" refers to (a) the vision states that "spatial separation is an indispensable attribute for visual numerosity" (p. 47); and (b) the audition states that the "frequency is an indispensable attribute for auditory numerosity" (p. 49). In general, an object is defined as visual and/or tactile object, but Kubovy and Van Valkenburg (2001) introduce a new definition for objects that allows the auditory objects: "A *perceptual object* is that which is susceptible to figure-ground segregation" (p. 102)." (Kubovy and Schutz 2010, p. 50) An important characteristic for vision is that the early perception is bottom-up (sub-personal and cognitively impenetrable[1]), the middle perception is under control by processes bottom-up and top-down, and the late perception is top-down controlled (knowledge is used for

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[1] It means cognition does not affect perception. (See, for instance, Pylyshyn 1999)

grouping process and even identifying object). (Kubovy and Schutz 2010, pp. 51-52) The famous Milner and Goodale’s distinction between “what” and “where” subsystems is applied for both vision and auditory functions. Quoting some experiments, the authors believe that audition is more important than vision regarding the temporal information. (p. 55) More interestingly, Schutz and Lipscomb (2007) show that the “binding depends on the ecological fit between visible events and sounds” (Kubovy and Schutz 2010, p. 55), that is, when “the observers heard the sound while seeing the marimbist perform it, the gesture affected the perceived duration of the sounds”. (p. 57) Important for the EDWs perspective is the following observation:

> *if we did not move the position of disk that represents the head of the mallet, its duration still affected the perceived duration of the sound*. So the visual information required for the binding is quite abstract. (Kubovy and Schutz 2010, p. 57)

and

> audio-visual objects are constructs of the mind—they are the endproduct of a process that operates on sensory information, and attempts to produce the most plausible reading of this information as caused by objects and events taking place in the environment. (Kubovy and Schutz 2010, p. 59)

We find again that the binding process is quite abstract and the audio-visual objects are construction of the mind! However, on the one hand, even if the authors emphasize that they do not want to undermine the notion of the “mind-independent physical objects” (p. 58), they follow the Kantian line of thinking: the audio-visual representations of objects are certain constructions of the mind. In this respect, this position is quite close to the EDWs perspective. On the other hand, the homunculus is required since a process that “operates on sensory information” is necessary! The mixture of EDWs is very clear.

Somehow related to the cross-modal interactions, based on the notion of “neural correlated of consciousness” (NCC), is the distinction between NCC-pr and NCC-co, the distinction between the processes that are prerequisite (NCC-pr) and processes that are consequences (NCC-co) of NCC. (Aru et al. 2012) Examples of NCC-pr are the stochastic fluctuations in the excitability neurons, the "spontaneous excitability as also indexed by oscillatory power" or certain processes related to attention, decision bias, etc. (section 2 of this article in press) An example of NCC-co processes is the neurons in the medial temporal lobe that participate in the formation of memory trace (not, as it has been thought, in the conscious processes). Such processes reflect the differences in performance. Several times, the authors emphasize that there is no clear separation of all these three kinds of processes. Therefore, they reject the classical method of contrastive analysis (on the same stimulus conditions, the human subject perceives the object consciously or not, Baars 1989) and propose other methods of disentangling NCC-pr and NCC-co from NCC. They propose manipulation of NCC-pr processes while NCC remain constant. (Section 3) For instance, under the same stimuli, we could vary "potential NCC-pr" like stimulus expectation, adaptation, working memory or allocation of attention.

> Which neural processes resulting from the stimuli contrast (consciously perceived) vs. (not consciously perceived) are similar and which ones are different in these two conditions? Neural signatures that differ between conditions should belong to the NCC-pr; neural signatures common to both comparisons are likely to be related to the NCC. (Aru et al. 2012, p. 741)

Another example of NCC-pr process is the short-latency event-related potential (in the past included in NCC for perception). From my viewpoint, the distinction between NCC-pr and NCC is quite arbitrary. Even more difficult is to make the distinction between NCC and NCC-co.[1] (section 3.2) Based on recent research, the

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[1] The authors mention that "the P3 event-related potential typically associated with conscious access (Dehaene and Changeux, 2011), does not follow conscious perception when subjects already have a conscious working memory representation of the target stimulus (Melloni et al., 2011). This result points to the tantalizing possibility that late waves of EEG activity such as the P3 might reflect NCC-cos, and not the NCC itself." (Aru et al. 2012, p. 742)

authors offer details about the temporal distinction between these processes (4.1) and spatial distinction (4.2) but some areas recognized in the past as being involved in conscious processes are discarded (for instance prefrontal cortex involved in conscious perception[1]). From different studies, the authors conclude that the processes (like event-related potential) before 100ms (P100) belong to NCC-pr processes while the processes after 300ms (event-related potential P300) belong to NCC-co processes. P200 in occipital parietal areas seems to be the most consistent process for NCC. Nevertheless, the authors recognize that this case is not a rule for disentangling these three classes of processes. “This further complicates the search of the NCC, as they might change in time depending on which NCC-pr determines perception”. (Aru et al. 2012, p. 743) Actually, there are strong debates regarding the neuronal zones that are involved in CNN: are all or only some of the sensorial areas, the higher “levels” (prefrontal cortex)[2], and are other areas involved in NCC or NCC-co or in both and in what degree? Again, offering different experiments as argument, the authors consider that the prefrontal cortex, some parietal areas or even V1 are correlated with NCC-co (for instance, memory, executive functions, top-down abilities/control) and not with NCC. Importantly, “whether some brain area is necessarily involved in NCC may depend not only on its neuroanatomical locus, but also on the specific details of the experience (Haynes, 2009).” (p. 744) If the NCC depends on experience (and context), the problem becomes much more complex. We would need to return to the dynamical system approach (and its related approaches) in order to answer this question.

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[1] In fact, the “PFC could provide top-down support for either strengthening or maintaining the (cognitive results of the) conscious percept (…).” (Aru et al. 2012, p. 742)

[2] Particular zones like the “prefrontal cortex serve a crucial role in conscious perception, as proposed in some theories (…), or whether they reflect other cognitive processes, such as top-down control, report, or performance on a task.” (Aru et al. 2011, p. 743)

In cognitive neuroscience, it is believed that the parietal lobe is the place for the multisensory integration. (But see the last footnote of the previous page!) Through certain experiments involving different sensorial mechanisms, Zmigrod and Hommel (2011) suggest the integration between the auditory stimulus features (loudness and pitch) and the multimodal stimulus features (pitch and color), on the one hand, and between stimulus (unimodal or multimodal) and response, on the other hand. (Zmigrod and Hommel 2011, p. 148) However, in their paper, they emphasize several times that nobody offered a viable alternative to the intermodal binding:

> Multimodal perception (such as with audiovisual stimuli) faces binding problems that are far more complicated than within a single modality, due to the fundamental differences both in the physical properties of, say, sound and light and in the sensory transduction mechanisms (e.g., in transduction latencies, which prevent the use of tight temporal-synchrony criteria for crossmodal binding). And yet, our conscious perception of multimodal stimuli is commonly coherent and unified, suggesting that binding works. (Zmigrod and Hommel 2011, p. 143 or 144)

Indeed the problems seem to be related to the differences regarding both "physical properties" and "sensory transduction mechanisms". However, these problems are constructed within the unicorn world. From my viewpoint, the main mistake with these two problems is the mixture of EDWs. There are no "sensory transduction mechanisms", since such mechanisms would require the mixture of EDWs. Moreover, the "binding" does not "work" since this would be a pseudo-process. (See Chapter 7) Within the brain, there is no such binding process! We have neurons, neuromodulators and neurotransmitters but the unity of the mind (the unity of the "I") exists nowhere in the brain. *It would be meaningless also to check for the processes that are correlated with the unity of the mind!* The nature or ontology of the "I" assures this necessary unity and coherence (or better, this unity is the "I"). It is a huge mistake to check for this unity within the ocean of neurons! From an EDWs perspective, we can return to the classical analogy of the table-microparticles and the integration-differentiation. The integration is not at the “level” of microparticles! The color of that table is nowhere at the level of microparticles. We have to take into account that, in both cases, we use different conditions of observation that pass an epistemological-ontological threshold and consequently we have EDWs.

I add another final idea: the virtual space, like color, does not exist in the mind but it is represented in it. This representation implies the implicit knowledge that is the “I” (not only an explicit knowledge, see Vacariu 2008). Therefore it is quite impossible to localize the neuronal parts that correspond to the representation of virtual space.

Chapter 11

Holism in cognitive neuroscience

In this chapter, I analyze the perspective of holism (quite contrary to "localization") in cognitive neuroscience (first part). Holism means that any mental state is correlated to widely distributed neuronal patterns in the brain. Then I investigate Raichle's default network showing that we have not created yet the apparatus to grasp many activities of the brain (second part). In the context of holism, I will show that it is quite difficult to separate conscious from unconscious mental states, and therefore their localization in the brain is meaningless (third part).

11.1 The parts-whole relationship in cognitive neuroscience

As we saw in Chapter 6, Bartels confirms that large parts of the brain interact for mental processes like attention, binding and segmentation. (Bartels 2009) In other words, a neuronal pyramid is required for the accomplishment of relatively simple mental processes. It seems more and more obvious that any cognitive function activates an entire "neuronal pyramid" but the functions of such mechanism and the exact correlation between a mental function and a neuronal pyramid still remain unclear. The progress of research in this direction suggests that the brain activity is much more complex than we thought in the past. The parts-whole relationship is reflected by the modularity-holism dispute in cognitive (neuro)science. Modularity means that certain mental parts are specialized in certain mental processes: cognition, perception, motor, etc. Some researchers in cognitive neuroscience believe that these modules are correlated with particular specialized neural areas. To support Fodor's modularity, Pylyshyn realized some experiments (1999, 2003). I prefer to discuss a recent paper on modularity. Using the transmagnetic stimulation, Downing tries to prove the modularity of visual system. Three areas of the visual cortex would play a causal role in the perception of human face, body and various objects. (Downing 2008) For me, in order to explain the perception of a human face or an object, we have to solve the binding problem. As we saw in Chapter 7, this problem has not been solved yet. On the contrary, it seems there are less and less chances to solve it, even if there are more and more experiments trying to solve the binding problem. Moreover, in some cases, the visual system is strongly related to consciousness. Thus, the problem of modularity becomes more and more complicated: there are quite many complex relationships between low-level (primary visual areas) and high-level (cognition).

There are many experiments against modularity. For instance, there are no constant correlations to a particular neuronal area (Haynes, 2009) for a specific feature – the color of an object. The role of context for color and the experience of human subject in the perception of colors was acknowledged long time ago. Analyzing in detail the relationship between visual consciousness and neural areas, Haynes believes that

> representation in modality-specific regions is not sufficient to explain why perceptual information enters consciousness. This indicates that additional processes are required that regulate which contents gain access to consciousness (…). These mechanisms are believed to be closely linked to attention (…) but clearly involve more than attentional selection (…). (Haynes 2009, p. 200)

Haynes emphasizes that the physical stimuli are different from the properties of objects that are perceived[1] (Haynes 2009, p. 198) concluding that Baars' global workspace theory seems to be the best alternative, many experiments showing that distributed areas are involved for each mental task. (Haynes 2009)

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[1] For instance, "the encoding of chromatic signals in the retina and in V1 does not match the subject's conscious colour perception that exhibits colour constancy across different illumination conditions" and, therefore, the activity patterns in retina and V1 cannot explain color perception just because there is no constant mapping between these neural areas and individual color percepts. (Haynes 2009, p. 198) We have here another argument for "filling the perception" that supports directly the EDWs.

Van Leeuwen introduces the "coherence intervals" for the durations of the episodes of synchronous activity that ("quasi-stable properties") are correlated to mental representations.[1] Each mental representation has to maintain its integrity and content. The quasi-stable properties are necessary for communication between different neural areas. (van Leeuwen and Bakker 1995, van Leeuwen 2007 in Nikolaev et al. 2009)[2] Such oscillations "synchronize from time to time and, after some time interval, desynchronization occurs. Sometimes, the synchronization spreads to encompass an entire brain region. We called this phenomenon of emerging macroscopic order a coherence interval (van Leeuwen et al., 1997; 2002)." (van Leeuwen 2013) Van Leeuwen relates coherence interval to the notion of mechanism that transmits information. (Fries's article from 2005 is mentioned.) "Coherence intervals, thus, represent global broadcasting of visual information." (*idem*) Interestingly, van Leeuwen offers some arguments to identify "coherence intervals" with "conscious experience":

> The correspondence between visual experience and brain mechanism would go beyond a simple correlation of mind and brain activity. Firstly, the observation was

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[1] Van Leeuwen introduces the "coherence intervals" for the durations of episodes of synchronous activity ("quasi-stable properties") that are correlated with mental representations. "According to the theory of coherence intervals, periods of synchrony are the periods during which communication between brain structures takes place." (Nikolaev et al. 2009, p. 14)

[2] In his paper from 2013, van Leeuwen analyzes the mind-body problem through dealing with free will and consciousness in relationship with neuronal knowledge. The mind-body problem is reflected by two different vocabularies, and van Leeuwen writes that no "ontological doctrine, be it dualism, idealism, nor materialism, will then ever be able to provide a satisfactory answer to the question, what entities ultimately make up our world. It makes one wonder: is there a more productive way of addressing the problem?" (van Leeuwen 2013) The author tries to show that "neither methodological principles, ontological commitments, theoretical nor empirical reasons for science to oppose free will". For instance, van Leeuwen considers that Libet's famous experiments are quite limited because their "choice tasks in a repetitive setting, to which the individual has limited personal involvement". The subject's decisions are run under "automatic pilot". (van Leeuwen 2013)

> made in an experimental setting, which excludes other factors. Therefore, the effect of the independent variable, AR, can be interpreted as causal. Second, the independent variable was not a subjective experience, but an objective one: AR is an established and quantitatively specific, theoretical predictor of ambiguity. Third, the brain activity is understood theoretically as having a function associated with consciousness. For these reasons, we may propose the coherence intervals as having an identity relation to conscious experience. (van Leeuwen 2013, p. 9, about "AR" see the footnote.[1])

From my viewpoint, we cannot talk of "identity" but only of "correspondence" between two entities/processes that belong to EDWs. However, more interesting is the following paragraph:

> Note that the identity considered here is between a mental phenomenon and a dynamically assembled, self-organized brain activity. This is not unimportant. As with the waves mentioned earlier, coherence intervals are caused by movements of particles. But once set in motion, their collective dynamics determines whether a visual pattern is consciously registered (Nakatani et al, 2005). Thus, it means that a phenomenon at this high-level of organization, once brought into existence, is perfectly well capable of causing other events at that level. In other words, the brain has, though its own activity, produced the conditions for mental causation. In turn, the activity at the pattern level modulates that of the different particles that collectively produce it. This means, specifically, that differences in coherence interval lengths will result in differences in perception and behavior. (For these, see van Leeuwen & Smit, 2012). (van Leeuwen 2013)

A mental state is identical with a "dynamically assembled, self-organized brain activity".[2] Much better would be if a mental state *corresponded* to a dynamically assembled, self-organized brain

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[1] "The correspondence between visual experience and brain mechanism would go beyond a simple correlation of mind and brain activity. Firstly, the observation was made in an experimental setting, which excludes other factors. Therefore, the effect of the independent variable, AR, can be interpreted as causal. Second, the independent variable was not a subjective experience, but an objective one: AR is an established and quantitatively specific, theoretical predictor of ambiguity. Third, the brain activity is understood theoretically as having a function associated with consciousness. For these reasons, we may propose the coherence intervals as having an identity relation to conscious experience." (van Leeuwen 2013, p. 7-8)

[2] We argued for such an idea even in 2001! (Vacariu, Terhesiu, Vacariu 2001)

activity. The “coherence intervals” (related with waves) are not caused by but correspond to the “movement of particles”. Moreover, a mental state corresponds not only to a particular wave but also to the activation of all other elements (neuronal patterns, neuromodulators, etc.). Moreover, within the EDWs perspective, the mental causation (downward causation) is meaningless (see Vacariu 2008). “Levels” has to be replaced with the EDWs. Nevertheless, the last sentence is probably true! Van Leeuwen introduces certain experiments that support an important idea: the perceptual switching is a “radically multiply realizable process, in that various neurological states can instantiate it in a single individual at different times”. (p. 11) From my viewpoint, the “multiple realizability” between a mental state and some neuronal patterns of activation exists just because these states belong to the EDWs.[1] However, any mental state is the “I”, so the things are much more complicated. I emphasize that the “multiple realizability” is possible just because any mental state is the “I”!

Following the route of holism, Bressler and Menon (2010) strongly argue that cognition is much better explained at the “large-scale networks”. Their opinion is that, according to new empirical data offered by brain imaging, the old framework of cognitive neuroscience (“modular paradigm” – different brain areas are responsible for particular mental functions – not only has serious limitations but “might in fact be misleading”, p. 277) has to be replaced with this new framework: any mental function is correlated with large and distributed scale networks. In this context, the structure-function relationships become essential in cognitive neuroscience.[2]

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[1] About the multiple realizability and my idea of “interval of similarity”, see Vacariu, et al. (2001) and Vacariu (2008).

