INTERNATIONAL JOURNAL OF PSYCHOLOGY AND NEUROSCIENCE

# Consciousness and Cognition: Is Consciousness Confined in the Brain?

# Consciência e Cognição: Estará a consciência Confinada ao cérebro?

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REVIEW

**Abstract**

Cognition is discussed within a basic monistic idealist ontology and the theory of quantum functionalism as an alternative to dualism, realism, and operationalism. Quantum functionalism is briefly reviewed. Various cognitive paradoxes are discussed and resolved; among them, brain-mind identity, self-reference, color-phi, Libet's series of experiments, qualia, unity of experience, unconscious perception, and nonlocality. An emphasis on experimental data is maintained throughout.

**Keywords:** consciousness, cognition, dualism, realism, quantum functionalism.

**Resumo**

A cognição é discutida no âmbito da ontologia idealista monista básica e a teoria do funcionalismo quântico como uma alternativa ao dualismo, realismo e operacionalismo. O Funcionalismo Quantico é sumariamente revisto. Diversos paradoxos cognitivos são discutidos e resolvidos; entre eles, a identidade cérebro-mente, a auto-referência, cor-phi, a série de experimentos Libet´s, qualia, unidade da experiência, a percepção inconsciente e não-localidade do Libet. Uma ênfase em dados experimentais é mantida ao longo do artigo.

**Palavras-Chave:** consciência, cognição, dualismo, realismo, o funcionalismo quântico.

## Introduction

Recently there have been some beginnings of discussion of consciousness in cognitive science. However, all of the discussion presupposes realist/materialist ontology (also called physicalism) – consciousness is a property of matter emerging at some threshold of complexity. In this description, consciousness is local and quite confined in the brain of the cognizing individual.

The straw opponent cognitivists employ, as the alternative to this model is Cartesian dualism - non material consciousness separate from the brain and interacting with the brain through a localized site. Descartes suggested the pineal gland for this site, more recently; the reticular formation has been suggested as the seat of consciousness. And in computer models we have the concept of the central processing unit as the site of consciousness. None of these sites has ever been confirmed experimentally. And of course, whenever we conceptualize a site for consciousness, the inevitable specter of the dualistic homunculus haunts us.

Dualism, of course, is easily refuted. The question is: Is there a monistic alternative to physicalism or operationalism with physicalistic undertones (Dennett, 1991)?

We propose a monistic idealist alternative to dualism, materialism, physicalism, and operationalism. The purpose of this paper is to review all earlier work - both theory and experiment - and bring this monistic alternative to the attention of cognitivists (realists/physicalists).

## Material Realist and Monistic Idealist Ontologies

The material realist ontology is fundamentally based on the idea that only matter (and its correlates, energy and force fields) is real (the doctrine of material monism) and that matter can be thought of as independent separate objects independent of consciousness

In contrast, the philosophy of monistic idealism postulates consciousness, not matter, as the ground of being. Material and mental objects from the immanent world of space-time manifestation that codependently arise in consciousness along with a subject of experience from a transcendent world of possibilities. The realist appearance of the world is due to the apparent separateness arising from the subject-object split of one undivided transcendent consciousness. The word transcendent paradoxically indicates both within and without. Thus the transcendent and immanent worlds do not form a dualist separate pair of worlds.

The philosophy of material realism is monistic because ultimately everything s reducible to matter, matter is the only reality, everything else is epiphenomena. The philosophy of monistic idealism is monistic because ultimately there is only consciousness, everything else –both subjects and objects resulting from the split - are epiphenomena.

Note the important symmetry and inclusivity in the philosophy of monistic idealism –both subjects and objects of experience are considered as epiphenomena. In contrast, the philosophy of material realism posits that the objects of our experience are real, but the subject is epiphenomenon; this philosophy is exclusive.

Now we can understand why modern science and even psychology have overly emphasized the objects of experience, it is a sign of the tacit acceptance of material realism as the underlying philosophy. If monistic idealism were to be accepted as the underlying philosophy, obviously subjects can demand equal time with objects in the scientific investigation of the world.

So which philosophy is the right one for science? Some philosophers called logicalpositivists think that asserting either ontology is unnecessary; it is impossible to decide between them empirically and, therefore, the right course is to give up metaphysics altogether. Meanwhile, the tacit underpinning of material realism in scientific work is okay because it is operationally useful (operationalism).

We disagree. We will show that the philosophy of material realism is logically inconsistent, giving rise to various paradoxes. We will show that these paradoxes do not negate ontologies per se, as logical positivists claim, since the paradoxes disappear in the face of monistic idealist ontology. Finally, we will show that, thanks to recent developments in quantum mechanics, cognitive science, and neurophysiology, the idealist ontology is finding experimental support.

## The paradox of quantum physics

The mathematical equation of classical physics involves quantities relating to macro objects that we directly observe: position, velocity, acceleration, and forces. Knowing the initial position and velocity of an object and all the forces that act upon it, the classical equation of motion (Newton's second law of motion) enables us to calculate the position of the body at all times past and future if we assume that the time development of the object's motion is continuous (the assumption of continuity) and their interactions are local (the assumption of locality).The theory thus supports the philosophy of determinism - the idea that the past ad the future of the universe is determined by its initial conditions.

The mathematical equation of quantum mechanics (called Schrödinger equation) at first sight looks deterministic enough: it gives us the law for the time development of a wave amplitude based on initial conditions. Unfortunately, the wave amplitude has to represent material objects, and the only satisfactory way it can do that is to interpret the wave amplitude as the amplitude of a wave of possibility and assert that the square of the wave amplitudedetermines the probability of where the object is. Thus the theory enables us to calculate only probabilities of finding particular values of observable quantities such as position and velocity of objects. And probability begets uncertainty. No longer can we ascertain simultaneous accurate values of both position and velocity of an object (the uncertainty principle); thus strict determinism is ruled out since it is impossible to know the initial conditions accurately.

The wave amplitude of objects of quantum mechanics corresponds to waves of possibility in potentia. We have to assert that a measurement brings one of these possibilities into actuality. A quantum measurement corresponds to a discontinuous and nonlocal collapse of a spread-out wave (many possible facets) into a localized particle (one particular facet). Banished are strict continuity and locality of classical physics. Even more intriguing is to ask: who/what chooses which possibility is manifested in a particular measurement? If choice is involved, is consciousness? And if consciousness can collapse the quantum wave, can such a consciousness be made of matter, be an epiphenomenon of matter?

Quantum physicists have argued these matters of interpretation for decades without consensus. Many quantum measurement theorists would rather search for a solution of the paradox of quantum measurement than find a solution. For in truth, a solution to the measurement paradox already exists. Namely, to assert, as the mathematician John von Neumann (1955) originally did, that it is consciousness that collapses the quantum possibility wave. All the objections (paradoxes) to this resolution are due to an almost universal misconception among scientists about the nature of consciousness. They tend to think that any positing of consciousness collapsing the possibility wave must be a dualistic consciousness - consciousness separate from matter (Wigner, 1962, 1967). Goswami (1989, 1993) has shown that if one understands consciousness as the ground of being, as in the philosophy of monistic idealism, all objections find simple satisfying answers (as we will se below).

Additionally, the idealist resolution involves the idea of self-reference in the rain-mind. This brings us to the subject of the mind-brain problem and the paradoxes of cognitive science. We shall see that the two sets of paradoxes will see simultaneous resolution under the idealist ontology if we posit additionally that the brain has quantum machinery in addition to the approximately "classical" neuronal machinery.

