 Mind & Matter Vol. 8(1), pp. 93–121

On the Quest of Defining Consciousness

Ram Lakhan Pandey Vimal
Vision Research Institute, Acton, USA
and
Dristi Anusandhana Sansthana, Gujrat, India

Abstract

About forty meanings attributed to the term *consciousness* can be identified and categorized based on *functions* and *experiences*. The prospects for reaching any single, agreed-upon, theory-independent definition of consciousness appear remote. Here, the goal is to search for a theory-dependent *optimal* (with the least number of problems) and *general* definition accommodating most views. This quest is mostly based on the premise that evolution must have optimized our mental system in terms of experience and function.

Based on a dual-aspect dual-mode proto-experience/subjective experience *optimal* framework, an *optimal* definition of consciousness describes it as *a mental aspect of a system or a process with two sub-aspects: conscious experience and conscious function*. A more *general* definition describes consciousness as *a mental aspect of a system or a process, which is a conscious experience, a conscious function, or both, depending on contexts and particular biases (e.g. metaphysical assumptions)*. Both experiences and functions can be conscious and/or non-conscious. Our definitions are *a posteriori* insofar as they are based on observation and categorization.

1. Introduction

In previous work (Vimal 2009e), over forty meanings (or aspects[1]) attributed to the term *consciousness* were extracted from the literature and from online discussion groups. Some of them overlapped and some were mutually exclusive, but certainly the list was in no way exhaustive. These meanings were categorized according to two groups: *mental function* and *mental experience*.[2]

[1]Here, the term "aspect" refers to "a way in which a thing may be viewed or regarded; interpretation; view; meaning (`dictionary.reference.com`). Examples: subjective experience aspect of consciousness, functional aspect of consciousness". The terms "aspect" and "meaning" are used interchangeably.

[2]Experiences are related to the subjective first-person perspective and functions are related to the objective third-person perspective. The distinction of conscious entities into conscious experience and conscious function would involve "function" as being understood either causally or teleologically. Functionalism in the philosophy of mind understands mental states as causal functional states (states that do something and

A specification of the meaning(s) of consciousness in each particular investigation is certainly needed to avoid confusion. However, the quest for *optimal* and *general* definitions of consciousness is also desirable. Optimality indicates a definition that has the least number of problems, and generality indicates that the definition can accommodate most views. Optimal and general definitions of consciousness can guide us to design subjective (first-person) and objective (third-person) experiments and to investigate, at least theoretically, the links between structure, function and experience.

For the purpose of arriving at an optimal and general definition of consciousness, with qualia as a related issue, I used all kinds of information available to me including metaphysics of consciousness, conceptual analysis, philosophy of science, neuroscience, psychophysics, and physics. The corresponding attempt goes beyond my previous work (Vimal 2009e), where I simply tried to categorize about forty definitions of consciousness from various sources. Now I try to analyze or synthesize them for a general definition. Based on this, future experimental and theoretical research on consciousness (from both Western and Eastern perspectives) can be designed in a better way.

The background information needed in search of definitions of consciousness is given in Sections 1.1 and 1.2. There are many metaphysical views related to consciousness (see Chalmers 2003, and Vimal 2008b, 2009e). Section 1.1 addresses the particular problems of each view in order to allow us to identify the view with the least number of problems required for an optimal framework. It is proposed that this view is the dual-aspect dual-mode protoexperience-subjective experience (PE-SE) framework (Bruzzo and Vimal 2007, MacGregor and Vimal 2008, Vimal 2008a, 2008b, 2009c, 2009g, 2009h, 2009i, 2009j, 2010a, Vimal and Davia 2008).

In this framework, every entity has dual aspects (material and mental). Its only problem is that these dual aspects are considered to be a brute fact. This can be justified by regarding SEs as irreducible, fundamental and inherent in normal mental states of awake subjects.[3] In Section 1.2, the PE-SE framework is concisely described.

Section 2 presents the main topic of the article, where I develop the *optimal* definition of consciousness, which is then extended to a *general* definition. This effort leads to a qualification in terms of contexts and

are defined by their causes and effects). But there are some philosophers who understand mental states as goal-directed. For example, Millikan (1989) and Papineau (1993a, 1993b) regard mental states as being purposeful and selected for by evolutionary pressures. In my view, the term "function" could refer to either causal functions or teleological functions, depending on the context.

[3]In so-called *samadhi* states, one might hypothesize that SEs are reducible (Vimal 2009b).

particular biases (e.g., metaphysical assumptions).[4] Concise comments on qualia and their definition follow. In Section 3, I summarize my quest for the definition of consciousness and qualia.

1.1 Various Views on the Metaphysics of Consciousness, Conceptual Analysis, and Philosophy of Science

1.1.1 Materialism/Emergentism

In materialism, a specific experience (such as the SE of redness) is assumed to be *identical with* a specific state (the redness-related state induced by corresponding wavelengths) of a specific neural network (the red-green V4/V8/V0 neural net); cf. Levin (2006, 2008), Loar (1990, 1997), Papineau (2006). In emergentism, subjective experiences (qualia) are assumed to mysteriously emerge from relevant states of neural nets.[5]

A major problem is Levine's explanatory gap (Levine 1983):[6] the gap between experiences and scientific descriptions of those experiences (Vimal 2008b). In other words, how can our experiences *emerge* (or arise) from non-experiential matter such as neural networks of our brain or organism-environment interactions?

In a framework proposed by Globus (2005, 2007), one always finds oneself already amidst a world of colors, sounds, and so on. Experience is superfluous, a manner of speaking grounded in dualistic metaphysics, a separation between experience and thing. Thus, this framework seems to eliminate SEs and hence bypasses the explanatory gap of materialism. However, if one finds the reduction or elimination of SEs problematic, then the problem remains.

Furthermore, materialism/emergentism has three additional assumptions (Skrbina (2009a): Matter is regarded as the ultimate reality, and material reality is essentially objective and non-experiential. These assumptions need justification.

1.1.2 Substance Dualism

Substance dualism goes back to Descartes' ideas about *res extensa* (matter) and *res cogitans* (mind). Let me point out five of its problems.

[4] The notion of a "context" has to be understood in its common linguistic meaning, as the natural-biological-psychological-social-cultural environment in which (where and when) an utterance is made.

[5] According to Carruthers (personal communication), very few materialists endorse a brute identity claim. Most are reductive representationalists of one sort or another. However, the contextual emergence of higher-level stable mental states from lower-level neurodynamics is a non-reductive framework (in analogy to temperature as an emergent property), where contingent contextual conditions are necessary (Atmanspacher 2007).

[6] Levine's argument is formulated in the context of the philosophy of science. But what is the impact of a problem in a scientific description for a metaphysical view? Is science relevant to metaphysics? Why? The interrelation between metaphysical and descriptive arguments is intricate and difficult.

(i) Association or mind-brain interaction problem: How does the non-material mind interact with the non-experiential brain? For example, how can we associate the experience of redness with red-green cells of a V4/V8/V0 neural net?[7] This problem is due to an unexplained epistemic gap: How is the relation established from mental redness to material V4/V8/V0 neural net activity (and *vice versa*). Furthermore, if nature has two distinct aspects, namely mind and matter, how can these distinct aspects of nature ever interact (Stapp 2009)?

(ii) Problem of mental causation: How can a mental cause give rise to a behavioral effect without the violation of basic assumptions about the physical world (conservation of energy and momentum, etc.)?

(iii) "Zombie" problem: Dualism "allows us to subtract the mind from the brain while leaving the brain completely intact. This possibility implies an 'epiphenomenalism' that claims that mind does not matter, that it makes no difference what happens in the world, because it does not cause behavior. My zombie twin behaves just like me but it has no mind at all" (Eerikäinen 2000).

(iv) The "ghost" problem is the converse of the "zombie" problem. If the mind is separate from the body, then not only can the brain exist without the mind but also the mind can exist without the brain. Thus, the so-called "disembodiment" becomes a real possibility" (Eerikäinen 2000). Nunn argues (personal communication) that the evidence for the occurrence of apparently disembodied states is actually quite strong, for example in near-death experiences (Blackmore 1996, French 2005). If this is true then the "ghost" may not be a problem. However, one could argue that although there is some evidence for states that *appear* to be disembodied, this is different from *evidence* for disembodiment. Subjective experiences may be illusory.[8]

(v) Problem of many-to-one or many-to-many relations: Interactionism in substance dualism is not favorable to neurophysiological tests because it entails many-to-one or even many-to-many relations between mental and brain states (Feigl 1967).

1.1.3 Idealism

The problem of idealism is the opposite of that of materialism and emergentism: How can non-experiential matter such as neural networks of

[7]The color area V4/V8/V0 refers to visual area V4 (Bartels and Zeki 2000), visual area V8 (Hadjikhani *et al.* 1998, Tootell *et al.* 2003), and V0 (Wandell 1999).

[8]Moreover, according to Klemenc-Ketis *et al.* (2010), higher partial pressure of carbon dioxide in arterial blood is important in the provoking of near-death experiences and higher serum levels of potassium might also be important. Additional factors are anoxia, hypercapnia, and the presence of endorphins, ketamine, and serotonin, or abnormal activity of the temporal lobes or the limbic system. Near-death experiences are psychologically explained as a way of dissociation, depersonalization, reactivation of birth memories, and regression.

our brain emerge from non-material conscious experiences? This problem was already discussed by Kant (1929). Stapp's framework is somewhat close to idealism at an ontological level: "orthodox quantum mechanics is Cartesian dualistic at the pragmatic/operational level, but mentalistic on the ontological level" (Stapp 2009).

1.1.4 Panpsychism

Skrbina (2005, pp. 255-265) discusses many sources of problems for panpsychism, covering some 25 problems in total – which reduce to six core problems. In addition, Globus (2009) raises the "restricted panpsychism problem". Some of these problems might also be relevant for panprotopsychism (Chalmers 2003), panexperientialism and panprotoexperientialism.[9] The relevant problems are as follows:

(i) Combination problem: This problem refers to the question of "how low-level proto-experiential and other properties somehow together *constitute* our complex unified conscious experiences" (Seager 1995), i.e., how a specific SE can *emerge* from the PEs of constituent elements in a related neural net (Vimal 2009i, 2009j).[10] In other words, "sub-minds, such as those of atoms, cannot be conceived to combine or sum into complex, unified minds such as humans have. Hence panpsychism is not an adequate account of mind" (Skrbina 2005, p. 265).

(ii) Verification problem: According to Seager (1995), "there is no evidence whatsoever of a nonphysical (nonmaterial) dimension to the elemental units of nature"[11] and there is no "sign" of mentality in the basic features of the world. In other words, there are "no 'new facts' or empirical basis on which to evaluate the panpsychist claim. ... This includes the assumption that non-verifiable theories are invalid in some fundamental sense" (Skrbina 2005, p. 265). However, Nunn (personal communication) argues that this is simply not true. Quantum counterfactuals (e.g., the bomb test due to Elitzur and Vaidman (1993)) show that what might be termed *knowledge* is built into the foundations of physics.

A related problem, the *completeness problem*, is that an inert system should also exhibit a causal power of proto-experiences, which is not the case (Seager 1995, Vimal 2009j). However, Nunn (personal communication) argues that the assumption of the causal completeness of the physical can only be justified if causation is confined to efficient (sponta-

[9] More information can be found at `en.wikipedia.org/wiki/Panpsychism`.

[10] As explained in detail by Vimal (2009h,i), some dual-aspect PE-SE frameworks yield dual-aspect panpsychist theories but others do not.

[11] In panpsychism, "all things have a mind, or a mind-like quality" (Skrbina 2003). In general, there are panpsychists with a dual-aspect view (substance monism but property dualism; Skrbina 2009a), panpsychist dualists, functionalists, identity theorists, reductive materialists, and so on (Skrbina 2005). Thus, panpsychism, in general, seems to be attached to the existence of non-material dimensions in addition to material dimensions.

neous or chance) causation. It is unjustified otherwise, as Stapp (2009, 2010) and Primas (2002, 2003) have shown with their "Heisenberg choice" arguments.

(iii) Inconclusive analogy or not-mental problem: "The purported analogical basis between humans and other objects is groundless" (Skrbina 2005, p. 265). The similar "not-mental" problem (Seager 1995) is "identifying the conjectured 'inner nature' of, say, an atom with something we can reasonably call mental" (Skrbina 2005, pp. 262–263).

(iv) Physical emergence problem: "Emergence is in fact possible because we see it in other realms of the physical world; mind is not ontologically unique; hence emergence of mind *is* conceivable" (Skrbina 2005, p. 265). A related problem is the *unconscious mentality problem*, which is "accepting the mentality of the elemental units of mind while denying that they are actually conscious experiences" (Seager 1995). In other words, "how can consciousness emerge from unconsciousness?" (Skrbina 2005, p. 262–263).

(v) Implausibility problem: "Panpsychism is so implausible and counterintuitive that it cannot be true. Also known as the *reductio ad absurdum* objection" (Skrbina 2005, p. 265).

(vi) Eternal mystery problem: "Mind-body problem is unsolvable in principle, and hence panpsychism, which purports to offer a solution, must be false" (Skrbina 2005, p. 265).

(vii) Restricted panpsychism problem: "Quantum thermofield dynamics does in fact prescribe a lower boundary below which there can be no cooperative dynamics, and without cooperative dynamics there is nothing mind-like ... If qualia were tied to the coherence of cooperative dynamics, then the descent into panpsychism would halt at the coherence length [of about 50 microns]" (Globus 2009).

A possible solution to the problems of most views above is addressed in the dual-aspect dual-mode PE-SE framework (Vimal 2008b, 2010a). It will be concisely described below.

1.2 Dual-Aspect Dual-Mode PE-SE Framework

This section is a summary of previous work (Vimal 2008b, 2009j, 2010a) where additional details can be found. There are three entities that need to be linked in a theory of consciousness: structure, function, and experience. Several materialist neuroscience models link structure with function well, but fail to link them with experience, thus leading to the explanatory gap addressed in Sec. 1.1.1. The dual-aspect dual-mode PE-SE framework extends neuroscience models by linking a specific conscious experience (e.g. of redness) to a specific state (related to long wavelengths) of a specific material structure (the V4/V8/V0 neural net) with specific functions (such as detection, discrimination, and recognition of red color).

