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„A critical analysis and evaluation of Edelman's and Baars' models of consciousness concerning the functional/phenomenal distinction“

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Resümee

Mit dieser These sollen die Bewusstseinsmodelle von Edelman und Baars über die funktionale und phänomenale Unterscheidung präsentiert, analysiert und evaluiert werden. Insbesondere soll geklärt werden, ob diese Modelle das funktionale und phänomenale Bewusstsein ohne Anwendung von Reduktionismus oder Eliminativismus erklären können. Die Hauptthese dieser Untersuchung ist, dass es anscheinend nicht möglich ist, ein subjektives Phänomen wie das Bewusstsein nur von einem funktionalen Ansatz aus komplett zu erklären. Die hier behandelten Modelle beginnen mit Grundannahmen. Diese Grundannahmen reichen nicht aus, um eine angebrachte Erklärung des phänomenalen Bewusstseins zu erklären oder zu finden. Laut Edelman könnte ein dynamischer Kern (dynamic core) bestehend aus rekurrenten Kreisläufe innterhalb des thalamokortilanen System, welches eine grosse Menge von Informationen in Perioden von < 500 ms zusammenbringt, für das Bewusstsein verantwortlich sein. Edelman (2003, Seiten 5522-5523) erkennt, dass das Bewusstsein persönlich und subjektiv wahrgenommen wird. Diese Wahrnehmung benötigt eine Erklärung und seiner Meinung nach wird diese phänomenale Erfahrung oder Wahrnehmung vom dynamischen Kern produziert. Aber man nimmt an, dass das Bewusstsein, wenn es einmal vom dynamischen Kern produziert wurde, keine Macht über Ereignisse und Entscheidungen der Person; das Bewusstsein ist ein Ephiphänomen, aber er befasst sich nicht detailliert mit der Frage: wie das phänomenale Bewusstsein entsteht. Laut Newman & Baars gibt es ein allgemeines Übereinkommen, dass die Wahrnehmung durch eine verteilte Parallelverarbeitung von einer Anzahl von spezialisierten Verarbeitungen entsteht. Das Problem ist, wie erklärt man, dass dieses mehrfach verarbeitendes zu einer integrierten Bewusstseinserfahrung wie Gedanken, Erinnerungen und Wahrnehmungen von mehrfachen, unabhängigen Subsystemen führt. GWT – das Baars Modell – wurde in funktionellen Begriffen verstanden. Baars befasst sich hauptsächlich mit den kognitiven, funktionellen Aspekten des Bewusstseins, erklärt jedoch nicht die persönliche Erfahrung, die

es charakterisiert. Diese Modell erklärt viele Aspekte des funktionellen Bewusstseins, erklärt jedoch nicht, warum diese Funktionen von einer Bewusstseinserfahrung begleitet werden muss. Es ist möglich, daraus zu schliessen, dass die Analysen, die für dieses Modell durchgeführt und hier auf einem funktionellen Niveau analysiert wurden, das phänomenale Bewusstsein nicht erklären können.

Summary

The aim of this thesis is to present, analyze and evaluate Edelman's and Baars' models of consciousness concerning the functional/phenomenal distinction. In particular, its interest relies on determining if these models can explain functional and phenomenal consciousness without resort to reductionism or eliminativism. The main thesis of this research is that it does not seem possible to fully explain a phenomenon subjective in nature as consciousness based only on a functional approach. The models addressed here begin with basic assumptions. These assumptions are not enough to explain or to find an adequate explanation to phenomenal consciousness. According to Edelman a dynamic core consisting of recurrent circuits within the thalamocortical system that binds a big quantity of information in periods of < 500 ms could be responsible for consciousness. Edelman (2003, pp. 5522-5523) recognizes that consciousness is experienced subjectively, personally. This experience requires explanation, for him, the dynamic core produces phenomenological experience, but it is assumed that consciousness, once generated by the dynamic core, has no causal power over events and decisions of the person, consciousness is an epiphenomenon, at the same time he does not address in detail how qualia arise. According to Newman & Baars, there is a general agreement that cognition is created by a distributed parallel processing of a number of specialized processors. The problem how to explain this multi-processing system can give rise to integrated conscious experience like thoughts, memories and perceptions from multiple independent subsystems. Baars'

model, GWT has been conceived in functional terms. Essentially Baars deals with cognitive functional aspects of consciousness but does not explain the personal experience that characterizes it. This model explains many aspects of functional consciousness, but does not explain why these functions must be accompanied by a conscious experience. It is possible to conclude that the analysis performed for the models here analyzed at the functional level so far cannot explain phenomenal consciousness.

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Introduction

The aim of this thesis is to present, analyze and evaluate Edelman's and Baars' models of consciousness concerning the functional/phenomenal distinction. In particular, its interest relies on determining if these models can explain functional and phenomenal consciousness.

Among the various models that seek to explain this relationship between the neurophysiology of the brain and the phenomenological nature of the mind Edelman's and Baars' models have been chosen for this purpose. Regardless of their different points of view, these models have contributed to the understanding of consciousness and the debate in the field. Both are looking to find physiological mechanisms that can explain consciousness. An effort to indicate the strengths and criticisms of each model will be made in the following pages.

It is possible to separate the analysis of consciousness in a functional consciousness, from an external perspective or third person point of view and a phenomenological consciousness, from a first person view. From an external point of view consciousness could be seen as a complex function with several other associated functions.

The main thesis of this research is that it does not seem possible to fully explain a phenomenon as subjective in nature as consciousness is, based only on a functional approach. The models addressed here begin with basic assumptions. These assumptions are not enough to explain or to find an adequate explanation to phenomenal consciousness.

Any empirical research about consciousness begins with some basic assumptions. These assumptions can be clearly defined or not, but in any case this has repercussions in the way research is developed and the conclusions that stem from it. Models are no exceptions, as we will see when analyzing the models proposed here, these are based on basic assumptions. Edelman is not clear about what his position regarding the nature of consciousness is. In the case of Baars' model, his assumption of phenomenal consciousness as intractable subject from a third person approach eliminates the possibility of explanation.

Some authors like Llinás, R., Ribary, U., Contreras, D. & Pedroarena, C. (1998); Dennett, D. (1993), resort to reductionism or eliminativism to explain consciousness. This paper does not intend to state that reductionism (as in the case of Llinás) or eliminativism (as in the case of Dennett) are the right path to explain consciousness. For the purposes stated above, the research that follows considers on Edelman's and Baars' models, relevant to the functional and phenomenal distinction.

The first model to be addressed is Gerald Edelman's. He developed a biological theory of consciousness. According to Edelman (2003, p. 5522) a dynamic core consisting of recurrent circuits within the thalamocortical system that binds a big quantity of information in periods of < 500 ms could be responsible for consciousness. Edelman (2003, pp. 5522-5523) recognizes that consciousness is experienced subjectively, personally. This experience requires explanation, for him, the dynamic core produces phenomenological experience, but it is assumed that consciousness, once generated by the dynamic core, has no causal

power over events and decisions of the person, consciousness is an epiphenomenon, at the same time he does not address in detail how qualia arise. Qualia are often constituent of the phenomenal properties of experience; these experiences are pertaining as being phenomenally conscious. Qualia are phenomenal properties of our experiences, often related to the “what is like” of our experiences, for example what is like to see a color; experiences which have qualia are considered phenomenally conscious. He assumes a position against dualism and his vision of qualia as epiphenomena has repercussions which are not explicitly developed in his model.

It is important to suppose that Edelman could have explained how qualia are generated and then prove that it has no causal power. Epiphenomenalism has several problems, though it is not obviously false, as a matter of fact, it is counterintuitive, difficult to conceive. If brain states require a transformation to become conscious, it means that they are not the same. This could lead to them being characterized as property dualists.

The second model is Baars’ model Global Workspace Theory (GWT), according to Newman & Baars (1993, pp. 255-290), there is a general agreement that cognition is created by a distributed parallel processing of a number of specialized processors. The problem how to explain this multi-processing system can give rise to integrated conscious experience like thoughts, memories and perceptions from multiple independent subsystems. In agreement with Blackmore (2002) criticism about Baars’

explanation of consciousness, GWT “equates the contents of consciousness with the contents of working memory. But how does being ‘in’ memory turn electrical impulses into personal experiences?” (Blackmore, 2002, pp. 26-29). The fact that there is a working memory where information is maintained does not explain how consciousness is generated, why we have conscious personal experiences.

Baars’ model, GWT has been conceived in functional terms. Essentially Baars deals with cognitive functional aspects of consciousness but does not explain the personal experience that characterizes it. This model explains many aspects of functional consciousness, but does not explain why these functions must be accompanied by a conscious experience. The model does not make reference to qualia. Another problem is that the theory does not have a micro-level explanation. It is possible that this model can lead to a better understanding of some aspects of the operation of conscious processes, but not clarify how we have personal conscious experiences.

Functional consciousness can be studied and explained at least in part for Edelman's and Baars’ models. On the other hand it does not seem possible to explain phenomenological consciousness appealing only to functional arguments like those used by Edelman's and Baars’ models or other neurophysiologic models of consciousness.

In the first part of the thesis an analysis will be made on the several definitions of consciousness relevant to the thesis, in particular regarding the functional and phenomenal distinction. In section two, functional and

phenomenal consciousnesses will be considered in more detail. This segment will discuss mental causation and the problem of epiphenomenalism. In chapter three Baars' Global Workspace Theory GWT will be addressed in detail and Intelligent Distribution Agent (IDA) approached as an application of the model. In chapter four, the dynamic core of Edelman and Tononi, will be thoroughly broken down into their features, the mechanism they propose for explaining consciousness, the problem of mental causation within the model and applications of the model: Brain Based Devices, BBD. Part five, will develop a critical analysis and evaluation of Edelman's and Baars' models of consciousness.

This thesis will have an interdisciplinary approach– the philosophical analysis and critical evaluation of the neural and cognitive theories and empirical investigation. It requires subject areas such as neurophysiology and philosophy of mind. An analysis of Edelman's and Baars' models of consciousness will be conducted in order to understand how they explain functional and phenomenological consciousness.

1. Definitions of consciousness

One problem concerning the study of consciousness is that researchers use the term consciousness referring to different meanings and senses. These concepts encompass a wide variety of phenomena and concepts, which has been considered under the concept of consciousness. As Lycan (2002, p. 34) notes these can vary from very theoretical to

completely empirical: “Some of the topics and issues that have gone under the heading of ‘consciousness’ are brutely empirical. Some are more abstractly theoretical. Some are outright philosophical and conceptual.”

For example in medicine, consciousness is the capacity to be alert to the external or internal environment. This definition corresponds to what others would call wakefulness. But for the purposes of this paper this definition is too narrow, it was created in order to solve practical problems and is not appropriate for a broader study of consciousness. According to John Searle (1999, p. 4) consciousness begins when the person wakes up in the morning and lasts until the person returns to sleep state, dies or falls into a coma. Searle states the dream would be a form of conscious activity. But he acknowledges that this definition does not enjoy universal acceptance. This definition is too simple to be useful. As Damasio & Meyer (1999, p. 4): “this explanation may help if we were explaining consciousness to a newly arrived extraterrestrial, or to a child, but it would fail to describe what consciousness is, mentally speaking”.

A problem that arises when viewing consciousness as a complex phenomenon is to determine how may be characterized.

According to Rosenthal (2009, p. 1) the term consciousness is used in three different ways: **First**, it is used to describe a person or other living being on alert and responding to the Environment. In this sense someone is unconscious if he is asleep or in coma. He calls it *creature consciousness*. **Second** a person or another living being is conscious of something if he is aware of something. When he can see, hear, touch or

feel something, but is also possible for a person to be aware of something even without perceptual contact with that object, for example if the person has in mind a representation of something. He calls this *transitive consciousness*. **Third** the term can be used to refer to the ownership of mental states such as perceptions, emotions and thoughts that can be conscious or unconscious. We may be aware of many things, or we may be aware about our perceptions and thoughts about them, but these perceptions or thoughts may or may not be aware themselves. Subliminal perceptions could be an example of unconscious perceptions as well as many thoughts of which we are unaware. He calls the last *state consciousness*. When we compare creature consciousness with state consciousness, we can see that not all mental states of a creature that is itself conscious are conscious.

Chalmers (1996, pp. 25-27) claims there are two basic aspects of consciousness, psychological consciousness which in turn involves several aspects such as wakefulness, introspection etc. and phenomenological consciousness, that is conscious experience as experienced from the subjective viewpoint of the first-person. According to Chalmers this is irreducible. This differentiation will be critical in the development of this thesis as it will be seen further in this research.