That the human brain may contain a quantum system in addition to its classicalneuronal system is a decades-old idea (Walker, 1970; Bass, 1975; Wolf, 1984; Eccles, 1986; Stuart *et al.*, 1978; Stapp, 1982; Goswami, 1990; Lockwood, 1991). What follows is a brief summary.

How does an electrical impulse pass from one neuron to another across a synaptic cleft? Conventional theory says that the synaptic transmission must be due to a chemical change. Walker (1970) has challenged this view in favor of a quantum mechanical process. Walker thinks that the synaptic cleft is too small that quantum tunneling of electrons may play a crucial role in the transmission of nerve signals. Eccles (1986) has discussed a similar mechanism for invoking the quantum in the brain - his "micro sites" that mediate the quantum connection with the mind do seem to satisfy the requirement of quantum behavior (Herbert, 1993).

Bass (1975) and Wolf (1984) have suggested that for intelligence to operate, the firing of one neuron must be accompanied by the firing of many correlated neurons across macroscopic distances involving as much as the width of the cortical tissue. For this to happen, notes Wolf, we need EPR nonlocal correlations existing at the molecular level in our brain, at our synapses.

Quantum mechanics of the brain-mind is the quantum mechanics of “warm, wet, switches,” says Donald (1990). He theorizes that the states of certain ion channels in the heart of the neurons have quantum mechanical ambiguity and that consciousness is needed to resolve the ambiguity.

The crucial question, indeed, is, How does the brain accommodate self-consciousness, the subject pole of our experiences? Perhaps the brain accommodates consciousness because it has a quantum system sharing the job with its classical one, suggest Stuart *et al.* (1978); and Stapp (1982) has emphasized that in biological systems both the quantum system and the classical system that supposedly “measures” it are of small, roughly equal sizes, so what is measuring what? In this model, which Goswami (1990) has adapted into an idealist model of consciousness and quantum measurement, the brain-mind is looked upon as two interacting classical and quantum systems forming a “tangled hierarchy.” For the rest of the paper, it is on this last model (Goswami, 1990, 1993) that we will focus on. The reader can find a useful review of many of the physicists’ models of consciousness in Burns (1990, 1991).

## Paradoxes of cognitive science

Is the brain similar to the silicon computer? The answer is unequivocally, yes. Both the brain and the silicon computer process and translate symbols. The brain can be seen as the analog of a computer’s hardware and the mind as analog of computer software.

Cognitive science assumes that it is not just an analogy; the brain-mind is a computer. Brain is literally the structure or hardware of the computer and mind the function/software (Fodor, 1981) and we will call it classical functionalism since it is patterned after machines of classical physical intake. There are problems with this kind of thinking. For example, the more we learn about them, the more we can see that the neurons have many more intricate connections among them than the serial connections of ordinary silicon computers. Furthermore, neurons change and their synaptic connections develop as a result of learning or conditioning; in other words, the hardware in the brain is modified to formsoftware programs. In contrast, ordinary silicon computers operate in a top-down serial manner on the basis of programs that represent a large number of explicit algorithms and rules, and the hardware is fixed. Furthermore, although there is a superficial similarity between the central processing unit of the serial computer and the self of the brain-mind, the latter seems to be capable of free will, creativity, affect, qualia (the subjective qualities of felt experiences) and such that seem to be beyond the reach of the silicon computer.

Many people think that a breakthrough in cognitive science came with the realization that it is possible to construct a "connectionist" machine after a neural network consisting of parallely arranged arrays of units connected by way of junctions that operate in a bottom-up manner; namely, the computer can learn some of its rules by trial and error. In other words, although these parallely distributed processing (PDP) (Rummelheart *et al*., 1986) computers have some given algorithms, many of the algorithms are generated by the processes of the computer itself.

With the advent of the theory of determined chaos, we can even think of modeling the units of a connection machine operating under an algorithm that embodies a nonlinear dynamics; unprecedented and unpredictable new order can be expected to emerge from such a bottom-up chaos machine. Although ultimately determined, such a machine can simulate the (apparent) free will and creativity of the brain-mind - determined is not the same as predictable - thus removing one further obvious difference between the brain-mind and the silicon computer.

Still the parallel-processing connectionist machine lacks some obvious controls that the brain-mind has, for example, the ability of directed attention. The PDP model also lacks an explanation of the oneness of conscious experience. This has given rise to the idea that perhaps the brain-mind is both (Posner, 1973; Johnson-Laird, 1983); it can be said to have a directing self (central processor) which is not always rule bound, which is capable of learning from experience, which is capable of unpredictable behavior. Is this a fair representation of us?

Let's set aside for the moment the fact that we have not found any place in the brain that can be called the control room, the site of the central processor. That may be due to the inadequacy of our looking. The real problem is, there are paradoxes (such as self-reference, Van Gulik, (1988), and qualia, Grinberg-Zylberabaum, (1988)) and real disagreement with experimental data (see below) that the above model cannot resolve. These are the aspects that can be attributed to faulty philosophy -material realism. A major objective of this paper is to discuss these inconsistencies and inadequacies of the cognitive science model, all due to its inadequate underlying philosophy, and to show how these inconsistencies and inadequacies disappear if we make a radical shift to an idealist philosophy of consciousness, while still retaining the basic power of the computer model of the brain-mind.

So what are these logical and experimental difficulties that the cognitive-science model of consciousness faces? Concisely, there are the paradox o brain-mind identity, paradoxes of perception, paradoxes of perception of time, the paradox of unconscious perception, the paradox of qualia, and finally, paradoxes of nonlocality including the binding problemand the oneness of conscious experience. Let's discuss each of these items in some detail.

**The paradox of brain-mind identity**

Is the brain/mind identity the same as the identity of software and hardware in a silicon computer in which the programs are "hardwired" in? Computers process symbols. Computer programs have syntactical rules that transform symbols to other symbols. Unfortunately, the symbols don't mean anything outside the context of the programs. In other words, computer programs have no semantics; they cannot represent things outside of themselves. On the other hand, this is precisely what mental events have - semantic content. Mental events more often than not speak of things outside the person. Thus the analogy of minds and programs may not be such a great analogyafter all.

Consequently, philosophers such as John Searle (1987) do not think that computers are capable of mentation, as the strong artificial intelligence (strong AI) view claims. But this leaves a vacuum in the functionalist identity of brain andmind processes. The functionalist can lamely propose psychophysical parallelism and epiphenomenalism. Mental processes are epiphenomena of brain processes that go on parallely, but they have no causal function. As Herbert (1993) points out, this is a kind of dualism. Alternatively, Searle has proposed to eliminate the idea of the program altogether. In Searle's causal identity theory, brain processes at the micro level directly cause mental processes at the macro level just as the interactions of hydrogen and oxygen atoms at the micro level directly cause the wetness of water at the macro level. But the difficulty of such an approach is that nobody has any idea what kind of material interaction can ever give rise to anything mental like the processing of meaning (Penrose, 1990).

This is a paradox. Let's face it. Matter is law-like and brain-mind is program-like. Law-like behavior is cause-driven; programmed behavior is purposive. Matter obeys the eternal mathematical laws of physics and it evolution is transformational, independent of the environment. In contrast, all living objects, and especial the brain-mind, use programmed matter to carry on functions that do not seem to be reductible to matter and its interactions. And the evolution of biological objects involves the environment in a fundamental way. The biological programs are not eternal, they themselves evolve.