[2] Regarding the structural notion, Fletcher mentions Scholz et al. (2009) who argue that the learning to juggle involves changes in both gray matter density and white matter tracts. (Fletcher in Baars and Gage, 2010, p. 82) “This is groundbreaking work; for many years there have been assumptions that the brain is structurally immutable. Insights such as this point to both a functionally and structurally evolving organ, surely a step forward in refining our understanding of learning

In their paper, the authors analyze the “brain networks” that depend on “structural connectivity” (anatomical linkage of neurons) or “functional interdependence” (the structures depend on mental function on behavior). Each essential notion is defined in structural and functional terms. The “network nodes” (“if they have a uniquely identifiable local structural organization, a large-scale structural connectivity pattern or a local functional activity[1] pattern that allows them to be distinguished from their neighbors”) and the “network edges” (“long axon pathways that project from one neuronal population to another”) are the most important notions. (Bressler and Menon 2010, p. 278) A network can be characterized by “graphs” (mathematical instruments constructed on nodes and edges) and subnetworks (sub-graphs). Interestingly, the authors emphasized that the “most anatomical parcellation” in cognitive neuroscience has concentrated on the cerebral cortex and precluded the subcortical structures (basal ganglia and thalamus)![2] In order to detect the structural networks edges (“to trace axonal fiber pathways”), one

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processes.” (Fletcher in Baars and Gage, p. 82) Fletcher adds that information regarding the macroanatomical level needs to be complemented with that from the microanatomical level for understanding the adaptability of the brain. From an EDWs perspective, Fletcher’s remarks clearly reflect that the mind and the brain are EDWs. Both the functional and the structural segregations are only very rough approximate images of the mind and respectively the brain, or more exactly, certain methodological segregations. The brain changes constantly its functionality and anatomical structure but the self does not change its status during the entire life of any normal subject. Even if we learn every day quite a lot of things, the self does not change in each day. We have here the “interval of similarity” for the “I” even if the brain is in constant changes. (see Vacariu 2008 or Vacariu, Terhesiu and Vacariu 2001)

[1] “The functional interdependence of brain network nodes refers to joint activity in different brain structures that is co-dependent under variation of a functional or behavioral parameter.” (Bressler and Menon 2010, p. 278)

[2] In the whole book, I show that any mental state (that is the “I”) corresponds not only to some cortical areas but also the entire cortex, the subcortical areas, in reality, to the whole brain and body. I repeat, this sentence (like all 13 principle) are constructed within a hyperontological framework (not empirical, methodological, or pragmatic approaches). Bressler and Menon ignore the body, but as I showed in 2005 and 2008, following Sporns, the brain cannot be isolated from the body!

uses autoradiographic tracing, diffusion tensor imaging (DTI) and diffusion spectrum imaging (DSI)[1], or anatomical features ("local cortical thickness and volume to measure anatomical connectivity"). (Bressler and Menon 2010, p. 280) The functional networks are the results of dynamic interactions among nodes. Within this framework, the authors introduce the default-mode network (DMN)[2], the intrinsic functional brain networks and its dynamicity or the "multidimensional context" of any brain functions.[3]

I do not want to offer many details from this article, but what I find interesting is that they enumerate five major points regarding the functional networks: a spatial attention network (in the posterior parietal cortex and the frontal eye fields); a language network (in Wernicke's and Broca's areas); an explicit memory network (in the hippocampal–entorhinal complex and the inferior parietal cortex; a face-object recognition network (in the midtemporal and the temporopolar cortices); and a working memory-executive function network anchored in the prefrontal and the inferior parietal cortices. (pp. 284-285) From my viewpoint, the neuronal areas mentioned for

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[1] Diffusion-based magnetic resonance imaging methods are useful for determining the "major fiber tracts of the human brain in vivo by identifying the density of connections between brain areas". However, the main problem of these methods is that they do not illustrate the feedforward and the feedback connections between brain areas. (Bressler and Menon 2010, p. 280) Any mental state corresponds not only to some particular neuronal areas that are the most activated ones and to the rest of the brain but also to feedforward and feedback interactions (in a particular period of time) between many parts of the brain. Such interactions are quite impossible to grasp by the present tools of brain imaging. The problem is that for each mental state these interactions take place in different particular periods of time.

[2] "(…) DMN is seen to collectively comprise an integrated system for autobiographical, self-monitoring and social cognitive functions (…). (Bressler and Menon 2010, p. 285) (About DMN see next section of this chapter)

[3] "Another candidate core brain network is the aforementioned salience network, comprised of cortical areas AI and
ACC and subcortical areas including the amygdala, substantia nigra or ventral tegmental area and thalamus. It has been suggested that the salience network is involved in the orientation of attention to the most homeostatically relevant (salient) of ongoing intrapersonal and extrapersonal events (…)." (Bressler and Menon 2010, p. 285)

each network are just the top of the iceberg (probably the most activated neuronal patterns) but, obviously, not the only ones. Within the context created by the brain networks, the main problem for the authors is the same as for many other scientists:

> A crucial open question concerning core brain networks is whether a given network can be said to support a specific cognitive function. The answer to this question for any network will depend on a deeper understanding of its input–output relations, its temporal dynamics and the ways in which it interacts with other networks. (Bressler and Menon 2010, p. 285)[1]

The main problem in this paragraph is the notion of "interactions" between networks. Bressler and Menon need to offer more details about this notion. In reality, in the future, it will be probably discovered that each network interacts in different ways with all the other networks of the brain. The authors introduce a clear example against classical "localization": for the process of face recognition, we have to correlate not only the fusiform area[2] but also other areas like visual, limbic and prefrontal cortical regions.[3] (Bressler and Menon 2010, p. 296) For these networks the main problem is the

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[1] Obviously, this notion of "networks" reminds me of the connectionist networks. The mind-brain problem was not solved by connectionism. (See Vacariu 2008)

[2] Pessoa et al. consider that "while changes from house to face percepts were accompanied by increasing activation in the right FFA, perceived changes from a face to a house led to decreases in FFA responses. This suggests that the right fusiform gyrus plays an important and specialized role in conscious face perception." (Pessoa et al. 2008, p. 1084)

[3] "Category-specificity has rapidly become a major focus in human neuroimaging research, exemplified by studies demonstrating face-category specific responses in the fusiform gyrus (Kanwisher et al., 1997). However, a drawback of many such studies is that they employ very strict univariate statistical criteria that conceal all but the largest amplitudes in the activity patterns. Nonetheless, studies that have characterized the distributed response to faces have reported that greater category-specificity is revealed by the entire activity pattern in occipital and temporal cortices than by any specific area (Ishai et al., 1999; Haxby et al., 2001). Importantly, these studies have determined that the specificity of the distributed response is not dramatically altered if the regions typically associated with the category of interest are excluded." (Bressler 2007a, p. 408)

relationship between inputs and outputs. It is compulsory for both the inputs and the outputs to be within the same EW, otherwise we would create a mixture of EDWs. The inputs are some external stimuli that produce the activation of some neuronal patterns, but these actions have to be followed by other actions from the same EW, i.e. the activation of other neuronal patters. We cannot "correlate" the first set of activated patterns only to the features of the object perceived and the second set to the binding process.[1] (See Chapters 7 and 8 of this book)

In other two previous articles (Bressler 2007a, b), rejecting the central supervisor, Bressler claims also that there is no single neuronal area specialized in a particular mental function, even if the function of every cortical area is "determined by its unique patterning of long-range connectivity". (Bressler 2007b, p. 62) The "spatial pattern of amplitude modulation (AM) of the wave packet" is responsible for the emergence of "global neurocognitive state".

> The rapid emergence of large-scale patterns of phase-synchronized cortical sites at specific stages of cognitive task performance suggests that creation of the cognitive microstate (---) depends on the transient coordination of specific sets of areas by long-range oscillatory phase synchronization (---). It is thus likely that phase synchronization serves not only to coordinate local neuronal populations in wave packets within cortical areas, but also distant populations in different areas.[2] (Bressler 2007b, p. 64)

Interestingly, Bressler introduces two notions:

(1) The "neural context" as being "the local processing environment of a given neural element that is created by modulatory influences from other neural elements. Neural context allows the

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[1] I think the same problem is with the connectionist networks which cannot mirror neuronal activations and mental states at the same time. Moreover, we have to eliminate the homunculus (the central supervisor). We can do this job only within the EDWs perspective!

[2] "A potential mechanism for the creation of a global neurocognitive state, representing the assessment of organismic state, involves the generation of packets of high-frequency oscillatory wave activity in cortical areas." (Bressler 2007b, p. 66) (About the problematic "brain oscillations", see Chapter 7 of this book)

response properties of one element in a network to be profoundly ffected by the status of other neural elements in that network."[1] (Bressler 2007a, p. 403)

(2) The "situational context", that is some "interrelated environmental factors, including aspects of the sensory scenes and response demands of both the external and internal milieus". (Bressler 2007a, p. 404) In this case, we have to take into account the contextual effects in the brain.

Important is that the situational context determines the neuronal context. Within this holism that reminds me of the dynamic system approach (and its related perspectives, see Vacariu 2008), it is obvious that the multiple recurrent interactions (feedforward, feedback and lateral connections) produce the current situational context. (Bressler 2007a, p. 407) A neuronal area has a specialized role in any cognitive function because of its unique position "within the overall connectional framework of the brain", even if the same neuronal area, with different roles, can be involved in different mental functions.[2] (*idem*, p. 414)

Bassett and Gazzaniga (2011) relate the notion of "levels" to that of "complex system"[3]. I would like to analyze in detail this article because some dangerous notions are used in it. The main problem is that, under the framework of "complex system", the authors introduce many notions (that are used by more and more people in cognitive neuroscience) so as to characterize the mind-brain relationship. A very problematic philosophical notion is used:

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[1] An example of the neuronal context is "top-down attentional control" (the influence of higher levels on lower levels). (Bressler 2007a, p. 410)

[2] Obviously, Bressler's idea reminds us of Uttal's postulates! (Uttal 2011)

[3] Working within the unicorn world, very intelligent people needed to create, with the help of complex mathematics, the idea of "complex systems" that exist in the Universe (the world). Since the world does not exist, the complex system theory is one of the most complicated Ptolemaic epicycle, clearly without any remarkable empirical results. (For the complex system theory applied to biology, see Kauffman's work and our interpretation of this work in Vacariu and Vacariu 2010. I mention that Kauffman worked at the Santa Fe Institute, an institute created for the "complex system theory".)

the “emergence”. In the abstract, their first paragraph is this one: the brain “we argue, can be understood as a complex system or network, in which mental states emerge from the interaction between multiple physical and functional levels.” Obviously, from the viewpoint of an electron, a neuron or a planet, the notion of “emergence” is meaningless. From the viewpoint of a neuron, the emergence of the mind is also meaningless! Only the human beings, as observers, created the notion of emergence mixing phenomena that belong to EDWs. (See Vacariu 2008) Nonetheless, as we will see analyzing this article, the “interactions” among the “multiple physical and functional levels” is a much more complicated notion because, in some cases, this notion is completely wrong, in others, quite correct. Interestingly, the first paragraph of the article reflects exactly the actual status of cognitive neuroscience:

> The human mind is a complex phenomenon built on the physical scaffolding of the brain (…), which neuroscientific investigation continues to examine in great detail. However, the nature of the relationship between the mind and the brain is far from understood (…). (Bassett and Gazzaniga 2010)

As a consequence of the unknown relationship between the mind and the brain, Bassett and Gazzaniga appeal to the “complex system theory”, another grand Ptolemaic epicycle constructed within the unicorn world![1] This relationship is obviously “far from understood” since the mind and the brain are or belong to EDWs! Many people believe that the complex system theory (“applicable to the study of the human brain - a complex system on multiple scales of space and time that can be decomposed into subcomponents and the interactions between them”, p. 201) grasps very well the complexity of the brain and its “multiscale” temporal and spatial organization.[2]

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[1] In a glossary on the first page, we can find the definition of “complex system”: “a system whose overall behavior can be characterized as more than the sum of its parts.” (Bassett and Gazzaniga 2011, p. 200) It is not surprising that such famous authors appeal to the “complex system theory”, a theory constructed by the human being for the “complexity” of the unicorn-world!

[2] In opposition to this “complexity” of the brain, we can return to Van Wedeen’s discovery regarding the simplicity of the brain anatomy (see Chapter 3 of this book)

Introducing new experiments with fMRI, the authors strongly argue for the "functional and structural hierarchical modularity of the brain connectivity"[1] (modules of cortical and subcortical regions with "soft boundaries" like motor or visual networks) (p. 201). I think that the authors have to clarify what exactly "soft boundaries" mean. We can talk of such "soft boundaries" working only with the fMRI signals but ignoring many other signals (EEG, etc.). On the contrary, within the mind-EW, there are no such boundaries because of the unity of the "I", while this notion is meaningless in characterizing the brain. The authors are aware that not only the anatomical structure (more exactly, the "structural connectivity" or "connectome" that represent the "wiring diagrams") imposes constraints on functions but also the "*neuromodulatory networks*" (that act in parallel). Even if Bassett and Gazzaniga are quite optimistic regarding the theory of complexity and the "wiring diagrams", they write that although

> the functional interpretation of the connectome is potentially immensely powerful it is also fraught with caveats. It is plausible that structural connectivity might enable

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situated within the EDWs perspective! The complexity of the brain vanishes completely. If we give up our dictatorial viewpoint of observing and thinking about all phenomena in the "world" (i.e., placing all phenomena in the same "world"), we will understand that nothing is "complex". "Nature" does not think: fortunately for the appearance of life (that corresponds to a cell or an organism) from hypernothing, unfortunately for the very powerful human thinkers obliged to elaborate very difficult and "complex" theories (see for instance the theories about hyperspace in Vacariu and Vacariu 2010) in explaining the "complex systems" of the "world".

[1] The authors introduce Meunier et al.'s ideas about modular and hierarchical modular organization of the brain under the complex system theory and dynamical system theory (with notions like topological structure, small-worlds, hub nodes, fractal property, lattice-like organization, graph, etc. (Meunier et al. 2010) "One of the earliest and most influential ideas was formulated by Simon (1962, 1995) who argued that a 'nearly decomposable' system built of multiple, sparsely inter-connected modules allows faster adaptation or evolution of the system in response to changing environmental conditions. Modular systems can evolve by change in one module at a time, or by duplication and mutation of modules, without risking loss of function in modules that are already well adapted." (Meunier et al. 2010p. 2) From my viewpoint, even if theory of complexity is quite interesting, I believe that nature (brain is included) is not complex at all. We needed such complex theory just for explaining the "complexity" of the unicorn-world!

> us to predict function but it is not yet clear how to make that prediction. (Bassett and Gazzaniga 2011, p. 204)

This kind of weak skepticism is imposed by the degeneracy (many) functions of the identical neuronal patterns. (*idem*)[1] Another paragraph mirrors the state of affair in cognitive neuroscience:

> Rather structure–function mappings are many-to-many and inherently degenerate because they depend on both network interactions and context. Therefore, although a one-to-one relationship between structure and function might be inconsistent with our current understanding of the brain, a more complicated emergence of function from multiscale structure is plausible...” (p. 204)

In Vacariu (2008), I analyzed in detail the many-to-many “complex” relationships between structure and function, but if we use “more complicated emergence of function”, we have to clarify this problematic notion of emergence. Bassett and Gazzaniga introduce “emergence”: certain properties of the system are more than the sum of its parts or emergence occurs at multiple physical and functional “levels” (this idea being against reductionism). Moreover, the mind “emerges” from the physical brain. What a wonderful hyperontological contradiction! Here we can find the same mistake about emergence even if the authors are aware that the brain is decomposable and the mental properties are indivisible! However, the authors make a greater mistake introducing *upward and downward causations* between multiple levels (or “bidirectional causation”). In Vacariu (2008), I clearly showed that the downward causation is a great mistake made by the people working in philosophy of mind. Unfortunately, a notion that is quite close to the EDWs perspective, the “mutual complementarity”, is not developed at all in the article. The notion of “mutual complementarity” sends us directly to the complementary relationship between the EDWs. However, it is not about Bohr’s complementarity constructed within the unicorn world! Even within the EDWs perspective,

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[1] Again, we find here Uttal’s one postulate!

complementarity exists only in the eyes of the beholder (the human being) since it is meaningless to ask about the relationships between any two EDWs. This is the reason why the hyperverse (the sum of all EDWs) is an abstract notion. It would be necessary to have a hyperbeing (God) that has no place in the EDWs.[1]

I analyzed the whole-parts relationships from physics, biology and cognitive (neuro)science in various works (Vacariu 2008) and Vacariu and Vacariu (2010). Nevertheless, because biology includes neuroscience, I introduce some ideas about the whole-parts relationship from Powell and Dupre's paper. This article mirrors the power of the unicorn-world in biology regarding the relationship between molecular biology and cellular and organism biology. The same problem is in cognitive neuroscience in our days. Powel and Dupre analyze the failure of reductionism in the face of complexity, emergence and causality in biology.[2] The reductionism-nonreductionism debate in biology and philosophy of mind/cognitive science is an old topic. The reductionism thesis was established by Oppenheim and Putnam (1958) who

> conceived of nature as being constituted by a hierarchy of objects that, in turn, defined a hierarchy of distinct sciences. At each level above the root level the objects are structures composed of objects from the next lower level. Thus elementary particles combine to form atoms, and atoms combine to form molecules; so the hierarchy ascends through living cells, multicellular organisms, and social groups. The sciences are individuated on the basis of the ontological level with which they deal, and scientific reduction, on this model, consists in relating the laws pertaining to the objects at one level with those of the next lower level via bridge principles that identify the objects at any level with the set of lower-level objects of which they are composed. (Powel and Dupre 2009, p. 55)

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[1] Regarding the "death" of God, see my presentation "God dead long time ago. Who can we rule out the infinite?", at "Theism-Atheim" Symposium, Department of Philosophy, Univ. of Bucharest, September 2012. (on my webpage) In this presentation, I show that the existence of God would raise many (hyper)ontological contradictions.