Other authors such as Searle (1999) think that we should not consider issues such as attention, self-awareness. It is his belief that "Consciousness consists of inner, qualitative, subjective states and processes of sentience or awareness." These inner, qualitative and subjective states characteristic of our consciousness are important to

differentiate human awareness from awareness of other forms as a computer may have, for example.

As seen, there is no agreement as to the exact meaning of the concept “consciousness”. Many problems also arise when scholars try to explain through models how consciousness works. Is it possible to find an anatomical substrate of consciousness? Does it depend on specific brain areas? Is consciousness something material or immaterial? While no one in science denies the role of the brain in the formation of consciousness, there is no universally accepted explanation about how the brain contributes to the formation of consciousness, as it will be thoroughly discussed in another section of this search. Consciousness is not dependent on sensory or motor modality, it is not modal specific. We can be aware regardless of our perceptions or the actions we take. We may be aware of diverse stimuli, visual, auditory, tactile, motor, etc. Therefore consciousness must be the result of a system that can access various functions widespread in the brain.

While we are aware, we are aware of something. Consciousness is not an empty process, it always has content. In this sense consciousness is a process not fully independent of content. From there, it is a problem to be distinguished from other neuropsychological functions such as attention or memory.

Another problem to be dealt with is that consciousness is a phenomenon which at one point requires a subjective point of view or first person analysis, on the other hand science has been characterized by a third person analysis of phenomena. The problem in itself is, starting from an

external view, how can neuroscience explain a phenomenon that is subjective by nature? Can science which is based on observations in the third person give a full account or a full explanation of the phenomenon of consciousness? This point is particularly relevant in the case of Baars, who believes it is impossible for science to answer this question. Behavioral psychology chooses to eliminate the subjective or internal aspects, according to this, the psychological research field would be behavior and could be described as such, without recourse to events or internal psychological states as the mind, emotions or other internal cognitive states. Behaviorism in this sense is a psychology based on a third-person approach. This eliminativist approach eliminates consciousness, pretends that it does not exist or in the best case that it cannot be scientifically studied.

A different approach to study the phenomenological aspect of consciousness is that of the phenomenologists, these are based on the experience and not the study of the neurological aspects to explain the phenomenon. They are interested in the systematic study of the subjective experience of consciousness.

Following this brief initial presentation of the issues, a canvas of the problem of functional consciousness and phenomenal consciousness will be presented.

2. Functional consciousness and phenomenal consciousness

Several authors (like Block (1995); Chalmers (1996)) have noted the distinction between two forms of consciousness or two ways of studying consciousness. Ned Block (1995, p. 230) believes there are two forms of consciousness: P-consciousness (phenomenological consciousness) and A-consciousness (Access consciousness). The first is experience, experiential states, what are we aware of. When we look, hear, smell, taste, etc. we have experiential states. The properties of P-consciousness are the experiential properties of sensations, feelings, perceptions, thoughts, desires and emotions. These properties are different from any cognitive property or volitional function. In other words P-consciousness cannot be reduced to functional properties (those that can be defined like a computational algorithm), cognitive properties (those that involve thoughts), or intentional properties (those by which a state or representation refers or is about something). The second, access consciousness, or A-consciousness is concerned with the availability for its use in reasoning and rationally guide the process of language and action. A representation is A-conscious if it is generated for free use in reasoning and control "rational" direct action. An A-state is one that consists of an A-representation. The A-consciousness is a cluster concept in which reportability is the element that has less weight

but at the same time is the best guide to A-knowledge from a practical point of view.

Chalmers (1996, pp. 11-16), considers that there are two concepts of mind: the psychological and phenomenological. The psychological is the mind as a causal entity in human behavior and/or explaining human behavior. A state of mind from this concept would be one that plays a causal role in a certain behavior or at least can serve to develop an explanation of such behavior.

The phenomenological concept, on the other hand, is the experiential aspect. A mental state is one that is accompanied by an internal subjective experience.

Block and Chalmers's division into two concepts of consciousness is adequate for the purposes of this research, but the terms they use are not appropriate. Referring to the first one as psychological consciousness reduces the concept of psychology, which does not have to be so limited. The concept of psychology has been limited in part of the twentieth century mainly by a neo-positivist approach adopted by psychological science of which behaviorism was a result. A closer look at the history of psychology, shows that the concept has involved much more than the functional aspect that was attributed to some authors in part of the twentieth century.

For the purposes of this research, functional consciousness will be the first form of consciousness and phenomenological consciousness the second.

The term functional consciousness is more appropriate, as it indicates the nature of this concept. It is a form of consciousness that can be described in terms of functional or cause and effect. As Block (1995, p. 230) stresses functional properties can be described as an algorithm.

Phenomenological consciousness is consciousness as experienced by the subject in first person point of view. It arises immediately, it is not due to a process of reflection, and it is not the result of higher conscious functions such as introspection, reportability, self-awareness and theory of mind. It is not necessary to have insight into their own mental states, it is not based on the ability to describe these states, or the ability to think on our own thought or consciousness, and it is not the result of theorizing about the existence of one's mind or other people minds (Chalmers D. , 1996, pp. 3-31).

Chalmers (1996, pp. 24-26) claims that when consciousness is split into two parts, a psychological and a phenomenological, two problems arise. The first problem, which he calls the “easy problem”, represented by psychological consciousness, poses problems for cognitive science but they are not really complex metaphysical problems. For example if we pose problems about memory or learning, these are technical problems but they are not philosophically complex problems. The second problem, that he calls the “hard problem”, is different; here comes the mind-body problem. Despite all technological development and all knowledge acquired by science, this problem has not been solved; we do not know why this whole cognitive structure contained within our brain is accompanied by a conscious experience?

Chalmers (1996, pp. 26-27) claims that psychological consciousness comprises several aspects:

a. Awakeness

b. Introspection, being able to access our own internal states.

c. Reportability, capability to make a report of our own internal states.

d. Self-consciousness, the ability to think of ourselves, our own alertness, our existence as individuals and how we differ from others.

e. Attention, we are aware of something if a significant portion of our cognitive resources are dedicated to dealing with relevant information.

f. Voluntary control, being able to perform an act deliberately.

g. Knowledge, we are conscious of something when we know it.

The problem of self-consciousness

Does the self really exist? In the "Treatise of Human Nature", Hume states the following:

> For my part, when I enter most intimately into what I call myself, I always stumble on some particular perception or other, of heat or cold, light or shade, love or hatred, pain or pleasure. I never can catch myself at any time without a perception, and never can observe anything but the perception. When my perceptions are removed for any time, as by sound sleep; so long am I insensible of myself, and may truly be said not to exist […] I may venture to affirm of the rest of mankind, that they are nothing but a bundle or collection of different perceptions, which succeed each other with an inconceivable rapidity, and are in a perpetual flux and movement (Hume, A TREATISE OF HUMAN NATURE, 1739).

For Hume there is nothing but the content of consciousness –a bundle of perceptions- but not the conscious self. There is only intentionality; the consciousness is consciousness about, but not consciousness itself. Hume apparently hoped to find some quasi-perceptual catching of the self (Kriegel, 2007) However, even if it is not possible to catch the self without mental or perceptual state, that does not mean it is not possible to catch the self with a mental or perceptual state. The only thing this proves is that there is an intimate relationship between our perceptions and consciousness, so it is not possible to separate them. What is clear is that consciousness and perception should not be confused with the content of consciousness, attention or memory. For example we can think of an automaton with its environment perception, attention, and memory but without awareness. This shows that consciousness is a separate entity from the above, closely linked to them, even inseparable, but with its own existence. Of the fact that perception and consciousness are closely linked, it is not correct to conclude that they are identical. Is it not obvious through a process of self-reflection that there is something more that sensory information? There is a being that perceives and conceives the ideas, thoughts and perceptions; this self, which is not recognized Hume as well as some other modern authors.

Hume's view is relevant today because, present authors, like Dennett (1993) deny the existence of consciousness; specifically he denies the existence of qualia and thinks that consciousness is an illusion.

Dennett is eliminativist in terms of phenomenological consciousness. For him the qualia do not exist:

> So when we look one last time at our original characterization of qualia, as ineffable, intrinsic, private, directly apprehensible properties of experience, we find that there is nothing to fill the bill. In their place are relatively or practically ineffable public properties we can refer to indirectly via reference to our private property-detectors-- private only in the sense of idiosyncratic. And insofar as we wish to cling to our subjective authority about the occurrence within us of states of certain types or with certain properties, we can have some authority--not infallibility or incorrigibility, but something better than sheer guessing--but only if we restrict ourselves to relational, extrinsic properties like the power of certain internal states of ours to provoke acts of apparent re- identification. So contrary to what seems obvious at first blush, there simply are no qualia at all. (Dennett D. C., 1988, p. 409)

He denies that conscious experience to which we are accustomed to actually occurs. He argues that consciousness is just an illusion: “While there are still thinkers WHO gamely hold out for genuine consciousness being someone precious thing (like love, like gold) That thing is just to ‘obvious’ and very, very special, is the growing suspicion that this is an illusion” (Dennett D. C., 1993, p. 23).

Edelman (2003, pp. 5520-5524) does not deny the existence of qualia, but believes it has no causal power, in other words qualia are epiphenomena. To study this last point of view is necessary to explain mental causation.

One problem related to the existence of the mind is the problem of mental causation. This problem will be addressed in the next section.

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2.1. Mental causation

Mental causation problem is relevant to this work, because we need to understand how the relationship between body and mind is conceptualized on the field of the philosophy of mind in order to criticize Baars' and Edelman's models. These models make basic assumptions about the relationship between mind and body and this is related to the functional/ phenomenal distinction. Mental causation can be stated: how can a non-material mind, interact with the world and in particular with a body of a material nature and have a causal power on events that occur in this body? In our daily life we take for granted that there is a causal relationship between mind and body, but in the scientific field it is not easy to show that it is so. If someone looks at many of his bodily functions such as digestion and blood circulation, he will find that our mind has no control over them, but something different happens with our voluntary muscles. If someone chooses, for example, to raise his hand, his hand moves according to his will.

Most people admit the agency of the mind in their decision to move, this does not pose any problem, but for philosophers and scientists it poses a serious problem. For most scientists and philosophers involved in the study of cognitive science, thinking of an agent of nonphysical nature, as

the mind, which acts over physical human bodies, represents a challenge to the conception of a causally closed physical world.

David Hume and causation

David Hume sought to explain the causality or cause-effect relationship. He claims that knowledge of these relationships is not known a priori through rationing but it is due to experience.

According to Hume (A TREATISE OF HUMAN NATURE, 1739) Book 1, Part 3, the first important element is *priority* (Book 1, Part 3, Sec II), for establishing causation is necessary that the cause precedes to the effect, causes never occur after effects. The second element is *contiguity*, both cause and effect must be contiguous in space and time. It must be an immediate connection between them and this connection must occur in the same place, if not so, there must be a number of connections between the events that explain the connection.

The third element is a *necessary connection* between cause and effect, so that cause and effect have a connection in which the cause produces the effect.

Hume considers the first two elements, contiguity and priority unsatisfactory to prove causation, so the most important is the last, the necessary connection, but at the same time he finds that it is not possible to prove the necessary connection between two events.

> When we look about us towards external objects, and consider the operation of causes, we are never able, in a single instance, to discover any power or necessary connection; any quality, which binds the effect to the cause, and renders the one an infallible consequence of the other.

> We only find, that the one does actually, in fact, follow the other (Hume, An Enquiry Concerning Human Understanding Sec I, Part VI, 1739)

According to Hume that necessary connection between cause and effect, would allow to set unequivocally that one event is infallible caused by the other, but the fact is that things do not happen this way, everyone's experience is that an event follows another. Hume raises a problem about knowledge, he is skeptical that it is possible to prove causation, because it is not possible to establish a relationship of necessary connection between causes and effects.

He applies the same argument to the mind-body problem. Likewise, he claims that there is nothing more mysterious the union of body and soul and he find that it is not possible to find a necessary connection in terms of causal relationship between the two:

> Is there any principle in all nature more mysterious than the union of soul with body; by which a supposed spiritual substance acquires such an influence over a material one, that the most refined thought is able to actuate the grossest matter? [...] But if by consciousness we perceived any power or energy in the will, we must know this power; we must know its connexion with the effect; we must know the secret union of soul and body, and the nature of both these substances; by which the one is able to operate, in so many instances, upon the other." (Hume, An Enquiry Concerning Human Understanding Sec I, Part VI, 1739)

However, according to the last conclusion, it is not possible to find a necessary connection between mind and body. The problem with this analysis is that if is true that it is not possible to establish with certainty a causal relationship between mind and body, then, it is also true that it is

not possible to establish any cause and effect relationship. In other words people could not be sure that something causes an effect.