Is there a resolution of the paradox? Materialists say the answer is emergentism –program-like behavior emerges from holistic interaction (a la chaos theory?) of law-like matter. But then Searle's criticism –why the intermediary of cognitive science, the neuronal representations?

Consider another paradox. If we agree with cognitive scientists that the brain-mind processes internal representations or "images," then who is looking at the images? The existence of the image raises the specter of a theater where mental images are being projected on a screen (let's call it the Cartesian theater following Dennett, 1991) and a watcher is watching it. This is a very dualistic picture, but most of us succumb to it, as testified in the following anecdote by Francis Crick (1978).

> "Recently I was trying to explain to an intelligent woman the problem of understanding how it is we perceive anything at all, and I was not having any success. She could not see why there was a problem. Finally in despair I asked her how she herself thought she saw the world. She replied that she

> probably had somewhere in her head something like a television set. “So who,” I asked, “is looking at it?” She now saw this problem immediately”.

Denett (1990) contends that most cognitive scientists also use this picture of perception, at least implicitly, and certainly the postulated central processing unit does bring up the image of a homunculus looking at a television screen in the Cartesian theater of the brain-mind. Dennett’s solution (into which we will delve in more detail in little later) is to deemphasize the idea of the mental image.

Idealistic science has a very different resolution of the paradox which is also very straight forward. Consider how a computer scientist solves the problem of syntax/semantics of his of her programs? The computer scientist gives the program semantics, the connection to the physical environment. Today it is our everyday experience that consciousness can use matter to carry out its programs. This is easy tosee at the level of observing a human being using a computer. But how does consciousness supervene in material processes in the brain-mind? It sounds dualistic. This is the question to which quantum functionalism proposes a novel answer.

The answer of quantum functionalism (Goswami 1990, 1993) is simply that, aside from classical machinery, there is also quantum machinery in the brain-mind. Consciousness is needed to supervene in order to collapse the wave function of the quantum component of the brain-mind. And the identity of the micro quantum and macro measurement apparatus is blurred; the two systems make a tangled hierarchy and produce self-reference in the brain (Goswami, 1993).

In this way, the idealist solution is self-reference –both the mental image and the physical object are possibilities of consciousness to choose from. Consciousness is the ground of being that collapses the possibilities of the brain-mindand the external object. But consciousness identifies with the brain because of the brain's tangled hierarchy. As a result, the subject that supposedly looks at the object arises simultaneously in consciousness with the object that is looked at in the event of a perception. Let's discuss this in some detail.

## Self reference

Let's now analyze the tangled hierarchical encounter of the two machineries of the brain - quantum and classical - that quantum functionalism posits, with one another and with consciousness, that brings about our self-reference. Our starting point is a famous paradox, the paradox of Schrödinger's cat.

## Schrödinger's cat

Suppose we put a cat in a cage with a radioactive atom and a Geiger counter. (Radioactive atoms are atoms that decay following quantum probabilistic rules.) Further suppose that the atom in the cage has a fifty-fifty chance of decaying in an hour. If the atom decays, the Geiger counter ticks; the ticking of the counter breaks a poison bottle, and the poison kills the cat. Quantum machanics says that this cat (called Schrödinger's cat after Erwin Schrödinger whose brainchild it is) is half dead and half alive after the hour (Schrödinger, 1948). This is a paradox.

According to material realism, quantum mathematics is incomplete; there must be unknown hidden variables that resolve the state of the cat to a unique one at all times. To the idealist, however, the cat initially exists in a transcendent domain of potentia as what is technically called a coherent superposition of two contradictory states; our observation brings about the unique dead or alive state that we see.

But there is more subtlety here. As the mathematician John von Neumann showed, if we send a whole hierarchy of insentient machines successively to observe the reading of each previous machine, starting with the one that registers the state of the cat, it is logical (since all the machines ultimately obey quantum mechanism) that all of them will acquire the quantum dichotomy of the cat's state, ad infinitum (this is called the von Neumann chain).

When the cat catches the contagious quantum superposition of the radioactive atom, we are confronted with the possibility that all material objects in the universe are susceptible to contracting the quantum superposition if they are involved in the observation of the cat. The quantum superposition takes on a universal contagiousness, a glaring disease of infinity. But the infinitely coupled system and its measurement apparatuses do not collapse of themselves. This incompleteness is a logical necessity of the universality of quantum mechanics.

The remedy for the infinity is to jump out or the system, outside the domain of inanimate matter that obeys quantum mechanics. According to the idealist interpretation of quantum mechanics, the von Neumann chain stops at the brain-mind through the supervention of consciousness which is beyond the jurisdiction of quantum mechanics; nonlocal consciousness collapses the state of the brain-mind from outside space-time, thus terminating the von Neumann chain.

The collapse consists of choosing and recognizing one facet from the multifaceted coherent superposition representing the brain-mind and all the multifaceted states (such as the cat's) correlated with it. But there still is a paradox here. The consciousness of monistic idealism is the ground of being; it is omnipresent: So when can we say collapse occurs? We must say this happens when there is a brain-mind awareness looking. However, there is no manifest awareness before collapse, before choice. What comes first, the subject consciousness that chooses or the awareness? The answer is neither; the collapse happens self-referentially; in the event of a quantum collapse both subject and object arise simultaneously out of what is called a tangled hierarchy.

**Tangled hierarchies**

In a simple hierarchy the lower level feeds the upper level, and the upper level does not react back. In a simple feedback the upper level reacts back, but we still can tell what is what. With tangledhierarchies, the two levels are so mixed up (by a discontinuity in the causal chain, as we will see) that we can no longer identify the different hierarchical levels.

The famous liar's paradox is a prime example. "Epimenides was a Cretan who said, "All Cretans are liars." This is an example of a tangled hierarchy, because the secondary clause reacts back on the primary, and soon we lose track of which is primary (i.e., giving truth value) and which is secondary. Is Epimenides telling the truth? If he is, he must be lying. The answer every time oscillates; if true, then lie, then true, ad infinitum.

Compare the liar's paradox with an ordinary sentence, Your ball is blue. An ordinary sentence refers to something outside itself, or at least an objective statement can be made of its content. But tangled hierarchical systems are autonomous. The complex sentence of the liar's paradox refers back to itself and separate from all else. In other words, the tangled hierarchy is a way of achieving self-reference (Hofstadter, 1980).

The self-reference arises because of a veil, an effective stonewalling against our attempt to see through the system causally and logically. It is the discontinuity - in the case of the iiar's paradox, the infinite oscillation (infinity is a discontinuity) - that prevents us from seeing through the veil once we identify with the system.

Consider now the sentence: I am a liar. In this compressed form of the liar's paradox, the self-reference of the sentence, the fact that the sentence is talking about itself, is not necessarily self-evident as can be verified by posing it to a child or a foreigner who is not very conversant with the English language; there response might be, "Why are you a liar?" The self-reference of the sentence arises from the implicit, not explicit, knowledge of the English language that all native English-tongue adults have. The self-referential sentence is metaphorically the tip of an iceberg; there is a vast level underneath that is invisible. This invisible level is an inviolate and transcendent level - a level where the system cannot go. Yet it is the inviolate level (in the case of the self-referential sentence, the implicit conventions of the language, and ultimately, we) that is the "cause" of the self-reference of the system.

Hofstadter (1980) proposed that there are tangled hierarchies in our mind-brain's programs looked upon as a classical computer, as in classical functionalism. Hofstadter believes that if one could build a silicon computer with tangled hierarchical programs, then the computer would also be self-referent.