[2] Obviously, the same state of affair is in cognitive (neuro)science. The authors of this article mention the work of some people working in (philosophy of) cognitive science.

However, during the last 30 years, there were strong debates on reductionism-antireductionism programs of research. The "Human Genome Project" (1993) was the most important project on reductionism, while for anti-reductionism we have the unavoidable relationship between genome and phenomena, the context (environment) of genes and organisms, the complexity of living entities (chaos theory in biology), etc. Moreover, "connecting molecular biology, computing, bioinformatics, and genomics, clearly narrow the gap between the two halves of our overall story." (p. 58) The authors also analyze various notions like emergence, downward causation, mechanisms networks and cellular automata.[1] In biology, reductionism was lead by the idea of reducing biological elements to molecules and genes ("molecular biology" and "molecular genetics"). In 1966, Crick believed that the molecular biology is "explaining anything biological in terms of physics and chemistry" (Powell and Dupre, p. 56) I want to emphasize that, in a few pages, Powell and Dupre introduce some essential points regarding the reductionism-antireductionism debates (emergence and holism in relationship with genotype-phenotype relation in biology). In all these topics, the main element is the whole-parts relationship from ontological and epistemological viewpoints. Again, I strongly emphasize that the same topics (and theories) can be found in cognitive neuroscience. From an EDWs perspective, these problems are pseudo-problems because of the mixture of EDWs.

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[1] In my work (2008), I analyzed Anderson's "More is different" (physics) (1972) and Fodor's (1974) "Special sciences" (philosophy of mind) against reductionism. In 2010, with Mihai Vacariu, I investigated Kauffman's theory of complexity applied in biology. The main problem for all anti-reductionists is the ontological status of entities (and their relationships) they investigate. Their reductionism is epistemological, an ontological reductionism would require Cartesian paradigm rejected by scientists in our days. As every person working in (philosophy of) biology, Powell and Dupre inquire about the status of biological entities: what are these entities and could we reduce a biological entity to its components? The more general questions are about the notions of "levels" and their relationships. Are these levels epistemological, ontological, organizational, or "levels"of analysis/description? Special sciences were created so as to deal with various "levels". (About levels, emergence and reductionism, see Vacariu 2008)

11.2 Raichle's default network

Let me investigate Raichle's idea about the "default network" (2011) or the "dark energy[1] of the brain" (Raichle 2006; Raichle and Mintun 2006). The question is what does the brain need so much energy for? "The brain apparently uses most of its energy for functions unaccounted for – dark energy, in astronomical terms." (Raichle 2006, p. 1249) In modern times using PET and fMRI, some researchers realized that the energy necessary for the brain to manage the demands of the environment (or the "task-evoked responses", Raichle 2011) is less than 1% and the energy consumption necessary for changes in the brain activity is less than 5% (Raichle 2011)[2]. The conclusion is that "the enormous energy consumption of the brain is little affected by the task performance, an observation first made more than 50 years ago by Louis Sokoloff, Seymour Kety and their colleagues (Sokoloff et al. 1955) but rarely cited." (Raichle 2011, p. 148) It seems that 60-80% of this consumption is dedicated to the glutamate cycling and therefore to the neuronal signaling processes. (*idem*) From an EDWs perspective, we can clearly understand now that this energy necessary for the brain corresponds to the mind-EW. Without this corresponding energy, the mind-EW would not be at all. Probably, the unity of the mind corresponds to the dark energy of the brain. In another EW (the mind-EW), this energy of the brain is the "I".

What produces the energy for the brain? Raichle and Mintun write that gycolysis and oxidative phosphorylation produce energy as

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[1] In the previous books, I criticized the famous notions of "dark matter" and "dark energy". From my EDWs perspective, I consider these notions some strong Ptolemaic epicycles that reflect the human mind imagination within the unicorn world. It is not an unknown matter/forces, but there some phenomena from the macro-EW that correspond to the phenomena from another EW. (For a recent article against the existence of dark matter, see Bidin et al. 2012)

[2] "In the average adult human, the brain represents about 2% of the total body weight, yet it accounts for 20% of all the energy consumed (Clarke and Sokoloff 1999), 10 times that predicted by its weight alone." (Raichle 2011, p. 148) "The human brain constitutes only 2% of the body weight, yet the energy-consuming processes that ensure proper brain function account for approximately 25% of total body glucose utilization." (Magistretti 2008, p. 271)

adenosine triphosphate (ATP). (Raichle and Mintun 2006) It is well know that glycolysis is much faster than oxidative phosphorylation (McGilvery & Goldstein 1983 in Raichle and Mintun). Quoting various researchers, since the astrocytes produce glycolysis, the authors conclude that

> such complex processes elegantly embodying the integration of high-level behaviors also include the orchestration of glycogenolysis in astrocytes (Magistretti et al. 1981, 1995) lends credence to the hypothesis that astrocytes and the glycolytic machinery they house are uniquely involved in the coordination of the metabolic and circulatory requirements associated with changes in brain function.[1] (Raichle and Mintun 2006, p. 458)

The metabolism of the brain and its circulation for specific mental tasks in interactions with the environment require only a little part of the energy consumed by the brain. More exactly, "the cost of intrinsic functional activity which far exceeds that of evoked activity and dominates the overall cost of brain function". (Raichle 2009) More exactly, what is the relationship between "task-evoked responses" (or "sensory information") and this intrinsic activity of the brain?

> It may surprise some to learn that visual information is significantly degraded as it passes from the eye to the visual cortex. Thus, of the unlimited information available from the environment, only about 10 bits/s are deposited in the retina. Because of a limited number of axons in the optic nerves (approximately 1 million axons in each), only ~6 x 10･ 6 bits/s leave the retina and only 10･ 4 make it to layer IV of V1 (Nørretranders 1998; Anderson et al. 2005). These data clearly leave the impression that the visual cortex receives an impoverished representation of the world, a subject of more than passing interest to those interested in the processing of visual information (Olshausen and Field 2005). In the context of this symposium, it is important to note that estimates of the bandwidth of conscious awareness itself (i.e., what we 'see') are in the range of 100 bits/sec or less (Nørretranders 1998; Anderson et al. 2005).
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> Reinforcing this impression of the brain's "isolation" is the fact that the number of synapses in the lateral geniculate nucleus of the thalamus and in layer IV

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[1] Quoting the work of different authors, Raichle adds the activity of interneurons. (Raichle 2011)

> of primary visual cortex devoted to incoming visual information is less than 10% of the total number of synapses in both locations (Sillito and Jones 2002). (Raichle 2011, p. 149)

This empirical data referring to the relationship between the incoming sensory stimulus and the rest of the brain *reflect directly* the corresponding relationship between the mind-EW and the brain-body-environment interactions (that belong to the macro-EW). If the visual cortex manages so "impoverished" information of the external world (a lot of information is lost), then something else has "to fill" the missing information so as to "complete" the images of the external world.[1] As we saw in other chapters, quite many researchers in cognitive neuroscience consider that other parts of the brain "fill" and thus completely construct our perceptual mental states of the external world. From my viewpoint, it is not at all about "filling" or "completing" since we have here EDWs. The direct relation between the firing activity of neurons (produced by certain external inputs) and the perceptual mental states reflects a mixture of EDWs. All the external information is brought inside the brain by various biological mechanisms (so we have a direct relationship brain-body-environment). In correspondence, the external world is "brought inside" the mind-EW, that is, all mental representations and processes that correspond to the external world are the "I". The mental "impoverished" information (that corresponds to the neuronal impoverished information) is already parts of the "I" since the representations of the external world are the "I". Again, the EDWs perspective is not an extension of the mind (Clark 2008) but, on the contrary, following Kant's movement, I "insert" the external world inside the mind, that is, the mental representations of the external world are the "I".[2]

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[1] In this context, we have to recall Frith's approach: "My perception is not of the world, but of my brain's model of the world". (Frith 2007) (For Frith's approach and the EDWs perspective, see Vacariu and Vacariu 2010)

[2] Contrary to this Kantian movement is Heidegger's "thrownness" (his theory is quite related to the dynamical system approach and its relatives): "the term 'thrownness' expresses the Heideggerian claim that in everyday cognition the

Within the framework of EDWs it is much easier, I believe, to explain the strange phenomena of the human brain: the *default mode network* (DMN). (Raichle 2011) Without any external input (an idealized situation), the activity of the brain corresponds entirely to the mind-EW: many and large neuronal patterns are activated by the corresponding relationships among entities (the unconscious mental states) that belong to the mind-EW. When an external input disturbs this neuronal activity, many neuronal patterns become des-activated, while the small neuronal patterns respond to that external stimulus. The intrinsic activity of the brain (that corresponds probably to the implicit knowledge[1] of the mind) is disturbed, more or less, by an external stimulus (that has a correspondent that is also part of the mind-EW). So the external stimulus disturbs the intrinsic activity of the brain (while the corresponding perceptual state partially disturbs the coherence of the mind-EW or to the unity of the "I"). Only in this way can we explain the intrinsic activity of the brain as corresponding to the coherence of the mind-EW or the unity of the "I".[2]

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intelligent agent always finds herself located in a meaningful world (a context) in which things matter to her…" (Wheeler 2005, p. 276) (About Heidegger's "throwneness" and the relationship between phenomenology and cognitive science, see Wheeler 2005 and 2009)

[1] For the implicit (procedural, unconscious) knowledge vs. explicit (declarative, conscious) knowledge, see Vacariu (2008).

[2] Importantly, the "activity within the DMN did not represent conventional activations in the resting state but, rather, a new view of the organization of the brain's intrinsic activity, which we dubbed 'a default mode of brain function' (Raichle et al. 2001). It is important to note that the DMN is not unique in exhibiting both high levels of baseline metabolic activity and organized functional activity in the resting state. It is a property of all brain systems and their subcortical connections, as I will detail moving forward. The discovery of the DMN made apparent the need for additional ways to study the large-scale intrinsic organization of the brain." (Raichle 2011, p.151) Obviously, the mind-EW corresponds to the brain-body unity and this is the reason DMN is present everywhere in the brain (cortical and subcortical regions). Again, the context for understanding the DMN is only its correspondence with the "I" (its unity) within the EDWs framework. It is about the "I" and not consciousness because Raichle, quoting the work of some

Quoting the works of Logothetis (with his colleagues) and the work of other researchers, Raichle and Mintun (2006) strongly emphasize that BOLD signal has to be correlated to local field potentials (LFPs[1]) and not to the spiking activity of neurons. (Also, Raichle 2011) In this context, the logical answer seems to be that the energy is necessary for the intrinsic activity of the brain.[2] But what is this "intrinsic activity" necessary for? Raichle analyzes some possible answers to this question:

(a) Spontaneous cognition – our daydreams or the stimulus of independent thoughts. However, his reply to this alternative is that the brain responds with a small amount of energy for controlled stimuli so the energy cannot be larger for the stimulus of independent thoughts.

(b) Intrinsic functional activity facilitates responses to stimuli. Receiving continuously excitatory and inhibitory inputs, the neurons (patterns of neurons and large parts of the cortex) pass through various "balances" that determine their responses.

(c) Interpreting, responding to and predicting environmental demands.[3] Finally, Raichle suggests that further research is necessary in order to clarify the spontaneous activity of neurons. (Raichle 2006, p. 1250)

The default function is a property of all brain areas: "Task-specific decreases from a resting state occur in many areas of the brain". (Raichle and Snyder 2009, p. 85) Important for the EDWs is

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people, emphasizes that the DNM seems to "transcend levels of consciousness" (DNMs is present under anesthesia in humans and rats, early stages of sleep. (p. 152)

[1] "LFPs is the electrical fields recorded from microelectrodes in the brain that mirror the weighted average of input signals on the dendrites and cell bodies of neurons." (Raichle and Mintun 2006) (See Chapter 5)

[2] "While spatial patterns of coherence in resting-state fluctuations of the fMRI BOLD signal were first noted by Biswal and colleagues in 1995 in their studies of the somato-motor cortex of humans, it was for us the observation of Greicius and colleagues of resting-state coherence in the default network that ignited our interest." (Raichle and Snyder 2009 or Raichle and Mintun p. 465)

[3] Or the "brain functions are mainly intrinsic, involving information processing for interpreting, responding to and predicting environmental demands." (Raichle 2011, p. 147)

that the “spatially coherent spontaneous activity of the fMRI BOLD signal persists despite major changes in levels of consciousness.” (*idem*) We can explain this idea only within the EDWs perspective: the “correlations” between mental and neuronal states are just rough approximations since we have here EDWs and thus we cannot talk of the identity between these states. As we saw above, the “aerobic glycolysis provides for us a window (a ‘glycolytic window’) through which we can observe changes in brain activity with fMRI BOLD”. (Raichle and Mintun 2006, p. 465) Important is that

> if blood flow and glucose utilization increase by 10%, but oxygen consumption does not, the local energy consumption increase owing to a typical task-related response could be as little as 1%. It becomes clear, then, that the brain continuously expends a considerable amount of energy even in the absence of a particular task (i.e., when a subject is awake and at rest) (Raichle and Mintun p. 467)

and

> ….. a variety of experimental settings have indicated that up to 80% of the entire energy consumption of the brain at rest is devoted to glutamate cycling and, hence, neural signaling processes. (Raichle and Mintun p. 468)

In this context, Raichle and Mintun conclude that a great amount of energy is consumed by the intrinsic activity of the brain.[1] From an EDWs perspective, this intrinsic activity perfectly corresponds to the mind-EW or the “I”. This intrinsic activity corresponds to the unity of the “I” (again the analogy with the table-microparticles relationship: the intrinsic activity is quite similar to the micro-forces that glue together the microparticles). Thus, it is about the EDWs, one in which we find the neuronal states, the other is the “I”[2], that is, an EW that has its unity that offers us its ontological status. The intrinsic activity of the brain has to be correlated with the mind-EW

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[1] About the “spontaneous activity” of the brain, see also Logothetis et al. (2009).

[2] Again, in analogy, the neuronal states are in similar position with the microparticles and their forces, while the “I” is not completely similar with a table (the table is an entity within the macro-EW, the “I” is an entity and an EW).

that obviously requires such correlate energy. Moreover, we have to take into account the period of development of the individual and the evolution of species.[1]

Important for my analysis is that He and Raichle (2009) emphasize the difference between oscillation and fluctuation. (About oscillations, see Chapter 7) They introduce the notion of "slow cortical potential" (SCP)[2], a low-frequency end of field potentials (<4 Hz), that seems to be the best alternative to carry large-scale information integration in the brain.[3] SCP is the neural activity correlated to consciousness. Nevertheless, they consider the SCP being a kind of fluctuation and not oscillation. They classify the EEG results in three distinct groups: rhythmic, arrhythmic, and dysrhythmic.

> The first two appear in normal subjects and refer to waves of approximately constant frequency and no stable rhythms, respectively. The latter refers to pathological rhythms in patient groups. Rhythmic EEG is further subdivided into frequency bands known as d, u, a, b and g, etc. The SCP frequency range does not normally contain any true rhythmic activity, except the 'up-and down states' (also called the 'slow oscillation' by its discoverer (…) that occurs during deep sleep (0.8 Hz). The 'up-and-down states' is a distinct phenomenon that can be easily differentiated from the SCP (for detailed discussions see supplementary materials in He et al. (…). Therefore SCP is a fluctuation rather than oscillation (…) (B. J. He et al., unpublished).[4] (He and Raichle 2009, p. 303)

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[1] "In brain scans, we see a dramatic reduction of cortical activity when a predictable voluntary action is practiced to the point of automaticity. There is evidence that routinized voluntary actions may be taken over in part by subcortical regions of the brain, notably the basal ganglia and cerebellum." (Baars and Gage 2010, p. 52) Obviously, this dramatic reduction is the result of the evolution of species.

[2] "Often all three (delta, up-and-down states and ISFs [infra-slow fluctuations]) are subsumed under the designation slow cortical potentials, or SCPs (Rockstroh et al. 1989; He et al. 2008)." (Raichle 2011, p. 153)

[3] For me this difference creates another important problem with the taxonomy of oscillations!

[4] "The confusion between fluctuations and oscillations, or, arrhythmic and rhythmic activities, is quite common. This is largely because time-frequency analyses widely adopted create artificial rhythmic signals. However, as pointed out by T. H. Bullock (…) 'Most of the time in most animals there is little evidence of really rhythmic

Quoting the work of various researchers, these authors conclude that the SCP has a close correspondence to fMRI signal and synaptic activities at apical dendrites in superficial layers produce the SCP. More exactly, it is about the “long-lasting excitatory postsynaptic potentials (EPSPs) at these apical dendrites [that] underlie negative-going surface recorded SCPs (…)” (p. 303) Introducing various experiments, He and Raichle conclude that the “long-range intracortical and feedback cortico-cortical connections, as well as the nonspecific thalamic inputs, all contribute directly and significantly to the SCP.”[1] (p. 305) Essentially, they believe that it is possible for the SCP to be a “more fundamental correlate of the fMRI signal than LFP power is”. (*idem*) Thus, the SCP is the best alternative for neural processes that are correlated to consciousness (integration):

> We suggest that the SCP might be an optimal neural substrate to carry such information integration across wide cortical areas because (i) its slow time scale allows synchronization across long distance despite axonal conduction delays (…) (ii) long-range intracortical and corticocortical connections terminate preferentially in superficial layers and thus contribute significantly to the SCP. (He and Raichle 2009, p. 305)

He and Raichle introduce some experiments that show that many mental processes (attention, perception, volition) require the presence of SCP.