1.2.1 Hypotheses for PEs and SEs

Addressing the explanatory gap mentioned above, Vimal (2008b) hypothesized that elementary particles (fermions and bosons) have two aspects: (i) a material aspect characterized by mass, spin, charge, force, quanta, and space-time, and (ii) a mental aspect. Its components (the mental aspects of elementary particles and inert matter) are considered as the carriers of superimposed fundamental experiences in unexpressed form. The superposition of multiple possible experiences is based on the dual aspects wave/particle of matter, where the mental aspect of the wave aspect is a wave-like function of experience. These possibilities are actualized when neural networks are formed via neural Darwinism, and a specific SE is selected by a matching process. For example, the SE of redness would never be selected and experienced without the formation of the redness-related V4/V8/V0 neural network. The "brute fact" of dual aspects is motivated because SEs appear fundamental, inherent, and irreducible in normal waking states of mind-brain systems.

Three competing hypotheses have been proposed for the dual-aspect dual-mode PE-SE framework (Vimal 2009j). As proto-experiences, PEs are precursors of SEs (to be defined below). They can be *superposition-based* (hypothesis H_1), *superposition-then-integration-based* (hypothesis H_2), or *integration-based without superposition* (hypothesis H_3).

Under H_1, the fundamental entities of inert matter are the carriers of superimposed fundamental SEs and PEs. In H_2, the fundamental entities of inert matter are the carriers of superimposed fundamental PEs (not SEs) which are integrated by neural Darwinism (co-evolution, co-development, and sensorimotor co-tuning by the evolutionary process of adaptation and natural selection). PEs are attached to every level of evolution (atomic PE, molecular PE, genetic PE, bacterial PE, neural PE).

Under H_3, an elementary particle has its own elementary-particle-PE. Matter is not a carrier of PEs in superposed form as in H_2, rather it is a PE entity and has two aspects at every level. H_3 is a dual-aspect panpsychism because the mental aspect occurs at all entities at all levels, even though conscious SEs only emerge when PEs are integrated.

Under H_1, a specific SE arises in a neural net as follows: (i) there exists a virtual reservoir that stores all possible fundamental SEs/PEs, (ii) the interaction of stimulus-dependent feed-forward and feedback signals in the neural net creates a specific neural net state, (iii) this specific state is assigned to a specific SE from the virtual reservoir due to neural Darwinism, (iv) this specific SE is embedded as a memory trace of a neural net PE, and (v) when a specific stimulus is presented to the neural net, the associated specific SE is selected by the matching and selection process and experienced by this net.

Under hypotheses H_2 and H_3, a specific SE emerges in a neural net from the interaction of its constituent neural PEs, such as in feed-forward stimulus-dependent neural signals and fronto-parietal feedback attentional signals. Under all hypotheses, SEs occur when essential ingredients of SEs are satisfied (Vimal 2009g). One could argue that the PE-SE framework with hypotheses H_1 and H_2 resembles a dual-aspect naturalism or non-reductive physicalism.

A SE is an *expressed* first-person conscious experience that occurs, arises, emerges due to the interaction between feed-forward signals and feedback signals in a neural net. This requires that the interaction satisfies the necessary ingredients of consciousness (Vimal 2009g) such as the formation of neural networks, wakefulness, re-entry, attention, working memory (Rowlatt 2009), stimulus above threshold, and neural net PEs.

This is perhaps related to first-order, phenomenal, or access (reportable) consciousness and experienced by the specific neural network. For example, the V4/V8/V0 neural net experiences the color of, say, a red tomato. For phenomenal consciousness, feedback attentional signals are not necessary and do not get time to become active (Block 2005, Lamme 2003, Vimal 2009g). Phenomenal consciousness, presumably occurring during less than 50 msec stimulus presentation such as in Sperling type experiments (Sperling 1960), is not reportable. The temporal-lobe system might be included in the neural correlates of phenomenal/access consciousness (Carruthers 2007, Glover 2004, Milner, and Goodale 1995).[12]

When the self or I is explicitly involved, as in "I saw a red tomato", self-related neural networks (Bruzzo and Vimal 2007) such as cortical midline structures (Northoff and Bermpohl 2004, Northoff *et al.* 2006) might interact with the above feed-forward and feedback signals. This may also be the case for inner-sense awareness (Armstrong 1993, Lycan 1996), self-awareness (Perrett 2003), awareness via diagonal representation (Prosser 2007), or higher-order types of awareness (Carruthers 2000, 2007, Dennett 1991, Rosenthal 2009, Kriegel and Williford 2006, Van Gulick 2004) such as "I am aware that I saw a red tomato". Further research is needed to test these hypotheses.

In general, PEs are precursors of SEs. Under hypothesis H_1, PEs are precursors of SEs in the sense that PEs are superposed SEs in unexpressed form in the mental aspect of every entity from which a specific SE is selected. Under hypotheses H_2 and H_3, PEs are precursors of SEs in the

[12]In the temporal lobe system, Kosslyn (1994) envisages a complex interaction between incoming non-conceptual information and conceptual templates, the result of which may be (consciously) seeing a tomato as a tomato and not just a red sphere (Carruthers, personal communication). Some authors include the interactions of feedback (attentional) signals with feed-forward signals in phenomenal consciousness. In this article, the attentional feedback interactions are considered to be part of access consciousness, not phenomenal consciousness.

sense that SEs somehow arise or emerge from PEs, as elaborated above (cf. Vimal 2009h, 2009i,j).

1.2.2 Extension to Dual Modes

The dual-mode concept was originally formulated in the framework of dissipative thermofield quantum brain dynamics (Globus 2006, Vitiello 1995) and explicitly incorporated into the PE-SE framework by Vimal (2010a). It does not decrease the degree of parsimony of the original framework, and matching and selection processes are further elaborated.

In the dual-aspect dual-mode PE-SE framework, the two modes are the non-tilde and tilde modes of Vitiello (1995). The non-tilde mode is interpreted as the material and mental aspect of cognition (memory and attention) related feedback signals in a neural network. Since memory contains past information, the non-tilde mode represents the cognitively nearest past approaching towards the present. The tilde mode is interpreted as the material and mental aspect of the feed-forward signals due to external environmental input or internal endogenous input. Since input signals contain information related to the near future, the tilde mode represents the nearest future approaching towards the present. It is a time-reversed, or entropy-reversed, representation of the non-tilde mode. In thermofield dissipative quantum brain dynamics (Globus 2006, Vitiello 1995), entropy is related to time.

One can argue that there are at least five options for pathways of information transfer in brain dynamics: (i) quantum dendritic-dendritic microtubule (MT) pathway (dendritic webs), (ii) classical axonal-dendritic neural pathway, (iii) calcium-related astro-glial-neural pathway, (iv) extracellular volume transmission and extrasynaptic signal transmission (Vimal 2010a), and (v) soliton propagation.

Furthermore, there are two types of matching mechanisms: the matching mechanism for the quantum dendritic-dendritic MT pathway (i), and the matching mechanism for classical pathways (ii)-(v). We propose that (a) the quantum conjugate matching between experiences in the mental aspect of the tilde mode and the mental aspect of the non-tilde mode is related mostly to the mental aspect of the quantum MT-dendritic-web (i). And we propose that (b) the classical matching between experiences in the mental aspect of the tilde mode and in the mental aspect of the non-tilde mode is related to the mental aspect of the remaining non-quantum pathways (ii)-(v).

In all cases, a specific SE is selected under two conditions: (a) the tilde mode (the material and mental aspect of feed-forward input signals) interacts with the non-tilde mode (the material and mental aspect of cognitive feedback signals) to match for a specific SE; and (b) the necessary ingredients of SEs are satisfied. When the match is made between the two modes, the *world-presence (Now)* is disclosed. Its content is the SE

of the subject (self), the SE of objects, and the contents of these SEs. The material aspects in the tilde mode and in the non-tilde mode are matched to link structure with function, whereas the mental aspects in the tilde mode and in the non-tilde mode are matched to link experience with structure and function.

Since a specific state of a system is correlated with a specific SE, one could argue that the (quantum) superposition of states in the material aspect of the system is correlated with the superposition of respective SEs in the system's mental aspect. The occurrence of the SE aspect of consciousness may be determined by two steps. The first step is the (quantum conjugate) matching of SEs (and/or qualia) superposed in the stimulus (such as long wavelength light) with SEs superposed in a neural net (such as the red-green V4/V8/V0 neural net). The second step then is the selection of a specific experience (such as redness) that is correlated to a specific state (such as the redness-related state) of the neural net.[13]

One could object that strings or elementary particles are not specific to any SE/PE – to prove that they (and all inert matter) are carriers of SEs/PEs would require extraordinary evidence, given that the particle interactions occur on scales that are many orders of magnitude smaller than the scales of chemical events that characterize brain function.

However, the evidence is that all matter behaves as if it were non-experiential. This behavior is consistent with methodological assumptions on which all our physical science is based. Only when a neural network is formed, and when this network satisfies the necessary ingredients of experiences, has it a specific experience via matching and selection mechanisms (e.g., the V4/V8/V0 neural network for color).

Moreover, there is evidence that experiences are irreducible, fundamental and inherent. For example, one cannot reduce redness to any other entity of a mind-brain system in its normal wakeful state. Our hypothesis is that all experiences are superposed in the mental aspect of matter in unexpressed form. In the absence of the necessary conditions for the occurrence of conscious experiences matter behaves as if it is non-experiential. Other critiques and responses can be found in Vimal (2010a).

Summarizing, the dual-mode dual-aspect PE-SE framework has fewer problems (such as the justifiable "brute fact" of dual-aspect models) and addresses the problems of other frameworks, including the explanatory gap in materialism.

[13]This resembles a sort of orchestrated objective reduction (OrchOR) for quantum dendritic-dendritic MT pathways à la Hameroff and Penrose (1996). A difference is that the cause of OrchOR is self-collapse. The quantum gravity threshold in microtubules is orchestrated by microtubule-associated proteins and occurs in a MT-network isolated from its environment. The cause of a collapse in the PE-SE framework could depend on environmental stimuli, endogenously generated feed-forward signals, or self-collapse.

2. Definitions of Consciousness

One of the premises for the search of an *optimal* definition of consciousness is that biological evolution should have optimized living systems with the three aspects of structure, function, and experience.[14]

According to the adaptationist view I assume here, any structure should have some function; otherwise, the natural selection of evolution would have selected it out. Nunn (personal communication) recalls a term used by evolutionists for structures that exist only because they are concomitants of something which has a function – namely "spandrels". I am not considering such structures in the following argumentation because spandrels, as Nunn argues, do not have useful functions.

Experience must have some function. Following a large number of philosophers of mind, Nunn argues that this may apply to classes of experience, but not to experience *as such*. For example, natural selection may not have any interest in one's liking of El Greco's pictures. In such special cases, there could be other premises for the quest of an optimal definition of consciousness. For example, one could argue that the experience of "liking" serves appropriate emotion-related functions. Even if an experience indeed does not have any function, it can still be a part of a definition of consciousness because it is a conscious experience.[15]

For consciousness *as such* (Rao 1998), I argue that it is still an experience of *samadhi* (Vimal 2009e). Awareness or consciousness *as such* or pure awareness is a state often reported in mystical experiences by yogis (Rao 1998, 2005). Among them are (i) experiences of the unification (merging) of the observer (*karta* or self) with the observed (*karm* or experiences of observed objects) and the observation (*kriya* or the processing of SEs) (Vimal 2009a,b,c,d,f,h,i), (ii) SEs appearing reducible (Vimal 2009b), and (iii) inner-light experiences in *samadhi* states (Prakash and Caponigro 2009, Prakash *et al.* 2009).

According to Pereira and Ricke (2009, p. 43), "*consciousness is a process that occurs in a subject (the living individual) and the subject has*

[14]For an optimal definition of consciousness (Sec. 2.1) we assume that consciousness has two sub-aspects: conscious experience *and* conscious function. However, for a general definition of consciousness (Sec. 2.2), we relax the *and* to *and/or*: consciousness is a conscious experience, a conscious function, or both, depending on contexts and particular biases (e.g. metaphysical assumptions). Therefore, the general definition does not rule out the views and accounts of those who deny that conscious states must have a function, in particular those who regard the explanation of consciousness as problematic. In other words, the general definition of consciousness tries to accommodate as many views as possible.

[15]One could argue that, although the function of a subject's liking the pictures of El Greco is not clear at the present time, it may have useful function in the future or in another culture. One useful function of a subject's liking the pictures of El Greco would surely be financial security for El Greco. The function of a subject's liking the pictures of El Greco is clearly different from the function of the pictures themselves.

an experience (he/she interacts with the environment, completing action-perception cycles) and the experience has reportable informational content (information patterns embodied in brain activity that can be conveyed by means of voluntary motor activity)." This is an interesting definition for access consciousness, and can be easily extended to capture phenomenal consciousness by including non-reportability (Block 1990, 1992, 1995, 2005, 2007).

2.1 Optimal Definition of Consciousness

The problems listed in Section 1.1 are addressed in the dual-aspect dual-mode PE-SE framework (Vimal 2008b, 2010a), linking structure, function, and experience. This seems to be an optimal framework because it has the least number of problems (Vimal 2010a). In this section, I discuss the possibility of deriving a *definition* of consciousness from this framework that is also optimal.[16] In this framework, every entity has two aspects, material and mental. *The material aspect is composed of structures, whereas the mental aspect is composed of functions and experiences.* As shown recently (Vimal 2009e), "the *functions* and *experiences* together constitute the meanings attributed to the term *consciousness*". This framework is a non-reductive physicalist framework.

Functions are also considered (in addition to experiences) as a component of the mental aspect of an entity. From this simple rationale, one could argue that consciousness can be optimally defined as a mental aspect of an entity (system or process) that has two sub-aspects: conscious experience and conscious function. Conscious experience involves first-person subjective accounts and conscious function involves third-person objective accounts.

For example, the conscious function of the structure of the red-green V4/V8/V0 neural network is the detection and discrimination of colors between red and green. The related conscious experience is a SE in the range between redness and greenness. In this example, consciousness is a mental aspect of a system or a process that has two sub-aspects: redness and greenness as conscious experiences and the detection and discrimination of red from green as conscious functions.

[16] One could argue that the term "optimal" implies that a set of alternatives have been considered and one of them is chosen as the best according to a given set of parameters. However, in the above paragraphs only one alternative is presented and then called "optimal". What are the other options and why is this the optimal one? There are more than forty alternative definitions of consciousness, concisely discussed and tabulated by Vimal (2009e). They all have their problems, partly discussed above in this paper. The definition proposed here has been optimized with respect to all available frameworks in terms of the number of their problems. The only major problem of the PE-SE framework is the "brute fact" of dual aspects. For further details see Vimal (2010a).