For Hume there is not a necessary connection in the world, the only thing human beings can find is regularity, it means one event is always followed by another event. This regularity, according to him, creates an illusion of necessary connection and causation. This conclusion leads to the problem of induction, as is called nowadays, that was stated by Hume, the problem is how to justify inductive methods, because truths obtained by inductive methods cannot be proved using deduction. This problem has been analyzed by many philosophers trying to find solutions (Vickers, 2012). Persons use inductive methods in everyday life and in science, so they are crucial for their understanding of the universe.

The problem of mental causation is how it is possible that an immaterial mind can have an effect on a material body. This does not represent a problem for human beings in their daily lives, if they decide to move an arm or a leg; they notice that they move immediately and always. According to Hume this would only be proof that there is regularity in the succession of events. Some situations in which this pattern is broken are: 1. the alien hand syndrome and 2. External control hallucinations presented in psychosis. In patients with the alien hand syndrome, one of the hands of the subject moves without his voluntary control. This condition usually arises as a result of brain injury, tumors, accidents or surgery. It may involve injury to the corpus callosum, the dominant medial frontal lobe and posterior cortical or subcortical areas (Bundick & Spinella, 2000, pp. 83-85). Among the forms of mental causation there is

one that is relevant to this thesis, epiphenomenalism, which will be discussed below.

2.2. The problem with epiphenomenalism

Edelman's model assumes an epiphenomenalist position to explain mental causation. He believes that qualia exist, but that the mind cannot have a causal effect on the body. In other words the mind is an epiphenomenon. It is for this reason that epiphenomenalism will be analyzed in detail below.

Epiphenomenalism considers that physical phenomena can cause mental phenomena but mental phenomena are just epiphenomena and they cannot cause anything. Epiphenomenalists believes that for any event that causes a physical changes in turn must be physical in nature, otherwise there would be a overdetermination of events. For example if a mental event A caused a physical event B, then, physical C could not be the cause of event B, as this would imply one overdetermination (fig.1), two events A and C would cause an event B . If a mental event could cause a physical event, this would be a violation of the laws of physics. Whether a physical cause is sufficient to cause an event, then there would not be the need to invoke a mental cause for this event in any case.

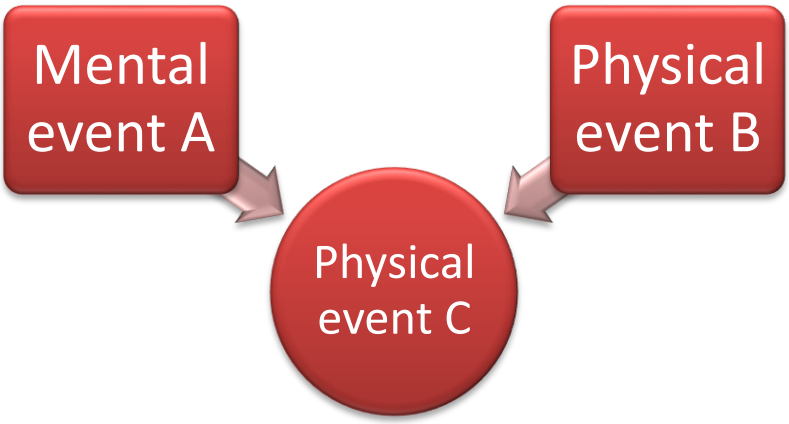

Figure 1 causal overdetermination, a mental event A and a physical event B cause a physical event C

Epiphenomenalism has a problem; it is obvious for individuals, that if they have intentions to move or to do something, their thoughts have an influence over their body movements, for example if they want to raise their arms, their arms rise. Consequently epiphenomenalists have to demonstrate that people's thoughts and feelings have no influence over their body movements.

Apart from the philosophical debate about whether or not the mind has a causal power in behavior, there are several experimental studies, which authors believe to have shown that the mind is an epiphenomenon (Wegner, The illusion of conscious will, 2002); (Wegner & Wheatley, Apparent Mental Causation, Sources of the Experience of Will, 1999); (Libet, 1999).

Experiments on free will: Benjamin Libet, Daniel Wegner

To scientifically demonstrate that mind is an epiphenomenon is a difficult task. Some seminal experiments in the development of this notion are

the experiments of Benjamin Libet; he concluded that the source of volitional processes leading to an action is initially unconscious. At the same time he sustains that while free will could not initiate the event, it could control the outcome by a vetoing process (Libet, 1999, pp. 45-57). This “veto right” would be the last redoubt of consciousness.

Libet's interpretation on his experiment depends on the assumption that physiological potentials recorded before the conscious actions are evidence of unconscious processing associated only with the preparation for movement. Another interpretation could be that the potentials recorded by Libet are produced by nonspecific activity involved in the participation of subjects in the task but not attributable to unconscious processing. Judy Trevena & Jeff Miller conducted two experiments to observe the relationship between the times in which people reported having taken a decision to move and two types of preparatory cortical potentials: the readiness potential RP and the readiness lateralized potential LRP (Trevena & Miller, 2002, pp. 162-190) They found that there is no convincing evidence that the potential recorded before an action are different from those registered in a state of no action. (Trevena & Miller, 2009, pp. 447-456). Libet interpreted the presence of potential prior to action as evidence of unconscious processing. The results of these experiments contradict this interpretation. Potentials prior to the decision to move or not move are not significantly different. Trevena & Miller believe that these results may be associated with a process of attention or effort and not the preparation to make a move.

Another series of experiments were realized by Daniel Wegner. According to Wegner (2002, pp. 8-11) there are four basic possibilities when we establish a contrast between the actions of human beings and the own sense of deliberate act. Two of them, he thinks, are not controversial: The first one, normal voluntary act occurs when people do something and at the same time they feel they are doing it voluntarily and the second one, when they do anything and they feel that they act voluntarily. However, for him there are two of them that are controversial: the third one, when people do something but they feel that they do not act voluntarily. This would include dissociative automatisms such as occurred during hypnosis, table turning, Ouija movements, dowsing, Chevreul pendulum and alien hand syndrome. The fourth possibility is evident when people are doing something but they feel that they are not acting voluntarily. Wegner believes that this condition occurs frequently in a subject's interaction with machines, computers and so on. In which they believe that they have done something that has produced an effect and it is not the case.

Although Wegner believes that the first two cases are not controversial, there is considerable controversy about any form of mental causation.

These situations (Ouija board movements, table turning, etc.), are exceptional cases, most of the time there is no dissociation between people's actions and the feeling of ownership in them. For most of these situations, there is no standard universally accepted explanation. There is the possibility that in the future situations such as the case of alien hand syndrome may be understood in detail.

From the perspective of the functional/phenomenal difference, it is viable to say that the above experiments are controversial, all involve a functional aspect, which may lead to different accounts, for example the experiments of Trevena & Miller using different research paradigms, come to completely different conclusions to those obtained by Libet. The phenomenological aspect may also be problematic. Assuming that similar verbal reports of two or more people share a common phenomenological experience is debatable, as mentioned by Overgaard (2001) regarding Libet's experiment. The question is whether or not it is correct to assume that the ways in which the phenomenological experience of individuals who participate as subjects in the experiments were judged without controversy? For example, Libet assumes that all people by pressing a button have the same level of experience, that all their actions have the same character, the same willfulness, but as is known in neuroscience, once an act becomes repetitive the level of awareness decreases, passing the execution originally ordered by the motor cortex, to be directed by the cerebellum, in other words automatically, which means little or no participation of consciousness. Another problem is that Libet's experiment, as mentioned by Overgaard (2001), assumes that the experience of making a decision occurs at a particular time and is not a process that requires a period of time.

Wegner has the idea that free will is intuitive, but as Bayne (2004, p. 171) suggests, he established a relationship with other phenomenological aspects: "the experience of authorship; the experience of intentionality; the experience of effort; the experience of

free will; and the experience of Mental causation" could be that his model fits to some of the above but not all.

A problem for Wegner's experiments is that the particular situations he studied do not represent the total experiences people share, so it seems unreasonable to establish a model of apparent causality regarding all the actions people take.

3. Baars' Global Workspace Theory GWT

Bernard J. Baars is a former neurobiologist researcher at the Neurosciences Institute in San Diego. He developed a cognitive theory about consciousness called Global Workspace Theory. Stan Franklin has created the Intelligent Distribution Agent (IDA) a computer application of Baars' model.

In the next section Baars' model of consciousness will be described.

3.1 Baars' Global Workspace Theory GWT in detail

Global Workspace Theory or GWT is a model or cognitive architecture created by Bernard Baars (1988); (1996); (2008). This model explains contrasting conscious and unconscious processes. The contrast of these processes allows understanding their differential nature. Conscious or unconscious processes can be psychological or neurological. The

psychological are: priming, selective attention, automaticity, and so on. Some neural include blindsight and coma (Baars & McGovern, 1997).

GWT has been applied successfully in computational models by Stan Franklin and other authors (Franklin & Graesser, 1999); (Franklin, et al., 2007); (Faghihi & Franklin, 2012) between others. Susan Blackmore has criticized this model (Blackmore, Consciousness in meme machines, 2003, pp. 19-30).

According to Newman & Baars (1993, pp. 255-290), there is a general agreement that cognition is created by a distributed parallel processing of a number of specialized processors. The problem is to explain how this multi-processing system can give rise to integrated conscious experience like thoughts, memories and perceptions from a multiplicity of independent subsystems. Furthermore, how to explain the function of attention as a control system that can direct individual's cognitive resources towards activities aimed at solving specific problems and adaptive requirements planted by the changing surrounding environment. According to the neurophysiologic evidence this modular system is supported by a diffuse intracortical network that would be responsible for integrating the activity derived from this modular architecture in a global system of cognitive representations. This explains how the centralized attention control system is produced and how an integral consciousness is generated from modular functions (Newman & Baars, 1993, pp. 255-90).

Baars proposal, GWT is an architecture that seeks to explain conscious and unconscious processes, including psychological aspects such as

memory, attention, automaticity, evaluation, verbal report, or subliminal priming, as well as neurological aspects such as coma. The main idea is that the content of consciousness is available globally to other cognitive processes in the brain. This idea helps to explain the relationship of consciousness with integrative processes such as attention and decision making. It is possible to think about GWT through the metaphor of the theater (See fig. 2 and 3).

The characteristics of GWT are:

1. Consciousness corresponds to a bright spot on the stage of a theater.
2. Only the bright spot would be conscious.
3. The theater would correspond to the working memory.
4. The management function would be executed by the attention.
5. Processes outside of this bright spot would remain unconscious.
6. A series of sensory inputs and outputs plans compete to gain access to the bright spot (figure 4).
7. Offstage a variety of contextual unconscious processes, such as the visual system and dorsal cortical stream would be responsible for shaping the content of consciousness.

The theory assumes that sensory cortical projection areas exert an inhibitory action with each other within a step period of 100 ms; besides, the sensory cortex could be activated either externally or internally to allow functions as imagination and inner language. After a content of the sensory areas of the brain has been established, this is broadcasted through intracortical or corticothalamic fibers to other brain areas or

expert processes that remain like an audience on the dark side of the theater. Among this audience would be the "self-systems," such as the prefrontal cortex or parietal cortex responsible for receiving and shaping information. According to the model the primary function of consciousness would be to develop a "blackboard" architecture or theater that allows the integration, coordination and access to a large number of specialized autonomous subsystems or modules around a central resource that remains globally accessible. (Baars & McGovern, 1997).