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oscillators in the ongoing cerebral activity, let alone that rhythms account for much of the total energy’.” (He and Raichle 2009, p. (303)

[1] Related to Raichle’s default network, let me quote here a single paragraph from Baars and Gage: “Voluntary brain mechanisms, guided by explicit goals, are associated with cortex in humans. Very sophisticated subcortical circuitry is also engaged in planning and executing actions. Spinal centers may carry out commands from higher centers using sensorimotor reflexes, but they also return feedback signals to the brain. All these levels of control have *endogenous* (internal) as well as *exogenous* (sensory) input, both conscious and unconscious (Goodale and Milner, 1992). Thus, while there are certainly some simple reflex circuits like the famous knee-jerk reflex in Figure 3.8, reflexes rarely work in isolation. They normally work in the service of cortical goals.” (Baars and Gage 2010, p. 69)

Raichle offers more details about SCPs in his article from 2011:

> SCPs and quite possibly the spontaneous fluctuations in brain oxygenation as seen by fMRI BOLD and optical imaging techniques (White et al. 2009) represent fluctuations in cortical excitability (for review see Schroeder and Lakatos 2008) These fluctuations in cortical excitability have a remarkable effect on other elements of the LFP frequency spectrum, both during task-evoked activity (Monto et al. 2008) and in the resting state (He et al. 2010). SCPs also influence the spiking activity of neurons (Montemurro et al. 2008; Petermann et al. 2009). This coupling or nesting with SCPs serving an important coordinating role provides a logical structure for the integration of functional activity. Not surprisingly, the phase of the SCPs affects both evoked responses (Bishop 1933; Arieli et al. 1996; Fiser et al. 2004; Fox et al. 2006) and behavioral performance (Fox et al. 2007; Lakatos et al. 2008; Monto et al. 2008). One among many results of this functional organization might well be the emergence of conscious awareness (He and Raichle 2009). (Raichle 2011, p. 154)

The brain is organized as a hierarchy of subsystems ("hubs") that strongly influence one another but at the top of this hierarchy is the DNM! Importantly, the SCPs can explain the predictions of the brain in relationship with the external environment or in Raichle's terms, DNM is responsible for interpreting, responding and predicting environmental events.[1] (Raichle 2011, p. 155) As we saw above, the DNM requires the corresponding mind-EW. Otherwise, we would not be able to explain the DNM. At the end of his paper (2011), Raichle believes that in order to understand the intrinsic activity and consciousness we need to clarify the non-conscious activity of the brain. (p. 155)[2] Translating this idea within the EDWs framework, it

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[1] "Obviously, the world in which we live is not entirely predictable, which calls for a complementary strategy in which SCPs are temporarily suppressed in a setting in which task performance requires considerable effort (i.e., goal-directed attention) because of novelty and uncertainty (for review, see Schroeder and Lakatos 2008). This is precisely the circumstance in which we have come to expect activity decreases in the DMN (Fig. 1a) and increases in brain areas associated with goal-directed attention (Corbetta and Shulman 2002; Dosenbach et al. 2008)." (Raichle 2011, p. 155)

[2] Obviously, this idea has to be related to Baars's global workspace and Crick and Koch's (1995) feedforward and feedback projections between sensorial areas and the frontal regions of cortex, the neuromodulators and neurotramitters.

is more important to understand the “I” (that corresponds to the intrinsic neuronal activity) than to understand only some conscious perceptual mental representations (corresponding to the neuronal patterns that are the most activated ones by some sensorial inputs) just because these perceptions, from my viewpoint, are the “I”. In the context created by a necessary Kuhnian paradigm shift, Raichle mentions that the integration “across the necessary levels of analysis will obviously be challenging and will demand the willingness to accept the multidisciplinary nature of the task.” (p. 155) In general (not in all cases), levels are EDWs, while integration is the unity of the“I”.

11.3 Conscious and unconscious mental states

Baars was among the first who initiated the research on the relationship between conscious and unconscious states. He proposed the concept of “global workspace theory”. (Baars 1988, 2002, 2007) This global workspace is directly related to consciousness. There are different mental/psychological functions acting in this workspace. Thus, consciousness is an integrative function, a “global workspace of integration”. (Baars 2002) These mental functions are correlated to the “independent” functions of the brain. Baars strongly underlines that the conscious processes are the product of unconscious processes. (Baars and Franklin 2007) In other words, cognition is the result of unconscious processes. For instance, the working memory is achieved through some special distributed systems (language components, long term memory, space and temporal framework, etc.) selected by consciousness. These components are correlated to the widely distributed cortical and subcortical structures. (Baars and Franklin 2007) The conscious contents are guided or constrained by the unconscious contents: the contents of goals, perceptions, conceptual or cultural. For instance, the sentences of words that we think or pronounce are the results of unconscious processes that produce them. Baars specifies other important people from cognitive science who adopted this “global workspace” theory: Edelman (1989), Damasio (1989), Freeman (1991), Llinás et al. (1998), Edelman, Tononi (2000), Kanwisher (2001), Dehaene, Naccache (2001), Rees (2001), John (2001), Varela et al. (2001). For instance, Kanwisher proposes a similar approach (if neural representation is more active then the mental representation correlated with it is consciously active). Kanwisher takes up an idea introduced by Green and Swets, according to which perceptual awareness is not "an all-or-none affair, but a graded phenomenon which admits many shades of grey". (Kanwisher 2001, p. 103) In their turn, Llinás and Parre indicate that the "fact that all frequencies are not equal probably determines that certain resonant frequencies will be observed preferentially". (Llinás and Parre 1996) In the same line, "The selective property of attention is presumed to be expressed by a positive difference between the activity levels in columns that code for the target and the activity levels in neighboring columns that code for other (distracting) objects." (LaBerge 2002) To grasp the mind-brain relationship, Merzenich and deCharms introduce the notion of *representational perceptual constancy*. Constant perceptual representations emerge from the neural level where the pattern of activity of the ensemble of neurons is permanently changing and moving. (Merzenich and deCharms 1996) Nevertheless, the authors do not explain the origin of this constancy.

Dehaene et al. (2011) develop the Baars' global workspace into a "global neuronal workspace" (GNW) model.

> Implemented as "formal organisms", these neuro-computational models should ultimately address the challenge of decades of attempts to account for subjective experience, which provides a unified or global mental scene where a synthesis between past, present and future takes place and where multimodal perceptions, emotions and feelings (present), evoked memories of prior experiences (past), together with anticipations of actions (future) become subjectively integrated in a continuously changing and dynamic stream of consciousness (Baars 1989; Crick and Koch 2003; Dehaene et al. 1998; Dehaene and Naccache 2001; Edelman 1989; James 1890). (Dehaene et al. 2011)

Indeed, some cognitive neuroscientists become interested in the "subjective experience" (and many more in consciousness) in the last years. Again, how can we fit the subjective experience with various mental functions/processes like multimodal perceptions, emotions, memories and anticipations, i.e., how do we "integrate" all these processes and what does this integration represent? What is the ontological status of "integration" and "subjective experience"?[1] The main idea of GNW model ("distributed set of cortical neurons characterized by their ability to receive from and send back to homologous neurons in other cortical areas horizontal projections through long-range excitatory axons") refers to the "conscious access" that is "the selection, amplification and global broadcasting, to many distant areas, of a single piece of information selected for its salience or relevance to current goals." (Dehaene et al. 2011, p. 56) This definition has to be incorporated within the framework created by the conscious (serial process)-unconscious (parallel processes) dichotomy. Recurrent top-down, bottom-up cortical and subcortical loops are inserted into this model. Quoting the works of many people, the authors investigated conscious access-unconscious states through several methods: fMRI, event-related potentials (ERPs) and MEG, intracranial recordings (frequency bands), and single-cell recordings. Without offering details of their work, I would like to analyze, very shortly, their conclusions for each of this method. The fMRI results indicate that the conscious access of perceptual representations are correlated to the fusiform gyrus area (sometimes V1 area included) but also to a distributed set of areas (including bilateral parietal and prefrontal cortices). (p. 67) Both ERPs and MEG results suggest that visual access consciousness is correlated to widely distributed neuronal areas form cortical and sub-cortical areas (including hippocampus and temporal, parietal and frontal association cortices).[2] (Dehaene et al. 2011, p. 69) Moreover, the

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[1] For instance, Miller and Wallis write that the neurons of PFC "are activated by visual, auditory, tactile, and gustatory stimulation (and their memory) as well as voluntary limb and eye movements. Further, these neurons seem capable of synthesizing this information in accord with task demands." (Miller and Wallis 2008, p. 1212) Moreover, some parts of the PFC are responsible for coding abstract rules representation. (*idem*, p. 1216)

[2] "While time-frequency power increases occur in a very broad band (up to 100 Hz and above), in several intracranial MEG and EEG studies, synchrony across distant

single-cell recordings results support the “formation of global brain-scale assemblies” and confirm the “key role” of synchronization in conscious access.[1] (p. 73) My general observations regarding the GNW model are quite similar to the one that I wrote about Baars’ GWS model. “Integration” is the “I” that corresponds to the entire brain and body. Some neuronal areas are more activated than other areas but, anyway, the activities of all neuronal areas correspond to conscious and unconscious states that are the “I”.

Globus and O’Carroll (2010) replace Baars’s “global workspace”, “emergent properties” or Tononi and Edelman’s “dynamic core” (that presupposes “re-entrant interactions”) with “holonomy” (a notion borrowed from Bohm’s quantum theory, holonomy meaning “the law of the whole”). The global workspace and the dynamic core are under “density interaction” or “functional reciprocation” framework and against the traditional static framework of hierarchy. (p. 426) However, Globus and O’Carroll emphasize that “*these new theories remain at heart localizing* (...) having a ‘’workspace,’ a ‘core’... whereas the present formulation of binding will be nonlocal, which entails a paradigm shift indeed.” (Globus and

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cortical sites tends to appear in the lower frequency range, either in the beta band 13–30 Hz or in the low-gamma band around 30–40 Hz, and to be a more specific indicator often exclusively seen during conscious access (Doesburg et al. 2009; Gaillard et al. 2009; Gross et al. 2004; Kranczioch et al. 2007; Rodriguez et al. 1999). With their slow period (25–80 ms), these frequencies may be more appropriate for forming brain-scale assemblies across long cortical distances and time delays (Fries 2005).” (Dehaene et al. 2011, p. 70)

[1] “Across distant areas such as FEF and V4 (Gregoriou et al. 2009) or PFC and LIP (Buschman and Miller 2007), synchrony is enhanced when the stimulus in the receptive field is attended and is thus presumably accessed consciously. Consistent with human MEG and intracranial studies (e.g., Gaillard et al. 2009; Gross et al. 2004), synchronization involves both gamma and beta bands, the latter being particularly enhanced during top–down attention (Buschman and Miller 2007). During the late phase of attention-driven activity, causal relations between distant areas are durably enhanced in both directions but more strongly so in the bottom–up direction from V4 to FEF (Gregoriou et al. 2009), again similar to human findings (Gaillard et al. 2009) and compatible with the idea that sensory information needs to be propagated anteriorly, particularly to PFC, before becoming consciously reportable.” (p. 73)

O'Carroll 2010, p. 426, their italics) Reading this statement, I had the impression that it was written under the EDWs perspective! However, unfortunately, the authors work under the unicorn-world umbrella. In fact, borrowing the notion of nonlocality from quantum mechanics, the researchers working in cognitive neuroscience inevitably collapse in their huge effort of explaining the mind-brain relationship. In principle, it is clear that we cannot borrow notions that are available for explaining some phenomena belonging to one EW so as to explain phenomena that belong to another EW.[1]

Globus and O'Carroll claim that the "classical brain theory" could not explain the disunity of content within the unity of consciousness reflected by the Charles Bonnet syndrome (a kind of visual "cartoon world"), a case of disjunctive agnosia (a dis-integration between what is seen and what is heard), the splitting of schizophrenia in thought insertion. In these cases, even if we have the unity of consciousness, there is a dis-integration of certain mental phenomena. The authors consider that all the other theories cannot explain the disunity of content within the unity of consciousness.

> The brain is well known to be a system of richly interacting subsystems. Rich interconnectivity characterizes different levels of system analysis all the way down to the neuronal level. The brain cannot but be integrated because functional connectivity is the principle of its operation (…). If there were a true schism, then each of the systems would have its own integration. (Globus and O'Carroll 2010, p. 427)

Globus and O'Carroll attack even the (nonlinear) dynamical system approach (attractors, self-organization, state space topography, etc.)[2], Baars' "global workspace" or Edelman's "dynamic core theory": it is possible that these approaches try to explain the unity of consciousness but not the dis-integrated contents within conscious unity mirrored in

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[1] Moreover, I showed in Vacariu (2008) and Vacariu and Vacariu (2010) that the main notions from quantum mechanics are quite wrong because these notions were created by the mixture of EDWs (the wave and the particles).

[2] For the relationship between the dynamical system approach and the EDWs perspective, see Vacariu 2008.

the above clinical cases. (p. 427) Therefore, the authors describe as an alternative approach the quantum brain theory ("quantum computation"[1], the main notion), Pribram, Jibu and Yasue's "dissipative quantum brain dynamics", Hameroff, Freeman and Vitiello are the authors mentioned in this direction. From the work of different authors, Globus and O'Carroll emphasize three innovations for QBD. The first one:

> Jibu and Yasue emphasize quantum properties of a nanolevel web within neurons and neuroglia made up of protein filaments, which is a kind of Golgian reticulum of uninterrupted filaments (…). This intracellular space is continuous with the web-filled extracellular space via proteins embedded within cell membranes. This pervasive filamentous web which does not respect neuronal and glial boundaries is the brain's second communication system.
>
> Its innermost reach is the water-filled microtubules. Signals propagate rapidly through the filamentous web, with no synapses to plow through, which makes it much faster than the classical communication system with all its synaptic delays. The nanolevel filamentous web is the communication system of the cryptic holonomic brain that Jibue and Yasue characterize in terms of ‘‘quantum brain dynamics." The proposal is that there is soliton signaling through the filamentous web, propagating at speeds up to the limit at which sound travels, without synaptic delay (since the web disregards the membrane barrier as it passes through membrane proteins). Solitons are self-sustaining pulse-like waves travelling in nonlinear systems that do not disperse in space but act as quasi-particles (…). They are generated only at the ends of protein chains and are induced by ATP hydrolysis energy release. The same a-helic protein structure that supports soliton formation and propagation also characterizes transmembrane glycoproteins which solitons readily pass through to protein structures in the extracellular space. Soliton particles are accordingly local expressions of a whole; the whole acts as if it were a particle, hence the term ‘‘quasi-particle". Solitons can travel long distances in biological systems with little loss of energy or structure and are robust against thermal

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[1] "Quantum computation does introduce the idea of computing with waves (in the form of superpositions or interferences) and waves provide a point of contact with a historical leitmotif in brain theory. Karl Lashley [63] spoke somewhat vaguely of wave interference and his student, Karl Pribram [64, 65], fleshed out the idea substantially in his development of holographic brain theory (inspired by Gabor's Nobel prize winning work on holography). Pribram proposed that memory is like a hologram in which many memory traces are superposed in each small region of a neural wave interference pattern." (Globus and O'Carroll 2010, p. 428)

> perturbation at body temperature (…). The cryptic brain at the nanolevel uses soliton messaging at velocities up to that of sound which serves to integrate brain functioning. (Globus and O’Carroll 2011, p. 428)

I quoted this long paragraph to emphasize the amazing Ptolemaic epicycles constructed by Jibu and Yasue using notions borrowed from quantum mechanics. We can clearly notice the illicit extension of some notions from quantum mechanics to neuroscience. The “soliton signals” is an amazing invented notion to explain the mind (that includes consciousness and unconsciousness phenomena). The second notion is that “in QBD memory is total (…). At every moment a new memory formed convolves with all previous memories into a total memory. The total memory is a wave superposition.” (Globus and O’Carroll 2011, p. 429) This is quite an interesting idea! The mind as an EW needs this feature in relationship with its unity and the possibility of the corresponding organism to survive in its environment. The problem is that the unity of memory is based on fundamental physics (with notions like vacuum, symmetry, etc.). The third notion is about the consciousness from Vitiello’s notion of “dissipative quantum brain dynamics” (DQBD). “The brain as a living autopoietic system is dissipative, exchanging energy with its environment. When the brain’s order increases, then its environment must achieve balance by decreasing in order.” The vacuum state has two modes (to represent memory and sensory input) so as to model the dissipative situation. (p. 429) For Vitiello, consciousness is the match between the two modes, i.e., conscious state. (Globus and O’Carroll 2011, p. 430) With all these three innovations, DQBD is able to explain the dis-unity of content within the unity of consciousness.

> Communication between brain regions is near instantaneous via soliton signaling in the nanolevel web of protein filaments percolating through brain tissue. This accounts for what Lashley called the brain’s “mass action” [63]. Memory is a consequence of Noether’s theorem regarding symmetry conservation. Memory traces are Nambu–Goldstone boson condensates. Consciousness is between two in the match of dual quantum thermofield modes. Binding now becomes a matter of temporal coordination: whatever matches in the between-two at any moment will be

> a content of consciousness bound together by soliton signalling. Disparate matches are not mutually exclusive but co-occurrences. Whatever belongs together is disclosed within the unity of consciousness. (Globus and O'Carroll 2011, p. 430)

Is it not clear yet? No. It sounds almost like a SF story! For me, it is clear that the application of notions from quantum mechanics to cognitive neuroscience creates a mixture of EDWs and therefore such "innovative" notions become useless or lead to (ontological) contradictions.