An optimal definition in this sense can be related to Block's definition of consciousness distinguishing between phenomenal (non-reportable) consciousness and access (reportable) consciousness (Block 1990, 1992, 1995). For primates, fronto-parietal feedback attentional signals are necessary for access consciousness, whereas attention is not needed for phenomenal consciousness (Vimal 2009g). I argue that each of the phenomenal and access aspects of consciousness can have two sub-aspects: conscious experience, i.e. first-person subjective experience, and conscious function, i.e. third-person objective observations. Each aspect of conscious experience and of conscious function can have components of phenomenal consciousness and of access consciousness.

According to Block (2005), "[p]henomenally conscious content is what differs between experiences as of red and green, whereas access conscious content is content information about which is 'broadcast' in the global workspace". These distinct contents of phenomenal consciousness and access consciousness can be related to different contents of phenomenal and access conscious experiences, respectively, as well as to different contents of relevant phenomenal and access conscious functions. In addition, Block (2007) assumes that "the neural basis of phenomenal consciousness does not include the neural basis of cognitive accessibility". In the PE-SE framework, this translates to the assumption that (Block 2007) "the neural basis of phenomenal conscious experience and phenomenal conscious function does not include the fronto-parietal cognitive and attentional feedback signals".

According to Velmans (2009), "definitions of consciousness need to be sufficiently broad to include all examples of conscious states and sufficiently narrow to exclude entities, events and processes that are not conscious". On the other hand, Skrbina (personal communication) suggests that the term "consciousness", which must include conscious entities such as conscious experiences and conscious functions, should not exclude panpsychism. There seems to be a contradiction between Velmans' and Skrbina's positions with respect to panpsychism. In my view, the conscious aspect of panpsychism (such as in primates) should be included in a definition of consciousness that is composed of conscious experiences and conscious functions.

Nixon (2007) and Pereira and Ricke (2009) argued that experience can occur with and without consciousness. Hence, experiences could be conscious as well as non-conscious, and functions could be conscious as well as non-conscious. The non-conscious aspect of panpsychism (such as in inert matter) should thus be related to non-conscious experiences (or PEs) and non-conscious functions (see also Section 2.5 below).

2.2 Inclusion and Exclusion Criteria for Conscious Experiences and Related Functions

Since my goal is an optimal and general definition of consciousness, all kinds of conscious experiences and conscious functions should be included, and all types of non-conscious experiences and non-conscious functions should be excluded. All (or as many as possible) types of subjective first-person experiences and related functions should be covered, even if the criteria of what counts as conscious are intuitive or pre-theoretic.

Conscious experiences include all types of subjective or first-person experiences including: (i) sensory experiences as redness (Vimal 2009g), (ii) "what exists when there is something that it is like to be that thing" (Nagel 1974), (iii) phenomenal experience (Chalmers 1996), (iv) reportable content experienced by individuals (the "referential nucleus" of the concept of consciousness according to Pereira and Ricke (2009)), (v) emotional experiences such as happiness, sadness, etc., (vi) experiences related to thoughts (such as imagination or creative thinking), (vii) experiences of nothingness in meditation, (viii) experiences as the result of dynamical processes in the embodied and embedded view of cognition, (ix) experiences related to social interactions (Pereira and Ricke 2009); (x) experiences related to self (Bruzzo and Vimal 2007) and self-awareness (Perrett 2003), and perhaps higher-order awareness (Carruthers 2007, Rosenthal 2009); (xi) experiences related to phenomenal time (Vimal and Davia 2008), and (xii) inner/outer experiences, hidden (other's) experiences (via a process of theorization or simulation or both), singular-detachable-individual experiences, and shared experiences (Torrance 2009).

Non-conscious experiences are: experiences related to pre-conscious, subconscious and unconscious domains: slow-wave dreamless deep-sleep, coma, vegetative and anesthetized states. Non-conscious experiences can include experiences related to paradoxical awareness or awareness without being aware, such as subliminal perception and blindsight. According to Pereira and Ricke (2009):

> ... when we are sleeping without dreams we nevertheless have experiences without consciousness, e.g. the proprioceptive ones that prevent us falling out of our beds! Another good example of experience without consciousness is *blindsight*, a phenomenon in which people who are perceptually blind in a certain region of their visual field respond to visual stimuli without any associated qualitative experience ("quale"). ... In conscious experience there is a content experienced by a subject, while in the case of unconscious phenomena there may be – among other possible combinations – a subject without content (e.g. animals under general anesthesia), and informational content without a subject (e.g. information patterns in the hard disk of a computer). More precisely, ... an experience is conscious when there is a reportable content being experienced by

> a subject, such that the content is content *for the subject*. ... If a robot has feedback mechanisms allowing the completion of action-perception cycles, then it can be considered as having experiences, but not *conscious* subjective experience, because of the lack of content and subjectivity.

This conception of non-conscious experiences is similar to (or identical with) proto-experiences (PEs) in the PE-SE framework, but it differs from subjective experiences (SEs).

Conscious functions operate or are active when the system is awake and attentive (feedback signals modulating the feed-forward signals). According to Faw (2009), states of active wakefulness (normal waking state) should be distinguished from quiet (passive) wakefulness, altered forms of waking consciousness underlying trance, absorption, hypnosis, dissociation, meditative states, drug states, out-of-body experiences, REM/dream states, minimally conscious state, and drowsiness.

For access consciousness (that plays a role in global workspace theory; Baars 1988), attention and working memory are necessary. According to Carruthers (2009), the working memory system is, indeed, a kind of global workspace. For phenomenal consciousness, on the other hand, attention is not needed, but sensory memory (such as iconic memory for the visual system, echoic memory for the auditory system and odor memory for the olfactory system) is necessary (Rowlatt 2009, Vimal 2009g).

Conscious functions can include functions and processes related to: (i) conscious experiences as elaborated above, (ii) necessary ingredients of consciousness (Vimal 2009g), such as working memory (Rowlatt 2009), attention, re-entry, (iii) intentionality ("intending to do something", object-directedness; Faw 2009, Perrett 2003), (iv) executive functions (Vimal 2009g), (v) core and extended consciousness (Damasio 1999), (vi) control, inner-sense, higher-order-sense consciousness (Armstrong 1993, Carruthers 2007, Lycan 1996), (vii) primary, basic, or first-order consciousness ("consciousness of something") and secondary, self-reflective, reflexive consciousness (Duvall and Wicklund 1982, Faw 2009), (viii) higher-order consciousness ("awareness of our own mental states"; Rosenthal 2009), (ix) phenomenal and access consciousness (Block 2001, Rowlatt 2009), (x) paradigmatic consciousness states (day-dreaming; Faw 2009), (xi) transitive consciousness with conscious intentional and/or qualitative properties, and higher-order thoughts (Rosenthal 2009), (xii) thoughts (such as imagination or creative thinking), emotions (such as pain, pleasure, thirst, fear, anger, and happiness), decision/voluntary action (Pereira and Ricke 2009).

Examples for *non-conscious functions* are functions related to pre-conscious, subconscious and unconscious domains: slow-wave dreamless deep sleep, coma, vegetative and anesthetized states. Non-conscious func-

tions can include functions related to long-term memory, paradoxical awareness or awareness without being aware, such as subliminal perception and related state consciousness (Rosenthal 2009), implicit memory, and blindsight.

What is the difference between non-conscious experiences and non-conscious functions? Do they both reduce to proto-experiences? Since non-conscious experiences are those experiences that are not conscious, they are indeed proto-experiences in the PE-SE framework. However, since non-conscious functions are those functions that are not conscious functions, it would be appropriate to call them proto-functions.[17]

Material functions belong to non-conscious functions[18] and are functions of the material aspect of an entity, e.g. the function of a thermostat, of a car, of a spectrometer, and so on. From an idealist point of view, material functions are ultimately properties of the mind or of mind-like entities, and hence they are mental functions. In panpsychism, some – not necessarily all – fundamental states of nature have both mental and material properties. For instance, Skrbina (2009b) holds that even a material rock has mental properties. In the "holoworld" framework of Globus (1995, 1998), SEs are eliminated; instead, experiences are denoted by properties or qualities of objects (such as the red color of a ripe tomato; Byrne and Hilbert 2003, Globus 1995, 1998).

In the dual-aspect dual-mode PE-SE framework, the qualities of objects are considered as part of their material functions, i.e. part of their non-conscious functions. Under hypothesis H_1, the mental aspect of inert matter is a carrier of superposed SEs/PEs in unexpressed form and, hence, conscious experience is inactive. Therefore, the material function is the function of the material aspect of the inert matter. However, if neural networks along with necessary ingredients of SEs are implemented in a robot, if it can perform all the functions of a human being, and if matching and selection mechanisms are active, then that robot may be considered conscious.

Finally, I discuss *qualia* as a related issue. According to Beaton (2009), qualia are "properties of sensory experience broadly construed to include states such as seeing, hallucination, sensory memory, sensory imagination, and so on". In general, one could argue that qualia are (a) properties of conscious experiences, such as phenomenal redness (Beaton 2009, Byrne

[17]Take blindsight as an example: (a) Subjects do not have conscious experience but they report "seeing" something in the cortically blind field; this experience is a non-conscious experience or PE. (b) Moreover, one could argue that subjects have no conscious function but they "guess" above chance level, which can be interpreted as effective detection and discriminatioin of certain visual stimuli; this function is the related proto-function (Vimal 2010b).

[18]This claim implies, using elementary logic (if A $\rightarrow$ B then non-B $\rightarrow$ non-A) that conscious functions are not material. This is correct because, by definition, functions and experiences are mental non-material entities.

2008, Pereira and Ricke 2009) and/or (b) properties or qualities of objects, such as the red color of a ripe tomato (Byrne and Hilbert 2003, Dretske 1995, Globus 1995, 1998).

My view is that qualia are not equal to conscious states or processes, but rather they are properties of consciousness. For example, an experience of a bulging red tomato has the qualia (phenomenal qualities) of phenomenal bulginess and phenomenal redness. Especially (but not only) because a single experience of the world can have multiple qualia, it does not sound right to say that qualia are experiences, even though qualia are properties (arguably, the characteristic, defining properties) of conscious experiences.

Now one might ask: when we think about qualia, are we really thinking about properties of experience? Or are we thinking about the power of objects to cause certain properties of experience (secondary qualities)? In addition, how do we address the conscious experience of an achromat (which would be equivalent to grayness) versus that of a trichromat (which would be redness) for the same ripe tomato?

Some authors, such as Byrne and Hilbert (2003), might claim that phenomenal bulginess and phenomenal redness are properties of actual tomatoes in the world, whereas other authors, such as Beaton (2009), Byrne (2008), Pereira and Ricke (2009) refer to them as "phenomenal" or "qualitative" character of conscious experience. For most views, qualia are either properties of conscious experiences or properties of objects.

However, in idealism, where matter emerges from mind, tomatoes themselves are properties of experiences. In the dual-aspect dual-mode PE-SE framework (under hypothesis H_1; Vimal 2009h, 2010a), SEs are superposed (in unexpressed form) in the mental aspect of inert matter (both internal and external to the brain). A specific SE is expressed during matching and selection processes in a specific neural network when it satisfies the necessary ingredients of consciousness (Vimal 2009g). This framework implies that both neural networks and objects are involved in qualia.

Moreover, according to Shoemaker (1994), "the phenomenal character of the experience consists in a certain aspect of its representational character, i.e., in its representing a certain sort of property of objects, namely 'phenomenal properties' that are constitutively defined by relations to our experience." This implies that the phenomenal character of experiences is somehow related to the properties of objects for qualia. These views do not contradict the hypothesis that qualia are both properties of experiences and properties of tomatoes.

Therefore, an optimal definition is this: *consciousness is a mental aspect of a system or a process consisting of conscious experience and conscious function.* This definition is based on the dual-aspect dual-mode PE-SE framework. It is optimal in the sense explained above.

2.3 General Definition of Consciousness

A *general* definition of consciousness requires that most views and the contexts in which the notion of consciousness is used should be included in the definition. In a general definition as mentioned above, *consciousness is a mental aspect of an entity (system or process), which is a conscious experience, a conscious function, or both, depending on contexts and particular biases (e.g., metaphysical assumptions).* This definition tries to accommodate most metaphysical assumptions. If the dominating view is materialist or functionalist, then consciousness is likely to be considered as conscious function. If the dominating view is dualist or idealist, consciousness is more likely to be considered in terms of conscious experience. If the dominating view is dual-aspect, panpsychist, panprotopsychist, panexperientialist or panprotoexperientialist, consciousness is likely to be considered as both conscious experience and conscious function.

One could argue that *pure awareness* or *consciousness as such,* as for instance claimed by mystics, lacks subjectivity. However, I argue that it is still a conscious experience. The same experiential aspect of consciousness is likely to be addressed in epiphenomenalist stances such as "physical states cause phenomenal states, but not vice versa" (Chalmers 2003).

Another interesting topic in this respect is the dicussion about free will. Wegner (2002) argued that the experience of free will has no direct connection with actuality. Considering both conscious experience and conscious function, Wegner's conception of free will can be understood easily. "Experiences of conscious will thus arise from processes whereby the mind interprets itself – not from processes whereby mind creates action" (Wegner 2004). Here the notion of process indicates function; without such functional aspects, free will would have been selected out by natural selection.

Another interesting voice in this context is due to Stapp (2009):

> *In orthodox quantum mechanics, no elements of quantum randomness enter into man's choice.* Nor is man's choice fixed by the deterministic aspect of quantum mechanics: that aspect enters only via process 2. Von Neumann's process 1 human choice is, in this very specific sense, "free": it is von Neumann's representation of Bohr's "free choice of experimental arrangement for which the quantum mechanical formalism offers the appropriate latitude" (Bohr 1958, p. 51). Human choices enter orthodox quantum mechanics in a way not determined by a combination of the deterministic and random elements represented in the theory.

This seems like "semi-free will" and is a conscious experience. Also, if Nunn's argument (personal communication) is correct that free will could be an epiphenomenon, a type of spandrel, then it is still a conscious experience. There is evidence for a range of similar disjunctions in the

psychological literature. Therefore, it is not plausible that, generally, conscious experience and conscious function could be aspects of the same mental entity. In a general definition, free will is not necessarily both conscious function and conscious experience; rather it could refer to one of them at a time, depending on context.[19]

2.4 Are Optimal and General Definitions of Consciousness Consistent With the Criteria for Definitions?

It would be interesting to see whether our definitions meet a number of criteria discussed by Allen (2009). Indeed they do. The optimal and general definitions of consciousness (i) are neither too rigid nor too detailed. (ii) They are part of a theory that facilitates empirical prediction and explanation. (iii) They reveal "real" features and also inter-relations. (iv) They are useful for scientific or philosophical applications. (v) They are definitive or unrevisable in that they reveal the "essential nature" of consciousness, but they are working definitions in the sense that they can be modified based on future research. And (vi) they are *a posteriori* definitions because they are derived from observations and from categorizations with respect to two aspects (Vimal 2009e): functions (third-person perspective, consciousness as a multidimensional physical/neurobiological processes; Baars 1988, Edelman 2003, James 1977, Searle 2000, Vimal 2008a, 2009g) and experiences (first-person perspective), both linked with brain structures (neural networks).