But there is a category mistake in this kind of thinking, because a tangled hierarchyrequires a transcendent level as well as an infinite regression. Hofstadter cannot generate a transcendent, inviolate level from a material level any more than a material apparatus can collapse a quantum possibility wave. There has to be a real jump out of the system.

We, our consciousness, are the inviolate level for the self-reference of the self-referential sentence. Of course, the self-referential sentence is unconscious of its self-reference; it has no awareness, and no machinery to manifest awareness, of the self-reference. Paradoxically we are also the inviolate level for our own self-reference with one crucial difference; although we are also unconscious of our transcendent consciousness, we do have the machinery for manifest awareness of our self-referential apparent autonomy. It is this play of unconsciousness andself-reference that gives us the illusion of separateness between us and the objects we experience.

**Self Reference**

To see how tangled hierarchy and self-reference arise in the brain-mind, let us follow the exposition in *The Self Aware Universe* (Goswami 1993) and examine a crude model of the brain-mind's response to an ambiguous stimulus. The stimulus is processed by the sensory apparatus and presented to the dual quantum/classical system. The state of the quantum machinery expands as a coherent superposition, and all the classical measuring apparatuses that couple with it also become coherent superpositions. But there is no program that can choose among the different facets of the coherent superposition; there is no component in the mind-brain that we can identify as a central processing unit –the experiencing subject is not a homunculus acing at the same level as the mind-brain's interacting systems.

Instead, what we have is a tangledhierarchy where there is a discontinuity, a breakdown of causal connection within space-time in the process of selection from the possible choices in the possibility pool that the quantum system gives. The choice is a discontinuous act from the domain of transcendent potential, an act of our nonlocal consciousness; no linear cause-effect description of it in space-time is possible.

Consciousness collapses the total quantum state of the dual system of the mind-brain, resulting in the separation of the subject and the object in awareness, but, because of the veil of the tangled hierarchy, consciousness becomes identified with the manifest subject of the experience. This identity with the primary subject-experience (as opposed to secondary self-experience that gives rise to the ego; see below) will be referred to by the Sanskrit word *atman*. Clearly, the atman is the quantum modality of the self.

**Secondary awareness processes**

There is a well-known characteristic of learning - learning a performance reinforces the probability of the same subsequent performance. Thus it is reasonable to expect that learning increase the likelihood that the quantum-mechanical states of the dual system after the completion of measurement will correspond to a prior learned state; in other words, learning biases the self-referential quantum dynamics of the mind-brain. Before learning, the possibility pool from which consciousnesschooses it states spans the mental states common to all people at all places at all times. With learning, certain responses gradually gain greater weight over others (Mitchell & Goswami, 1992). Once a task has been “learned,” then for any situation involving it, the likelihood of a learned response approaches one hundred percent. In this limit, the behavior of the brain-mind’s dual quantum system/measuring apparatus becomes classical, behaviorally conditioned. This is the mind-brain analog of Bohr’s correspondence principle in quantum mechanics.

Fairly early in our physical development, learning accumulates and conditioned response patterns begin to dominate the brain-mind’s behavior despite the fact that the versatility of the quantum system is always available for new creative experiences (all we have to do is to “just say no” to a conditioned response). Experiences lead to learning, one aspect of which is developmental changes in the brain-mind's substructure - memory. Parallel with the conditioning of the coupled quantum system/classical-measuring apparatus is the development of a classical repertoire of memorized learned programs. So when the creative potency of the quantum system is not engaged, the tangled hierarchy of the systems of the mind-brain, in effect, becomes a simple hierarchy of the learned classical programs. At this stage, the creative uncertainty as to "who is the chooser" of a conscious experience is obscured, and we begin to experience a separate, individual self, the ego, that thinks it chooses, that presumably has "free will."

Thus an adult person is capable of operating in two modes of identity - ego and atman. The atman (quantum primary mode) - where creative responses remain available through the possibility pools o the mind-brain's quantum system - is the fountain of ourintuitive insights. The atman is the transpersonal component of our self-identity, an idea previously propounded by Roberto Assagioli (1976) and Abraham Maslow (1968). And the classical ego mode is associated with the continuous, conditioned, and predictable behavior of our individual self-identity that augments our creative ideas with reason, thatenables us to develop and manipulate these ideas into full-blown actualities, and that allows us to enjoy the fruits of our accomplishments.

We will now show that the model of self-reference developed here is also useful for solving other paradoxes of perception.

## Perception: Stalinesque or Orwellian?

We have a persistence of vision that enables us to see a parade of still pictures at a rate of twenty-four frames a second as a motion picture - the so-called phi phenomenon. In the simplest arrangement, an experimenter illuminates in quick succession two spots separated by an angle of three or four degrees.

Observers see this as a single spot moving back and forth. When one of the illumined spots is red and the other is green, though, a red spot is seen first, which then moves and changes color abruptly to green at the halfway point of its imaginary passage, henceforth it travels as green to the second location. Subjects can point to where the color switch took place with a pointer. And they see the effect even in their first trial - it is not a conditioned reflex. This phenomenon, called color phi, was first observed by Paul Kolers and Michael von Gruenau (1976). The observed experimenters illuminated each spot for 150 milliseconds with a 50 milliseconds pause in between.

From the point of view that there is a seat of consciousness in the brain, there is something deeply disturbing about the color phi phenomenon. The puzzling question is this: how can one perceive green before green is lit?

Daniel Dennett (1991) has analyzed this phenomenon and he says that there are two alternatives - both unpalatable - from the seat-of-consciousness (which he calls the Cartesian theater) point of view. There is a time delay (Grinberg-Zylberbaum, 1988) before we see anything in consciousness and during this period some tricky preconscious editing takes place in the "editing room" of the Cartesian theater. For example, the first frame that arrives is, of course, the red spot. But when the green frame arrives, the editing room inserts fictitious frames, additional red and green frames, and it is this edited version that finally makes it to consciousness and that gives the impression of motion and the change of color midway through the movement. Dennett calls this the Stalinesque scenario.

Interestingly, if subjects are asked to press a button as soon as they "see" the red spot alone versus a red followed by a green spot 200 milliseconds later. And the response time can be less than 200 milliseconds! Thus in the Stalinesque scenario such button pushes like the editing, must also be preconsciously triggered.

In the second scenario, called the Orwellian scenario by Dennett, the frame insertions take place as a post-conscious revision of memory/history of the events. Since the subject can only verbally report what is in his or her memory, obviously an Orwellian post-conscious revision of history is as much an explanation of the color phi phenomenon as the preconscious Stalinisque scenario.

The idealist explanation is based on the secondary processing events on the basis of which consciousness does the (preconconscious) editing.

A series of paradoxical experiments performed by the neurophysiologist Benjamin Libet with brain surgery patients finds satisfactory explanation when viewed from the point of view of primary and secondary awareness events as discussed above. Libet has found a way to apply direct electrical stimuli to the somatosensory cortex such that the subject has memory-elicitations that are similar in sensation to that of an external touch stimulus (Libet *et al*., 1979). Libet found that these critical stimulations must be of a minimum strength and duration (the duration and strength depend somewhat on each other) in order to be felt. For low stimulus-strength, the duration needed is about half a second. In contrast, even a very brief and very weak external stimulus leads to a sensation - a felt event. Clearly, a reasonable hypothesis is that whereas the external stimulus leads to a primary awareness event and irreversible collapse of the wave function involving the external world, the cortical stimulations lead only to secondary awareness events.