Globus and O'Carroll also introduce Zeki's ''theory of multiple consciousnesses": the microconsciousness (autonomous subsystems – for instance, distinct in space and time, color and motion are microconsciousness), macroconsciousness (color and motion are unified) and "my self as a perceiving person". Interestingly, working within a Kantian framework, Globus and O'Carroll Zeki write about Sperry's emergent approach that the human subject is at the highest level but a level that is different from and more than the sum of neural parts. (Globus and O'Carroll 2010, p. 430) Again, we have the wrong idea that the brain produces the mind or consciousness. Sperry inquires the "neural glue", a kind of holonomy, necessary to solve the binding problem.

> Within the framework of dissipative quantum brain dynamics the ''neural glue" would be the filamentous nanolevel web with its soliton signals traveling at near the speed of sound (and possibly gap junctions per Hameroff [82]). What becomes ''glued" is whatever belongs-together in the between-two of local brain systems. The disclosures of the between-twos are unified within consciousness. That one or more local modules are knocked out or disconnected does not affect the unity of consciousness that remains. (Globus and O'Carroll 2010, p. 430)

Returning to our analogy table-microparticles, we can ask where is the "glue" that unifies the microparticles (the micro-forces) that "make up" the table? At the end of the paper, the authors underline again that the nonlocal operations are not computations. Moreover, a conscious state is not a computation or a "dynamic mobilization" but an "unfolding from the whole". "The operations are not serially local (as in a computer) but near-instantly global. Nonlocal neurology armed with a holonomic understanding might see more deeply into what clinical neurology has always aspired to: the patient as a whole." (Globus and O'Carroll 2010, p. 431) At first glance, it seems that I need to borrow some notions from this article! Nevertheless, I strongly emphasize that this alternative has no ontological background. Sperry micro-, macro-consciousnesses and "self as a perceiving person", that is, "different from and more than the sum of neural parts" remind us of the Cartesian dualism with those famous ontological contradictions. (See Vacariu 2008, Chapter 1) From an EDWs perspective, we understand that the self is not *different from* the neural parts but *epistemologically-ontologically different* than the brain (and the body). Holonomy is nothing more than the "I" as an EW. The relationship between the "I" and the brain (and body) is meaningless since these parts belong to (are) EDWs.

Brogaard explores the blindsight cases and visual for action[1] in relationship with conscious or unconscious states. (Brogaard 2011)

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[1] "Dorsal stream processes, too, seem to be exemplars of unconscious visual processes. Dorsal stream processes compute information about the absolute size of objects and the properties of objects in egocentric space. Goodale and Milner (1992, 2004), Milner and Goodale (1996, 2008) have argued that this information never reaches conscious awareness but is translated directly into online, or immediate, action. Milner and Goodale warn against confusing vision for action with perceptual processes." (Brogaard 2011, p. 450) According to Milner and Goodale, the "visual system consists of the dorsal stream and the ventral stream. Both streams start in the early visual areas of the occipital lobe (V1, V2, and V3) but later they diverge. The ventral stream runs into the temporal lobe and then connects to other temporal and frontal lobe structures that are responsible for episodic memory, working memory, reporting, decision-making, and so on. The dorsal stream runs upwards through the occipital lobe into the parietal lobe and continues until it makes contact with the primary somato-sensory cortex and the primary motor cortex. Studies have shown that damage to structures in the dorsal stream can impair visuomotor control while leaving visual perception intact, and damage to structures in the ventral stream can impair visual perception while leaving visuomotor control intact." (Brogaard 2011, pp. 451-452) However, in our days among other reasons, it is known that there is cooperation between these two streams, so a categorical distinction between the dorsal stream and the ventral stream is rejected. (See Banich and Compton 2011, p. 162 or Baars and Gage 2010) Therefore, maybe it is better to consider this distinction a methodological one.

Traditionally, people have thought that blindsight[1] and visual for action are unconscious processes. Regarding blindsight, supporting the traditional view, Brogaard is against the new perspective introduced by some researchers that, based on recent experiments, believe that instead of being unconscious processes, a person having blindsight seems to have just "severely degraded vision". Against the famous idea of Milner and Goodale (1995) (vision for action is not a perceptual process), some researchers consider that the information processed by the dorsal stream (visual for action) reaches visual awareness. (Brogaard 2011, p. 450) In general, the ventral stream is responsible for the object recognition and classification, while the dorsal stream is accountable for the correct movements, computations about object in egocentric space and absolute size of object for some actions like grasping and reaching. (p. 452) "The dorsal stream thus calculates viewpoint-dependent properties and relations between the object and the perceiver, whereas the ventral stream calculates more fine-grained perceiver-independent and object-centered properties." (Brogaard 2011, p. 454) Large parts of Brogaard's article are dedicated to Peacocke's representational and non-representational properties, Noe's action in perception, and Block's phenomenal and accessible consciousness.[2] Under the conscious-unconscious dichotomy, I consider these notions quite unclear and volatile and therefore I do not investigate them. Brogaard's conclusion is that the blindsight processes are unconscious visual processes, while vision for action (correlated with the dorsal stream) is not cognitively

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[1] "Blindsight occurs as the result of damage to the primary visual cortex which results in a scotoma, or region of blindness. Individuals with a scotoma typically report no visual awareness of visual stimuli represented to them in their blind field. But they nonetheless have a preserved ability to predict attributes of visual stimuli. They typically make above-chance predictions about the motion, location and colors of objects they report not seeing. The visual processes underlying these predictions thus seem to be good candidates to be unconscious perceptual processes. They certainly seem to be mental representational processes." (Brogaard 2011, pp. 449-450) Weiskrantz is the father of the notion of "blindsight".

[22] For Noe's view, see Vacariu and Vacariu (2010), for Ned Block's famous distinction, see Vacariu (2007).

accessible. (462) From my viewpoint, all conscious and unconscious states/processes are the "I" and therefore it is difficult to identify them. The relationship between neuronal stream and mental processes is reflected by correspondences and not by identity (or even worst, causality).

Cohen and Dennett (2011) are against the dissociative theorists (the "phenomenology over and above" information can be accessed). Emphasizing that there are no empirical results that support the existence of consciousness independent of any function and access, Cohen and Dennett introduce a "perfect experiment" (the isolation of visual cortex parts responsible for color while preserving the other parts – colorblind person) so as to argue that consciousness cannot be separated from functions.[1] (Cohen and Dennett 2011) In this context, we return to Edelman and Tononi's approach**:** consciousness is a process that involves groups that are widely distributed in the brain. (Edelman and Tononi 2000, see also Vacariu 2008) Consciousness mainly presupposes the re-entrant interactions among these groups which are the most important feature of the brain: "reentry leads to the synchronization of the activity of neural groups in different brain maps, binding them into circuits capable of temporally coherent output". (p. 85) Every consciousness state "requires the activation and deactivation of many regions of the brain". (Edelman and Tononi 2000, p. 140) Crick and Koch argue that the neural correlates of consciousness at one time engage one part of the cells but their firing influences other neurons, the so-called "penumbra", which makes a contribution to the process of understanding.[2] (Crick and Koch 2003)

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[1] "A true scientific theory will say how functions such as attention, working memory and decision making interact and come together to form a conscious experience. Any such theory will need to have clear and testable predictions that can in principle be verified or falsified. Most importantly, such theories will not claim that consciousness is a unique brain state that occurs independently of function; instead, the focus will be placed on the functions themselves and how they interact and come together to form consciousness." (Cohen and Dennett 2011)

[2] Blumenfeld declares that "the anatomical structures important for the content of consciousness include: (i) multileveled cortical and subcortical hierarchies involved in sensory–motor functions, (ii) medial temporal and medial diencephalic structures

I will offer some details about Koch's framework for consciousness. (Koch 2008) His main questions are obviously formulated within the unicorn word.[1] Consciousness is strongly related to five problems and I investigate each problem from the EDWs perspective:

(1) The hard problem: Why "does a brain feel like anything?" (the explanatory gap between mental and physical worlds). (Koch 2008, p. 1224) From the EDWs perspective, the brain does not feel anything, any mental experience (thoughts, feelings, emotions) is the "I" and does not belong to the brain.

(2) Why our sensations (for instance, colors) can be mapped onto the topology of a circle and why are there some differences between perceptual states offered by different sensorial mechanisms? These questions have answers only within the EDWs perspective.

(3) "Why are feelings private?" It is because the "I" is an EW.

(4) "How do feelings acquire meaning?" Because each feeling state is the "I" and feelings are not the only states that are the "I". The relationships between the mental states and the relationships between these states and the "I" are quite strange within the actual

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interacting with cortex for generation of memory, and (iii) limbic system structures involved in emotions and drives. The level of consciousness in turn, also depends on multiple systems acting together. These include systems necessary for maintaining: (i) the alert, awake state, (ii) attention, and (iii) awareness of self and the environment." (Blumenfeld 2009)

[1] "Consciousness is one of the most enigmatic features of the universe. People not only act but feel: they see, hear, smell, recall, plan for the future. These activities are associated with subjective, ineffable, immaterial feelings that are tied in some manner to the material brain. The exact nature of this relationship—the classical mind-body problem—remains elusive and the subject of heated debate." (Koch 2008, p. 1223) One page later he asks: "A science of consciousness must explain the exact relationship between phenomenal, mental states, and brain states. This is the heart of the classical mind–body problem: *What is the nature of the relationship between the immaterial, conscious mind and its physical basis in the electrochemical interactions in the body?*" (Koch 2008, p. 1224) Such questions are quite strange for many people working in cognitive neuroscience today. Obviously, Koch works in the unicorn world, considering, for instance, consciousness as being a "state-dependent property" of the brain. (p. 1223)

framework of thinking. So we need to change it in order to understand these relationships.

(5) Why do we have conscious and unconscious states? Without such types of states (serial and parallel states), we would not be able to survive in any environment. We need the serial processes for attention (conscious states) and parallel processes (unconscious, implicit states) to survive in our environment.

In the first part of his paper, Koch enumerates different alternatives so as to localize consciousness in the brain (medial and lateral prefrontal cortex and parietal associative zones, the role of some neuromodulators - mainly acetylcholine and two "cholinergic pathways originate in the brain stem and in the basal forebrain"[1]), intralaminar nuclei of thalamus, certain synchronization rhythms or quantum entanglement. (Koch 2008, p. 1227) Obviously, there are no chances to localize consciousness in the brain, since unconscious states produce consciousness states (Baars) and it is quite impossible to identify the borders of these states in the mind-EW. The same observation is valid regarding the role of V1 for the neuronal correlates of consciousness (NCC).[2] Koch emphasizes that there are strong debates on this topic. Indicating some experiments made by different authors on perceptual illusions, binocular rivalry, flash suppression, or forward and feedback projections, Koch concludes that "consciousness requires sustained but well-organized neural activity dependent on the long-range cortico-cortical feedback". (p. 1233) Koch investigates Tononi's interesting notion "integration of information" (from Tononi's information integration theory of consciousness, 2004) and informs us that it posits the most important property of consciousness, that is, "extraordinarily *informative*" and information is highly integrated! "An experience of a particular

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[1] In this sense, the "cholinergic basal forebrain neurons send their axons to a much wider array of target structures. Collectively, brain stem and basal forebrain cholinergic cells innervate the thalamus, hippocampus, amygdala, and neocortex." (Koch 2009, p. 1227)

[2] "As defined by Crick and Koch (2003), the neuronal correlates of consciousness (NCC) are the *minimal neuronal mechanisms jointly sufficient for any one specific conscious percept* in conscious states." (Koch 2008, p. 1228, his italics)

conscious state is an integrated whole. It cannot be subdivided into components that are experienced independently (Tononi and Edelman, 1998).” (Koch 2008, p. 1233) Moreover, “the theory claims that *a physical system can generate consciousness to the extent that it can integrate information.*” (Koch 2008, p. 1233, his italics)

Again, the unity of the “I” offered that integration of information but this integration cannot be explained within the unicorn world (neither appealing to neuroscience, nor to psychology). Moreover, Koch’s mistake is that there is no physical system that “generates” conscious states! Information has meaning only within the mind-EW.

Related to the distinction between conscious and unconscious mental states is the state of prediction. In Melloni et al.’s paper (2011) the main idea is that prediction in the brain is based on experience (what it learned in the past).[1] The authors construct several experiments to show that it is possible for conscious perception to be influenced not only by the sensorial stimulus but also by the expectations constructed during the previous experiences. With the results of such experiments, the authors showed that the previous experiences alter the threshold of perceptual awareness: “the amount of prior knowledge and ensuing expectations determine whether the electrophysiological signatures of awareness occur early or late after stimulus presentation.” (Melloni et al. 2011, p. 1387) Obviously, the expectations are strongly related to predictions.[2] In fact, I believe that the brain constructs its “predictions” based on experiences acquired during the entire period of life. The problem is that the predictions are

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[1] About prediction and neuroscience, see Llinas (2001 in Vacariu and Vacariu 2010).

[2] “Predictions have been shown to aid perception (Biederman, 1972; Snodgrass and Feenan, 1990). For example, prior knowledge about the direction and velocity of moving targets enhances their detectability (Sekuler and Ball, 1977; Schwiedrzik et al., 2007). Similarly, previous exposure aids the recognition of incomplete or ambiguous figures (Dolan et al., 1997; Kleinschmidt et al., 2002). Predictions can also have detrimental effects on perception when they are wrong (Bruner and Potter, 1964) or not updated [as in change blindness (Rensink, 2000)].” (Melloni et al. 2011, p. 1393)

mental states that are the “I”, so it is completely wrong to illicitly extend this notion to the vocabulary of neuroscience. The predictions would be impossible without the stability of the self. More exactly, these predictions are the “I”. The main question for the authors of this article that remains open is “why expectations shorten the latency of signatures of visibility”. I quote the interesting end of this article:

> In light of our results, it appears necessary to reinvestigate the neuronal correlates of consciousness, taking into account how cognitive functions (attention, expectations, memory, etc.) influence the timing (and potentially other features) of processes required for access to consciousness. A thorough understanding of the neuronal correlates of consciousness might require a departure from the strategy of merely comparing seen with unseen conditions, and instead necessitates a proper characterization of the interactions among all cognitive processes that ultimately lead to conscious experience (Melloni and Singer, 2010). (Melloni et al 2011, p. 1395)

We can find the answers to these problems only within the EDWs. The expectations are the implicit knowledge that is the “I” and, therefore, we need indeed to “reinvestigate” the neuronal correlated of consciousness. In reality, cognitive functions and their interactions are the “I” that corresponds to the entire brain and body. Moreover, the time for neuronal processes and time for the “I” is not the same since we talk about EDWs.

Chapter 12

Fingelkurts's approach or the status of cognitive neuroscience

In this chapter, I analyze a paper written by the Fingelkurts brothers (quite young twin brothers) and another person, Neves.[1] (Fingelkurt et al. 2010) The Fingelkurts' approach is an extremely elaborated alternative to the mind-brain problem. The Fingelkurts work both in cognitive neuroscience (so they are not philosophers) having a huge background of knowledge from this area. I dedicated an entire chapter to their paper because (1) they have acquired a huge amount of information from this field (2) they made some huge efforts in constructing some very complicated Ptolemaic epicycles to solve a pseudo-problem (the mind-brain problem) within the unicorn world (3) Their approach reflects very well the status of cognitive neuroscience today.

In their paper, Fingelkurts et al. (2010) try to relate somehow the mind and the brain within a unified and common spatial-temporal framework. According to the Fingelkurts, there is a physical spatial-temporal framework, a spatial-temporal framework for the mind, and finally, an "operational" spatial-temporal framework in the brain that binds the brain and mind together.[2] Fingelkurts et al. borrow from

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[1] Regarding other approaches of important people working in neuroscience and cognitive neuroscience (Llinas, Libet, Frith, etc.), see Vacariu and Vacariu 2010.