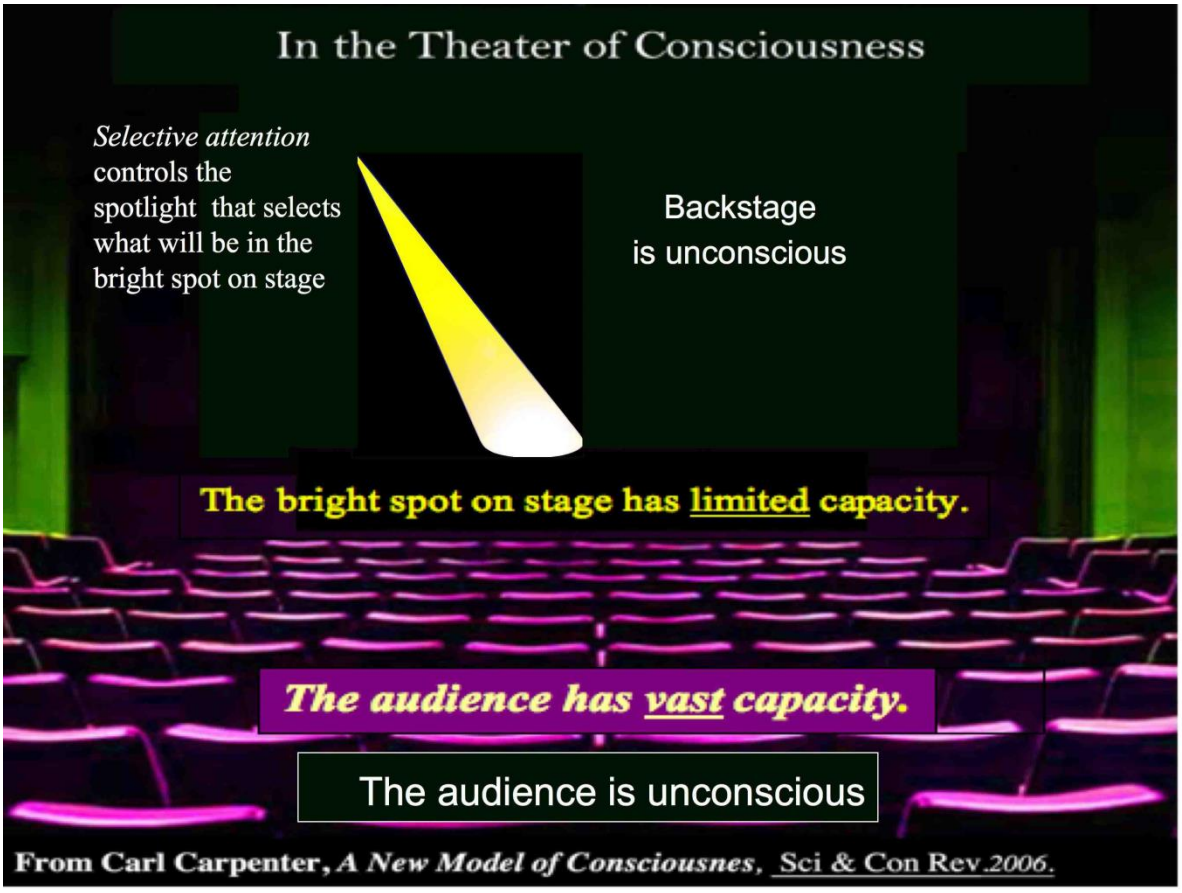

Figure 2. In the theater of consciousness (Baars, Global Workspace Model: a quick intro [PowerPoint slides], 2008)

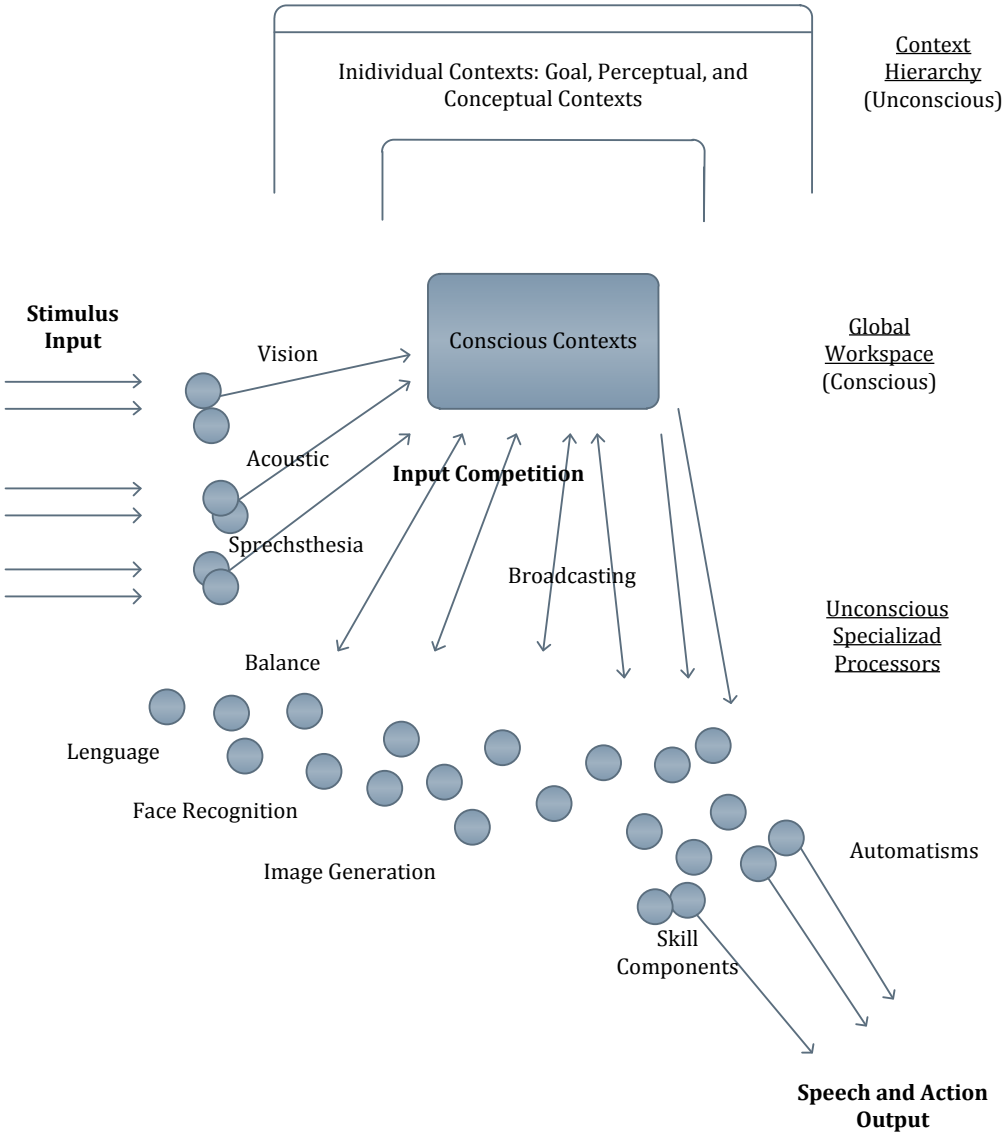

Figure 3 Global Workspace Theory (McGovern & Baars, 2007, p. 196). The idea of a stage in GWT corresponds, in physiological terms, to working memory or short-term memory that would allow access, control and coordination of different brain processes. Baars calls it "fleeting memory". For him consciousness acts like a gateway for different functions (conscious access hypothesis).

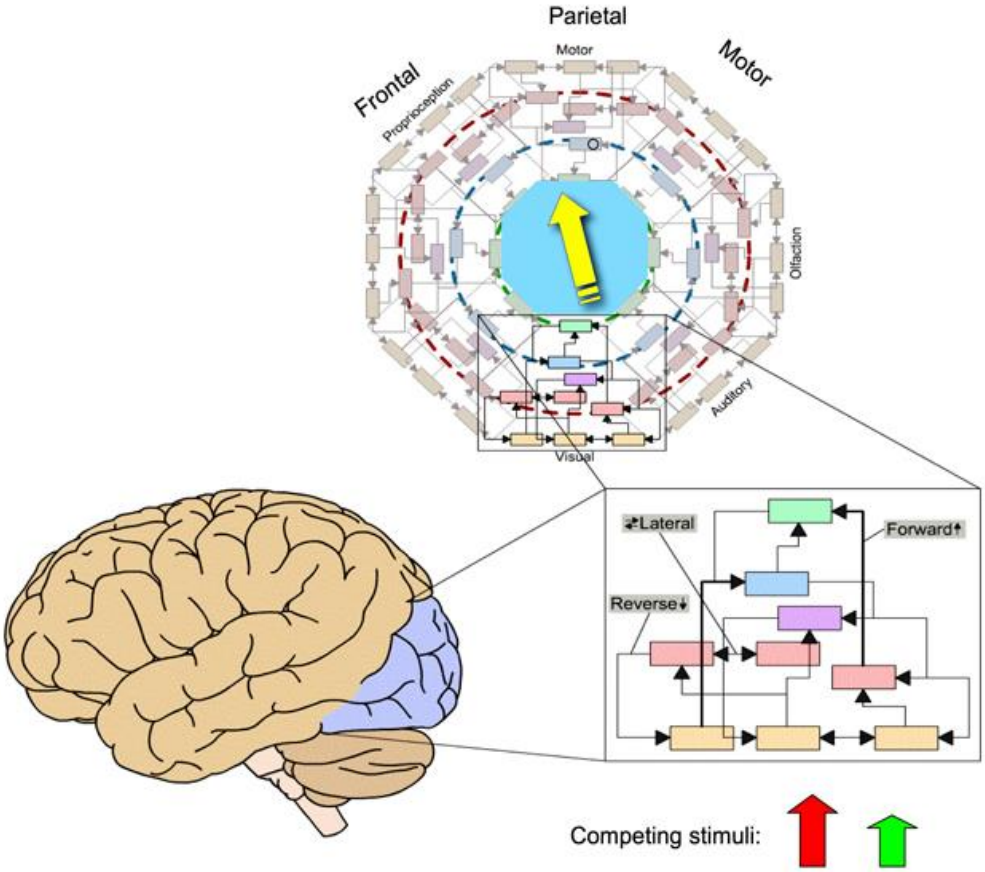

Figure 4. Conscious input activates more widely than similar unconscious input. There are two sensory inputs (the red and green arrows), and that the winning input evokes widespread "forward" activity in the brain. (Baars, Global Workspace Model: a quick intro [PowerPoint slides], 2008)

Some basic assumptions of GWT (Baars, The global brainweb: An update on global workspace theory, 2003); (Baars, A Cognitive Theory of Consciousness, 1988); (Newman & Baars, 1993) are:

1. Conscious perception allows a wide access to different functions in the brain; on the other hand unconscious perception has more limitations.

2. Conscious processes can give access to working memory but not the unconscious ones.
3. Conscious processes allow different types of learning: episodic, implicit and explicit learning.
4. The feedback of conscious perception permits willful control in motor operations, groups of neurons or single neurons.
5. The attention can be directed selectively by the content of consciousness.
6. The “self” consists of “executive interpreters” in the frontal cortex that can be accessed by consciousness.
7. Unconscious automatic processes in the brain are product of parallel sub-processors distributed in the brain. These are very efficient in their specialized tasks, automatic, autonomous, diverse, and they have a huge capacity compare with the conscious processes.
8. In contrast with unconscious activity, conscious processes operate in a serial way, are computationally inefficient, have different operational capacities, are slower, have more errors, but at the same time they have a wider range and bigger representational integration ability. They possess a bigger ability to relate different conscious contents between them and to relate conscious events to their unconscious contexts.

In table 1 it is showed a contrast of conscious and unconscious processes according to GWT.

Conscious processes	Unconscious processes
More serial processing	Parallel processing
Internal consistency, different operational capacities	Highly diverse and together, possess Huge processing capacity
Computationally inefficient, slower, with more errors, high mutual interference between conscious computations	Very efficient in their specialized tasks, high speed, few errors, little mutual interference
Possesses great range and integrative power in its representation of CNS activity. Great ability to relate different conscious contents to each other; great ability to relate conscious events to their unconscious contexts.	Every sub-processor has limited range over time, operates automatically and relatively autonomously
Permit a wide access to different functions in the brain	They have limited access to different brain functions
Can give access to working memory	Cannot give access to working memory

Table 1. Contrast of conscious and unconscious processes. Adapted from (Baars, The global brainweb: An update on global workspace theory, 2003); (Baars, A Cognitive Theory of Consciousness, 1988); (Newman & Baars, 1993).

Newman and Baars state that (Newman & Baars, 1993, pp. 255-90) there are three basic conscious states (see table 2) dependent on three attentional systems. The first one deals with the task to attend important or new stimuli. The second one enables an immediate awareness to percepts. The third one is relative to awareness in behaviors driven by a goal. These conscious states are mediated by a global attentional matrix centered upon the

thalamus that includes three systems: “1) the midbrain reticular formation; 2) the association areas of the posterior cortex; and 3) the prefrontal cortex.”

States of conscious awareness	Global attentional matrix centered upon the thalamus
Orienting responses to novel or significant stimuli	Midbrain reticular formation
Immediate perceptual awareness	Association areas of the posterior cortex;
Focal awareness involving goal-directed behaviors	Prefrontal cortex

Table 2. Three states of consciousness awareness mediated by a global atentional matrix.