Søgaard and Østerskov Søgaard (2009) discuss the format of a definition of consciousness as suggested by Suppe (2000). For example, (I) "a system is conscious iff [if and only if] it can interrupt or change a planned action in the absence of external stimuli". Or, (II) "a process is conscious iff there is a (higher order) thought about it". In this format, Nagel's (1974) definition, consciousness of a system S is "what it is like to be S", can be re-written as: S is conscious iff it has "what it is like to be S". Pereira and Ricke's (2009) definition can be re-written as: A process is conscious iff it occurs in a subject, and the subject has an experience, and the experience has reportable informational content.

Our optimal definition of consciousness can be rewritten as: A system or a process is conscious iff its mental aspect is conscious experience and conscious function. And our general definition of consciousness can be re-written as: A system or a process is conscious iff its mental aspect is composed of conscious experiences, conscious functions, or both depending on contexts and particular biases (e.g., metaphysical assumptions).

[19] Nunn commented: "This is correct in relation to 'mental entity', but unless the entity is consciously experienced, it is surely not 'conscious' from any ordinary perspective – it is only 'conscious' if one injects some theoretical (panpsychist or whatever) notion of consciousness into it." This is true, but our goal is to include more than panpsychism in the general definition.

2.5 Relations among Consciousness, Qualia, Mind, and Awareness

In summary, we represent the relations between the key notions of this paper in a condensed form. The symbol $\oplus$ stands for "and/or", the symbol & stands for "and".

$$\text{experiences} = \text{conscious experiences} \oplus \text{non-conscious experiences} \quad (1)$$

$$\text{functions} = \text{conscious functions} \oplus \text{non-conscious functions} \quad (2)$$

$$\text{qualia} = \text{properties of conscious experience} \oplus (\text{properties or qualities of objects}) \quad (3)$$

$$\text{consciousness (optimal)} = \text{conscious experiences \& conscious functions} \quad (4)$$

$$\text{consciousness (general)} = \text{conscious experiences} \oplus \text{conscious functions} \quad (5)$$

$$\text{mind} = \text{consciousness (general)} \oplus \text{non-conscious experiences} \oplus \text{non-conscious functions} \quad (6)$$

$$= \text{conscious experiences} \oplus \text{non-conscious experiences} \oplus \text{conscious functions} \oplus \text{non-conscious functions} \quad (7)$$

$$= \text{experiences} \oplus \text{functions} \quad (8)$$

$$\text{awareness} = \text{consciousness (general)} \oplus \text{non-conscious experiences} \oplus (\text{pre-conscious} \oplus \text{sub-conscious functions}) \quad (9)$$

$$= \text{conscious experiences} \oplus \text{non-conscious experiences} \oplus \text{conscious functions} \oplus (\text{pre-conscious} \oplus \text{sub-conscious functions}) \quad (10)$$

$$= \text{experiences} \oplus \text{conscious functions} \oplus (\text{pre-conscious} \oplus \text{sub-conscious functions}) \quad (11)$$

One can argue that consciousness should include only conscious entities, such as conscious experiences and conscious functions as in (4) and (5). Non-conscious entities such as non-conscious experiences and non-conscious functions should be excluded; rather they could be a part of mind as in (6)–(8). According to Carruthers (2004), mindedness requires capacities for at least perception, belief, and desire. This can be further elaborated (Carruthers 2004):

> Having a mind means being a subject of perceptual states, where those states are used to inform a set of belief states which guide behavior, and where the belief states in turn interact with a set of desire states in ways that depend upon their contents, to select from amongst an array of action schemata so as to determine the form of the behavior.

According to a panpsychist view (Skrbina 2009b), mind contains an inward-directed experiential, qualitative aspect and an outward-directed relational/representational/intentional aspect as two essential components.

This is not inconsistent with (8) if the experiential component is the sub-aspect experience and if the intentional component is the sub-aspect function. The intentionality, or directedness towards objects of the external world, is represented, and this representation might be associated with the function of the relevant structures.

The specificity to SEs in the dual-aspect dual-mode PE-SE framework (Vimal 2008b, 2010a) may be somewhat related to the issues of dimensionality and complexity in panpsychism (Skrbina 2009b).[20] Optimal consciousness (4) is equivalent to "total" consciousnesses because it includes all conscious experiences and conscious functions (Skrbina, personal communication). According to Rosenthal (2009), "states need not themselves be conscious to result in our being aware of things". Therefore, perhaps, awareness has more components than general consciousness but less than mind, as shown by (9)–(11). In a panpsychist framework, it may not be acceptable to everybody that a rock has awareness but it may be acceptable that a rock has non-conscious functions (such as material functions, e.g. interaction with its environment via continuous exchange of energy; Skrbina 2009b), hence mind-like properties. Perhaps, some of the non-conscious functions (such as unconscious functions) are excluded from the definition of awareness, but included in the definition of mind.

3. Conclusions

1. It would be difficult to arrive at any single, widely acceptable, definition of consciousness because of the multiplicity of its meanings (Vimal 2009e). Attempts to define consciousness often lead to confusion and circular discussion. This is particularly true for theory-independent definitions of consciousness, but the quest for definition(s) of consciousness in a theory-dependent manner may be more promising. We have made such an attempt, accommodating most views categorized by Chalmers (2003) and discussed further by Vimal (2008b, 2009e).

2. The dual-aspect dual-mode proto-experience/subjective experience (PE-SE) framework is an *optimal* framework because it has the least number of problems. The only major problem is the brute fact of dual aspects, which is justified because SEs appear fundamental, irreducible, and inherent in normal wakeful states of mind-brain.

[20]For example, the tension between the non-specificity to SEs of electrons and the high specificity of a neural network in the dual-aspect dual-mode PE-SE framework may be related to an extremely low dimensionality and complexity of the mentality of electrons and a high dimensionality and complexity of the mentality of a neural net in panpsychism. The continuity from unconscious states to conscious states rather than their discrete delineation (Skrbina 2009b) is an interesting hypothesis but needs further research.

3. *Experiences* can be conscious experiences, non-conscious experiences, or both; and *functions* can be conscious functions, non-conscious functions that include qualities of objects, or both.

4. According to our *optimal* definition of consciousness, *consciousness is a mental aspect of an entity (system or process) that has dual sub-aspects: conscious experience and conscious function.* In other words, a system or a process is conscious iff its mental aspect is conscious experience and conscious function.

5. According to our *general* definition of consciousness, *consciousness is a mental aspect of an entity (system or process) that is a conscious experience, a conscious function, or both depending on contexts and particular biases (e.g., metaphysical assumptions).* In other words, a system or a process is conscious iff its mental aspect is composed of conscious experiences, conscious functions, or both depending on contexts and particular biases (e.g. metaphysical assumptions).

6. These definitions, may guide us how to design subjective and objective experiments and how to investigate theoretically the link between structure, function, and experience.

7. Based on these premises, (i) *qualia* are properties of conscious experiences and/or qualities of objects, (ii) *mind* includes experiences, functions, or both, and (iii) *awareness* includes experiences, conscious functions, and/or pre- and sub-conscious functions.

8. The above definitions are *a posteriori* definitions (Vimal 2009e). This is because they are based on observations and categorizations of various definitions with respect to functions (third-person perspective) and experiences (first-person perspective).

Acknowledgments

This work was partly supported by research funds by VP-Research Foundation Trust and Vision Research Institute. I would like to thank anonymous reviewers, Chris Nunn, David Skrbina, Michael Beaton, Peter Carruthers, David Rosenthal, Serge Patlavskiy, Anders Søgaard, Manju-Uma C. Pandey-Vimal, Vivekanand Pandey Vimal, Shalini Pandey Vimal, and Love (Shyam) Pandey Vimal for their critical comments, suggestions, and grammatical corrections. The quotes and/or comments related to personal communication are from email correspondences with (a) Nunn in September 2008, (b) Skrbina in April 2009, (c) Beaton in March and April 2009, and (d) Carruthers in May 2009. Thanks to the JCS online group for critiques and discussions. I am thankful to Harald Atmanspacher for editorial suggestions.

The author is also affiliated with Dristi Anusandhana Sansthana, c/o NiceTech Computer Education Institute, Pendra, Bilaspur, C.G. 495119,

India, and Dristi Anusandhana Sansthana, Sai Niwas, East of Hanuman Mandir, Betiahata, Gorakphur, U.P. 273001, India.

References

Allen S. (2009): The definition of consciousness: Are triviality or falsehood inevitable? *Journal of Consciousness Studies* **16**(5), 127–138.

Armstrong D.M. (1993): *A Materialist Theory of the Mind*, Routledge and Kegan Paul, London.

Atmanspacher H. (2007): Contextual emergence from physics to cognitive neuroscience. *Journal of Consciousness Studies* **14**(1-2), 18–36.

Baars B.J. (1988): *A Cognitive Theory of Consciousness*, Cambridge University Press, Cambridge.

Bartels A. and Zeki S. (2000): The architecture of the colour centre in the human visual brain: New results and a review. *European Journal of Neuroscience* **12**, 172–193.

Beaton M. (2009): Qualia and introspection. *Journal of Consciousness Studies* **16**(5), 88–110.

Blackmore S.J. (1996): Near-death experiences. *Journal of the Royal Society of Medicine* **89**(2), 73–76.

Block N. (1990). Consciousness and accessibility. *Behavioral and Brain Science* **13**, 596–598.

Block N. (1992): Begging the question against phenomenal consciousness. *Behavioral and Brain Science* **15**, 205–206.

Block N. (1995): On a confusion about a function of consciousness. *Behavioral and Brain Science* **18**, 227–247.

Block N. (2001): Paradox and cross purposes in recent work on consciousness. *Cognition* **79**(1-2), 197–219.

Block N. (2005): Two neural correlates of consciousness. *Trends in Cognitive Sciences* **9**(2), 47–52.

Block N. (2007): Consciousness, accessibility, and the mesh between psychology and neuroscience. *Behavioral and Brain Sciences* **30**(5-6), 481–499; discussion pages 499–548.

Bohr N. (1958): *Atomic Physics and Human Knowledge*, Wiley, New York.

Bruzzo A.A. and Vimal R.L.P. (2007): Self: An adaptive pressure arising from self-organization, chaotic dynamics, and neural Darwinism. *Journal of Integrative Neuroscience* **6**(4), 541–566.

Byrne A. (2008): Inverted qualia. In *The Stanford Encyclopedia of Philosophy*, ed. by E.N. Zalta, accessible at `www//plato.stanford.edu/archives/win2008/entries/qualia-inverted/`.

Byrne A. and Hilbert D.R. (2003): Color realism and color science. *Behavioral and Brain Science* **26**(1), 3–21; discussion pages 22–63.

Carruthers P. (2000): *Phenomenal Consciousness: A Naturalistic Theory*, Cambridge University Press, Cambridge.

Carruthers P. (2004): On being simple minded. *American Philosophical Quarterly* **41**, 205–220.

Carruthers P. (2007): Higher-order theories of consciousness. In *The Stanford Encyclopedia of Philosophy*, ed. by E.N. Zalta, accessible at `www//plato.stanford.edu/archives/spr2009/entries/consciousness-higher/`.

Carruthers P. (2009): How we know our own minds: The relationship between mindreading and metacognition. *Behavioral and Brain Science* **32**(2), 121–138; discussion pages 138–182.

Chalmers D.J. (1996): *The Conscious Mind*, Oxford University Press, New York.

Chalmers D.J. (2003): Consciousness and its place in nature. In *Blackwell Guide to Philosophy of Mind*, ed. by S. Stich and F. Warfield, Blackwell, Oxford, pp. 102–142.

Damasio A.R. (1999): *The Feeling of What Happens: Body and Emotion in the Making of Consciousness*, Harcourt Brace, New York.

Dennett D.C. (1991): *Consciousness Explained*, Little, Brown and Company, Boston.

Dretske F. (1995): *Naturalizing the Mind*, MIT Press, Cambridge.

Duvall S. and Wicklund R.A. (1982): *A Theory of Objective Self-Awareness*, Academic Press, New York.

Edelman G.M. (2003): Naturalizing consciousness: a theoretical framework. *Proceedings of the National Academy of Sciences of the USA* **100**, 5520–5524.

Eerikäinen A. (2000): *Time and Polarity: The Dimensional Thinking of Karl Heim*, Yliopistopaino, University of Helsinki.

Elitzur A.C. and Vaidman L. (1993): Quantum mechanical interaction-free measurements. *Foundations of Physics* **23**, 987–997.

Faw B. (2009): Cutting consciousness at its joints. *Journal of Consciousness Studies* **16**(5), 54–67.

Feigl H. (1967): *The Mental and the Physical, The Essay and a Postscript*, University of Minnesota Press, Minneapolis.

French C.C. (2005): Near-death experiences in cardiac arrest survivors. In The Boundaries of Consciousness: Neurobiology and Neuropathology ed. by S. Laureys, Elsevier, Amsterdam, pp. 351–367.

Globus G. (2006): The saltatory sheaf-odyssey of a monadologist. *NeuroQuantology* **4**(3), 210–221.

Globus G. (2009): Halting the descent into panpsychism: A quantum thermofield theoretical perspective. In *Mind That Abides: Panpsychism in the New Millennium*, ed. by D. Skrbina, Benjamins, Amsterdam, pp. 67–82.

Globus G.G. (1995): *Forget Qualia, Zombies and Zimboes*, accessible at `www.imprint.co.uk/online/Globus.html`.

Globus G.G. (1998): Self, cognition, qualia and world in quantum brain dynamics. *Journal of Consciousness Studies* **5**(1), 34–52.

Globus G.G. (2005): The being/brain problem. *NeuroQuantology* **4**, 256–263.

Globus G.G. (2007): Mind, matter, and monad. *Mind and Matter* **5**(2), 201–214.

Glover S. (2004): Separate visual representations in the planning and control of action. *Behavioral and Brain Science* **27**(1), 3–24; discussion pages 24–78.