[2] In "Reply to comments" in the same issue, the authors write: "The focus of the target review essay was to discuss how space and time dimensions are implemented in the physical world, in the brain, and in the mind through hierarchy of space–time patterns. The main hypothesis was that via the brain operational space–time the mind subjective space–time is connected to otherwise distant physical space–time reality." (Fingelkurts et al. 2010, p. 264) At the beginning of this analysis, I draw the attention upon the fact that precisely the main topic is quite problematic from the EDWs perspective since, as I argue in Chapter 9 of this book, the mind-EW has no

Pauli (physics) the notion of “complementarity”: the relationship between the mental and the physical states/processes is complementarity not contradiction! Nevertheless, we already know that even with such complementarity, within the unicorn world, there are some hyperontological contradictions. Fingelkurts et al. write about different physical “levels” (micro-, meso-, macro-scopic levels) with a “circular causality” (pp. 197-8). From the EDWs perspective, such “circular causality” does not exist, only within the unicorn world could we speak about it. They construct the “*Operational Architectonics*” in order to create a relationship (“correlation” or “supervenience”) between the mind and the brain. (p. 199) Moreover, they focus especially on the cerebral cortex “as an essential component of brain–mind interaction” (p. 200) The

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spatial dimension. From my perspective, a quite problematic notion (but inevitable notion within the unicorn world) is the “hierarchy” of “space-time patterns” (or “levels”, in general). Such hierarchies exist only from the viewpoint of a researcher but from the viewpoint of a neuronal activated pattern (or a mental state) such hierarchies do not exist. This is a dramatic observation with frightening consequences. Many researchers will claim that, from a Kantian viewpoint, we have no other alternative than to accept that we can talk only from the viewpoint a human being. Apparently, this observation seems to be correct but from my viewpoint, this problem reflects the relationship between Newton’s and Einstein’s theories: Newton’s theory seems to be quite correct in many particular cases (for instance, the speed of the observer is much lower than the speed of light). In these cases, we cannot observe the dilation of space and contraction of time on observed objects. The reality can be described using Newton’s theory and only in special cases, we have to use Einstein’s theory of relativity. In fact, as Friedman showed (2001), Newton’s theory has notions that have completely other meanings than notions from Einstein’s theory and therefore the first approach is quite false (not an approximation of reality). Working in cognitive neuroscience within the unicorn-world, many results seem quite peaceful, but if we introduce not only the hyperontological difference between the mind-EW and the brain-EW but also the viewpoints of any classes of entities that exist, the number of EDWs increases dramatically. The researcher will claim that nobody can work under a framework with so many EDWs. My answer is that this is the “reality” and approximations of reality produce great paradoxes and many Ptolemaic epicycles in cognitive neuroscience. The EDWs perspective has to be taken into account not only in order to answer some questions through interpreting the empirical data furnished by fMRI and EEG (for instance), but also in order to formulate such questions.

problem is that quite recent fMRI, diffusion tensor imaging and tractography algorithm data show that many subcortical areas are "correlated" to different mental functions. Nevertheless, they are quite right in writing that the "cerebral cortex (as well as the whole brain) operates on a range of multiple spatial–temporal scales (...), which are ordered in a unified hierarchical organization (...)." (p. 200) From my viewpoint, these multiple spatiotemporal "scales" are not from the viewpoint of the human researcher but from the viewpoint of each set of entities that belong to EDWs (with different spatiotemporal "scales"). Let me analyze a paragraph from Freeman quoted in Fingelkurts et al.:

> Among the most difficult tasks scientists face are those of conceiving and describing the exchanges between levels, seeing that the measures of time and distance are incommensurate, and that causal inference is more ambiguous between levels than it is within levels, especially when the distance between levels is wide (pp. 3–4). (Freeman 2003 in Fingelkurts et al. 2010, p. 200-201)

The "exchanges between levels" do not exist within the EDWs and this is the reason why the measures of time and distance are "incommensurate", "causal inference between levels" is indeed "ambiguous" (in reality, it does not exist). Fingelkurts et al. analyze different spatio-temporal frameworks within the brain: the micro-, the meso-[1], and the macro-scopic levels. Are these levels some EDWs (so, there is an epistemological-ontological threshold between them) or are there just methodological "levels" created by the human mind in analyzing the mind-brain relationship? Answering this question is the job of cognitive scientists not of philosophers. The

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[1] The mesoscopic scale means the activity of neuronal assemblies (local field potentials and electroencephalography) or Brodmann's areas and correlated mental perceptual events. "According to Freeman [98,132], mesoscopic effects operate at spatial scale of ~ 1 cm and temporal scale of ~ 100 ms and, thus, mediate between the two extremes of cortex organization: single neurons and the major lobes of the forebrain." (Fingelkurts et al. 2010, p. 203) About these three levels of organization, multiple spatial and temporal scales, and multi-frequency oscillations, see also Le van Quyen (2011) in Chapter 7 of this book.

authors consider that the individual neurons do not "support" cognition and consciousness. (p. 202) Obviously, within the unicorn-world, they are correct, but from my viewpoint the question regarding the relationship ("support") between (individual) neurons and cognition (or consciousness) is much worse: it is meaningless. Fingelkurts et al. consider that there are different connections among neuronal assemblies in the brain:

> (a) convergent connections (many-to-one (...), (b) divergent connections (one-to-many (...), (c) reciprocal connections (corticothalamic projections (...), (d) local inhibitory connections (among pyramidal cells of cortex (…), and (e) topographic connections (one-to-one (...)). (Fingelkurts et al. 2010, p. 203)

Oscillations are also communication paths among different parts of the brain, they are "integrative brain functions" (p. 209). Important for the EDWs perspective is their idea that different frequency bands are related to the timing of various neuronal assemblies that are correlated to different sensorial-cognitive processes. (About oscillations, see Chapter 7 of this book) Fingelkurts et al. emphasize the existence of spatio-temporal interactions within the brain. (p. 204) For instance, some "experimental research has shown that each active neuronal assembly has its own fine temporal structure", the same neurons can take part in different assemblies at different times. (p. 205) Against the skepticism regarding the correlation between frequency band and properties of mental processes, the authors accept Bartels and Zeki's notion of "temporal fingerprints" of different cortical areas: some particular neural regions are correlated with distinct features (like color, smell, motion, etc.). I believe that the idea of "temporal fingerprints" of different cortical areas ("active neuronal assembly has its own fine temporal structure") has to be developed within the EDWs framework.

Fingelkurts et al. are aware of the same problem we analyze in the whole book: the relationship between "local autonomy" or fragmentation (segmentation or differentiation) and "global integration" of neural states and processes. Therefore, they write that

> the brain integrative functions are the result of competition of complementary tendencies of cooperative integration and autonomous fragmentation among many distributed areas [---]. The interplay of these two tendencies (autonomy and integration) constitutes the metastable regime of brain functioning [---], where local (autonomous) and global (integrated) processes coexist as a complementary pair, not as conflicting principles [----]. This emergent metastable dynamics directly constitute the complex dynamics of the EEG field [---]. (p. 207)

As we see throughout all the chapters of my book, the identification of differentiation and integration processes is the main problem in cognitive neuroscience. In the past, quite many researchers considered the synchronized oscillations as an alternative to integration. (See again Chapter 7) In this context, notions like "quasi-stable" and "meta-stable" are essential. Fingelkurts et al. indicate the research of various people on synchronization:

> Observations of EEG signal show that it is characterized by the more or less stable (quasi-stationary) episodes and sudden changes in amplitude [---], frequency [---] and phase [---]. Such abrupt changes in one or several of these EEG characteristics (amplitude, frequency or phase) mark a brief state of indeterminacy — transition (...). It has been shown that the quasi-stationary periods vary from 30 ms to 6 sec depending on the EEG characteristic and the type of brain operation. Kaplan [---] and Freeman [---] called such quasi-stationary periods "frames". John [---] proposed a mechanism, according to which a cascade of momentary "perceptual frames" converges on cortical "functional frames" to establish a steady-state perturbation (*spatial–temporal signature*) from baseline brain activity [---]. This mechanism has received substantial support from EEG studies: Research by Lehmann and colleagues [---] has demonstrated that the dynamics of the brain unified EEG field is represented by the intervals of quasi-stability (or "microstates") and by sudden transitions between them [---]. Furthermore, their studies have shown that these microstates are associated with different modes of spontaneous thoughts [---] or with spontaneous visual imagery, or abstract thinking [---]. According to the metastable principle, described above, EEG signals produced by local and autonomous neuronal assemblies should also be dynamically synchronized among each other, thus shaping large-scale functional connectivity [---], which supports cognition and eventually consciousness [---]. (p. 209)

I analyzed the problems created by the synchronized oscillations and their role of integration in Chapter 7, but I need to add that, from an EDWs perspective, even within the unicorn-world it is quite difficult to deal with both integration and segmentation at the same time without falling into some hyperontological contradictions. In reality, all mental states and their integration are the "I".[1] Therefore, the segmentation is just a *methodological process* introduced by the human beings in their efforts to explain the mind-brain relationship. In reality, the "segmented" entities/processes do not exist, they have no ontology. Obviously, from a methodological viewpoint, we can create such segmentations: some neuronal states (their processes) are strongly "correlated" to a particular mental function/state. However, any mental function corresponds to the most activated group of neuronal patterns, the counterpart of the brain (less and much less activated) and the rest of the body. The difference regarding the correspondences of various mental states with different neuronal patterns is given by the degree of activation and depends on our tools of investigation.[2] The problem is not only that any neuronal state and any mental function belongs to EDWs, but also the segmentation of the entire brain[3] (or the mind) in "parts" is quite problematic. Ontologically, we do not observe any neuronal group completely isolated in the brain (and body), but only more or less activated in correspondence with any particular mental functions. Nevertheless, as we discussed in Chapter 11, for any kind of correspondence, we have to take into account Raichle's default network or intrinsic activity of the brain. However, even the segmentation of body is quite artificial: a leg and an arm are not different ontological entities but methodological parts of the same entity, the body and we have here the philosophical parts-whole relationship.

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[1] In this footnote, I strongly draw the attention upon the fact that if we do not consider all mental states as being the "I", we will reach strong hyperontological contradictions.

[2] Imagine that the "I" is an instrument of observation for its mental state. When we construct such instrument, we will be able to read the mind. Unfortunately, it is impossible to construct such instrument.

[3] I have to recall Sporns' idea (Sporns 2006 and my analysis in Vacariu 2008) that, due to the evolution, we cannot separate the brain from the body. So, even the segmentation between the brain and the body can be only methodological assessments (with very useful results in medicine), but from a (hyper)ontological viewpoint, such segmentations are wrong.

Returning to Fingelkurts et al.'s article, the "associations" between "microstates" and different modes of spontaneous thoughts, visual imagery or abstract thinking are just methodological (and not ontological) processes introduced by the human researchers. These "microstates" and "macrostates" belong to the EDWs. In the review on comments of their article we find this paragraph:

> The central claim of the target review paper [1] is the '*ontological monism*'. However, unlike '*dual-aspect monism*', which argues that the mental and the physical are two different ways to characterize the one and the same phenomenon, we rather speak about '*emergentist monism*' according to which the relationship between the mental and the physical (neurophysiological) is hierarchical and metastable (…). (p. 265)

If we believe that mental and neuronal states are "two different ways to characterize" the same thing-in-itself, we return to an extended theory of Kant. As I showed in Vacariu (2008), the Kantian notion of thing-in-itself is meaningless. The strong notion (i.e., ontological-epistemological) of complementarity excludes the postulation of thing-in-itself or primordial entities. There is no argument in supporting this notion. Moreover, this notion projects our reasoning within the unicorn world. The "I" projects itself within the virtual external space (see Vacariu 2011), and because there is only one "I", we have the illusion that there is only one external world in which the "I" is included. The EDWs exclude completely the notion of thing-in-itself (that comes from Plato until Kant and Bohr). The same argument is available for the spatiotemporal framework of each EW. The EDWs are not situated within the same spatiotemporal framework since it depends on the relationships among ED entities. Moreover, the identity theory (the "ontological monism") and the emergentism are quite dubious approaches constructed within the unicorn-world. The relationship between the mental and the neurological states is neither the identity nor (ontological or epistemological) "hierarchical and metastable" since we have here EDWs that replace even the notion of "correlations" (a notion that has no ontological status) with correspondence (a much clearer notion in the context of EDWs). Essentially, the notion of correspondence assures an ontological framework for many concepts (and eliminates some of them) from Fingelkurts et al.'s theory.[1] Nevertheless, the framework of thinking for all these theories has to be radically changed, i.e., the unicorn world has to be replaced with the EDWs.

Essentially, in their reply to the observations made by some researchers regarding their target article, Fingelkurts et al. introduced great clarifications of some of their notions introduced in the first paper. Basically, the authors replace fig. 11 from the target article with another fig. 1 (in reply) in which the "supervenience" is introduced:

> It might be not completely clear in our target paper that in the proposed model *emergentism* allowed between brain (IPST) itself and its electromagnetic field (OST), while operational level of brain organization (OST) is related to phenomenal level (PST) though *supervenience*, which suggests a more strict relations between higher (mind) and lower (operational level) phenomena in comparison with emergentism (…) (p. 265)

"Supervenience", a notion introduced by Davidson in his famous article (1970), requires his "anomalous monism" within the unicorn-world. Indeed, within the unicorn world, there are quite many anomalies and "antinomies"! The problem for Fingelkurts et al. is that, in this context, if the mind, the brain and the external world all have spatio-temporal frameworks, what does it mean that the mental spatio-temporal dimensions "supervene" on the spatial-temporal dimensions of the OST/brain? From my viewpoint, supervenience would mean the superposition of at least two EDWs. Even within the unicorn world, this superposition is just a methodological instrument created by Davidson. The superposition creates great epistemological problems (or better inquires) and has to be replaced with "correspondence". In fact, within the EDWs perspective, we constantly have to avoid the dogmatic viewpoint of human being and

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[1] This observation is valid for other approaches from cognitive neuroscience.

to consider that the “viewpoint of observation/interaction” of any class of entities has the same objective reality as our viewpoint of observation. In this new framework, the anomalous monism is not replaced with either Cartesian dualism or Spinoza's “dual-aspect monism” (that require the distinction between epistemology and ontology), but with the EDWs. From this perspective, probably “more strict relations” between the mind and the “operational level” are given by the “correspondence” and not by the “supervenience”. The authors also introduce the notion of “emergent qualities”, but these qualities do not exist in any EW. If we accept such qualities, we are either dualists (property dualists), or we operate with different languages on the same ontological entities. I think that we can characterize Fingelkurts et al.’s approach as a new and improved version of Davidson's anomalous monism (with notions like supervenience and emergence). However, the next idea from their reply creates some problems within the EDWs framework:

> Within the context of the brain–mind problem conceptualized within our Operational Architectonics framework, this means that mental spatial–temporal patterns should be considered supervenient on their lower-order spatial–temporal patterns in the operational level of brain organization. Emergentism on the other hand, usually allows for changes of higher-order phenomena that need not possess a one-on-one, direct linkage with changes at any underlying lower-order levels (...). Thus, the mental is ontologically dependent on, yet not reducible to, the physical (neurophysiological) level of brain organization. However it is reducible to the operational level, which is equivalent to a hierarchically organized local electromagnetic brain fields and is constituent of phenomenal level. (p. 265)

Using supervenience and avoiding the dualism or the dual-aspect monism, Fingelkurts et al. use notions like “reductibility”, “equivalence”, “hierarchy” and “constituent” that also produce hyperontological contractions: in fig. 1 from Reply, the OST and the constitutive are the main ontological contradictions. (If these notions are methodological, then we move to Carnap's “linguistic frameworks”, but I believe Fingelkurts et al. should try to avoid this alternative.) Obviously, these contradictory alternatives are the only possible solutions not only for Fingelkurts et al. but also for many philosophers and scientists that work in cognitive neuroscience within the unicorn-world. From an EDWs perspective, we have to find some correspondences between the mind-EW and the brain (which belongs to the macro-EW). The "emergentist monism" seems to be related also to the "weak emergentism" (see Vacariu 2008), but this notion is followed by "the relationship between the mental and the physical (neurophysiologic) [which] is hierarchical and metastable" and thus it becomes meaningless within the EDWs. There is no ontological hierarchy in EDWs but only *methodological* hierarchies that can be useful in some cases (not in all) only from pragmatic reasons but not from (hyper)ontological grounds.

From my viewpoint, the most important problems of this article are the "space" of the mind (in section 3.1 they write about "subjective/phenomenal space") and the "downward causation" of mental events on neural processes (for instance, in the footnote 42, I understand that the authors accept Revonsuo's framework). Very important for EDWs perspective is the authors' idea that the "internal space" is not the result of a direct perception of external objects. (p. 212) On the contrary, the phenomenal consciousness has its own space, neurophysiological and cognitive experiments confirming this idea. Quoting Smythies and Searle, Fingelkurts et al. consider that phenomenal space may be identical with some "aspects" of the brain space but not with the external space! Even "Kuhlenbeck [---] made an even stronger claim, suggesting that 'physical events and mental events occur in different space–time systems which have no dimensions in common'". Someone reading this paragraph may have the impression that Fingelkurts lack the EDWs framework but they introduce the incorrect notion of mental "space". As we saw in Chapter 9, the mind has no space but there is the mental representation of space within the mind-EW. Maybe, we can talk of epistemologically different dimension of time, but we cannot extend this idea to the space. Therefore, from my viewpoint, the dispute between Pylyshyn and Kosslyn regarding the mental imagery has no meaning. From retina to the LGN, the representation of external space is already dissolved in different parts of the brain. In the occipital lobe, it is meaningless to check for the isomorphism ("retinotopic maps") between mental space and neuronal space. We can talk of a "virtual space" of the mind, but we have to make the difference between the real space and the representation of space (recall the analogy between space and color). Moreover, we cannot claim that this virtual space is different from or isomorphic with the real, external space. It is just a virtual space that is the "I". We have the illusion of a real space (or color) inside our mind exactly as we have the same illusion of tridimensional space on TV (or color). We have to analyze in more detail what it means that a perceptual representation of an object (that has an unity) "is correlated" with widely distributed neuronal patterns. In what sense can we talk about different spatio-temporal frameworks of mind, brain and the external world?[1] Only within the EDWs framework could we work to find a suitable alternative to this problem. As we saw in Chapter 9, the spatial dimension of the mind would reject the unity of the mind/consciousness. We can talk of the representations of space (that are the "I"), exactly as the representations of color are the "I" but are not real space or colors within the mind-EW. Moreover, notions like "inside" and "outside" are not even wrong, but simply meaningless.