There are different areas involved in the GWT according to Baars for example, Visual and auditory conscious modalities can be activated internally. Inner speech depends on a phonological loop in the left hemisphere located in the areas of language, Broca and Wernicke (Baars, 2003). Table 3 shows a summary of functions and areas involved in GWT.

Function	Areas involved
Inner speech	Phonological loop. Left hemisphere areas of language Broca's and Wernicke's areas.
Mental imagery	Visual sketchpad (Visual cortex)
Selective attentional system (spot light)	Controlled by 1. frontal executive cortex 2. automatic interrupt control from areas such as the brain stem, pain systems, and emotional centers like the amygdale
Sensory analyzers	Ventral visual pathway (visual content)
Contextual systems	Dorsal pathway. Defines a spatial domain within which the sensory event is defined. Parietal cortex. Allocentric and egocentric spatial maps required to shape conscious visual events.
Self-systems	The left-hemisphere narrative interpreter (prefrontal) is shaped by unconscious contextual executive influences like sensory inputs and frontal areas. Right hemisphere interpreter deals with emotional strategies.

Table 3. Functions and areas involved in the GWT. Adapted from Baars (The global brainweb: An update on global workspace theory, 2003)

GWT does not view consciousness like a separated group of representations due to multiple processors in the brain but like a global integrated representation. The global attentional matrix

binds all these separated representations into a single unified one. People are not aware of the attentional activity itself, but of the flow of unified pictures. (Newman & Baars, 1993, pp. 255-90). This points an important difference between GWT and models like Dennett´s Multiple Drafts model in which single isolated drafts never come together in the brain. As Newman and Baars state:

> Some prominent theorists, maintain the binding problem is not a scientific problem at all, but a deeply rooted misperception of the phenomenological nature of awareness. And this view gains support from contemporary characterizations of the cognitive and neural apparatus as highly modularized. (Newman & Baars, 1993, pp. 255-90)

The “rhythmic cortical activation” has been seen like incompatible with the modular “information processing” in order to explain the binding problem, but for Newman & Baars, this could not be the case, for them an alternative explanation is that, “binding involves the imposition of a secondary process (or processes) upon the activities of these smaller specialized information centers” (Newman & Baars, 1993, pp. 255-90). This hypothesis is compatible with Crick & Koch (1990) coalition of neurons.

According to Baars, some areas and nuclei suggested by several authors for the integration of these information centers in the brain are: 1. Posterior parietal, inferotemporal and prefrontal cortex 2. Polymodal nuclei of the thalamus 3. pulvinar, ventral anterior,

ventral medial, reticular and intralaminar nuclei 4. Basal ganglia and brainstem nuclei 5. The claustrum 6. Non specific thalamus nuclei (Newman & Baars, 1993, pp. 255-290).

In the next section I will describe Intelligent Distribution Agent (IDA) a computer application of Baars' model.

3.2 Intelligent Distribution Agent (IDA)

IDA was developed by Stan Franklin like an implementation of the GWT (Sun & Franklin, 2007). IDA was created like an autonomous agent for the navy. It was designed to assign new billets to the sailors after they have accomplishes their tour of duty. Normally this task was accomplished by trained army employees (detailers). The program must perform complex tasks like keep communication with the sailors in English, understanding the context and providing human-like answers. It must access data bases understanding contextual characteristics and at the same time satisfying Navy´s requirements and policies. For example, the program should be capable of assigning personnel to specific tasks taking in account the costs, the sailor's training, the sailor's desires, negotiate with the sailors via email in English, approbate the billets selected and write the orders. IDA has a modular higher level architecture (see fig. 5). Each module performs human analog functions: perception, working memory, sensory memory, transient episodic memory, autobiographical memory, constraint satisfaction, action selection, deliberation, language generation,

consciousness. The GWT lower level processors are implemented by small independent and specialized programs called codelets. Each of them keeps waiting for some specific situation in order to perform a simple task. They are diverse and often subserve a higher process or behavior. Others are independent like the attention codelets that carry information to the conscious module.

The senses of IDA can only recognize meaningless strings of characters analogous to sensorial inputs of the human receptors like cones and rods in the retina or Pacini receptors in the skin. The inputs may come from emails or data bases. In order to understand language the perception module uses “analysis of surface features”.

Perceptual memory is called slipnet, a form of semantic net. It represents the perceptual and conceptual contexts of GWT. Perceptual codelets analyze incoming messages looking for recognizable phrases or words. Once they find them, a process activates specific nodes in the slipnet and goes through the net until it is stabilized. Next, one or more nodes are selected due to their elevated activation level and some codelets fill a template with information from the message. The new information developed from the original message is transmitted to the workspace (working memory), and thus is accessible to other system elements. In order to avoid undue interference from earlier sequences of events with similar characteristics, IDA has a

transient episodic memory consisting of a sparse distributed memory which decays to prevent interference of this information to the long-term memory. This allows the long-term memory to distinguish the last details in long and similar sequences. The system that produces consciousness is made up of a coalition manager; a broadcast manager, a spotlight controller, and several attention codelets in charge of recognizing problems or new situations. The new information is incorporated to the conscious system by attention codelets. They remain alert to situations that require the attention of consciousness. When a situation of this type occurs, an attention codelet is associated to information codelets containing the information of the particular situation. The attention codelet along with the information codelets form a coalition. Attention codelets increase their level of activation according to how well the particular situation fits their interests and so the coalition can compete to achieve the attention of consciousness.

The coalition manager is in charge of shaping and monitoring the coalitions of codelets. These codelet associations can find a path to consciousness, at a given time, when selected by the spotlight controller, which selects the coalition with higher levels of activation. Table 4 summarizes the steps in the cognitive cycle of IDA.

IDA cognitive functions can be carried out in one or more cycles depending on its complexity. The IDA model has generated many hypotheses about the cognitive functions that could be investigated in practice at a high level so as to finer grained level but many of these could not be investigated due to limited temporal or spatial resolution of the techniques of investigation available today such as PET, fMRI, EEG etc. (Sun & Franklin, 2007, pp. 167-168) other applications of the model have studied theory of mind, the ability to attribute mental states and intentions to other agents and how it can be computationally implemented in humans and animals (Friedlander & Franklin, 2008).

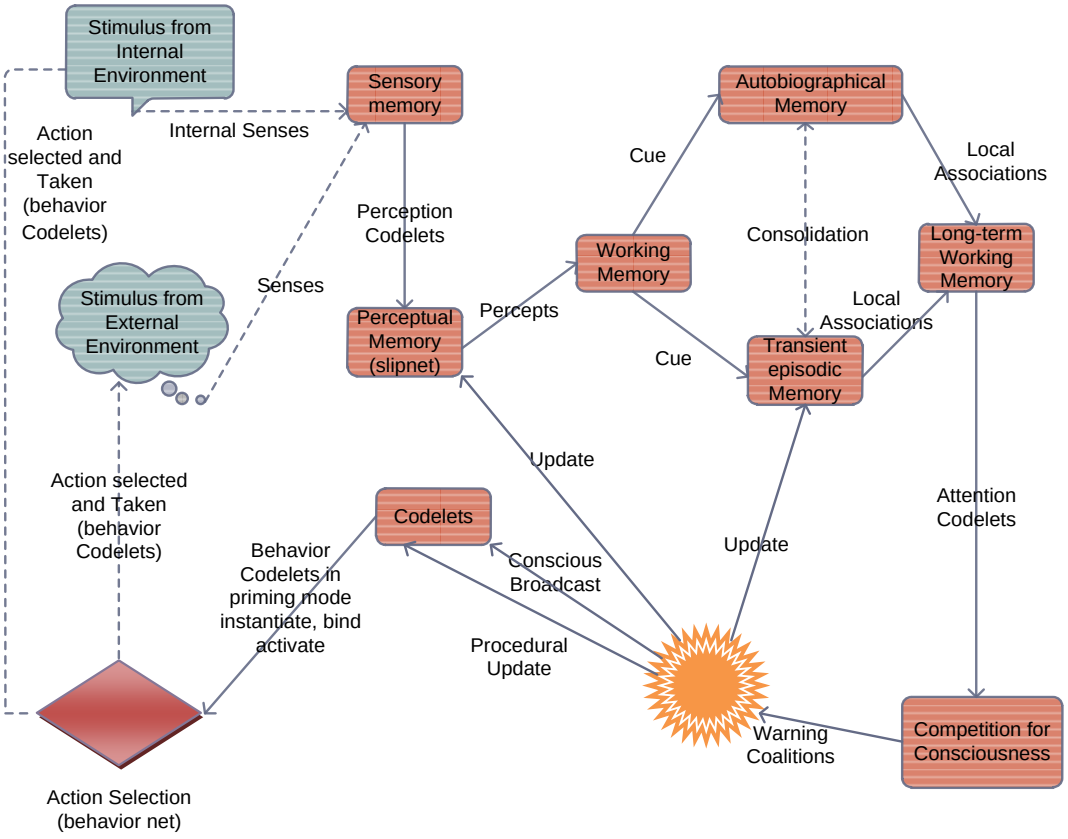

Figure 5. IDA´s cognitive cycle (From Sun and Franklin, 2007, P. 164)

1. Perception	**The internal and external sensory stimuli are captured and interpreted by perception**
2. Percepts to preconscious buffer	The percepts are stored in working memory´s preconscious buffers
3. Local associations	Local associations are incorporated automatically from transient episodic memory and long term autobiographical memory using as residual information of the preconscious buffers and the incoming percept
4. Competition for Consciousness	The coalitions compete with each other to bring the attention of consciousness. The attention codelets select those the most insistent, urgent or relevant events and take them into consciousness.
5. Conscious broadcast	A coalition of codelets like an attention codelet and its corresponding information gains access to the global workspace and its content is broadcast. Perceptual, procedural and transient episodic memories are updated according to the conscious content. Transient episodic memory contents are consolidated into long-term memory.

Table 4. Steps in the Cognitive cycle of IDA (adapted From Sun and Franklin (2007). pp 166-67)

Steps in the cognitive cycle (table 4)

1. Perception. The internal and external sensory stimuli are captured and interpreted by perception

2. Percepts to preconscious buffer. The percepts are stored in working memory´s preconscious buffers

3. Local associations. Local associations are incorporated automatically from transient episodic memory and long term

autobiographical memory using as residual information of the preconscious buffers and the incoming percept

4. Competition for consciousness. The coalitions compete each other to bring the attention of consciousness. The attention codelets select those the most insistent, urgent or relevant events and take them into consciousness.

5. Conscious broadcast. A coalition of codelets like an attention codelet and its corresponding information gains access to the global workspace and its content is broadcast. Perceptual, procedural and transient episodic memories are updated according to the conscious content. Transient episodic memory contents are consolidated into long-term memory.

6. Recruitment of resources Behavior codelets respond to the broadcast content related to their variables.

The central idea of GWT is the availability of cognitive content for a number of processes such as attention, memory, etc. this idea has proven to be quite fruitful, as it has been implemented in computational models such as Stan Franklin's, however leaves unexplained the phenomenological aspect of consciousness.

In the next section the dynamic core of Edelman and Tononi will be explained. This is perhaps one of the most elaborate psychophysiological models that try to explain how it is possible to develop a consciousness, based on the neurological processes.

4. The dynamic core of Edelman and Tononi

Gerald Edelman is a biologist who won the Nobel Prize in medicine in 1972 for his research on the immune system. Subsequently, he has written several books and articles on consciousness, from a biological perspective. Giulio Tononi is a psychiatrist and neuroscientist, has coauthored with Edelman books and articles on consciousness.

The model of the dynamic core of Edelman and Tononi holds that the existence of any conscious event in the brain involves a lot of discrimination. These events are very integrated, as they represent a complete holistic experience and at the same time very distinct because each event or experience is unique. This system is organized according to a process of “neural Darwinism”. This is a process of natural selection in which many groups of neurons or circuits are created but just some of them survive and others die. According to this model, qualia, subjective experiences with qualitative character, consists of such discrimination. He proposes that consciousness is not located in a unique place in the brain but in a dynamic core. This assumes that the dynamic core, the functional anatomical substrate of consciousness, is the thalamocortical system, in which a series of reentrant neural interactions cause relatively stable and differentiated states. These states change over time, some of the neuronal groups leave the core and other neuronal groups becomes part of it, this change is due to interactions with internal and external stimuli.

4.1. Features of consciousness

Gerald Edelman (2003, p. 5520) proposes to develop a theory of consciousness taking in account the special qualities of consciousness but without appealing to explanations beyond physics like dualism. For him consciousness is a process that arises from the interaction of the brain, the body and the environment. Despite the wide range of mental states, these have a unitary character; this implies a binding of different sensory modalities.