Hadjikhani N., Liu A.K., Dale A.M., Cavanagh P. and Tootell R.B. (1998): Retinotopy and color sensitivity in human visual cortical area V8. *Nature Neuroscience* **1**(3), 235–241.

Hameroff S. and Penrose R. (1996): Conscious events as orchestrated spacetime selections. *Journal of Consciousness Studies* **3**(1), 36–53.

James W. (1977): *The Writings of William James*, ed. by J.J. McDermott, University of Chicago Press, Chicago, pp. 169–183.

Kant I. (1929): *Critique of Pure Reason*, translated by N.K. Smith, McMillan, London.

Klemenc-Ketis Z., Kersnik J., and Grmec S. (2010): The effect of carbon dioxide on near-death experiences in out-of-hospital cardiac arrest survivors: A prospective observational study. *Critical Care* **14**, R56 (doi:10.1186/cc8952).

Kosslyn S. (1994): *Image and Brain*, MIT Press, Cambridge MA.

Kriegel U. and Williford K., eds. (2006): *Self-Representational Approaches to Consciousness*, MIT Press, Cambridge MA.

Lamme V.A. (2003): Why visual attention and awareness are different. *Trends in Cognitive Science* **7**(1), 12–18.

Levin J. (2006): What is a phenomenal concept? In *Phenomenal Concepts and Phenomenal Knowledge*, ed. by T. Alter and S. Walter, Oxford University Press, Oxford, pp. 87–111.

Levin J. (2008): Taking type-B materialism seriously. *Mind and Language* **23**(4), 402–425.

Levine J. (1983): Materialism and qualia: The explanatory gap. *Pacific Philosophical Quarterly* **64**, 354–361.

Loar B. (1990): Phenomenal states. *Philosophical Perspectives* **4**, 81–108.

Loar B. (1997): Phenomenal states (revised version). In *The Nature of Consciousness*, ed. by N. Block, O. Flanagan and G. Güzeldere, MIT Press, Cambridge, pp. 597–615.

Lycan W.G. (1996): *Consciousness and Experience*, MIT Press, Cambridge MA.

MacGregor R.J. and Vimal R.L.P. (2008): Consciousness and the structure of matter. *Journal of Integrative Neuroscience* **7**(1), 75–116.

Millikan R.G. (1989): In defense of proper functions. *Philosophy of Science* **56**, 288–302.

Milner D. and Goodale M. (1995). *The Visual Brain in Action*, Oxford University Press, Oxford.

Nagel T. (1974): What is it like to be a bat? *Philosophical Review* **83**, 435–450.

Nixon G. (2007): The continuum of experience: Non-conscious experience. Unpublished manuscript, accessible at `www.kjf.ca/95A-TANIX.htm`.

Northoff G. and Bermpohl F. (2004): Cortical midline structures and the self. *Trends in Cognitive Science* **8**(3), 102–107.

Northoff G., Heinzel A., de Greck M., Bermpohl F., Dobrowolny H. and Panksepp J. (2006): Self-referential processing in our brain – A meta-analysis of imaging studies on the self. *Neuroimage* **31**(1), 440–457.

Papineau D. (1993a): *Philosophical Naturalism*, Blackwell, Oxford.

Papineau D. (1993b): Physicalism, consciousness, and the antipathetic fallacy. *Australasian Journal of Philosophy* **71**, 169–183.

Papineau D. (2006): Phenomenal and perceptual concepts. In *Phenomenal Concepts and Phenomenal Knowledge*, ed. by T. Alter and S. Walter, Oxford University Press, Oxford, pp. 111–144.

Pereira Jr. A. and Ricke H. (2009): What is consciousness? Towards a preliminary definition. *Journal of Consciousness Studies* **16**(5), 28–45.

Perrett R.W. (2003): Intentionality and self-awareness. *Ratio* **16**(3), 222–236.

Prakash R. and Caponigro M. (2009): Inner light perception as a quantum phenomenon – Addressing the questions of physical and critical realisms, information and reduction. *NeuroQuantology* **7**(1), 188–197.

Prakash R., Haq Z.U., Prakash O., Sarkhel S. and Kumar D. (2009): Inner light perception of Vihangam Yogis – A qualitative study. *Journal of Consciousness Studies* **16**(2-3), 124–140.

Primas H. (2002): Hidden determinism, probability, and time's arrow. In *Between Chance and Choice*, ed. by H. Atmanspacher and R.C. Bishop, Imprint Academic, Exeter, pp. 89–113.

Primas H. (2003): Time-entanglement between mind and matter. *Mind and Matter* **1**, 81–119.

Prosser S. (2007): The two-dimensional content of consciousness. *Philosophical Studies* **136**, 319–349.

Rao K.R. (1998): Two faces of consciousness: A look at Eastern and Western perspectives. *Journal of Consciousness Studies* **5**(3), 309–327.

Rao K.R. (2005): Perception, cognition and consciousness in classical Hindu psychology. *Journal of Consciousness Studies* **12**(3), 3–30.

Rosenthal D.M. (2009): Concepts and definitions of consciousness. In *Encyclopedia of Consciousness*, ed. by P.W. Banks, Elsevier, Amsterdam, pp. 157–169.

Rowlatt P. (2009): Consciousness and memory. *Journal of Consciousness Studies* **16**(5), 68–78.

Seager W. (1995): Consciousness, information and panpsychism. *Journal of Consciousness Studies* **2**(3), 272–288.

Searle J.R. (2000): Consciousness. *Annual Review of Neuroscience* **23**, 557–578.

Shoemaker S. (1994): Phenomenal character. *Noûs* **28**(1), 21–38.

Skrbina D. (2003): Panpsychism as an underlying theme in Western philosophy. *Journal of Consciousness Studies* **10**(3), 4–46.

Skrbina D. (2005): *Panpsychism in the West*, MIT Press, Cambridge MA.

Skrbina D. (2009a): Minds, objects, and relations: Toward a dual-aspect ontology. In *Mind that Abides: Panpsychism in the New Millennium*, ed. by D. Skrbina, Benjamins, Amsterdam, pp. 361–382.

Skrbina D. (2009b): Transcending consciousness: Thoughts on a universal conception of mind. *Journal of Consciousness Studies* **16**(5), 79–87.

Søgaard A. and Østerskov Søgaard S. (2009): On definitions of consciousness. *Journal of Consciousness Studies* **16**(5), 46–53.

Sperling G. (1960): The information available in brief visual presentations. *Psychological Monographs* **74**(11), 1–29.

Stapp H.P. (2009): Quantum reality and mind. *Journal of Cosmology* **3**, 570–579.

Stapp H.P. (2010). The effect of mind upon brain. In *Life and Process: Towards a Whiteheadian Biophilosophy*, ed. by S. Koutroufinis, Ontos, Frankfurt, in press.

Suppe F. (2000): Definitions. In *A Companion to the Philosophy of Science*, ed. by W.H. Newton-Smith, Blackwell, Malden, pp. 76–78.

Tootell R.B.H., Tsao D. and Vanduffel W. (2003): Neuroimaging weighs in: In Humans Meet Macaques in "Primate" Visual Cortex. *The Journal of Neuroscience* 23(10), 3981–3989.

Torrance S. (2009): Contesting the concept of consciousness. *Journal of Consciousness Studies* **16**(5), 111–126.

van Gulick R. (2004): Higher-order global states (HOGS): An alternative higher-order model of consciousness. In *Higher-Order Theories of Consciousness*, ed. by R. Gennaro, Benjamins, Amsterdam, pp. 67–93.

Velmans M. (2009): How to define consciousness and how not to define consciousness. *Journal of Consciousness Studies*16(5), 139–156.

Vimal R.L.P. (2008a): Attention and emotion. *The Annual Review of Biomedical Sciences (ARBS)* **10**, 84–104.

Vimal R.L.P. (2008b): Proto-experiences and subjective eperiences: classical and quantum concepts. *Journal of Integrative Neuroscience* **7**(1), 49–73.

Vimal R.L.P. (2009a): Dependent co-origination and inherent existence: Dual-aspect framework. *Living Vision and Consciousness Research* **2**(7), 1–50. Available at `sites.google.com/site/rlpvimal/Home/2009-Vimal-Coorigination-LVCR-2-7.pdf`.

Vimal R.L.P. (2009b): Derivation of subjective experiences from a proto-experience and three *Gunas* in the dual-aspect-dual-mode framework. *Living Vision and Consciousness Research* **2**(5), 1–140. Available at `sites.google.com/site/rlpvimal/Home/2009-Vimal-Guna-LVCR-2-5.pdf`.

Vimal R.L.P. (2009c): Dual aspect framework for consciousness and its implications: West meets East for sublimation process. In *The Roar of Awakening. A*

Whiteheadian Dialogue Between Western Psychotherapies and Eastern Worldviews, ed. by G. Derfer, Z. Wang, and M. Weber, Ontos, Frankfurt, pp. 39–70. A longer and corrected version is available at `sites.google.com/site/rlpvimal/Home/2009-Vimal-Consciousness-and-its-implications-recent-version-LVCR-2-11.pdf`.

Vimal R.L.P. (2009d): Interpretation of empirical data of samadhi state and the dual-aspect dual-mode optimal framework. *Living Vision and Consciousness Research* **2**(3), 1–130. Available at `sites.google.com/site/rlpvimal/Home/2009-Vimal-Samadhi-LVCR-2-3.pdf`.

Vimal R.L.P. (2009e): Meanings attributed to the term consciousness: an overview. *Journal of Consciousness Studies* **16**(5), 9–27.

Vimal R.L.P. (2009f): The most optimal dual-aspect-dual-mode framework for consciousness: Recent development. In *Chromatikon: Yearbook of Philosophy in Process*, ed. by M. Weber, Presses Universitaires de Louvain, pp. 295–307. Manuscript available at `sites.google.com/site/rlpvimal/Home/2009-Vimal-Most-Optimal-Consciousness-Framework-Summary-2-12.pdf`.

Vimal R.L.P. (2009g): Necessary ingredients of consciousness: Integration of psychophysical, neurophysiological, and consciousness research for the red-green channel. *Living Vision and Consciousness Research* **2**(1), 1–40. Manuscript available at `sites.google.com/site/rlpvimal/Home/2009-Vimal-Necessary-Ingredients-Conciousness-LVCR-2-1.pdf`.

Vimal R.L.P. (2009h): Subjective experience aspect of consciousness part I: Integration of classical, quantum, and subquantum concepts. *NeuroQuantology* **7**(3), 390–410.

Vimal R.L.P. (2009i): Subjective experience aspect of consciousness part II: Integration of classical and quantum concepts for emergence hypothesis. *NeuroQuantology* **7**(3), 411–434.

Vimal R.L.P. (2009j). Towards a theory of everything: Unification of consciousness with fundamental forces in theories of physics. *Living Vision and Consciousness Research* **1**(11), 1–100. Manuscript available at `sites.google.com/site/rlpvimal/Home/2009-Vimal-TOE-LVCR-1-11.pdf`.

Vimal R.L.P. (2010a). Matching and selection of a specific subjective experience: Conjugate matching and subjective experience. *Journal of Integrative Neuroscience*, in press.

Vimal R.L.P. (2010b): Consciousness, non-conscious experiences and functions, proto-experiences and proto-functions, and subjective experiences. Submitted. Manuscript available at `sites.google.com/site/rlpvimal/Home/2010-Vimal-Consciousness-Experience-LVCR-3-6.pdf`.

Vimal R.L.P. and Davia C.J. (2008): How long is a piece of time? Phenomenal time and quantum coherence - toward a solution. *Quantum Biosystems* **2**, 102–151.

Vitiello G. (1995): Dissipation and memory capacity in the quantum brain model. *International Journal of Modern Physics* **B9**, 973–989.

Wandell B.A. (1999): Computational neuroimaging of human visual cortex. *Annual Reviews Neuroscience* **22**, 145–173.

Wegner D.M. (2002): *The Illusion of Conscious Will*, MIT Press, Cambridge.

Wegner D.M. (2004): Precis of the illusion of conscious will. *Behavioral and Brain Science* **27**(5), 649–659; discussion 659–692.

Received: 11 June 2009
Revised: 03 December 2009, 11 February 2010
Accepted: 17 March 2010

Reviewed by Sophie Allen and Alfredo Pereira jr.

Longer updated version

On the Quest of Defining Consciousness

Ram Lakhan Pandey Vimal

Vision Research Institute, 428 Great Road, Suite 11, Acton, MA 01720 USA;
Dristi Anusandhana Sansthana, A-60 Umed Park, Sola Road, Ahmedabad-61, Gujrat, India;
Dristi Anusandhana Sansthana, c/o NiceTech Computer Education Institute, Pendra, Bilaspur, C.G. 495119, India;
and Dristi Anusandhana Sansthana, Sai Niwas, East of Hanuman Mandir, Betiahata, Gorakhpur, U.P. 273001, India
rlpvimal@yahoo.co.in; http://sites.google.com/site/rlpvimal/Home

Abstract

In (R. L. P. Vimal, 2009d), forty meanings attributed to the term *consciousness* were identified and categorized based on *functions* and *experiences*. The prospects for reaching any single, agreed theory independent definition of consciousness appear remote. Here, the goal is to search for theory dependent *optimal* (that has the least number of problems) and a *general* definition (that accommodates most views). This quest is mostly based on the premise that evolution must have optimized our system (that has *structure*, *function*, and *experience*). Based on the dual-aspect-dual-mode proto-experience/subjective experience (PE-SE) *optimal* framework, the *optimal* definition of consciousness is '*consciousness is a mental aspect of a system or a process, which has two sub-aspects: conscious experience and conscious function*.' A more *general* definition is: '*consciousness is a mental aspect of a system or a process, which is a conscious experience, a conscious function, or both depending on the context and particular bias (e.g. metaphysical assumptions)*', where *experiences* can be conscious experiences and/or non-conscious experiences and *functions* can be conscious functions and/or non-conscious functions that include qualities of objects. These are *a posteriori* definitions because they are based on observations and the categorization.

Keywords: Structure; function; subjective experience; proto-experience; materialism/emergentism; dualism; idealism; panpsychism; dual-aspect view; consciousness; qualia; mind; awareness; combination problem; explanatory gap

1. Introduction

In (R. L. P. Vimal, 2009d), over forty meanings (or aspects)[1] attributed to the term *consciousness* were extracted from the literature and from online discussion groups; some of them overlapped

[1] Here, the term 'aspect' refers to (http://dictionary.reference.com) "a way in which a thing may be viewed or regarded; interpretation; view; meaning. Examples: *subject experience aspect of consciousness, function aspect of consciousness*." The terms 'aspect' and 'meaning' are used interchangeably.

and some were mutually exclusive, but certainly the list was in no way exhaustive. These meanings were categorized into two groups of mental entities: *function* and *experience*.[2] It was emphasized that the prospect for reaching any single, agreed framework independent definition of *consciousness* appears remote. The recommendation to specify the meaning(s) of consciousness in each investigation is certainly needed to avoid confusion. However, the quest for the *optimal* (that has least number of problems) and *general* (that can accommodate most views) definitions of consciousness is also desirable, which can guide us how to design *subjective* (first person) and *objective* (third person) experiments and how to investigate, at least theoretically, to link *structure*, *function* and *experience*.