Interestingly, Fingelkurts et al. argue that exactly this "phenomenal space" is the *bridge* between "nonconscious biological mechanisms" and "phenomenal consciousness". They (and other authors mentioned by them) introduce the "pure phenomenal space" that is an "empty 3D matrix" at the neural level and its ontological status is subphenomenal. (p. 212) I believe that the cognitive neuroscientists have to accept a better alternative to this complex and complicated problem: complex because it requires the correspondences between such virtual space, the space of the brain and the external space; complicated because the "virtual space" is just virtual (it is the "I") and not real! The notion of "isomorphism" cannot help us deal with these correspondences! Moreover, we have

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[1] We do not have to forget that the mental representations of the brain" (that correspond to the empirical data furnished by fMRI, dissections, etc. to the eyes) are the "I"!

to pay attention to the role of species evolution in the representation of “space” and finally we have to insert into the equation the Kantian a priori intuition of space.[1] From an EDWs perspective, it is obvious that there are certain correspondences between the external stimulus and some neural states, but unfortunately we cannot localize the mental states that correspond to these neural states, since we talk of EDWs and the “I” has an unity that rejects the spatial dimension. Even more interestingly, Fingelkurts et al. introduce Metzinger’s “transparency”: the phenomenal world (that contains a space) is “transparent surrogates” (or “virtual simulations”) of the physical world. (p. 214) These surrogates are “somehow” realized in the brain. For this idea, let me analyze footnote 53:

> One good example illustrating this kind of phenomenon was brought by Smythies [374]. In this thought experiment, when we watch a live broadcast of a football game on color TV, we see the game itself, not a complex arrangement of patterns on the TV screen. Here the screen is perfectly transparent for our perception: what we see are the events going on the football field, not the physical events on the TV screen. (p. 214)

What does it mean “we see the events on the football field, not the physical events on the TV screen”? This idea implies “perfectly transparent”, but what does it mean? I believe that we can talk about “perfectly transparent” only within the EDWs perspective where our mental perceptions (that represent space and color) are the “I”. The external events of a human physical entity correspond to certain mental images that are the “I”. In this sense, what “we see” are not events of the external world, not of the brain but of the mind-EW. More exactly, these mental images (the representation of space and color[2]) are the “I” and are not observed by an internal eye (as Kosslyn would claim). The “transparent surrogates” (or “virtual simulations”) of the physical world belong to the mind-EW. (See Kant’s Critique of Pure Reason and Vacariu 2008)

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[1] In my future work, I will try to offer an answer to this problem.

[2] Importantly, there is no representation of space separate from representation of color! Always, we see some entities/process within a spatiotemporal framework, but there are no different representations for space and color.

The problem of this internal space is strongly related to mental imagery and the dispute between Fodor and Pylyshyn (propositional representations) and Kosslyn (mental imagery and propositional representations). There are quite a lot of experiments supporting the space of mental imagery and very few thinkers have doubts regarding this "internal mental space". Moreover, nobody questions the existence of mental "concepts" in the human mind. Again due to the fact that all mental states/entities are the "I", I think that both alternatives are wrong. (See, for instance, Vacariu and Vacariu 2010 or Vacariu 2011)

(1) From an EDWs perspective, I consider that the "I" has no mental images (pictures) and therefore no spatial dimension (I repeat, with spatial dimension, the "I" loses its unity). Let me analyze the mental space dimension here. Metzinger's "transparent surrogates" (or "virtual simulations") send me directly to Kant's notion of a priori intuitions of space and time. From an EDWs perspective, it is not the "space" that exists "inside" the mind (it does not exist "inside" the mind) but the *representation* of external space ("surrogate" space or virtual space) exists, but it is the mind not "inside" the mind.[1] Exactly as there is a mental representation of an external object, there is a mental space that is the "I". However, there are no real objects inside the mind (no real colors, for instance – see

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[1] The notion of surrogate is quite close to the Kantian notion of "surrogate" introduced by Waxman. I investigate Waxman's analysis of Kantian notion of "surrogate" from Critique of Pure Reason in Vacariu (2008). I insert here two paragraphs so as to show that I borrowed Kant's notion of "surrogate" space (and time): "For Kant, as exponents (or operators) of synthetic unity, the categories 'act as a surrogate for space and time in the field of appearances by bringing sensation-reality of appearances to synthetic unity, and thereby endow space and time with objective validity.' (Waxman 1995, p. 848)" (Vacariu 2008, p. 345) For the EDWs perspective, the "I" with "its own identity in relation with all representations, self-consciousness, and the possibility of creating the synthesis of mental representations – represents the surrogate or exponent for "synthetic unitary of pure intuitions of space and time. (See 2.3 and Waxman 1995, p. 849) As we saw in 2.4, for Kant, the categorical understanding 'usurps the entire burden of objective representation, leaving sensibility with effectively no role to play at all.' (Waxman 1995, p. 814)" (Vacariu 2008, p. 189)

Vacariu 2011), so there is no real space inside the mind, but only the *representation* of space (that has nothing to do with the physical space exactly as the real color has nothing to do with perceptual color; moreover, perceptual color has nothing to do with the “color” in the brain, since there is no color in the brain). Both the surrogates of “color” and “space” (that are mental representations) are the “I” and there is no difference between the first-order and the second-order properties. (See Vacariu 2011) From an EDWs perspective, there are only “surrogates” for space and color (and also time) in the mind, surrogates that are the “I”. Without having mental space, there is no mental picture “inside” the mind.

(2) Following the same reasons as in (1), there are no “concepts” inside the mind. According to Baars, we can think that the conscious words (concepts, etc.) are only the *results* of unconscious processes. What are the formats of unconscious processes? From my viewpoint, I claim that these *results* do not have an independent ontological or epistemological status. They are the “I”, nothing more or less, even if Fodor’s compositionality and systematicity are preserved as attributes of the “I” not of the concepts. Fodor’s analysis of concepts needs to be reconstructed: the concepts are the “I” not “inside” the mind. The “I” does not use some concepts, does not have “access to” certain concepts, does not “observe” mental images (having “internal perceptions”, as Descartes claimed even if he believed the mind had no space). In reality, the “surrogates” concepts and pictures are the “I” and therefore, the concepts and the images are just methodological elements/segmentations without *any* ontological grounds. Exactly the same methodological status is valid in the case of neuroscience: the most widely distributed activated neuronal patterns are methodological “parts” of the brain but any particular mental state corresponds to those widely distributed activated neuronal patterns, the counterpart of the brain and the rest of the body and exactly the part-counterpart (see this principle in Vacariu 2008) corresponds to the “I”.

Within the internal spatio-temporal framework, for Fingelkurts et al. the binding problem requires a self-organized hierarchy: phenomenal features (qualities), patterns of qualities, phenomenal objects, and the organization of more complex objects. All these patterns are situated somehow within the mental spatial-temporal framework. From my perspective, this hierarchy is, at best, *methodologically possible* but, in reality, it does not exist, that is, it does not have any ontological status. On the same line, the authors consider that the self does not "directly perceive only the inner phenomenal presence" or "the subjective '*sense of presence*' " related to "now". (p. 215) Again, from my perspective, time is not re-presented by the "inner sense"; time is the "I" more than other mental state/process. Time is an implicit knowledge that is the "I" and all other mental representations are implicit or explicit knowledge. The minimum time interval (mental "quanta of time", "perceptual moment", or "perceptual frame") necessary for a single event is around 70-100ms. For Fingelkurts et al. it is the "phenomenal level as a whole that constitutes the 'subject'". (p. 266) From an EDWs perspective, all mental representations/processes (implicit or explicit, etc.) are the "I", but paradoxically, the "I" is something beyond these mental entities/processes exactly to preserve its unity. It is just "paradoxical" because the "I" as a whole is an indeterminate EW that has a particular unity. Without the unity of the "I", Hume would be right: and the self would be a simple sum of all mental states. Evolutionary, the human organism would not be able to survive in its environment without this unity or we would be nothing else than perfect robots. That is the "I" would not have the unity necessary for the corresponding It to survive in its environment. Hume's presupposition[1] contradicts the evolution of species (or at least what we think the evolution of species) and what the actual robots lack is the being of EDWs "inside" them.

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[1] Even if Kant considered causality as an a priori category, he could not offer an answer to the unity of the "I" and therefore he postulated it. From my viewpoint, we cannot indeed argue the unity or existence of the "I" since there are no conditions of possibility to observe the "I". (See the being-perceiving contradiction above and in Vacariu 2011)

Section 4, in which the authors introduce their approach, refers to the main problem of cognitive neuroscience: "the integration between the different levels of brain–mind organization: local and collective (global), neuronal and subjective, all originated through the spatio-temporal patterns of brain–mind activity". (p. 217) We see again that the *operational* spatial-temporal framework is the main tool for Fingelkurts et al. to deal with the mind-brain problem. Because I consider Fingelkurts et al.'s approach very elaborate and very fresh (many contemporary thinkers from cognitive science and philosophy are on the same route), I prefer to analyze it in detail.

In order to grasp the mind-brain "interactions"/relationships, Fingelkurts et al. introduce the so-called "Operational[1] Architectonics" (OA) framework (that grasps the "temporal structure of information flow"). EEG and/or MEG show us the "existence of particular *operational space–time* (OST) which literally resides within the brain *internal physical space–time* (IPST) and is functionally isomorphic to the *phenomenal space–time* (PST)". (Fingelkurts et al. 2010, p. 217) OST is the neurophysiological basis of mind phenomenal architecture. It seems that here we already have a pseudo-relationship between OST and consciousness (situated within the PST). (p. 218) Strictly speaking, such relationships do not exist within the EDWs![2] However, if the "functional isomorphic" relationship between ISPT and PST means a "functional correspondence", then again we need the EDWs framework. Therefore, I strongly suggest that Fingelkurts et al. need to reconstruct their elaborated theory (based on a very large amount of knowledge from cognitive science) within the EDWs framework. In their reply to comments, Fingelkurts et al. write that

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[1] "Operation" means any kind of process (conceptual, phenomenal, neuronal) or the "state of being in effect". (Fingelkurts et al. 2010, p. 218)

[2] We have to be aware that it is not incorrect to consider the EDWs in the same spatio-temporal framework, but it is meaningless! For each EW, any other EW does not exist. The *correspondences* between entities and processes that belong to EDWs are just abstract notions realized within the mind of the human observer.

> the operational level ties these two (neurophysiological and subjective) domains ontologically together. At this level of brain organization all OST phenomena reside and interrelate – in other words, the OST level constitutes consciousness, rather than "emits" it in any mysterious way. It might be not completely clear in our target paper that in the proposed model *emergentism* allowed between brain (IPST) itself and its electromagnetic field (OST), while operational level of brain organization (OST) is related to phenomenal level (PST) though *supervenience*, which suggests a more strict relations between higher (mind) and lower (operational level) phenomena in comparison with emergentism (…). (p. 265)

In the first sentence, the idea that those two domains are "tied" "ontologically" is a very problematic notion (hyperontological contradictions). Two EDWs cannot be ontologically "tied". Nevertheless, in this paragraph, the authors indicate much clearer than in the target article that the relationship between IPST and OST is emergence and between OST and PST is supervenience. As I showed in Vacariu (2005, 2008), both (strong) emergence and supervenience are Ptolemaic epicycles constructed within the unicorn-world by different authors in the past. Strong emergence is totally false (a Ptolemaic epicycle constructed within the unicorn world), while weak emergence is mostly methodologically available, and supervenience (Davidson‘s anomalous monism) is not a completely wrong notion but has no ontological ground.[1] The authors try to relate ("tie") somehow consciousness with neurophysiological entities/processes (at least with certain spatio-temporal frameworks that presuppose entities, processes or states and the notion of supervenience) and this idea contradicts the EDWs framework.

> Understanding of the operation as a *process* lasting in time and considering its *combinatorial* (spatial) nature, seems especially well suited for describing and studying the mechanisms of how information about the objective physical entities of the external world can be integrated, and how unified/coherent phenomenal objects or thoughts can be presented in the internal subjective world by means of entities of distributed neuronal assemblies in the brain. Therefore, this notion is fundamental in

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[1] Again, within the EDWs perspective, it is not surprising that a famous philosopher as Davidson introduced such an odd label as the "anomalous monism" within the unicorn-world. (Davidson 1970) Davidson apprehended that something is flawed in the "world", but he did not realize that the notion of "world" was incorrect.

> bridging the gap between brain and mind: It is precisely by means of the notion of "operation" that it is possible to identify what *at the same time* belongs to the phenomenal conscious level and to the neurophysiological level of brain activity organization, and what mediates between them. (Fingelkurts et al. 2010, p. 218)

Again, from my viewpoint, the "mediation" between the phenomenal conscious and the neurophysiological "levels" has to be "correspondence" and no other relationships. It seems that the "unification" (integration) is the main goal of the authors of this article. We can find the linguistic expressions like "presented" (again) related to "by means of" so as to grasp the unification between mind and brain. Nevertheless, the notions like "bridging the gap" and "mediate" are meaningless within the EDWs, since there are no relationships between the mind-EW and the brain (that belong to macro-EW). If the "operation" is a methodological notion, then we can develop this theory within the EDWs framework. Mental processes/entities and neural patterns are or belong to the EDWs, so "operation" (an "act" or an "object") is only a *methodological* "bridge" that furnishes the correspondences ("mediates") between the brain and the mind and, in this situation, we can insert the framework of EDWs. These ideas are followed by the hierarchy of "brain-mind operations": the lowest level is the neuronal operations with neurophysiological ontology, unconscious (Searle) without mental ontology.[1] For instance, if the mind "has" various frequency bands, then we have a hierarchical "levels" with certain spatial-temporal frameworks. In another level, we have the last level the "integrated phenomenal experience" with no direct access to the brain. One of the most important ideas is borrowed from Revonsuo: the electromagnetic field (EEG elements)

> may constitute the spatially organized subphenomenal matrix, which [...] is "exactly the kind of entity that could help us to bridge the explanatory gap: it is in itself wholly nonphenomenal, yet it allows all the phenomeno-spatial organization to be

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[1] We recall Searle's main idea: the mind is produced by the brain, both elements with different ontologies are in the same world. (Searle 1992)

> manifested at the higher phenomenal level. It has one foot in the non-phenomenal realm, the other in the phenomenal realm" (Revonsuo).[1] (p. 219)

Obviously, from the EDWs perspective, the waves (with various bands frequency) would bridge the explanatory gap only *methodologically*, that is the waves would correspond to the unity of the mind but the mind and the brain are or belong to EDWs. However, the problem is that some contemporary specialists working on oscillations have doubts in allocating particular frequency bands to particular mental functions. (See Tallon-Baudry 2009, 2010 in Chapter 7) From my viewpoint, this "spatial matrix" is subphenomenal only as a "virtual space" that is the "I" and it does not mediate between the nonconscious (purely neurophysiological/neurophysical) and the conscious (phenomenal) states (p. 220), but *correspond* to the mental states/processes. Therefore, the next paragraph has to be reconstructed within the EDWs perspective:

> (…) the spatially and temporally structured electromagnetic field (...) produced by the functional and transient neuronal assemblies is an appropriate candidate for the entity within which all operational and isomorphic (to them) phenomenal contents (including self) can be presented. Therefore the local fields of transient functional neuronal assemblies are equivalent to operations which can be conscious (phenomenal).

What does "can be presented" or "equivalent" mean? Again, if these notions mean "correspond", then we have here the EDWs. Otherwise, we would have supervenience with either ontological contradictions within the unicorn-world or being just "linguistic frameworks".[2] In the next paragraph, the authors use the "local and

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[1] In their reply, the authors mention again Revonsuo's ideas. Without offering more details, I mention that these ideas create great ontological contractions within the EDWs.

[2] In the Reply, Fingelkurts et al. emphasize that, even if complementarity is not contradictory with isomorphism, the isomorphism is "the 'glue' in the brain–mind metastable continuum. This brain–mind unity, in our view, has hierarchical organization and, therefore, the isomorphism is necessary. To be accurate,

dynamic electromagnetic fields corresponding to operations which instantiate self-presenting, qualitative features” (p. 220) and here “corresponding” is quite close to the same notion from the EDWs perspective. Based on their experiments, Fingelkurts et al. are quite convinced that the experiments proved that the EEG “quasi-stationary segments” are correlated with the particular simplest “phenomenal” features/operations (complex phenomenal patterns/ operations are realized by the binding of simple ones). Again, considering the EDW theory, we can “correlate” only with rough approximation certain particular wave with specific cognitive functions/tasks. Nevertheless, from an EDWs perspective, such correlations are quite problematic since the entities/processes from the mind-EW, the neural patterns and waves from the brain belong to EDWs with epistemologically different (spatio)temporal frameworks. It has to be clear that between these EDW we cannot find any spatial correspondences (it means that we do not have “localizations” for mental states and processes). In this case, there are three points that I want to emphasize:

(1) The mind-EW has no spatial dimension, so the localization becomes meaningless.

(2) We can talk about “parts” of the brain only from a methodological viewpoint, that is, there are indeed some “most activated patterns” that correspond to particular mental function, but we have to add, ontologically, the entire “I” (since any mental function/state is the “I”).

(3) The “phenomenological space” is the representation of space (that is the “I”) but not a real space (maybe a kind of “virtual space”). The “I” has no space because it is indivisible and has the unity of subjectivity.

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isomorphism is only one aspect of our much more general framework of Operational Architectonics, which utilizes the complementarity as well.” (p. 267) I believe that preserving “complementarity” within the EDWs perspective and eliminating “hierarchical organization”, “isomorphism” and the “brain-mind unity”, the Operational Architectonics would receive a better hyperontological status.

I quote another paragraph that mirrors the relationship between different spatial-temporal frameworks:

> the *phenomenal space–time* (PST) is limited by 3D *operational space–time* (OST) which is at the level of electromagnetic fields, and which in its turn is partially determined by the 3D structural and dynamic properties of the brain *internal physical space–time* (IPST). (p. 221)

Again, considering the EDWs framework, the mind is not (spatially) “limited” by the electromagnetic fields, since the mind is an EW that has no spatial dimension. We can say only that the mind corresponds to the brain (its elements and processes that include oscillations).