According to Edelman (1999, pp. 68-89) the brain has special features that make it very different from a computer. For example, the world does not work like an unambiguous devise such as a computer tape, it is full of stimuli that are perceived by the brain, which in turn categorizes this variety of stimuli, emit responses to these stimuli, generates learning processes, stores information and regulates a number of internal processes. The brain has the ability to categorize stimuli of different sensory modalities such as vision and hearing, without relying on a preset code.

Another feature is that many of their activities depend on value systems. Edelman (1999, pp. 68-89) defines those value systems as: “parts of the organism (including special portions of the nervous system) that provide a constraining basis for categorization and action within a species”. Between those value

systems Edelman mention the serotoninergic, dopaminergic, noradrenergic, cholinergic, histaminergic systems. During brain activity these are concerned to establish the importance of stimuli, set thresholds and regulate wakefulness.

As shown in Table 5, consciousness, according to Edelman, is a complex phenomenon with many features. These features can be classified as general, informational or subjective. Among them three in particular represent a major challenge to establish a theory: a. consciousness is composed of many processes but also is experienced by the subjects as a unitary experience.

This fact shows his great binding ability and constructive characteristics such as Gestalt properties. b. It is also characterized by its intentionality -generally refers to objects or events- and finally c. Consciousness has a subjective qualitative character that philosophers call qualia. This would include not only the isolated qualities of red, heat, pain, but also other more complex as images, emotions, memories, etc.

Features of conscious states
General 1. Conscious states are unitary, integrated, and constructed by the brain. 2. They can be enormously diverse and differentiated. 3. They are temporally ordered, serial, and changeable. 4. They reflect binding of diverse modalities. 5. They have constructive properties including gestalt, closure, and phenomena of filling in. Informational 1. They show intentionality with wide-ranging contents. 2. They have widespread access and associativity. 3. They have center periphery, surround, and fringe aspects. 4. They are subject to attentional modulation, from focal to diffuse. Subjective 1. They reflect subjective feelings, qualia, phenomenality, mood, pleasure, and unpleasure. 2. They are concerned with situatedness and placement in the world. 3. They give rise to feelings of familiarity or its lack.

Table 5 Features of conscious states. (From Edelman, 2003, p.5520)

Functional segregation and integration

Tononi, Edelman, & Sporns (1998, pp. 474-484) note that the brain possesses great spatial specialization, this occurs in many areas of the brain such as visual or auditory cortex. This is a basic principle of brain organization. Despite the fact that the brain has a

high degree of specialization, must be also a highly integrative in order to produce adaptive behavior. This integration occurs at multiple levels both spatially and temporally. For example at the level of the visual system, many individual points must be integrated to produce images according to Gestalt laws: continuity, proximity, completeness, contrast, etc. different perceptual characteristics such as color, shape, size, must be integrated to form objects. Also several objects are integrated to form images.

Although neurons can achieve an integration process right through convergence, Tononi, Edelman and Sporns consider this process can hardly be the explanation of the binding problem because it has not been possible to identify a master area in the brain which control the process; besides the changing number of stimuli exceed the number of neuronal groups and even single neurons; finally convergence cannot explain the dynamic conjunction of new stimuli.

Neural Darwinism: brain is a selectional system

This theory has three main features: (1) developmental selection: during the development of the brain, the anatomical features of the brain are limited by genetics and heredity. However at connectivity level, the synapses are established by somatic selection. This produces great variability in neural circuits and the formation of groups of neurons of different types. Neurons within these groups are more interconnected than with neurons in other groups. (2)

Experiential selection: throughout the life of the individual, neuronal synapses undergo a process of selection. The synapses within neuronal groups and among these, changes; some synapses are strengthened, while others are weakened. This selection process is controlled by ascending value systems. (3) Reentry: This process produces a spatiotemporal correlation between different events occurring in various brain maps. This process of reentry occurs due to “massively parallel reciprocal connections” performing a process of selection of the synapses between brain maps. A kind of “higher-order selection” according to Edelman (1999, pp. 73-74)

According to Edelman (1999, pp. 68-89) the human mind had to evolve like the other biological processes. He believes that this occurred throughout two processes: a. natural selection and b. somatic selection. The first one is the process described by Darwin, and the second is the one he calls TNGS (Theory of Neural Group Selection), or neural Darwinism.

According to Edelman, the brain is a selectional system, not an instructional system in which a large number of circuits are created but only part of them survives. This system is organized according to a process of “neural Darwinism”, which he calls “theory of neuronal group selection” (TNGS). This is a process of natural selection in which many groups of neurons or circuits are created but just some of them survive and others die. Changes in synaptic

efficacy should explain why some circuits of neurons are selected instead of others. Some important value systems that modulate the synaptic activity are the raphe nucleous, locus coeruleus and dopaminergic, cholinergic and histaminergic nuclei. These systems give a value to stimuli, some stimuli are better valued over others, in this way this value process explains the specific behavior preference.

Reentry

An important process of signals, that he calls reentry, provides recursive communication between ‘massive parallel reciprocal fibers’ that communicate brain maps. This reentry is a parallel massive selectional process different to feedback because the last one is developed in single fibers and has instructional purposes and error correction. Reentry produces correlation between neuronal groups which are competing between them, as results of this correlation, the synchronous in wide number of areas in the brain are favored by selection. This selection should explain the binding problem – the coordination of remotely distributed areas of the brain- without recurring to a higher rank coordinator process or map. The value systems give positive or negative value to stimuli. They are diffuse ascending systems that include cholinergic, dopaminergic, and histaminergic nuclei, the locus coeruleus and raphe nucleus. They serve as the modulators of the activity of the selection process by altering the synaptic thresholds. The parietal,

frontal and temporal cortices support a ´value-category memory´ fundamental for consciousness (Edelman G. M., 2003, pp. 5522-5523). Edelman (1999, p. 74) gives an example, if we had a string quartet, where each musician improvises his part according to his own ideas and the notes received from the other members of the quartet. Here there is not a score and everyone decides to play and how to coordinate with others. These musicians are interconnected by thousands of connections, so that the signals come and go in cycles occurring instantaneously. These reentrant signals lead to produce a more integrated music. This process would produce changes in each subsequent movement of each musician producing more coordinated melodic lines even if there is a not a conductor in the group. This would lead to the creation of musical pieces that none of the members could create individually.

The reentry causes interactions between neuronal groups belonging to different brain regions, -as in the example of the musical quartet- the spatiotemporal correlation would be responsible for the integration of perceptual and motor activity allowing a unitary overall consistency. In other words, this process would allow the coordination of our perceptual process and behavior. It would explain the integration process in the brain in the absence of a control center which should produce algorithms and specific instructions to centers and functionally independent areas.

Computer simulations

According to Tononi, Edelman, & Sporns (1998, pp. 474-484) computer simulations in the visual system were made, which proved that reentrant signals can synchronize the activity of neuronal groups, thus explaining the operation of the Gestalt laws. Besides the Gamma band synchronization in the firing of neurons may explain the integration of the stimuli according to Gestalt principles.

4.2. Mechanism of consciousness

Edelman (2003, pp. 5521-5522) recognizes that consciousness is experienced subjectively, personally. This experience requires explanation, for him, the dynamic core produces phenomenological experience. He suggests that consciousness arises through a process of embodiment, in which the brain, body and environment interact from early neural development. The brain can discriminate motor and sensory signals originating inside of those of external origin. The interactions of these sensory and motor signals are influenced by “diffuse ascending value systems”. He assumes that these value systems affect synaptic communication processes and memory, which can enable the perceptual categorization.

Edelman, (2003, pp. 5520-24) proposes that consciousness is not located in a unique place in the brain, but is a dynamic function distributed in different brain structures. One of these, the thalamocortical system is essential for consciousness.

To explain a mechanism of consciousness according to TNGS, Edelman divided it into two: primary consciousness and higher-order consciousness (Edelman G. M., 2003, pp. 5521-5522):

1. Primary consciousness brings together motor, perceptual and memory events in a single scene that he calls remembered present. The signals that make up this scene might have connection with the value system and prior learned information, which would allow the animal to display adaptive behavior. This system does allow the animal to interact and plan with regard to the immediate situation of their remembered present. An animal with this type of awareness can have an adaptive behavior but is not able to have narrative skills unless it has a long-term memory.

2. Higher-order consciousness is characteristic of animals that have semantic abilities in particular humans. This would allow access to information of our past, make plans for the future and awareness of being in conscious states. There are two key ways of primary consciousness: a. Signals from the self, originated in the body and brain, which include value systems and regulatory signals and b. Signals from nonself, these are inputs from the external environment that are incorporated by global mappings.

These give rise to memory and make possible the process of perceptual categorization located in the posterior part of the brain. The value-category memory, that allows conceptual categorization, is located in the frontal part of the brain. This is connected to the actual categorizations of the external world from the perceptual categorization system through recurrent connections (reentrant loop). This connection is essential for the formation of primary consciousness. The process of primary consciousness could have originated in the distant past in evolutionary history, when mammals and reptiles were separated. Animals with this kind of awareness do not have self-consciousness. Higher-order consciousness could have come later when new connections were established between categorical and conceptual memories and the areas of language as Broca's and Wernicke. According to Edelman these linguistic abilities are crucial to the development of self-consciousness.

Figure 6 shows a scheme for higher-order consciousness according to Edelman:

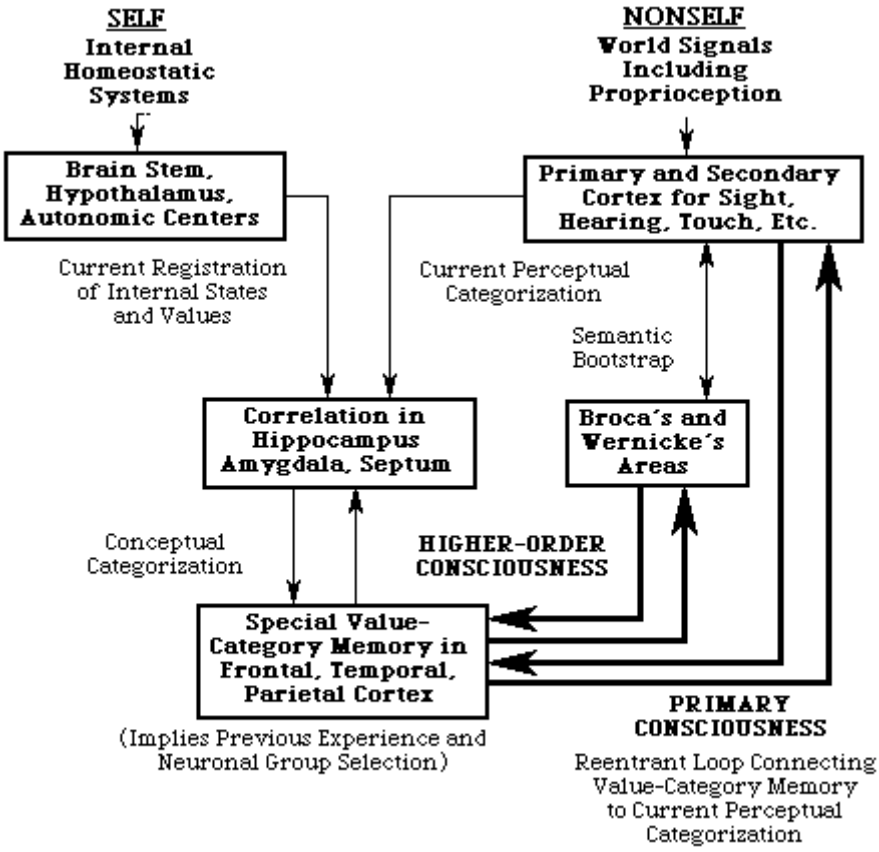

Figure 6. A scheme for higher-order consciousness (Jones, 1995). There are two important signals: 1. from the self, consisting of value systems and control systems of the brain/body and 2. nonself, coming from the outside world that is incorporated in the system by global mapping. The primary consciousness is allowed by a reentrant loop connecting value-category memory to current perceptual categorization. Higher-order consciousness is possible due the concurrence of the areas of language, Broca and Wernicke.