The half a second (500 milliseconds) is the processing time of secondary awareness events before we become aware of a stimulus at the ego-level. The processing time is needed irrespective of whether the stimulus is internal or external. Indeed, if a strong cortical stimulus is applied after an eternal skin-touch stimulus within the 500 milliseconds duration of its secondary processing, Libet found that it is able to mask the skin-stimulus –the secondary events of the cortical stimulus drown out the secondary events of the skin-stimulus. This phenomenon is called backward masking. It establishes that the processing timeof secondary awareness events for an external stimulus are also about 500 milliseconds.

The backward masking phenomenon gives us evidence that there is a processing time between a sensory event and its awareness at the ego-level capable of verbal expression, but is there any evidence that there is also a primary awareness event in the case of an external stimulus? There is. Libet, in addition to the backward masking measurements did another experiment which is very puzzling until we invoke the ideas of the primary awareness event and quantum collapse. To this experiment, which seems to deal with the subjective perception of time, we now turn.

**The paradox of perception of time**

Cognitive science is based on the idea that the brain's organization and its relationship to the world at large can be completely described by a computer model. In general, this amounts to making a map, a prepresentarion of things in one space into things in another.

Things in ordinary space can be represented by points in a three dimensional coordinate system. And if wewant to keep track of movement, either we can keep track of changes in the three coordinates as a function of time or we can make another six-dimensional space that plots not only the coordinates but also the velocities along each of the coordinate directions. The latter space is called *phase space* and it's an example of a different kind of space.Now mental phenomena are felt as conscious events in a space that we have identified as our awarenss. It is analogous to physical space and is related to it (that is, events in awareness correspond to events in actual physical space in some intricate manner) but not identical to it. Now a difficult question, how is the time of mental events related to physical time?

The measure of subjective time is clearly different than the objective measure we use for our clocks; but that is a minor point. Is subjective time qualitatively the same as objective time? Do they pertain to the same directional arrow of time? Do events retain their sequentiality in their subjective perception? These are questions that also give rise to paradoxes.

The greatest difference between objective time as defined by physics and subjecive time is that the former is of a static characteristic but the latter is dynamic. Objective time in physics is treated quite symmetrically with space; there is no flow of time. The events of the universe are laid out in a canvas of static space-time so to speak. But in the subjective time that we experience, time flows.

There are theories in physics that accommodate a directional flow of time. For example, one invokes the idea of entropy (the amount of disorder) increase of the universe as a result of physical processes to give us an arrow of time. But the irreversibility of the entropy arrow of time is only an apparent irreversibility arising from the overwhelming probability in any event of collision for the occurrence of “nothing special” final states of which there are so many, compared to a “special” orderly initial state. If we wait long enough, nothing in the physical laws prevents us from getting back to the initial state.

In the idealist interpretation of quantum mechanics, the arrow of time finds a simple explanation. This is because when conscioustness collapses the wave function (of a system or of the universe), there is real irreversibility - the casual pathway leading to the event is fixed once and for all. In the idealist interpretation the static time of physics belongs to the transcendent domain of possibnility. Collaps marks the real time of the manifest reality as we experience it (see also, Szilard, 1929). Hence this subjectively experienced time has direction; it *flows*.

Now, for the most paradoxical of Libet's experimental results (Libet, 1985), suppose we have two readily distinguishable cortical and skin stimuly; for example, suppose that the cortical stimulus simulates a touch to the right hand whereas the skin touch is applied to the left hand. Here is the surprise. If the touch is applied some 300 milliseconds after the cortical stimulus, and both take a 500-milliseconds processing time to arrive at ego-awareness, we would expect that the subject would report the sensation of the cortical stimulus first and that of the skin stimulus some 300 milliseconds later. What Libet found is that the subjects invariably refer the touch stimulus back to its time of arrival at the cortex (which is only 10 milliseconds after the touch) and report it to have occurred first, *before* the cortical stimulus.

There is something strange about this result if we think that the events are perceived in the same way irrepective of the event being internal or external. The subjective sequencing seems to be reversed compared to the objective sequencing in the laboratory of the time of application of electrical cortical stimulus and the skin touch.

But there is no paradox in the idealist description presented here. There is no primary event of collapse for a cortical stimulus, only secondary awareness events. In an ordinary perception when there is only a touch stimulus, the secondary events dress up this primary event and we are deceived into perceiving only one event of sensation. But, of course, the primary awareness is there. In Libet's experiment, when asked about the timing of the external stimulus, subjects correctly refer back to this primary awareness event, thus establishing its presence.

Independent evidence for the primary awareness event abounds. People in unusual circumstances, such as in a creative "aha" experience, report an immediacy of experience that is not normally reported. We believe that this immediacy is felt due to the absence of secondary processing - there is no memory to process.

**Voluntary action**

There is one other series of experiments that supports the view presented here. These are experiments that show that whereas we can flex a finger within 200 milliseconds in response to an external signal, if we are asked to voluntarily flex our finger, it takes a second or more to do that from the time of onset of electrical activity connected with the action in the brain, called the readiness potential (Deeke, Grotzinger, & Kornhuber, 1976). The explanation fits the notion of the primary atman self being the locus of free choice; even the thought of free-willing at the ego-level does not surface without its processing time. And execution of the "free" will takes longer.

Libet (1985) asked subjects to flex one hand at the wrist while also noting the position of a spot on a revolving disk (like the second hand of a clock) as to when they formed ther intention. A few seconds afterwards, the subjects told the experimenter where the spot was when a conscious will was made, which enabled Libet to calculate the time of that event. Libet found that there indeed is a 400 milliseconds or so time lag between the onset of the readiness potential and the awareness of the will to flex the wrist. This further supports the above idea that conscious choice is a function of the atman percolates via secondary processing to the ego level and we have the thought that we will to flex our wrist, an external observer already can know of our “free” will by simply looking at the EEG if it is connected to our brain. The ego simply is not free.

However, Libet has discovered a twist. Although the will to flex the wrist is formed before we become aware of that will in thought, we are able subsequently to stop our willed action during the 500 or so milliseconds that remains between the actual action and the thought. What is the explanation? Even in ourEgo identity, we are not totally conditioned (remember, according to Mitchell and Goswami (1993), a 100% conditioned response requires an infinite amount of conditioning).

**Qualia and Oneness of Experience**

There is unique quality to a conscious experience –eating a banana and talking about it are not the same thing. Dunn (1927) questioned how physics could ever explain to a born-blind person the experience of seeing light. Dunne insisted that the quality of an experience can be understood only by direct experience. The experience of light does not reside either in the light waves or in the receiving apparatus - the brain. Let’s elaborate on this idea-let’s examine the response of the brain upon receiving a stimulus.

There are now experiments suggesting that a stimulus is processed in several brain areas. In the first area, a direct one-to-one representation of the object is made. For example, for a visual stimulus, the primary occipital cortex plays this role. In a second area, the brain performs an analysis of the stimulus involving massive amounts of neurons. For a visual stimulus, this is done in the secondary and tertiary occipital cortex. Similar primary, secondary, and tertiary areas also exist in the temporal (auditory) and parietal (somatosensory) cortex. In a third area, the analytical representations from the vious areas seem to be integrated.In tha associated area of the cortex, we find occipital-temporal, temporal-parietal, andparietal-occipital axes for this integration

There is a debate as to how the brain carries out the analysis of the one-to-one representation. Pribram (1991) contends that the brain performs a Fourier analysis and makes a frequency representation (like a hologram). Grinberg-Zylberbaum (1976), on the other hand, has theorized that the analysis takes place with the help of "neuroalgorithms." John (1988) points out that there are massive neuronal activity patterns associated with this self-coding; the neuronal mass is called the "hyperneuron." All agree, however, that the analytical image (hologram or hyperneuron) is constructed for the purpose of memory - it is more advantageous to have the memory stored nonlocally than locally.