Another major problem from the point of view of EDWs is the causal relationships between OST and PST even if, in the next sentence, Fingelkurts et al. claim that whenever “any pattern of phenomenality is instantiated, there is a neurophysiological pattern of amplitude modulation that *corresponds* to it”. (my italics) From an EDWs perspective, such causations are meaningless; “corresponds” in the last sentence is also meaningless within the unicorn-world but it has a very strong meaning in the EDWs perspective. Again, I think that Fingelkurts et al. have to change their paradigm of working (that is to replace the unicorn-world with the EDWs) for their quite complex theory. In this way, they would avoid the ontological contradictions and some meaningless or useless notions. At pages 222-223, we find that the Operational Modules are the metastable temporal and spatial patterns in the electromagnetic field that represent the “higher level of abstractness”. Each Operational Module[1] exists within its own “Operational Space-Time” (virtual space-time) “self-constructed” in the brain. (p. 223) This notion of virtual space-time (as many other notions and ideas) is quite close to the EDWs perspective. Nevertheless, it is not self-constructed in the brain since the virtual space-time is the mind which is an EDW from the brain (which belongs to the macro-EW).

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[1] The Operational Modules are identified with any complex phenomenal object/image/scene. Some of OMs constitute Raichle's “default network”, autobiographical self, self-consciousness, or self.

> Formally, the OST concept holds that for a particular complex operation, the *spatial* distribution of the locations of neuronal assemblies together with *synchronous* activity at repetitive instants of time (beginnings and ends of simple operations) comprises the OM. (p. 223)

Again, the notion "comprises" is quite unclear and I think "correspondence" would be a much better notion. The most important idea seems to be the following: the more complex OM is not the sum of more simple OMs but their "natural union". (p. 224) The segmentation and the integration are solved through the status of these OMs.[1] Let me analyze in more detail these OMs (fig. 9 in the article). We can see that "each OM exists in its own OST, which is 'blind' to other possible time and space scales present simultaneously in the brain 'system'." (p. 224) It means that the neural patters that do not "contribute" to a specific OM are "excluded from the OST of that particular OM". The "natural union" is a perfect notion within the EDWs framework and mirrors "blindly" the relationship between EDWs. Again, we have to be aware of the fact that "supervenience" becomes useless in a new framework of thinking.

I strongly emphasize again that in Fingelkurts et al.'s approach, we can find quite many fruitful ideas for future research in checking for the *correspondences* between a mental state and some neuronal assemblies (including oscillations). For instance, the authors write that "OMs could coexist on different time-scales, over spatial patches ranging from a small number of brain areas to an entire hemisphere and, eventually, the whole brain". (p. 225) It is possible, I think, to identify the correspondences between specific mental states and particular neuronal processes (including oscillations).[2] However, from the point of view of EDWs framework,

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[1] In the Reply, we find that "these metastable spatially and temporally organized patterns in the electromagnetic field as OMs" and the "whole Operational Architectonics theory can be considered as one variant of the 'field theory of consciousness'." (p. 267) Again, here is a mixture of EDWs.

[2] Important is the following paragraph: the "operational level *ties* these two (neurophysiological and subjective) domains ontologically together through the shared notion of *operation*. In this sense if, for example, the physical body moves in physical space and time, the body phenomenal image moves in phenomenal space–

mental states do not have spatial dimension but only temporal dimension and, in this sense, we claim that all mental states are the "I". *Avoiding the spatial dimension, we avoid some ontological contractions and in this sense the framework of EDWs is absolutely necessary.* We have to reject our habituation of extending some characteristics/features/dimensions that belong to one EW to another EW. Rejecting the notion of "emergence"[1] and any relationship (except correspondence) between mind and brain, we embrace the EDWs and not the unicorn-world. The last figure (no. 11) with these spatio-temporal frameworks (brain and mind, the external world) can be constructed only within the unicorn-world. From my viewpoint, it is meaningless to talk about these relationships[2] since these

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time. The causal relations mentioned here are of the Humean type: Whenever a certain event A (spatial–temporal pattern) occurs in the brain OST, an appropriate kind of event A that corresponds to A occurs in the relevant spatial–temporal part (PST) of the phenomenal consciousness." (p. 228-229) The authors add that consciousness really exists, consciousness is not "emitted" by OST but OST level "constitutes" it. (p. 229) Considering the EDW, I have the following observations: (1) Operation does not tie *ontologically* these "levels"; if we related operation with correspondence the results would be much better. (2) Finkelkurts and Finkelkurts try to avoid Humean causalities, but their approach is not ontologically (hyperontologically) clear since it is constructed within the unicorn-world. (3) Very correctly, they reject the identification of "constitution" with "emitted", but within the unicorn-world "constitution" requires "correspondence". (See Vacariu 2011)

[1] For instance, the authors write that the "OA framework provides a natural explanation for how, in the words of Baars (...), 'a serial, integrated and very limited stream of consciousness emerges from a nervous system that is mostly unconscious, distributed, parallel and of enormous capacity' ". (p. 226) Or the "micro-level elements (neuronal assemblies) can now explore different structural relationships with each other. When these micro-elements arrive at a new configuration (OM), then the whole system (OST) exhibits different structure". Obviously, within the EDWs, such "emergence"/"exhibit" does not exist. (See Vacariu 2008)

[2] "The gap in knowledge between the brain and the mind can only be bridged with an understanding of how brain operational-space–time and mind phenomenal-space–time are unified within the same metastable continuum." (p. 228) From the EDWs perspective this unification within the "same metastable continuum" does not exist. As Waxman strongly emphasizes (1995), for Kant (the EDWs is somehow an extension of Kantian transcendentalism), the world is not *my* world (as for idealists), the world (that is the representations of the worlds) is the self. The space of the world (in which the brain is placed) *corresponds* to the mental representations that

frameworks are very problematic! The last paragraph of section 4 clarifies Fingelkurts et al.'s efforts:

> (…) the brain–mind interaction does no longer seem so mysterious. The neurophysiological reconceptualization of consciousness we proposed here is not a reduction of subjective phenomenology to something else. It is an attempt to provide a low-level (in comparison with higher phenomenal level) neurophysiological explanatory mechanism of consciousness that takes into account what phenomenal consciousness feels like from the first-person perspective. It also depicts the relations between consciousness, brain and external physical world in a scientifically plausible way. (Fingelkurts et al. 2010, p. 229)

In conclusion, working within the unicorn-world, Fingelkurts et al. (2010) use notions like reductionism, supervenience, constitution, levels ("low-level" and "high-level"), relationship between levels, first- and third-person viewpoints that, within the EDWs perspective, lead either to the ontological contradictions or to the linguistic frameworks. Fingelkurts et al. try to avoid both alternatives, but they want – as many other contemporary thinkers - to situate consciousness within the physical world. Within the EDWs, the consciousness (mind) has no place (somehow related – through supervenience, emergence, causality, etc. - with the brain) in the physical world.[1] Quite innovative and elaborated the theory of Fingelkurts et al. is a fresh alternative to the existent theories within cognitive neuroscience. However, from the EDWs perspective this theory has no ontological background as the majority of approaches in the philosophy of mind/cognitive neuroscience. Again, I believe that Fingelkurts' et al.'s theory will benefit if it is revised within the EDWs framework.

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are the mind. However, returning to Kant, we need to remember that the external space belongs to noumena, what we perceive is the "I"! Moreover, the authors consider that "the OA framework is that operational synchrony may represent a binding mechanism that is responsible for the integrated subjective experience." (p. 233) Again, we have here the synchronized operations as an alternative to the binding problem.

[1] We recall the title of Searle's chapter "Consciousness and its place in nature" (Searle 1992) and Chalmers' article with the same title (Chalmers 2003). Both authors are non-reductionists but they work within the unicorn-world framework.

Conclusion

The status of cognitive neuroscience: "No ontology landscape"

Bassett and Gazzaniga (2011) end their article (analyzed in Chapter 11) with this conclusion:

> Neuroscience desperately needs a stronger theoretical framework to solve the problems that it has taken on for itself. Complexity science has been posited as a potentially powerful explanation for a broad range of emergent phenomena in human neuroscience (…). However, it is still unclear whether or not a program could be articulated that would develop new tools for understanding the nervous system by considering its inherent complexities. (p. 208)

The authors refer to cognitive neuroscience in this paragraph. If one of the fathers of cognitive neuroscience signed an article with this conclusion, this domain has a great questionable status. This paragraph is followed by some questions regarding the route, the direction of research for people working in cognitive neuroscience nowadays. As an alternative to this problematic situation, the authors introduce the "complex theory"! From my EDWs perspective, the complex system theory would create, like in biology (see Kauffman's theory, 1995, 2000, 2007 and our interpretation in Vacariu and Vacariu 2010) a landscape of analysis with many hyperontological contradictions.

Gazzaniga introduces the same analysis in his quite interesting paper from 2010. (Gazzaniga 2010) The main hero of this very short paper (written in a novelistic way) is an ET who, landed on Earth, analyzes the work of cognitive neuroscientists in their laboratories (who try to explain the mind and through the neuronal information the brain). Gazzaniga refers to the relationship between matter and life mentioning Mill[1] and the irreducibility of emergent properties (indicating Broad's work 1925). The ET remarks that, in opposition with these two authors, the neuroscientists "dislike this type of thinking" believing that the understanding of the neurological parts would offer a full explanation of the psychological states! (Gazzaniga 2010, p. 291) The problem is that the mind "emergences" from the brain and produces the feeling that a ghost would "sneak into the brain"! On the contrary, other thinkers from physics, chemistry, biology (Anderson 1972 is mentioned, but see Vacariu 2008) used the notion of "emergence" without any problems. In this context, Gazzaniga asks the following

> So how does the brain do it? Understanding how each and every neuron functions still tells us absolutely nothing about how the brain manufactures a mental state. Sure, they all conduct electrical impulses and secrete neurotransmitters in the service of communication. But how does this produce thoughts and feelings? And how can this system keep ticking after the interacting neurons are disrupted by structural or metabolic lesions? Just as a social democracy continues to work when component individuals are eliminated, so too does this biologic network. It is as if the emergent function guides the underlying physics. (p. 291)

From my viewpoint, these questions are pseudo-problems within the unicorn world! Gazzaniga analyzes more difficult notions from the philosophy of mind and cognitive (neuro)science, like levels of analysis, bottom-up causality, the bidirectional causality between micro- and macro-entities, and mainly emergence. The ET remarks that the neuroscientists already started accepting "emergence". It is worth quoting the last words of that ET:

> ET's spaceship was waiting for him. As he boarded the craft, he mused that the report to home base would be easy. 'The earthlings are stuck in a quagmire. They don't see that brains are decision-making devices and should be understood in those terms – that level of description, not lower. They are only partially evolved. It will be eons before they ever find us. It might also be eons before they ever understand themselves.' (p. 292)

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[1] "no mere summing up of the separate actions of those elements will ever amount to the action of the living body itself." (Mill "A system of logic" 1872 in Gazzaniga 2010, p. 291

From my viewpoint, this ET is an entity landed in the unicorn world who notices the hypercontradictions "discovered" by the living entities of a strange world. The ET tries to convince them that their knowledge is too complicate in explaining quite simple EDWs, but obviously nobody believes him.

Cooper and Shallice (2010) draw the attention upon the fact that if cognitive neuroscience focused too much on the knowledge that belongs to neuroscience and avoided thus the knowledge from psychology, two consequences would take place: this domain would lose its decisive contribution to cognitive science and the neurological knowledge would become meaningless! (Cooper and Shallice 2010, p. 403) In each "special science" (for instance, physics, neuroscience, psychology, Fodor 1974), we can find different theories/approaches (quantum mechanics, Einstein's theory of relativity, Fodor's LOT, some neuronal perspectives) that deal with particular entities (micro- and macro-particles, neurons and mental representations) and laws.[1] Such particular entities have questionable ontological status (relative or not). Cognitive neuroscience deals mainly with the notion of "correlations" that reflects directly the relationships between mental and neuronal states. If mental, neuronal and physical states have ontological status, in general, the "correlations" have no ontological status, not even "questionable"/relative ontological background. Cognitive

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[1] In a famous article from 1972, Anderson (Nobel Prize for physics) shows that reductionism is not appropriate to explain some physical phenomena. That is, the explanations/ theories of some macro-physical phenomena cannot be reduced to quantum mechanics. In philosophy of mind, we can notice Fodor's article (two years later than Anderson's paper). If, for Anderson, we can talk of a kind of organizational non-reductionism, Fodor establishes somehow a linguistic non-reductionism. Each special science (for instance, neuroscience or psychology) has its own taxonomy that cannot be reduced to basic science (physics) and we cannot mix the taxonomy of neuroscience with that of psychology. (Fodor, 1974) Special sciences exist not because "of the nature of our relation to the world, but because of the way the world is put together: not all the kinds (not all the classes of things and events about which there are important, counterfactuals supporting generalizations to make) are, or correspond to, physical kinds." (Fodor 1974, p. 439) (For Anderson and Fodor's works, see Vacariu 2008)

neuroscience is a “science” with no ontological entities and therefore without laws. From a standard framework (in which we define all other particular sciences like physics, neuroscience, cognitive psychology), cognitive neuroscience is not a real science but a pseudo-science created by the mixture of information that describe entities/processes that belong to the EDWs investigated by different “special sciences”. These mixtures produce strong hyperontological contradictions. It is clear that the enormous amount of “correlations” of the last decade created an ocean of contradictions for the young researchers.[1]

Maybe we can regard cognitive neuroscience as a new kind of “new engineering”. We can make an analogy between brain imaging (the main tool of cognitive neuroscience in our days) and the “neural networks” (a domain in vogue between 1990 and 2005). Even if, since the end of the 80s, the connectionism has been quite important in cognitive science, the interest on neuronal networks among researchers strongly declined in the last years. The reason is that the connectionism was an engineering not a “special science”. Its role in cognitive science strongly diminished in the research field becoming mostly complementary to other more important empirical information. More exactly, connectionism was replaced by the brain imaging (mainly fMRI) which furnishes much more direct and palpable results regarding the relationships between mental functions and brain areas. As we saw in this book, the brain imaging (and therefore CNS) has a controversial status. I think that brain imaging in cognitive neuroscience is in a similar situation: a lot of enthusiasm today, a decline tomorrow. However, cognitive neuroscience is a fascinating, captivating area of research but the reality (the EDWs)

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[1] Amazingly, in quite many papers that I read I found something similar to this expression: “It is for the first time when…”. Such expressions refer to either the experiments or the empirical results from which the authors conclude amazing statements. It is very beautiful that the researchers are so convinced of their work, but just because of this conviction, it will be very difficult for the majority of them to change the framework of thinking! This is the reason why the EDWs perspective is addressed to young people unregimented in old fashion (wrong) framework of thinking and working.

does not accept the mixture of knowledge and ontologies that belong to different special sciences that refer to the EDWs.[1] Like connectionism, cognitive neuroscience is not science, but only a kind of "new engineering".[2] Since Descartes until our days, people working in philosophy of mind and cognitive science have been looking in the wrong place (the unicorn world). The "unexpected" movement (see the first motto of this book) for these people is to reject the unicorn-world and to accept the EDWs perspective. This movement throws the young researcher in a paradoxical situation: the first feeling is that you are completely frightened! This is because we have been used with completely different images of the "world": we were situated in the middle of the world, we were created by God, the animals are completely different entities than human beings, our reasoning is controlled by the self, and we have free will. With the strikes of Copernic, Darwin, Freud and other thinkers, the human being has being loosing this dictatorial position in the "world". However, with the EDWs, the position of human being is lost completely since even the "world", the Universe does not exist. The second feeling is the freedom that is produced by the rejection of many pseudo-problems in cognitive neuroscience and other special sciences.

In the context of the EDWs perspective, we have to be aware that the "viewpoint" of a neuron (i.e., its interactions with other

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[1] This is the first reason why I selected the stereogram of 3Dimka from the first cover: it is about a real figure on a 2D plane, but if you insist in looking at it, you can perceive an amazing 3D structure with 3 geometrical figures. (Recall, perceptions are the mind-EW!) When we look directly we see a simple bidimensional plane with spots of different colors. If we try the divergence method (beyond the figure), we can observe some amazing 3D dimensional figures.This is the reason why I added those two paragraphs as motto: biology indeed always started by looking in the wrong place and Poicare correctly invited us to reject the unique reality! We have to reject the unicorn world (the wrong place) and accept the existence of EDWs. The second reason is that the stereograms illustrate the power of human "eye's mind": the mind has always created fantastic things!

[2] In 1999, Peter Mcleod (who, with Rolls and Plunkett, wrote a book on connectionism in 1997) told us (particular conversation) that connectionism is already a kind of "new engineering", not science.

neurons and cells glia) creates an EDW than what we observe using our perception, the fMRI, and any other tool of investigation. Moreover, the parts of the neuron like ARN, ADN, molecules and proteins have their EDW other than that of a neuron! Therefore, the number of EDWs increases dramatically. It is not the job of a philosopher to identify how many EDWs are. This is the job of scientists who work in special sciences within the EDWs perspective. I hope that the articles and chapters that I analyzed in this book (and many others that I would read in the future) will help me to descifrate the nature of the “I” in my next book.

I end this book with a suggestion for both scientists and philosophers. It is time for us to give up our dictatorial framework of thinking theories and start elaborating empirical experiments, a framework imposed by human thinking in the last two millennia. Our viewpoint made us postulate the existence of one ontological world. In reality, there are quite many “viewpoints” (i.e., points of interactions), each set of entities represents an EW. So, there are quite many points of epistemologically different interactions among the epistemologically different entities that represent EDWs. Changing a framework of thinking requires changing a language. We need to rethink the essential notions of each particular science within the EDWs perspective. A notion that describes a particular entity (set of entities) that belongs to an EW has to be re-defined not from our dictatorial viewpoint, but from the viewpoint of that entity (set of entities) that is characterized. This change is the most difficult movement in any particular science (more difficult in philosophy). If scientists remain incarcerated in the old framework, their work will probably be successfully regarding some “local” goals, but for the long term, such results will be overcome by better works constructed within a new framework of thinking.

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