An explanation of consciousness must reconcile the multiple natures of their duties while maintaining the unit of its character. Such a system should consist of many different areas with specialized skills and also should include massive recurrent connections between its components. A good candidate is the thalamocortical system which has these characteristics. In it, many specialized areas interact at a distance giving rise to new

functions. The dynamic core consists of recurrent circuits within the thalamocortical system that binds a big quantity of information in periods of < 500 ms, this dynamic core allows the rise of a higher-order phenomenal unified scene that the philosophers call qualia. It is possible to characterize the core like a self interaction but it receives circuits from non-conscious parts of the brain. The neuronal groups in the core are changing in time, so the members of the core are not the same all the time. The conscious states are modulated by inputs from reticular nucleus (thalamus) and basal ganglia going to the cortex. Table 6 shows some basic assumptions of Edelman's dynamic core.

Some basic assumptions of Edelman´s dynamic core
Brain is a selectional system not an instructional system.
Theory of neuronal group selection´ (TNGS) a process of natural selection in which many groups of neurons or circuits are created but just some of them survive.
Value systems modulate the synaptic activity giving positive or negative value to stimuli.
The value-category memory located in the parietal, frontal and temporal cortices is fundamental for consciousness.
Brain maps are topographically organized neuronal areas similar to those in the cortex.
Reentry provides recursive communication between ´massively parallel reciprocal fibers´ that communicate brain maps**.**
No higher rank coordinator process. The correlation between neuronal groups due the reentry activate a wide number of areas in the brain and should explain the binding problem without recurs to a higher rank coordinator process or map.
Two conscious mechanisms: **1. Primary consciousness.** Bring together motor, perceptual and memory events in a single scene that he calls “remembered present”. **2. Higher-order consciousness**. Characteristic of animals that have semantic abilities in particular humans
The dynamic core that makes possible the phenomenal conscious consists of recurrent circuits within the thalamocortical system that binds a big quantity of information and changes over time.

Table 6 Some basic assumptions of Edelman´s dynamic core. (Edelman, 2003, pp. 5520-24)

4.3. Edelman´s dynamic core and mental causation

About mental causation, Edelman believes the world is a causally closed system in which there is only room for material events. The cause of all, therefore, should be considered the matter and

energy. This poses a problem in terms of consciousness. He believes that the neural interactions in dynamic core the cause of consciousness, so the personal consciousness cannot have a causal effect. Edelman argues that consciousness has no causal power only informational power. If the activity of the dynamic core is called C' and C is the qualia, produced by it, then is possible to say that C' is the cause of human actions not C (see fig 7). Qualia are product of physiological process according to Edelman and have no causal power on person's actions. Quale variations in individual experiences would be determined by the specific sequences in the neurological status of the core and its complex dynamics. Due to the huge number of connections of the core is impossible that two people have the same subjective experience or qualia (Edelman, 2003, pp. 5520-24).

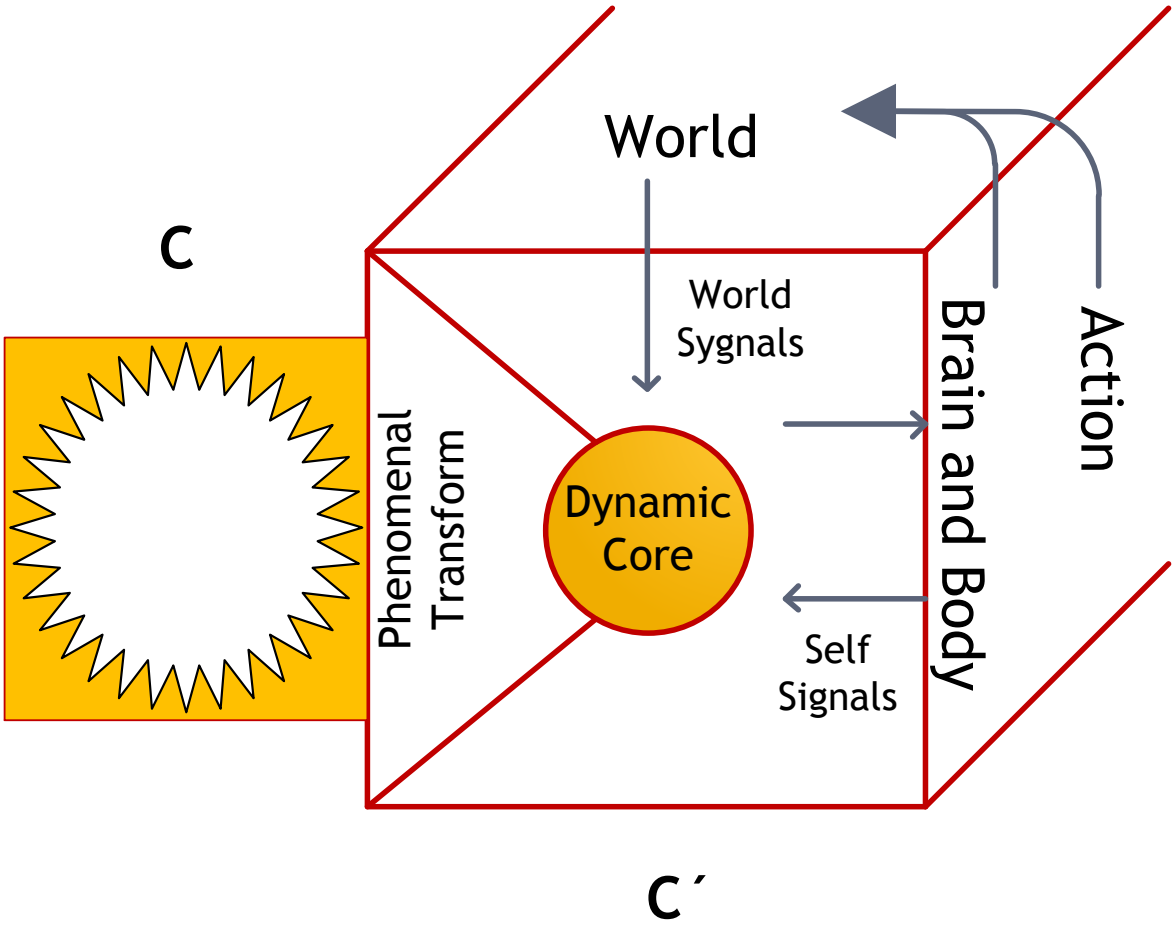

Figure 7. The Dynamic Core (Edelman, 2003, p. 5523) the dynamic core C´ integrates self signals from the brain and body with world signals form senses into a phenomenal consciousness C.

The dynamic core does not fully explain how phenomenological consciousness arises; it just assumes that it arises within the neural substrate of a dynamic core within the thalamocortical system. However, the model accepts the existence of qualia or subjective experiences and suggests that a dynamic core mechanism causes it. This model establishes an anatomical and physiological substrate in which phenomenological consciousness may arise.

4..4. Applications: Brain Based Devices, BBD

Edelman and The Neurosciences Institute, San Diego, California, have built several robots and devices based on his theory called Brain Based Devices (BBD). Unlike conventional robots, BBD are not developed through conventional engineering, but to perform intelligent functions, through principles borrowed from biology, they can be capable of independent learning. Edelman, who is the founder of the Institute, developed the first model, Neurally Organized Mobile Adaptive Device (NOMAD) at the end of 1980. This device can learn from the experiences through its brain called Darwin, which has been designed with the brain capacity of vertebrates. Edelman designed Darwin's brain to be a selective device, not one who follows instructions. He believes that the human brain works by pattern recognition, not by running tasks with exact logic. They have developed several generations of NOMAD and Darwin which has auditory sensors, video, distance sensors, graving capabilities, electrical conductivity sensors and 'whiskers' that can perceive when an object makes contact with it. They can move through a system of wheels and can rotate around itself. They have several simple controllers, but also have a nervous system, simulated on several computers, which execute the main control functions. This nervous system integrates

sensory input and motor responses emitted, which are transmitted to the device wirelessly. NOMAD can sense and avoid obstacles while navigating in the environment, can approach and grab objects, can taste objects and avoid those whose taste is unpleasant according to its experience. The main objective of the research is to study the functioning of the nervous system in a real environment.

They have also built a BBD that emulates the functions of the cerebellum, an area responsible for controlling movements accurately. The device was used to navigate in an environment full of traffic cones. At first the movements were somewhat awkward, as dependent on their infrared sensors to indicate when it was 30 centimeters close to the cones, but eventually it learned to move more precisely between these, thanks to its electronic cerebellum which could predict the cone position in advance.

They have also developed a robot that can play football. It is able to recognize objects in the soccer field, such as the other players, balls, goals, etc. can catch the balls and kick them, and remained undefeated in RoboCup tournament in 2005, against other BBD teams (Robots, 2007).

In the next section I will make a critical evaluation of Edelman's and Baars' models of consciousness.

5. A critical analysis and evaluation of Edelman's and Baars' models of consciousness

The preceding sections described the most important aspects of the two models of consciousness selected for this work. Hereinafter this work will analyze how these models explain consciousness in relation to the functional-phenomenal distinction. Functional consciousness is one that has causal role in behavior, a form of consciousness that can be described in terms of cause and effect and can be explained like an algorithm. Phenomenal consciousness is an internal subjective experience.

The next section looks at Baars' and Edelman's models of consciousness in relation to the functional-phenomenal distinction.

5.1. Global Workspace Theory

According to Bernard J. Baars "The Hard Problem is hard because it involves an implausible criterion" which he calls "The empathy criterion" This means that an outside observer could share the subjective experience of another subject and this is something that has not been proposed previously by science. In medicine consciousness is defined in empirically measurable terms as the EEG, the response of patients to mental state assessments demonstrating alertness, memory, orientation, speech, motor control, etc. Similarly, Baars states that we should

establish a simple standard criterion for an empirical study of consciousness (Baars, 1996, pp. 211-216). Global Workspace Theory (GWM) was created with empirical purposes. It has been effectively applied to empirical problems such as computational models of consciousness like Intelligent Distribution Agent (IDA) (Sun & Franklin, 2007); (Friedlander & Franklin, 2008). It has been conceived in functional terms. Baars considers that it is not possible to study phenomenological consciousness in a scientific manner. This does not necessarily imply that it does not exist, but that it could not be subject to scientific research. Computational models follow a functional explanation pattern. This feature makes them highly compatible with cognitive models. A theory or model of the consciousness should include: 1. An explanation of the conscious processes. 2. An explanation of unconscious processes. 3. An explanation of how the above are related. Some relevant questions are: How conscious and unconscious processes arise? What is the functional role of conscious and unconscious processes? How can conscious processes be explained in neurophysiologic or functional terms? How can conscious processes be implemented in computational models?

Explanations can arise at two levels, the macro and micro-level. The first one tends to be more modular. In general, explanations at the micro-level are more difficult to explore due to limitations of spatial and temporal resolution of current techniques.

GWT proposes an interesting metaphor of consciousness that can be easily understood and applied in computational models such as IDA. Baars makes a contrast between conscious and unconscious processes.

One of the most important features is the dichotomy between a spotlight of consciousness and a multiplicity of unconscious processes. It explains how the last ones may become conscious through a competitive process in which some of them manage to be disseminated consciously. At this time, the theory only has macro-level and modular explanations (see for example Baars, (2003)). The theory does not have a micro-level explanation, but this shortcoming could be resolved in future.

Baars' remark about the inherent limitations and incompatibility of first person and third person approaches does not seem appropriate, because any explanation of a phenomenon should be sufficient to explain the phenomenon in question. If this is not the case, it would be best to accept our limitations. GWM is a promising model but is still lacking an explanation about how phenomenological consciousness arises. Chalmers (1996, p. 112) is right when he states that Baars' model gives an explanation of many of the psychological properties of human consciousness as access to information, the role of consciousness in attention, reportability, voluntary control, and self-concept but fails to explain experience. There is no explanation in the model about why the information that is disseminated in the workspace is accompanied by a phenomenological experience. Essentially Baars deals with cognitive functional aspects of consciousness but does not explain the personal experience that characterizes it.

This model explains many aspects of functional consciousness, but does not explain why these functions must be accompanied by a conscious

experience. The model does not make reference to qualia, why do people have a conscious experience? Of all the above physiological processes, which of them explains the existence of this experience? How and why it arises? He explains brain processes that are accompanied by a conscious experience, but does not explain why these processes should be accompanied by that experience.

IDA is a very complex system that implements the GWT, but does not explain the phenomenal consciousness. In that sense, it does not add anything extra to the theory in the explanation of conscious experience, but only about how this model could be implemented in the nervous system functionally.