My goal is to search for the *optimal* and *general* definitions[3] of conscious and concisely comment on 'qualia' as a related issue. For this purpose, I use all kinds of information available to me including metaphysics of consciousness, conceptual analysis, philosophy of science, neuroscience, psychophysics, and/or physics.[4]

The background information needed in search of the definitions of consciousness is given in Sections 1.1 and 1.2. There are many metaphysical views related to consciousness as categorized by (Chalmers, 2003) and discussed further in (Vimal, 2008b; R. L. P. Vimal, 2009d). Each view has its own problems, which are listed in Section 1.1; this information is used to investigate the

---

[2] The meanings attributed to consciousness by various authors were categorized into two groups of mental entities: *function* and *experience* in (R. L. P. Vimal, 2009d). Experiences are related to the first person subjective perspective and functions are related to the third person objective perspective. As one of the reviewers elaborated, the distinction of conscious entities into conscious experience and conscious function would involve 'function' as being understood either causally or teleologically, i.e. the use of 'function' is of a concausal function or a proper (teleological/final cause) function. It could be in the former sense, as functionalism in the philosophy of mind and cognitive science understands mental states as functional states (states that do something and are defined by their causes and effects). But there are some philosophers who understand mental states as those, which are goal-directed (for example, (Millikan, 1989) and (David Papineau, 1993; D. Papineau, 1993) regard mental states as being purposeful, that is as being proper functions) and selected for by evolutionary pressures. In my view, the term 'function' could be either concausal function or a proper (teleological/final cause) function depending on the context.

[3] The term '*optimal*' indicates that the definition has the least number of problems. The term '*general*' indicates that the definition can accommodate most views.

[4] In (R. L. P. Vimal, 2009d), I simply collected over 40 definitions of consciousness from various sources and tabulated in two categories *functions* and *experiences*. It was obvious that the prospects for reaching any single, agreed theory independent definition of consciousness appear remote. I did not analyze or synthesize them for a limited or a general definition that has less number of problems. In this article, I provide this important missing information. The point is to use the information in Journal of Consciousness (JCS) articles and information from all other available sources and come up with an *optimal* and a general simple definition of consciousness. Thus, this article has a very important needed analysis and synthesis of information from various sources and from various views, leading to well defined working definitions. Based on this, future researches on consciousness can be designed, experimented, and theorized in a better way from both western and eastern perspectives.

metaphysical view that has the least number of problems, which is considered the litmus test on the quest for the *optimal* framework. So far, the view that passes this litmus test is the dual-aspect-dual-mode proto-experience/subjective experience (PE-SE) framework (Bruzzo & Vimal, 2007; MacGregor & Vimal, 2008; Vimal, 2008a, 2008b; R. L. P. Vimal, 2009b, 2009f, 2009g, 2009h, 2009i; Vimal, 2010; Vimal & Davia, 2008). This is the *optimal* framework, where every entity has dual-aspect (material and mental); it has the least number of problems: the only problem is that the dual-aspect considered to be a *brute fact*, but it is justified because SEs appear irreducible, fundamental and inherent in the normal waking state of mind.[5] In Section 1.2, the PE-SE framework is concisely described. Section 2 contains the main topic of current article, where I search for the *optimal* definition of consciousness using also the information from Sections 1.1 and 1.2. This definition is then extended to make it more *general*, which can encompass most views; this effort is represented by qualifying the definition with '*depending on the context and particular bias (e.g. metaphysical assumptions)*'.[6] This investigation is extended to concisely comment on 'qualia' as a related issue and define it. In Section 3, I summarize my quest for the definition of consciousness and qualia.

1.1. Problems in various views on the metaphysics of consciousness, conceptual analysis, and philosophy of science

The relevant problems in some of views are described as follows.

1.1.1. Materialism/Emergentism

In materialism, a specific experience (SE: such as *redness*) is *identical with* a specific state (such as redness-related state caused by long wavelength light) of a specific neural-network (such as red-green V4/V8/VO-neural-net) (Levin, 2006; Levin, 2008; Loar, 1990, 1997; Papineau, 2006). In emergentism/materialism, qualia/subjective experiences (such as *redness*) are assumed to mysteriously emerge or reduce to (or *identical with*) relevant states of neural-nets, which is a *brute fact* (that's just the way it is).[7] The major problem is Levine's explanatory gap (Levine, 1983)[8]: the

[5] In the *samadhi* state of mind, a hypothesis is that SEs might be reducible (R. L. P. Vimal, 2009a).

[6] The term 'context' has to be understood in the common linguistic meaning, as the natural-biological-psychological-social-cultural environment where and when an utterance is made.

[7] According to Carruthers (personal communication), "very few materialists endorse a brute identity claim. Most are reductive representationalists of one sort or another." However, the contextual emergence of higher-level stable mental states from lower-level neurodynamics is a non-reductive framework (in analogy to temperature as an emergent property), where contingent contextual conditions are necessary (Atmanspacher, 2007).

[8] Levine's argument is in the context of Philosophy of Science. One could ask: what is the impact of a detected problem in scientific explanation for a metaphysical view? Is science relevant to metaphysics?

gap between experiences and scientific descriptions of those experiences (Vimal, 2008b). In other words, how can our experiences *emerge* (or arise) from non-experiential matter such as neural-networks of our brain or organism-environment interactions?

In the *holoworld* framework (Globus, 2005; Globus, 2007), one always find oneself already amidst a world of colors, sounds, and so on; "experience" is superfluous, a manner of speaking grounded in dualistic metaphysics, a separation between experience and thing. Thus, this framework seems to eliminate SEs and hence *bypasses* the explanatory gap of materialism. However, if one finds the reduction or elimination of SEs problematic, then the problem raised remains, i.e., SEs exist and cannot be eliminated.

"The suggestion that the mental may still be conceptually irreducible to the physical is but a sop: from an ontological point of view, it amounts to nothing more than noting that there can be complex physical structure types which conform to high-level patterns of instantiation. […] The flipside of the reductionist view that mental activity is not fundamentally distinctive is that the qualitative and intentional character of mental states from which such activity flows is likewise unremarkable. Here, too, the general reductionist line flies in the face of deep intuitive judgments derived from introspection" (O'Connor & Wong, 2005).

Furthermore, materialism/emergentism has 3 more assumptions (Skrbina, 2009a): matter is the ultimate reality, and material reality is essentially objective and non-experiential. These assumptions need justification.

1.1.2. Substance Dualism

"[Substance] Dualism supposes that minds are basic substances wholly distinct from any physical, substances and have primitive causal capacities to influence physical events within associated brains" (O'Connor & Wong, 2005). The problems of (substance) dualism are as follows:

(i) Association or mind-brain interaction problem: how does the non-material mind interact with the non-experiential brain? For example, how can we associate *redness* with red-green cells of 'V4/V8/VO' neural-net?[9] This is a problem of unexplained epistemic gap: how is the jump made from the mental *redness* to material 'V4/V8/VO' neural-net (and vice versa). Furthermore, if nature has two distinct aspects, namely, mind and matter, then how can these distinct aspects of nature ever interact (Stapp, 2009)?

Why? In my view, for consciousness research, borders between various departments should melt and one should able to take advantage of critical information from one department to another. Therefore, argument in the context of Philosophy of Science should be relevant to metaphysics, and *vice-versa*.

[9] The color area 'V8/V4/VO' refers to visual area V8 of Tootell-group (Hadjikhani, Liu, Dale, Cavanagh, & Tootell, 1998; Tootell, Tsao, & Vanduffel, 2003), visual area V4 of Zeki-group (Bartels & Zeki, 2000), and VO of Wandell-group (Wandell, 1999); they are the same human color area (Tootell et al., 2003). VO is ventral-occipital cortex.

(ii) Problem of mental causation: how can a mental cause give rise to a behavioral effect without the violation of the conservation of energy and momentum?

(iii) **'Zombie' problem**: Dualism "allows us to subtract the mind from the brain while leaving the brain completely intact. This possibility implies an "epiphenomenalism" that claims that mind does not matter, that it makes no difference what happens in the world, because it does not cause behavior. My zombie twin behaves just like me but it has no mind at all" (Eerikäinen, 2000).

(iv) 'Ghost' problem: It is "the converse of the zombie problem. If the mind is separate from the body, then not only can the brain exist without the mind but also the mind can exist without the brain. Thus, the so-called "disembodiment" becomes a real possibility" (Eerikäinen, 2000). Nunn argues (personal communication) that the evidence for the occurrence of apparently disembodied states is actually quite strong, for example, near-death experiences (NDEs) (Blackmore, 1996; French, 2005). If this is true then this may not be a problem. However, one could argue that although there is some evidence for states that **appear to be disembodied**, but this is different from **evidence for disembodiment**, since the phenomenon may be illusory.[10] Moreover, according to (Klemenc-Ketis, Kersnik, & Grmec, 2010), the higher partial pressure of carbon dioxide (pCO_2) in arterial blood proved to be important in the provoking of NDEs and higher serum levels of potassium (K) might also be important. In addition, the "factors that could be important in provoking NDEs are anoxia …, hypercapnia …, and the presence of endorphins …, ketamine …, and serotonin …, or abnormal activity of the temporal lobus … or the limbic system ... These psychological theories try to explain the NDEs as a way of dissociation …, depersonalisation …, reactivation of birth memories …, and regression" (Klemenc-Ketis et al., 2010).[I]

(v) Neurophysiological many-one/many relation problem: Interactionism or substance dualism is not favorable to neurophysiological tests because it entails a many-one or many-many relations or correspondences (Feigl, 1967).

(vi) Causal pairing problem: "It is exceedingly odd that particular minds and brains form a lifelong 'monogamy' despite the absence of any apparent relational framework. For it is only within the terms of such a framework that we could explain the persistent individual pairings as a consequence of a contingent, external relationship between them, which relations structure mental-physical causality in a general fashion. […] This difficulty might be overcome by positing the emergence of the mental substance, so that the asymmetrical dependency of mind on brain grounds their monogamous interaction" (O'Connor & Wong, 2005)

(vi) Developmental problem: "[E]ven an emergentist version of substance dualism requires what is empirically implausible, viz., that a composite physical system gives rise, all in one go, to a whole, self-contained, organized system of properties bound up with a distinct individual. For

[10] In the dual-aspect framework, the mental aspect (OBE/NDE) of psychophysical entity related to relevant NN-state appears projected outside (as we experience outside objects). However, activities (such as visual and auditory) are still going on in NNs (but not detected clinically). To reject this hypothesis, subject must wear eye-patches and ear-plugs effectively so no external stimulus-information can travel inside visual and auditory system. Under these conditions, hypothesis predicts no visual and auditory OBE/NDE related to external objects; however, endogenous OBE/NDE can still occur.

we cannot say, as we should want to do, that as the underlying physical structure develops, the emergent self does likewise. This would require us to posit changing mereological complexity within the self, which would give rise all over again to problems of endurance that substance dualism is supposed to avoid, and which would run counter to intuitions of primitive unity that substance dualists have regarding persons. No, the emergent dualist view will have to say, instead, that at an early stage of physical development, a self emerges having all the capacities of an adult human self, but most of which lie dormant owing to immaturity in the physical system from which it emerges" (O'Connor & Wong, 2005).

1.1.3. Idealism

The problem of idealism is reverse to that of materialism/emergentism: how can non-experiential matter such as neural-networks of our brain emerge from non-material experiences/consciousness? For example, for idealism, see (Kant, 1929). Stapp's framework is somewhat close to idealism at ontological level: "orthodox quantum mechanics is Cartesian dualistic at the pragmatic/operational level, but mentalistic on the ontological level" (Stapp, 2009).

1.1.4. Panpsychism

(Skrbina, 2005)(p.255-265) discusses many sources of problems for panpsychism, covering some 25 problems in total – which reduce to six core problems. In addition, (Globus, 2009) raises the "restricted panpsychism problem". Some of these problems might also be that of panprotopsychism (Chalmers, 2003), panexperientialism and panprotoexperientialism[11]. The relevant problems are as follows:

(1) Combination problem: This problem is "how low-level proto-experiential and other properties somehow together *constitute* our complex unified conscious experiences" (Seager, 1995), i.e., how a specific SE can *emerge* from the PEs of constituent elements in a related neural-net (R. L. P. Vimal, 2009h, 2009i).[12] In other words, "sub-minds, such as those of atoms, cannot be conceived to combine or sum into complex, unified minds such as humans have. Hence panpsychism is not an adequate account of mind" (Skrbina, 2005)(p.265).

(2) No sign or not testable problem: The problem is "there is no evidence whatsoever of a nonphysical [nonmaterial] dimension to the elemental units of nature"[13] (Seager, 1995) and there is no

[11] See http://en.wikipedia.org/wiki/Panpsychism

[12] The dual-aspect PE-SE framework with hypothesis H_3 is a dual-aspect panpsychist theory. However, other hypotheses H_1, H_2, H_4, and H_5 are not panpsychist views. Details are given in (R. L. P. Vimal, 2009g, 2009h).

[13] In panpsychism, "all things have a mind, or a mind-like quality" (Skrbina, 2003). In general, there are panpsychists with dual-aspect view (substance monism but property dualism) (Skrbina,

'sign' of mentality in the basic features of the world. In other words, there are "no 'new facts' or empirical basis on which to evaluate the panpsychist claim. … This includes the assumption that non-verifiable theories are invalid in some fundamental sense" (Skrbina, 2005)(p.265). However, Nunn (personal communication) argues that it is simply not true. Quantum counterfactuals (e.g. the Elitzur-Vaidman bomb test)[14] show clearly that what one might term *knowledge* is built into the foundations of physics.

A related problem, the **completeness problem,** is that the inert system should also show sometime causal power of proto-experiences, which is not the case (Seager, 1995; R. L. P. Vimal, 2009i). However, Nunn argues that if (Seager, 1995) is implying that the physical is causally closed, then it can only be thought to be true if *causal* is confined to efficient (spontaneous or chance) causation. It is not true otherwise as Henry Stapp and Hans Primas have shown with their *Heisenberg choice* arguments (Primas, 2002; Primas, 2003; Stapp, 2009; Stapp, 2010).