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What happens in the area of integration? Generalizing John's idea of the hyperneuron, Grinberg-Zylberbaum has theorized the idea of the neuronal field, which is the integrated and unified totality of all the representations in the primary, secondary, and tertiary cortical areas. The neuronal field explains the unity of a percept; the phenomenological experience of an image as a unit.

Suppose the stimulus is a red car with its engine running and you let several people experience the sight and sound and touch of the car. Suppose also that you have available to you the right combination of some super technology and high-power mathematics that you are able to make a complete description of the neuronal field of the brains of your subjects, even one for your own brain, upon experiencing the car. Except for minor differences, you would expect the neuronal fields of all the brains, including yours, to be identical.

And yet, you know that in the case of your brain, something is left out, something that the objective neuronal field cannot possibly describe, and that is your subjective experience as observer. You might say that the neuronal field of your observer brain is special compared to all the observed brains. But then you would be admitting (barring solipsism) that your conscious experience of your brain state changes your supposedly objective brain state. The alternative is to admit that the neuronal field does not provide complete description of the experience.

This is the paradox of self-reference back again and without addressing it, it is impossible to address the issue of the qualia of experience. The theory of quantum functionalism, thus, having addressed the paradox of self-reference, also successfully eradicates the paradox of qualia of experiences. Here the incoming stimulus not only excites the neuronal apparatus but also the quantum components, which the neuronal apparatus amplify and "measure." The neuronal field is the measurement-actualization of the quantum potential represented by the interaction state of the quantum machinery and its classical measurement apparatus. Because consciousness of the experience transcends the brain state, the neuronal field unifies the disperse activity of the brain but is clearly an incomplete description of the experience. Yet the consciousness of the experience (the subject pole with the qualia of experience) arises co dependently and tangled hierarchically with the neuronal field (the object pole) that exists only as possibility until the collapse, and no dualism is involved. Nor is operationalism - basically a negation of the authenticity of qualia (Dennett, 1991) necessary to invoke. Even the question of secondary qualities is handled properly; they arise from secondary awareness processing - the reflection from the mirror of individual brain memory.

The idea of consciousness self-referentially collapsing both the neuronal field and the quality of the experience also resolves the thorny issue of the oneness of a conscious experience (that we can be consciousy aware at any given instant of only one particular thing). It is well known that all attempts by psychologists and neurophysiologists to plot the unity of a conscious experience (for example, by surgically splitting the brain hemispheres) have failed. In the quantum functionalism scenario there is only one collapse at a given time, and that defines the event in awareness. However, the secondary awareness processes of two primary events can overlap in time. This is responsible for the fact that we can be vaguely aware of several things in awareness at the same time.

In this way we can see that an understanding of all the different aspects of the qualia of experience can be obtained within the extended context of quantum functionalism. We do not need to resort to operationalism and negate qualia altogether as Dennett (1991) has done.

So far our theoretical development has been explanatory. In the following sections, we will discuss two more paradoxical phenomena, unconscious perception and nonlocal communication, that lead to the possibility of clear cut experimental discernment between classical and quantum functionalist theories.

**Unconscious perception**

Unconscious perception is a class of phenomena that cause cognitive dissonance in many people because of the unfortunate choice of words - how can one perceive but have no consciousness of it? Well, the unconscious does not mean that there isn't consciousness (Goleman, 1986). (In monistic idealism, consciousness is the ground of being; where would it go?) In the unconscious there is consciousness, but no awareness. Unconscious perception is perception without awareness.

Evidence abounds for such phenomena. There is a phenomenon called blind sight in which people who have lost their normal cortical vision (but the pathways for collicular vision through the hindbrain remain intact) clearly can sense obstacles or distinguish between patterns beyond chance coincidence and yet claim unawareness of sight (Humphrey & Wiskrantz, 1967; Humphrey, 1972). Similarly, if a picture of a bee is flashed very fast before a subject, the subject does not have conscious awareness of the picture, and yet a subsequent association test elicits words such as honey of sting, suggesting that there was seeing after all (Shervin, 1980).

The experiment of Tony Marcel (1980) involved measuring the recognition time for the final words in strings of three words such as HAND-PALM-WRIST and TREE-PALM-WRIST where the middle ambiguous word is sometimes pattern-masked so that it can be perceived only unconsciously. The effect of pattern masking seems to be to remove the congruent (as in the case of HAND above) or incongruent (as in the case of TREE above) effect of the first (priming) word on the recognition time.

The results for the no-mask condition in which the subjects are aware of the second word, support what is called the selective theory of the effect of prior context in word recognition (Selfridge & Neisser, 1968). In the congruent case, the “hand” meaning of the unmasked polysemous word PALM is facilitated by the associated meaning of the prime word HAND, while the “tree” meaning of PALM is inhibited. Therefore, the response time to WRIST receives facilitation and no inhibition. The opposite is true for the incongruent case: the “tree” meaning of PALM is selected, which has no association with WRIST, and hence the response time for WRIST is increased. If the mind-brain is looked upon as a classical computer, as in classical functionalism, then the computer seems to operate in a serial, top-down, linear, and unidirectional fashion in this kind of situation.

However, when the polysemous word is pattern-masked, both its meanings seem to be available in the subsequent processing of information, since the congruent and incongruent conditions take similar recognition times. Marcel noted that a "nonselective" theory must apply to the unconscious identification. It appears that such a nonselective theory can be based on parallelly distributed processing (PDP), in which multiple units of information are simultaneously processed with feedback included (Rumelhart, McClelland & PDF Research Group, 1986).

This is the paradox. Classical functionalist models that are linear and selective have no difficulty in explaining the effect of biasing the context in cases where no masks are used, but these models cannot explain the change that occurs in the unconscious perception experiments with pattern masking. The parallel processing nonselective theory may fit the case of unconscious awareness but cannot explain both sets of data in a coherent fashion.

A cognitive solution put forth by Michael Posner (Posner, 1973; Posner, 1978; Posner & Boies, 1971; Posner & Klein, 1973; Posner & Snyder, 1975a, 1975b) invokes attention as the crucial ingredient for distinction between conscious and unconscious perception. Attention comes with selectivity; thus, according to Posner, we act as a serial processing computer and select one of two meanings when we are attentive, as in conscious perception of the ambiguous word in the Marcel experiment. However, when we are not attentive, there is no selection; the mind-brain's computer acts in the parallel processing (PDF-D) mode. Thus both meanings of an ambiguous word are perceived, as in the unconscious perception of pattern-masked words in the Marcel experiment.

Certainly, there is nothing wrong with the assertion that a PDF computer like the brain can act as a serial machine when occasion demands, since the computing ability of Turing machines is not tied to any particular hardware. But a real problem is this: who/what focuses our attention? According to Posner, a central processing unit switches attention on or off (Posner and Klein, 1973). By invoking a central processing unit to switch attention on or off, Posner can invoke either selective serial processing of nonselective parallel processing. Unfortunately, this raises the paradox of the homunculus, as discussed earlier.