Susan Blackmore has criticized GWT:

> "Global Workspace" theory, Bernard Baars, of the Wright Institute in Berkeley, California, equates the contents of consciousness with the contents of working memory. But how does being "in" memory turn electrical impulses into personal experiences? (Blackmore, 2002, pp. 26-29)

Blackmore criticism is correct in that the fact that there is a working memory where information is maintained do not explain how consciousness is generated, why we have conscious personal experiences. Baars somehow accepts the limitations of his model when he says that we cannot find a solution to the problem of consciousness with a focus in the third person like science. Blackmore is right to say that if a machine was developed using the principles of GWT should be

aware, but it obviously is not. If a computer has GWT, it would not guarantee the existence of consciousness.

> So presumably a machine should be conscious if it is designed with a GW whose contents are broadcast to the rest of its system … Unfortunately, as mentioned above, even if such machines were built, it would be impossible to test whether they were conscious or not. I can only say that I do not believe that GWT is the way to understand consciousness, and in any case it will have to be tested by other means than making such machines. In the mean time I prefer the third approach which is to say that consciousness is not what it appears to be. (Blackmore, 2003, p. 21)

The correct assessment is that if a machine or application is developed in accordance with the GWT, this would not allow Baars to say that a machine or conscious program has been created. This model can lead to a better understanding of some aspects of the operation of conscious processes, but does not clarify how we got personal conscious experiences. About Blackmore's affirmation that "consciousness is not what it appears to be" it could be true in part, but it is not correct to deny its existence based on that, like some authors propose.

5.2. The dynamic core of Edelman & Tononi

Edelman and Tononi take into account the phenomenological consciousness. For them consciousness is composed of many processes but also is experienced by the subjects as a unitary experience (Edelman, 2003, pp. 5520-5524). They specifically mention the existence of subjective qualitative experiences or qualia and believe

that it is necessary to find an explanation for them. This model therefore takes into account both the functional and phenomenological consciousness, but the nature of this consciousness is merely epiphenomenal since they do not attribute causal power to it but only informational. The theory of Edelman and Tononi is a biological theory. They attempt to explain consciousness as a biological phenomenon that can be explained within the framework of Darwin's evolution.

Edelman rejects Cartesian dualism. He believes that in the study of consciousness we should reject "extra physical assumptions" like dualism; an explanation of consciousness must be based on physical knowledge and also must be consistent with the principles of evolution, (Edelman, 2003, p. 5520). For him natural selection of neurons is the explanation of consciousness:

> I argue that the evolutionary emergence of consciousness depended on the natural selection of neural systems that gave rise to consciousness, but not on selection for consciousness itself. (Edelman G. M., 2003, p. 5520).

Emergence of consciousness depends on the selection in the neural circuitry. The basic process responsible of consciousness is reentry, a complex process in which multiple fibers recursively send signals in parallel pathways.

> Theory of neuronal group selection (TNGS) abandons the basic computational notions of logic and a clock, a means for spatiotemporal coordination must be put in place. This is provided by a process called reentry, the operation of which is central to the emergence of consciousness. Reentry is an ongoing process of recursive signaling

> among neuronal groups taking place across massively parallel reciprocal fibers that link mapped regions such as those found in the cortex. Reentry is a selectional process occurring in parallel; it differs from feedback, which is instructional and involves an error function that is serially transmitted over a single pathway. As a result of the correlations that reentry imposes on the interactions of competing neuronal groups, synchronously active circuits across widely distributed brain areas are selectively favored. (Edelman, 2003, p. 5521)

According to Edelman consciousness is equivalent to qualia, which also includes the perception of color, memory, images and emotions. Qualia would be the same as the higher-order discriminations. He denies the existence of a “hard problem” or explanatory gap in the explanation of subjective experience or qualia.

> The framework position I have taken here is that consciousness consists of qualia, by which I mean not just isolated submodalities of red, warm, etc., but also complex scenes, memories, images, emotions; indeed, the entire rich panoply of subjective experience. If, as I have suggested, the neural systems underlying consciousness arose to enable high-order discriminations in a multidimensional space of signals, qualia are those discriminations. (Edelman, 2003, p. 5521)

Yet when he tries to explain the existence of qualia, or subjective experience, he recurs to functional descriptive terms such as images, memories, etc.

Although Edelman does not believe in the Cartesian dualism, he assumes the existence of phenomenological consciousness or qualia,

but in his view these are epiphenomena, a byproduct of brain function. Epiphenomenalism has several problems, though it is not obviously false, as a matter of fact, it is counterintuitive, it is difficult to conceive. Edelman & Tononi claim that the existence of states of consciousness requires a phenomenological transformation. If brain states require a transformation to become conscious, it means that they are not the same. This would imply that despite the biological nature of consciousness it has properties that are somehow different from the brain. This could lead to them being characterized as property dualists, but they dismiss dualism as a possibility, which leads to a contradiction.

Within the functional consciousness they distinguish primary consciousness a form of “remembered present” and higher consciousness present in animals with semantic capabilities. Similar to the neuropsychological model, Edelman (2003) believes that consciousness is not located in a unique place in the brain, but is a dynamic function distributed in different brain structures. One of these, the thalamocortical system is essential for consciousness. As mentioned earlier the thalamocortical system is essential in the formation of conscious processes particularly in wakefulness, basic and higher consciousness. Dynamic core model shares a lot in common with the GWT, both assume that there is a central function of consciousness and the contents of it are changing during time but unlike the last one the dynamic core does not believe that simply by making content accessible it becomes conscious. The dynamic core does not believe in the location of consciousness in a specific area of the brain because brain activity

becomes conscious to the extent that there is part of the core. This does not correspond to specific areas but is constantly changing. The changing nature of consciousness is also emphasized by Llinás (2002); (2003); (1998).

The main shortcoming of the model is the lack of explanation by Edelman and Tononi of how the dynamic core transformation gives rise to the phenomenological experience, the way neuronal processing give rise to phenomenological consciousness, in this respect his explanation is vague, lacking in detail.

If Edelman's position was that the phenomenological transformation is due to a form of property dualism, he would have to demonstrate that there is a physiological mechanism by which it is possible to generate phenomenological properties distinct from those of physical nature. This task seems quite unlikely as Edelman says it believes there is an explanation of consciousness within the framework of the laws of the physical world, “rejecting extra physical assumptions” like dualism and without appealing to “estrange physics” (Edelman, 2003, p. 5520), In this sense Edelman’s position looks more like a leap of faith, but leaves little room for alternative explanations. If the appreciation were true, a model that appeals to purely functional arguments, like Edelman’s model, cannot give a full explanation of phenomenological consciousness; he would be in a dead end, trying to use functional arguments to explain a process that cannot be explained in these terms.

This argument can be summarized as follows:

a. Functional explanations cannot give a full explanation of phenomenal consciousness, because functional explanations can only explain functional consciousness
b. Functional models like Baars' and Edelman's models recur only to functional explanations
c. Functional models like Baars' and Edelman's models cannot explain in full phenomenal consciousness.

   Even if it is accepted that phenomenological consciousness is an epiphenomenon, they would be in the position of explaining how this arises, not because it is supposedly ineffective to cause behavior -as is assumed by Edelman- this kind of consciousness ceases to be a big and difficult problem to explain. In this case consciousness is so problematic to explain as if it has a causal power. As can be seen, models such as Edelman's, which resort to epiphenomenalism to explain consciousness, are in danger of falling into the problems inherent to this approach. None of the models studied above provide adequate and sufficient explanation to the phenomenon of phenomenological consciousness.

6. Conclusion

In this thesis Edelman's and Baars' models of consciousness presented, analyzed and evaluated concerning the functional/phenomenal distinction. In particular, in the interest of determining if these models can explain functional and phenomenal consciousness.

The models studied here have provided important elements for the understanding of consciousness, but are incomplete since they give a functional explanation of consciousness. An element that is missing in the

neurophysiologic models is an explanation of phenomenological consciousness. Most of them resorted to subterfuge like denying the existence of consciousness (Dennett) or reduce it to physical elements such as electric activity (Llinás) or recognize its existence but without an explanation (Edelman) even deny the possibility of studying it in a scientific way (Baars). Without this component a complete explanation cannot be achieved. The limitations of these models are not flukes, phenomenological consciousness is a very complex problem that is considered by some researchers in the field as the greatest unsolved problem in science. Chalmers (Chalmers D. , 1996, p. xi) wrote: “Consciousness is the biggest mystery. It may be the largest outstanding obstacle in our quest for a scientific understanding of the universe”.

In Baars’ model GWT, cognition is created by a distributed parallel processing of a number of specialized processors. The problem is to explain how this multi-processing system can give rise to integrated conscious experience like thoughts, memories and perceptions from multiple independent subsystems.

GWT considers the hard problem an impossible problem to deal with, this point of view removes phenomenological consciousness as a viable subject of science. This model explains many aspects of functional consciousness, but does not explain why these functions must be accompanied by a conscious experience. Essentially Baars deals with cognitive functional aspects of consciousness but does not explain the personal experience that characterizes it.

Blackmore's (2002) criticism is correct in the fact that if there is a working memory where information is maintained, this does not explain how consciousness is generated or why we have conscious personal experiences. For example if a machine was developed using the principles of GWT, it should be conscious, but it is obviously not.

Edelman (2003) claims that consciousness can be explained by a dynamic core consisting of recurrent circuits within the thalamocortical system that binds a big quantity of information in periods of < 500 ms. He believes that qualia exists and it is a product of physiological process but at the same time he assumes that is an epiphenomenon without causal power.

In criticism to Edelman's model mental causation and epiphenomenalism have been studied in some detail. It is not possible to assume that consciousness is an epiphenomenon without problems. Libet's experiment is not conclusive in this regard as some people think, another experiment by Trevena & Miller (2009) questioned the results of Libet's experiment. If someone accepts that phenomenological consciousness is an epiphenomenon; that someone would be in the position of explaining how this arises.

In their model Edelman and Tononi assume that qualia is generated in a dynamic core, but the model lacks an explanation of how the dynamic core transformation gives rise to the phenomenological experience, the way neuronal processing gives rise to phenomenological consciousness, in this respect his explanation is vague, lacking in detail. The neuropsychological models of consciousness show the complexity of consciousness. On one

hand people have functional consciousness, on the other hand phenomenological consciousness. It is viable to explain functional consciousness based on neuropsychological models, but the problem persists because phenomenological consciousness cannot be reduced to physical elements or eliminated as some models propose. Furthermore, it is possible to conclude that the analysis performed for the models here analyzed at the functional level so far cannot explain phenomenal consciousness.

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Resume of Roberto Cruz Murcia

Col. Miraflores b-50 c-1916 Tegucigalpa, Honduras.

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Objective

This resume was written for this thesis

Experience

teacher
Universidad Nacional Autonoma de Honduras, Tegucigalpa Honduras august 1985 to 2006.

- Teacher of the following courses: organizational behavior, personnel management, research metodology and others.

teacher
Universidad Tecnologica Centroamericana. Tegucigalpa Honduras 1990-91.

Teacher of the following courses: consumer behavior

teacher
University of Jyväskylän (JyväskyläänYliopisto), Jyväskylä Finland

I teach latin american literature during several months to a group of students of Spanish language studies in Jyvaskyla. This was a voluntary work

- I gave lectures about latinamerican literature
- I receive a recognition letter from the university autorities

Industrial relations manager
Battery industries (Ray-o-Vac) Tegucigalpa Honduras march 1994 june 1995

- personnel selection hiring and training
- industrial security and higieneindustrial relations
- suply purchases, providers, services, etc.
- Recreational activities

Education

Master in theology, Miami International Seminary MINTS Miami Florida from February 2004 to 2005.

MBA Universidad Tecnológica Centroamericana UNITEC, Tegucigalpa Honduras.

B. A. In psychology Universidad Nacional Autonoma de Honduras UNAH, Tegucigalpa Honduras.

Publications

Cognitive neurophysiologic models of conscious and nonconscious states.

http://www.univie.ac.at/meicogsci/php/ocs/index.php/meicog/meicog2010/paper/view/138

Effect of attention distraction in awareness during transitive performance in human adults

http://www.univie.ac.at/meicogsci/php/ocs/index.php/meicog/meicog2009/paper/view/43

Cruz Murcia, Roberto (2006). Argumentos Acerca de la Existencia de Dios “arguments about God Existence”. Editorial Universitaria: Tegucigalpa.

Downloadable version:

BAT815 Argumentos de la Existencia de Dios - Roberto Cruz (doc) (pdf)

http://www.mintsespanol.co.cc/

Special skills

I speak Spanish, English, German and I understand French, Portuguese and Italian. I have computer training, and several courses in neuropsychology, personnel administration, I can play guitar and sax.

References

References available on request