(3) Inconclusive analogy or not-mental problem: "The purported analogical basis between humans and other objects is groundless" (Skrbina, 2005) (p.265). The variant 'not-mental' problem (Seager, 1995) is "identifying the conjectured 'inner nature' of, say, an atom with something we can reasonably call mental" (Skrbina, 2005)(p.262-263).

(4) Physical emergence problem: "Emergence is in fact possible because we see it in other realms of the physical world; mind is not ontologically unique; hence emergence of mind *is* conceivable" (Skrbina, 2005)(p.265). A related problem is **unconscious mentality problem,** which is "accepting the mentality of the elemental units of mind while denying that they are actually conscious experiences" (Seager, 1995). In other words, "how can consciousness emerge from unconsciousness?" (Skrbina, 2005)(p.262-263).

(5) Implausibility problem: "Panpsychism is so implausible and counter-intuitive that it cannot be true. Also known as the '*reductio ad absurdum*' objection" (Skrbina, 2005)(p.265).

(6) Eternal mystery problem: "Mind-body problem is unsolvable in principle, and hence panpsychism, which purports to offer a solution, must be false" (Skrbina, 2005)(p.265).

(7) Restricted panpsychism problem: "Quantum thermofield dynamics does in fact prescribe a lower boundary below which there can be no cooperative dynamics, and without cooperative dynamics there is nothing mind-like […] If qualia were tied to the coherence of cooperative dynamics, then the descent into panpsychism would halt at the coherence length [of about 50 microns]" (Globus, 2009).

2009a), panpsychist dualists, functionalists, identists, reductive materialists, and so on (Skrbina, 2005). Thus, panpsychism, in general, seems to be attached to the existence of non-material dimensions in addition to material dimension.

[14] See http://en.wikipedia.org/wiki/Elitzur%E2%80%93Vaidman_bomb-tester

A possible solution to the problems put to most views above is addressed in the dual-aspect-dual-mode PE-SE framework with hypothesis H_1 (Vimal, 2008b, 2010), which is concisely described below.

1.2. Dual-aspect-dual-mode PE-SE framework

This section is a summary from a broader work where additional details can be found (Vimal, 2008b; R. L. P. Vimal, 2009i; Vimal, 2010). There are three entities that need to be linked in a theory of consciousness: *structure, function,* and *experience*. Several materialistic neuroscientific models link *structure* with *function* well, but fail to link them with *experience*, leading to the explanatory gap (Section 1.1.1). The dual-aspect-dual-mode PE-SE framework is complementary to neuroscience models; it complements them because it closely depends on them for linking *structure* with *function* including *global broadcasting* (Baars, 1988). In non-reductive views, such as in this dual-aspect framework, a specific conscious *experience* (such as mental aspect *redness*) *is linked to* (*or coincides with*) a specific state (such as redness-related state caused by long wavelength light) of a specific *structure* (such as material aspect red-green V4/V8/VO-neural-net) that has specific *functions* (such as detection, discrimination, and recognition of red color).

In (Vimal, 2008b), to address the above explanatory gap, it was hypothesized that strings or elementary particles (fermions and bosons) have two aspects: (i) material aspect such as mass, spin, charge, force, quanta, and space-time, and (ii) mental aspect. The mental aspects of strings, elementary particles, and inert matter are considered as the *carriers* of superimposed fundamental *experiences* in unexpressed form. The superposition of multiple possible experiences is based on the hypothesis 'the mental aspect of wave is wave-like and is a function of experiences', which is based on the assumption that matter (wave/particle) has double aspects (mental and material aspect). These possibilities are actualized when neural-networks are formed via *neural Darwinism*, and a specific subjective experience (SE) is selected by a *matching* process. For example, SE *redness* would never be selected and experienced without the formation of redness-related V4/V8/VO-neural-network. The 'brute fact' of dual-aspect is justified because SEs appear fundamental, inherent, and irreducible in normal waking state of mind-brain.

In (R. L. P. Vimal, 2009i), I describe three competing hypotheses of the 'dual-aspect-dual-mode PE-SE' or simply 'PE-SE' framework, where PEs are proto-experiences that are precursors of SEs (defined in the next paragraph). They are (i) *superposition* based (hypothesis $\mathbf{H_1}$), (ii) *superposition-then-integration* based ($\mathbf{H_2}$), and (iii) *integration* based ($\mathbf{H_3}$) where superposition is not required.

In $\mathbf{H_1}$, the fundamental entities and inert matter are the *carriers* of superimposed fundamental subjective experiences (SEs)/proto-experiences (PEs). In $\mathbf{H_2}$, the fundamental entities and inert matter are the *carriers* of superimposed fundamental PEs (not SEs), which are *integrated* by *neural-Darwinism* (co-evolution, co-development, and sensorimotor co-tuning by the evolutionary

process of adaptation and natural selection). There is a PE attached to every level of evolution (such as atomic-PE, molecular-PE, genetic-PE, bacterium-PE, neural-PE, and neural-net-PE). In **H_3**, a string has its own string-PE; a matter is not a *carrier* of PE(s) in superposed form as it is in **H_2**; rather it is a proto-experiential entity and has two aspects at every level. **H_3** is a dual-aspect panpsychism because the mental aspect is in all entities at all levels, even though *psyche* (conscious subjective experience) only emerges when PEs are integrated. These two aspects are rigorously *integrated* by *neural-Darwinism*.

In **H_1**, a specific SE arises in a neural-net as follows: (i) there exist a *virtual reservoir* that *stores* all possible fundamental SEs/PEs, (ii) the interaction of stimulus-dependent feed-forward and feedback signals in the neural-net creates a specific neural-net state, (iii) this specific state is assigned to a specific SE from the *virtual reservoir* during *neural Darwinism*, (iv) this specific SE is embedded as a memory trace of neural-net-PE, and (v) when a specific stimulus is presented to the neural-net, the associated specific SE is selected by the matching and selection process and experienced by this net.

In hypotheses **H_2** and **H_3**, a specific SE *emerges* in a neural-net from the interaction of its constituent neural-PEs, such as in feed-forward stimulus-dependent neural signals and fronto-parietal feedback attentional signals. In all hypotheses, SEs occur when essential ingredients of SEs are satisfied (R. L. P. Vimal, 2009f). One could argue that the PE-SE framework with hypotheses **H_1** and **H_2** is Dual Aspect Naturalism[15] or Non-Reductive Physicalism.

A subjective experience (SE) is an *expressed* first person conscious experience that occurs/arises/emerges during interaction between feed-forward signals and feedback signals in a neural-net, which satisfies the *necessary* ingredients of consciousness (R. L. P. Vimal, 2009f) such as wakefulness, re-entry, attention, working memory (Rowlatt, 2009), stimulus at above threshold, and neural-net proto-experiences (PEs).

This is perhaps related to the *first-order*, *phenomenal,* or *access* (reportable) consciousness and is experienced by the specific neural-network; for example, the V4/V8/VO-neural-net experiences color, such as 'saw red tomato'. For *phenomenal* consciousness, feedback attentional signals are not necessary and do not get time to become active (Block, 2005; Lamme, 2003; R. L. P. Vimal, 2009f). *Phenomenal* consciousness is not reportable, which presumably occurs during less than 50 msec stimulus presentation such as in Sperling type experiments (Sperling, 1960). The temporal-lobe system might be included in the neural correlates of *phenomenal/access* consciousness (Carruthers, 2007; Glover, 2004; Milner & Goodale, 1995).[16]

[15] See http://en.wikipedia.org/wiki/Naturalism_(philosophy)

[16] In temporal lobe system, (Kosslyn, 1994) envisages a complex interaction between incoming non-conceptual information and conceptual templates, the result of which may be (consciously) seeing a tomato *as* a tomato and not just a red sphere (Carruthers, personal communication). Some authors include the interactions of feedback (attentional) signals with feed forward signals in *phenomenal* (P) consciousness. In this article, the attentional feedback interactions are a part of *access* consciousness, not P-consciousness.

When the self or 'I' is explicitly involved, as in 'I saw red tomato', perhaps *self*-related neural-network (Bruzzo & Vimal, 2007), such as cortical midline structures (Northoff & Bermpohl, 2004; Northoff et al., 2006), might also interact with the above feed-forward and feedback signals. For inner-sense awareness (Armstrong, 1968; Lycan, 1996), self-awareness (Perrett, 2003), awareness via diagonal representation (Prosser, 2007), or *higher-order* awareness (dispositional (Carruthers, 2000; Carruthers, 2007; Dennett, 1991); non-dispositional/actualist (Rosenthal, 2009); self-representational (Kriegel & Williford, 2006; Van Gulick, 2004))[17], such as 'I am aware that I saw red tomato', perhaps the related neural-network also interacts with all above networks. Further research is needed to test these hypotheses.

In general, PEs are precursors of SEs. In hypothesis $\mathbf{H_1}$, PEs are precursors of SEs in the sense that PEs are superposed SEs in unexpressed form in the mental aspect of every entity, from which a specific SE is selected via matching and selection process in brain-environment system. In hypotheses $\mathbf{H_2}$ and $\mathbf{H_3}$, PEs are precursors of SEs in the sense that SEs *somehow* arise/emerge from PEs, as elaborated above and in (R. L. P. Vimal, 2009g, 2009h, 2009i).
In (Vimal, 2010), (a) the dual-mode concept from the framework of thermofield dissipative quantum brain dynamics (Globus, 2006; Vitiello, 1995) is explicitly incorporated in the PE-SE framework without decreasing the degree of parsimony as it was implicitly already present, and (b) *matching* and *selection* processes are further elaborated.

In dual-aspect-dual-mode PE-SE framework, the two modes are non-tilde and tilde modes. The non-tilde mode is defined as the material and mental aspect of cognition (memory and attention) related feedback signals in a neural-network of the brain. Since memory contains past information, the non-tilde mode represents the cognitive nearest past approaching towards present. The tilde mode is defined as the material and mental aspect of the feed forward signals due to external environmental input and/or internal endogenous input. Since input signals contain information related to near future, the tilde mode represents the nearest future approaching towards present and is an entropy-reversed representation of non-tilde mode. In the thermofield dissipative quantum brain dynamics (Globus, 2006; Vitiello, 1995), entropy is related to time.

Furthermore, one could argue that there are at least five pathways for information transfer in the brain dynamics: (i) quantum dendritic-dendritic microtubule (MT) (dendritic webs) pathway, (ii) classical axonal-dendritic neural pathway, (iii) Ca-related astro-glial-neural pathway, (iv) extracellular volume transmission, and (v) soliton propagation.

[17] The terms 'dispositional' vs. 'non-dispositional' are from (Prosser, 2007); and the terms 'dispositional' vs. 'actualist' are from (Carruthers, 2007): "A conscious mental event M, of mine, is one that is *disposed [or available] to cause* [*potentially causing* vs. *actually causing*] an activated belief (generally a non-conscious one) that I have M, and to cause it non-inferentially" (*italics* mine).

There are two types of matching mechanisms: (a) the matching mechanism for the quantum dendritic-dendritic MT pathway, and (b) the matching mechanism for classical pathways. In other words, we propose that (a) the *quantum conjugate matching* between *experiences* in the mental aspect of the tilde mode and that of the non-tilde mode is related mostly to the mental aspect of the quantum MT-dendritic-web, namely (i); and (b) the classical *matching* between *experiences* in the mental aspect of the tilde mode and that of the non-tilde mode is related to the mental aspect of the remaining non-quantum pathways, namely (ii)-(v).

In all cases, a specific SE is selected (a) when the tilde mode (the material and mental aspect of feed forward input signals) interacts with the non-tilde mode (the material and mental aspect of cognitive feedback signals) to *match* for a specific SE, and (b) when the *necessary* ingredients of SEs are satisfied. When the match is made between the two modes, *the world-presence* (*Now*) is disclosed; its content is the SE of subject (self), the SE of objects, and the content of SEs. The material aspects in the tilde mode and that in the non-tilde mode are matched to link *structure* with *function*, whereas the mental aspects in the tilde mode and that in the non-tilde mode are matched to link *experience* with *structure* and *function*.

Since a specific *state* of a system is *identical with* or *correlated with* a specific SE, one could argue that the (quantum) superposition of *states* in the material aspect of the system *is identical with* or *correlated with* the superposition of respective SEs in its (system's) mental aspect. The occurrence (or threshold) of subjective experience (SE) aspect of consciousness may be determined by (a) the *(quantum conjugate) matching* of SEs (and/or qualia) superposed in the stimulus (such as long wavelength light) with SEs superposed in a neural-net (such as red-green V4/V8/VO-neural-net), and then (b) the *selection* of a specific experience (such as *redness*) that is correlated to a specific state (such as *redness* related state) of the neural-net. Making a comparison with a well-known proposal, it is a sort of Orch OR for quantum dendritic-dendritic MT pathway. A difference is that the cause of Orch OR is self-collapse, and the quantum gravity threshold in microtubules is orchestrated by microtubule-associated-proteins (MAPs), and occurs in MT-network isolated from its environment (Hameroff & Penrose, 1996). Whereas, the cause of collapse in the PE-SE framework could be (a) environmental stimulus dependent or endogenously generated feed-forward signals interacting with feedback signals for the matching and selection of a specific SE and/or (b) self-collapse.

It is argued that (a) this dual-mode-dual-aspect PE-SE framework has fewer problems (such as the justifiable 'brute fact' of dual-aspect), and (b) it addresses the problems of other framework including the explanatory gap in materialism (see Section 1.1). In addition, we have worked through double aspect theory at a level, which has not been previously elaborated.

One could critique this view by arguing that strings or elementary particles are not specific to any SE/PE; rather, to prove that they (and all inert matter) are carriers of SEs/PEs would require extraordinary evidence, given that the particles are at least eight orders of magnitude smaller

than the chemical events that characterize brain function, and the strings are ten orders of magnitude smaller yet.

The evidence is that they (strings, elementary particles, inert matter, molecules, proteins, neurotransmitters and so on) behave as if they were non-experiential entities. This behavior is consistent with methodological assumptions on which all our physical science is based. It is only when a neural-network is formed and when this network satisfies the necessary ingredients of experiences, it has a specific experience via matching and selection mechanisms, for example, V4/V8/VO-neural-network for color. Furthermore, there is evidence that experiences (such as *redness*) are irreducible, fundamental and inherent; for example, one cannot reduce *redness* to any other entity at normal wakeful state of mind-brain system. Our hypothesis is that all experiences are superposed in the mental aspect of matter (such as strings, elementary particles, molecules, proteins, neurotransmitters and so on) in unexpressed form because in the absence of necessary conditions for the emergence of conscious experiences matter behaves as if it is non-experiential entity. Other critiques and responses are rigorously given in (Vimal, 2010).