Suppose, on the other hand, that when somebody sees a pattern-masked word that has two possible meanings, the brain-mind becomes a quantum coherent superposition of two states, each state carrying one of the two meanings of the word. This assumption can explain both sets of Marcel data - both conscious and unconscious perception - without invoking a central processing unit.

The quantum mechanical interpretation of the unmasked congruent case is that the contextual word HAND projects out of the dichotomic word PALM (a coherent superposition) the state corresponding to the “hand” meaning (that is, the wave function collapses with the choice of the “hand” meaning only). Since this state has a large overlap (positive associations are expressed in quantum mechanics as large overlaps of meaning between two states) with the state corresponding to the final word WRIST, the recognition of WRIST is facilitated.

Similarly, in the quantum model description of the unmasked incongruent case, the contextual word TREE projects out the state with the “tree” meaning of the coherent superposition state PALM, the overlap of meaning between TREE and WRIST is small, hence the inhibition. However, in the pattern-masked case, both congruent and incongruent, PALM is unconsciously perceived and therefore there is no projection of any particular meaning, no collapse of the coherent superposition, and hence there are equal recognition times.Notice that in this model, awareness plays a role similar to the role of attention in the Posner model. But a central processing unit is not needed since in a conscious perception collapse and awareness of the collapsed object arises simultaneously and self-referentially with the conscious choice of one meaning.

More detailed calculations (McCarthy & Goswami, 1993) have demonstrated the quantitative superiority of the quantum model over the cognitive model of Posner, which is not a satisfactory model anyway because it trades one paradox for another.

The quantum model also predicts interference effects unique to quantum mechanics in word-sense disamibuation experiments involved with two polysemous words with both conscious and unconscious perception (see McCarthy & Goswami, 1993).

## The Paradox of nonlocality

There are some superficial similarities between the description of self in quantum functionalism given here and that proposed by operationalism (Denett, 1991). Both descriptions tend to negate the efficacy of the self at the local ego level or the self as the watcher of the Cartesian theater; in that they are similar to the view of deconstructionists (Derrida, 1990).

However, as we begin to deconstruct the ego-self, the difference between the two approaches begins to appear. For the operationalist, the deconstruction leads to annihilation of experience itself. All that is left is material and mechanism. But for quantum functionalism, the deconstrution enlarges our identity to a nonlocal, transpersonal one. It is, of course, the retrospection of these, admittedly rare, nonlocal experiences that convince some of us that consciousness is not merely local, merely confined to the brain-mind, that we are the whole world in some sense. Thus the most important experimental test of quantum functionalism lies in the verification of nonlocality of the brain-mind.

The impossible paradox of consciousness for cognitive models I nonlocality. As Richard Feynman has pointed out, a classical computer can never simulate nonlocality. If nonlocality of consciousness is a necessary aspect of consciousness, cognitive models will never be able to explain consciousness.

Yet the nonlocality of consciousness seems to follow even from a simple consideration (Robinson, 1984) of the paradox of perception already introduced. We cannot "perceive" an object supposedly "out there" without the intermediary of a mental image in our head. The representation we actually see is a theoretical image as opposed to the object itself. About the object, we can form a consensus based on our individual theoretical images.

It is not useful to deny that there is a consensus reality external to us. It is also impossible to deny that the theoretical mental picture is all we really see in any case of perception. So what is really "real"? The theoretical image with which we have immediate relationship or the empirical object about which we can form a consensus?

This is, of course, the old idealism versus realism debate. The debate is further intensified when we realize that the other people with whom we collaborate to form a consensus are also ultimately knowable to us only through a theoretical image that nobody else can share. And we know that sometimes these theoretical images are illusory. So a consensus formed from collaboration with my theoretical images, which are sometimes illusory, doesn't seem very reliable.

But there is a simple solution to the paradox due to Leibnitz and Russell.

Suppose both pictures of an object - theoretical image and empirical object - are correct. Suppose we have two heads. A big head which encompasses all objects, so that all perception consists of theoretical images of this big head. And a small head for which the empirical objects are outside, so small heads can form a consensus about them. Behold: The idea of a big head is not absurd when we recognize it as nonlocal consciousness (Goswami, 1993). In the nonlocal consciousness, all objects are “inside” and theoretical. But when the nonlocal consciousness self-referentially expresses itself in a brain-mind and looks at the world through local signals, the world seems objective and outside it. No paradox and no solipsism either. If others are self-referential manifestations of the same nonlocal consciousness, I don’t need to worry about their causal efficacy vis-à-vis mine.

But if monistic idealism is the correct philosophy, then what happens to realist science and all its success? The answer is that realist science (for example, the cognitive science/classical functionalism model of mentation) is valid in the limit of complete conditioning of the brain-mind. Mitchell and Goswami (1993) have proposed that the quantum equation of motion be modified for a self-referential quantum system (such as in the brain-mind) to incorporate the nonlinearity represented by the effect of measurement on the system. In the case of the brain-mind, measurement entails experience, and its effect on the wave functionsis to condition them; that is, the probabilities become biased in favor of those states that have been conditioned as already mentioned. Thus these authors have demonstrated that classical behavior pertains in the limit of infinite conditioning. In this correspondence limit, realist behavioral science holds.

The big question, of course, is whether there is any experimental evidence for the nonlocality of consciousness. The famous Aspect experiment (Aspect *et al*., 1982), where the Einstein-Podolsky-Rosen nonlocal correlation between two photons is measured, also verifies the nonlocality of consciousness within the context of the idealist interpretation of quantum mechanics (Goswami, 1989).

Can one directly verify EPR correlations in the brain-mind and hence the nonlocality of our consciousness? Great progress has been made toward this end by Grinberg-Zylberbaum and his collaborators. To these experiments we now turn.

In 1935, three renowned physucustsm Albert Einstein, Boris Podolsky, and Nathan Rosen (1935), published an article in which they criticized quantum mechanics, claiming that if it were complete a complete model of reality, then nonlocal interactions between particles had to exist. Since that was deemed inconsistent with the theory of relativity, quantum mechanics had to be either wrong or at least incomplete. This critique is known as the Eisnten-Podolsky-Rosen (EPR) Paradox.

For almost half a century, the EPR paradox remained without experimental tests until Aspect *et al.* (1982) experimentally verified that a nonlocal correlation between particles indeed exists once these particles have interacted. Since nonlocality can never be simulated by a classical system (Feynman, 1982), EPR nonlocality can be used to test the explicit quantum nature of systems.

There is now evidence that EPR correlation ocurrs in the human brain. The crucial step was to develop a methodology, a protocol, capable of correlating a pair of human subjects (brains). In their first attempt, Grinberg-Zylberbaum *et al*. (1978) recorded the EEG activity of a senior psychotherapist and his patients during therapeutic sessions. Video and sound recordings were also made. A group of experts analyzed the sound and video recordings and quantified the degree of communication through the sessions using a communication scale from a value of 0 (no communication) to 10 (highest intensity of empathic communication). Another group of technicians, without knowledge of this group, analyzed the EEG recordings and calculated both individual interhemispheric correlation and the degree of intersubject (between therapist and patient) EEG correlations. A direct correlation was found between the degree of communication and the coherence of the EEG of the therapist-patient pairs. Also the changes of interhemispheric correlation in each individual brain were found to correspond to the degree of communication.

However, EEG recordings are difficult to make when subjects communicate verbally because of movement. It is well-known that meditation produces increases in interhemispheric correlations in a subject's EEG recordings (Orme-Johnson *et al*., (1982); Grinberg-Zylberbaum & Ramos, 1987) tried subjects meditating together and looked for both interhemispheric and intersubject correlations of the EEG recordings. In this experiment subjects also pushed a button signaling the moment at which they felt "direct communication." The researchers found that both the individual patterns of interhemispheric correlations and the overall averages of the interhemispheric correlations of the two brains become very similar during shared meditation with direct communication established. Using control experiments, they checked that the similarity of the EEG patterns is not due to fatigue or habituation but really reflected a specific pattern of correlation for each pair. Subsequent experiments demonstrated that this direct communication could be maintained, as shown by the similarity of their EEG traces, even when the subjects were separated.

The possibility of the existence of a nonlocal transference of specific stimuli, such as those that generate evoked potentials (electrophysiological brain responses produced by a sensory stimulus), was first studied by Grinberg-Zylberbaum *et al*. (1989). They observed that an evoked potential in a stimulated subject is “transferred” to another subject once they have interacted to achieve a level of “direct nonlocal communication.” This study was conducted in two Faraday chambers separated by a distance of approximately three meters. Later the experiment was repeated, replicating the former experiment at a larger distance (14.5 meters). In both experiments, the following protocol, suggested by the earlier experiments cited above, was used:

1: Two subjects meditated side by side inside one of the Faraday chambers for twenty minutes with the objective of reaching direct communication.

2. A mild signal was then given to the subjects at which time one of them went to the second Faraday cage and took a reclining position with eyes closed while they both continued to maintain direct communication. The subject that stayed behind was now stimulated (generally by 100 light flashes given a random intervals), but the other subject was not stimulated, nor did he have knowledge that a stimulus was being received bay the first subject.

EEG recordings were made from the brains of both subjects synchronized with the stimulus given to one of them. The recordings were averaged over the hundred samples and compared using on-line computers. Low frequency filters were used to eliminate low frequency EEG correspondence such as alpha waves. At both distances, when the stimulated subject showed distinct evoked potentials, the non-stimulated subject showed “transferred potentials” similar to those evoked in the stimulated subject. Control subjects showed no such transferred potentials.

The results indicate that after an interaction between two human beings, in which both feel each other’s presence even at a distance, and when one of them is stimulated in such a way that his/her brain responds clearly (with a distinct evoked potential), in roughly 1 in 4 cases the brain of the non-stimulated subject will also react and show Transferred Potentials of a similar morphology. Control experiments show that the transferred potentials do not occur when interaction between the subjects does not take place, or when the interaction isn't deemed successful (in establishing direct communication) by the subjects themselves, or when the evoked potential is unclear.

These findings indicate that the human brain is capable of establishing relationships with other brains (when it interacts with them appropriately) and sustaining such correlations even at a distance. Our results cannot be explained as due to sensory communication between subjects (since these were separated during the experiment and located in two semi-silent, electromagnetically isolated chambers distant more than 14 meters from one another in one case) or as due to low frequency EEG correspondence.

This means that neither sensori stimuli nor electromanetic signals may be the means of communication. This point is further borne out by the fact that we have not seen any distance attenuation of the transference effect compared to our previous measurement, which involved a shorter distance between the subjects. As is well-known, local signals are always attenuated and the absence of attenuation is a sure signature of nonlocality of the observed correlation between brains.

According to Bell's theorem (Bell, 1965) and to the results of Aspect's experiments (Aspect *et al.*, 1982) on correlated photons, the transferred potential could be interpreted as a manifestation of nonlocal interactions among "members" of a correlated quantum system whose parts, separated individuals before interaction, become one system after interaction. Via the interaction, the quantum brains of the subjects become correlated; stimulation and observation of one subject collapses the wave function of both in identical states as indicated by the similarity of the distinct evoked potential in the stimulated subject to the transferred potential in his nonstimulated partner.

In other words, it can be concluded that the phenomenon we are dealing with is the action of nonlocal collapse of the wave function of a unified system and not the result of a local transmission from one brain to the other.

It is also extremely significant that the occurrence of a transferred potential is always associated with the participants' feeling that their interaction has been successfully completed. The interaction that correlates the subjects under study is entirely an interaction of nonlocal consciousness. This indicates that consciousness is involved in the process of correlation, and thus the idealist interpretation that a nonlocal consciousness collapses the quantum wave function upon measurement also makes sense. Thus these experiments are also providing important evidence that a solution of the quantum measurement problem has been achieved in the work of Goswami (1989).

As mentioned above, the transferred potentials appear only in one in four pairs of correlated subjects on the average, but when they do, they can be replicated. For one pair of subjects, Grinberg-Zylberbaum *et al*. (1993), working with the 3.5 m separation of Faraday chambers, replicated the transferred potential experiment on four different occasions, separated by several days. A clear average transferred potential was obtained.

**Summary and Conclusions**

This paper is a response to operationalism in dealing with consciousness in cognitive science. Operationalists see the paradoxes of classical functionalist cognitive science clearly, but they tend to ignore the issues rather than to resolve them. We have shown that a genuine solution of the mind-brain paradoxes is the same one as that of quantum paradoxes. It is to invoke the ontology of monistic idealism and to build a cognitive science based on this ontology. The postulate of a quantum component in the brain along with the familiar classical apparatuses is an important ingredient of this theory of quantum functionalism.

We have shown that quantum functionalism successfully resolves the paradoxes of brain-mind identity, the paradox of self-reference, the color-phi phenomenon, Libet’s series of paradoxical experiments, the paradoxes of qualia and the unity of experience, the paradox of unconscious perception, and the paradox of nonlocality. Throughout we have emphasized the explanation of experimental data. A recent experiment which may be demonstrating quantum nonlocality in the brain directly is discussed in some detail.

Two major questions remain. Can we isolate the quantum system in the brain to directly validate its existence? A major problem here is the one that Niels Bohr perceived long ago in connection with complementary measurements. It is impossible to study life separately from the living organism. Similarly, it may be impossible to study consciousness and the quantum system it collapses separately from the measurement apparatuses.

Second important open question is implied by the phraseology used to describe our theory - quantum functionalism. If the theory is really a functionalism, then we may hope that self-reference in this fashion can manifest not only in the brain-mind but also in other systems. In particular, the idea of building a nonorganic “Quantum computer” - classical measurement apparatus combination that manifests self-reference is an interesting one to pursue.

To close, we want to emphasize that the idealist quantum functionalist approach does not negate the conventional cognitive research by virtue of the correspondence principle. Classical functionalism remains useful in the limit of infinite conditioning. However, the adoption of an idealist ontology and quantum functionalist framework will enlarge the domain of cognitive science to truly subjective phenomenta such as thinking, and willing without compromising their efficacy. This will also make the job of connecting to neurophysiology much simpler and unequivocal.

We wish to thank Maggie Goswami for a careful editing of the manuscript. This work was partially funded by Grant IN 502592 an IN 503693 of DGAPA-UNAM awarded to J. Grinberg-Zylberbaum.

**To the esteemed Dr. Goswami Colleague, the late Professor Jacobo Grinberg Zylberbaum .**

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**How to cite this Article:** Amit Goswami, A., & Grinberg-Zylberbaum, J. (2015). Consciousness and Cognition: Is Consciousness Confined in the Brain? *International Journal of Psychology and Neuroscience*, *1* (1), 135-183.
**Received:** 02/Jun/2014**; Revised:** 09/Jul/2014**; Accepted:** 15/Jul/2014; **Published online**: 17/Jun/2015 **ISSN 2183-5829**