2. Definitions of consciousness

One of premises for the search of an *optimal* definition of consciousness is that biological evolution should have optimized living systems in all of these three aspects: *structure*, *function*, and *experience*.[18] According to the Adaptationist view I assume here, any (functional) *structure* would have some *function;* otherwise, the natural selection of evolution must have selected it out. Nunn (personal communication) recalls a term used by evolutionists for structures that exist only because they are concomitants of something, which does have a function – namely *spandrels*. I am not considering such *structures* in the following argumentation because such *spandrels*, as Nunn argued, do not have useful *function*. I assume that experience must have some *function* (in the *optimal* definition of consciousness); otherwise, natural selection must have selected it out. However, Nunn (following a large crowd of Philosophers of Mind) argues that this may apply to classes of experience, but not to *experience as such*; for example, natural selection may not have any interest in one's liking of El Greco's pictures[19] (Nunn, personal communication). In such special cases, there could be other premises in quest of an *optimal* definition of consciousness. For

[18] In the *optimal* definition of consciousness (Section 2.1), we have assumed that consciousness has two sub-aspects: conscious *experience* AND conscious *function*. However, in the *general* definition of consciousness (Section 2.2), we have relaxed this AND assumption to AND/OR: consciousness is a conscious *experience*, a conscious *function*, or both depending on the context and particular bias (e.g. metaphysical assumptions). Therefore, the *general* definition does not rule out the views and accounts of those who deny that conscious states must have a *function*, in particular those who regard the explanation of consciousness as problematic. In other words, the general definition of consciousness tries to accommodate almost all views.

[19] See http://en.wikipedia.org/wiki/Art_of_El_Greco.

example, one could argue that the *experience* of 'liking' in the above example serves appropriate emotion related *function*. However, if an *experience* indeed does not have any *function*, then obviously we cannot link them, but it can still be a part of the definition(s) of consciousness because it is a conscious *experience*.[20]

For *consciousness-as-such* (Rao, 1998), I argue that it is still an *experience* at *samadhi* (R. L. P. Vimal, 2009d). *Awareness/consciousness-as-such* or pure awareness is a state often reported in mystical experiences by *yogis* (Rao, 1998, 2005), such as (i) an experience of the unification of self (SE of subject), SE of observed objects, and the processing of SEs (R. L. P. Vimal, 2009; R. L. P. Vimal, 2009a, 2009b, 2009c, 2009e, 2009g, 2009h) and (ii) inner-light experiences at *samadhi* state (Prakash & Caponigro, 2009; Prakash, Haq, Prakash, Sarkhel, & Kumar, 2009).

According to (Pereira Jr. & Ricke, 2009), "*consciousness is a process that occurs in a subject (the living individual) & the subject has an experience (he/she interacts with the environment, completing action-perception cycles) & the experience has reportable informational content (information patterns embodied in brain activity that can be conveyed by means of voluntary motor activity).*" This is an interesting definition for *access* consciousness, and can be easily extended to include *phenomenal* consciousness by including *non-reportable* attribute in the definition (Block, 1990; Block, 1992; Block, 1995; Block, 2005; Block, 2007).

In any case, within the above limitations, the *structure*, *function*, and *experience* can be linked. For example, in (R. L. P. Vimal, 2009f), we have linked the *structure* 'V4/V8/VO' (color area for the Red-Green channel) with the *function* 'detection and discrimination of red and green color', which is linked with the subjective *experiences* redness and greenness.

2.1. *Optimal* definition of consciousness

The problems listed in Section 1.1 are addressed in the dual-aspect-dual-mode PE-SE framework (Vimal, 2008b, 2010) where *structure*, *function*, and *experience* are linked. So far, this seems to be the *optimal* framework because it has the least number of problems (as discussed in (Vimal, 2010)). In this section, I discuss the possibility of a definition of consciousness derived from this framework also being *optimal*.[21] In this framework, every entity has two aspects: material and

[20] However, one could argue that although the *function* of a subject's liking the pictures of El Greco is not clear at the present time, but it may have useful *function* in future or in culture. For example, the subject's liking the pictures of El Greco could serve some useful *functions*, such as the financial security for El Greco. The function of a subject's liking the pictures of El Greco is clearly different from the function of the pictures themselves.

[21] One could argue that the term "optimal" implies that a set of alternatives have been considered and one of them chosen as the fittest according to a given set of parameters. However, in the above paragraphs only one alternative is presented and then called "optimal". What are the other options and why is this the optimal one? There are over 40 alternative definitions of consciousness as concisely discussed and

mental. The material aspect is composed of *structures*, whereas the mental aspect is composed of *functions* and *experiences*. As shown in (R. L. P. Vimal, 2009d), "the *functions* and *experiences* together constitute the meanings attributed to the term *consciousness*." This framework is a *Non-Reductive physicalist one*.

Functions are also considered (in addition to *experiences*) as a component of the mental aspect of an entity. From this simple rationale, one could argue that consciousness can be *optimally* defined as *a mental aspect of an entity (system or process) that has two sub-aspects: conscious experience and conscious function*, where *conscious experience* involves first person subjective observations and *conscious function* involves third person objective measurements.

For example, the *conscious function* of the *structure* red-green V4/V8/VO-neural-network is the detection and discrimination of colors between red and green; the related *conscious experience* is a SE between redness to greenness. In this case, the consciousness is a mental aspect of a system or a process that has two sub-aspects: (i) redness and greenness as *conscious experiences* and (ii) the detection and discrimination of red from green as *conscious functions*. This *optimal* definition is derived from the dual-aspect-dual-mode PE-SE framework that is *optimal* as discussed rogorously in (Vimal, 2010), where other alternative frameworks are discussed; discussing alternatives again will be counted as unnecessary repetition. Experiences and functions are elaborated further as follows.

The *optimal* definition can be usefully related to Block's definition of consciousness. Block proposed a conceptual distinction between *phenomenal* (non-reportable) and *access* (reportable) aspects of consciousness (Block, 1990; Block, 1992; Block, 1995). For primates, fronto-parietal feedback attentional signals are necessary for *access* consciousness; whereas attention is not needed for *phenomenal* consciousness (R. L. P. Vimal, 2009f). I argue that each of *phenomenal* and *access* aspects of consciousness can have two sub-aspects: (i) *conscious experience*: the *experiential* aspect refers to first person subjective observations; and (ii) *conscious function*: the *functional* aspect involves third person objective measurements. In other words, in the *optimal* definition of consciousness, each of the *conscious experience* and *conscious function* sub-aspects can have *phenomenal* consciousness and *access* consciousness components.

According to (Block, 2005), "Phenomenally conscious content is what differs between experiences as of red and green, whereas access conscious content is content information about which is 'broadcast' in the global workspace". These distinct contents of *phenomenal* consciousness and *access* consciousness can be related to differed contents of *phenomenal* and *access conscious experiences*, respectively; and also that to differed contents of relevant *phenomenal* and *access conscious functions.* In addition, (Block, 2007) assumes that "the neural basis of phenomenal consciousness does not include the neural basis of cognitive accessibility". In the PE-

---

tabulated in (R. L. P. Vimal, 2009d). They all have problems in addition to their own *brute facts*. I have discussed briefly relevant problems of most alternatives by categorizing them in terms of metaphysical views in Section 2. I have concisely discussed some of more relevant definitions in various sections. The definition proposed here is *optimal* because I have optimized it with respect of all available frameworks in terms of number of their problems. The PE-SE framework has the least number of problems, namely, the justifiable *brute fact* of dual-aspect. Other frameworks have more number of problems in addition to their own *brute fact*. Further details are given in (Vimal, 2010).

SE framework, this translates to "the neural basis of phenomenal conscious experience and phenomenal conscious experience do not include the fronto-parietal cognitive and attentional feedback signals".

According to (Velmans, 2009), "*Definitions of consciousness need to be sufficiently broad to include all examples of conscious states and sufficiently narrow to exclude entities, events and processes that are not conscious.*" On the other hand, Skrbina (personal communication) suggests that the term 'consciousness' should include only conscious entities (such as *conscious experiences* and/or *conscious functions*) but panpsychism should not be explicitly excluded. There seems to be a contradiction between Velmans and Skrbina positions with respect to panpsychism. In my view, the conscious part of panpsychism (such as in primates) should be included in the definition of consciousness that is composed of *conscious experiences* and *conscious functions*; whereas, the non-conscious part of panpsychism (such as in inert matter) should be included non-conscious experiences and non-conscious functions, which are defined below (see also Section 2.4).

In addition, (Nixon, 2007) and (Pereira Jr. & Ricke, 2009) argued that experience can occur with and without consciousness. In this context, *experiences* could be *conscious experiences* and *non-conscious experiences*, and *functions* could be *conscious functions* and *non-conscious functions*.

Inclusion and exclusion criteria for conscious *experiences* and related *functions*: Since my goal is to search for *optimal* and *general* definitions of consciousness, all kinds of conscious experiences and conscious functions should be included, and all types of non-conscious experiences and non-conscious functions should be excluded. This is because these definitions should encompass all or as many as possible types of subjective or first person experiences and related functions, including intuitively meeting pre-theoretic criteria of what it is to be conscious.

One could argue that lists are too general and too broad to have a non-trivial classificatory use. However, these definitions should encompass all or most views in a non-trivial manner, so that they do not suffer what previous definitions have suffered (namely, they led us to the jungle of over 40 meanings attributed to the term 'consciousness' and confused the readers: which aspect an author is addressing (R. L. P. Vimal, 2009d)). The following lists serve for both the *optimal* definition and the *general* definition (Section 2.2) of consciousness.

Conscious experiences include all types of subjective or first person experiences including such as: (i) sensory experiences as *redness* (R. L. P. Vimal, 2009f); (ii) 'what exists when there is something that it is like to be that thing' (Nagel, 1974); (iii) phenomenal experience (Chalmers, 1996); (iv) *reportable* content experienced by living individuals (the "*referential nucleus*" of the concept of consciousness, according to (Pereira Jr. & Ricke, 2009)), emotional experiences such as happiness, experiences related to thoughts (such as imagination/creative thinking), the experience of *nothingness* in meditation, experiences as the result of dynamical processes in the *embodied and embedded* view of cognition, experiences related to social interactions (Pereira Jr. & Ricke, 2009); (v) experiences related to *self* (Bruzzo & Vimal, 2007) and self-awareness (Perrett, 2003), and perhaps higher-order awareness (Carruthers, 2007; Rosenthal, 2009); (vi) experiences related to

phenomenal time (Vimal & Davia, 2008); and (vii) *inner/outer* experiences, *hidden (other's)* experiences via a process of theorization or simulation or both, *singular-detachable-individual* experiences, and *shared* experiences (Torrance, 2009), and so on.

Non-conscious experiences are those experiences that are not conscious experiences; for example, experiences related to pre-conscious, subconscious and unconscious domains, slow-wave dreamless deep-sleep, coma, vegetative, and anesthetized state. Non-conscious experiences can include experiences related to paradoxical awareness or awareness without being aware, such as subliminal perception and *blindsight*. According to (Pereira Jr. & Ricke, 2009), "when we are sleeping without dreams we nevertheless have experiences without consciousness, e.g. the proprioceptive ones that prevent us falling out of our beds! Another good example of experience without consciousness is *blindsight*, a phenomenon in which people who are perceptually blind in a certain region of their visual field respond to visual stimuli without any associated qualitative experience ('quale'). […] In conscious experience there is a content experienced by a subject, while in the case of unconscious phenomena there may be - among other possible combinations - a subject without content (e.g. animals under general anesthesia), and informational content without a subject (e.g. information patterns in the Hard Disk of a computer). More precisely, according to the referential nucleus above, an experience is conscious when there is a reportable content being experienced by a subject, such that the content is content *for the subject*. […] If a robot has feedback mechanisms allowing the completion of action-perception cycles, then it can be considered as having experiences, but not *conscious* subjective experience, because of the lack of content and subjectivity [artificial consciousness]." This conception of non-conscious experiences is similar to or identical with proto-experiences (PEs) in the PE-SE framework at various levels, such as PEs related to sleep, dream, *blindsight*, general anesthesia, robots, and so on. This is because PEs are those experiences that not SEs.

Conscious functions are those functions that operate or are active when the system is awake and attentive (feedback signals modulating the feed forward signals). According to (Faw, 2009), the *states of consciousness* such as the *active* wakefulness (*normal waking state*) should be distinguished from *quiet* (passive) wakefulness, altered forms of waking consciousness underlying trance, absorption, hypnosis, dissociation, meditative states, drug states, and out of body experiences, REM/dream state, minimal conscious state, and drowsiness. Here, their functional part is considered within the conscious functions as a 'working definition'.

For *access* consciousness (that plays a role in global-workspace theory (Baars, 1988)), attention and working memory[22] are necessary; whereas for the *phenomenal* consciousness, attention is not needed, but sensory memory (such the *iconic memory* for the visual system, the *echoic memory* for the auditory and the *odor memory* for the olfactory system) is necessary (Rowlatt, 2009; R. L. P. Vimal, 2009f).

Conscious functions can include functions and processes related to: (i) conscious experiences elaborated above; (ii) functions listed in Table 1 of (R. L. P. Vimal, 2009d) except non-conscious functions (see below); (iii) necessary ingredients of consciousness (R. L. P. Vimal, 2009f), such as

[22] According to (Carruthers, 2009), the working memory system is, indeed, a kind of global workspace.

working memory (Rowlatt, 2009), attention, re-entry; (iii) *intentionality* ('intending to do something'; object-directed) (Faw, 2009; Perrett, 2003) and executive functions (R. L. P. Vimal, 2009f); (iv) *core* and *extended* consciousness (Damasio, 1999); (v) *control* and *inner-sense/higher-order-sense* consciousness (Armstrong, 1968; Carruthers, 2007; Lycan, 1996); (vi) primary, basic, or first-order consciousness ('conscious of something') and secondary, self, reflective/reflexive consciousness (Duvall & Wicklund, 1982; Faw, 2009); (vii) higher-order consciousness ('awareness of our own mental states') (Rosenthal, 2009) (viii) *phenomenal, access,* and *reflexive (or reflective)* consciousness (Block, 2001; Rowlatt, 2009)**;** (ix) paradigmatic consciousness states (night-dreaming or day-dreaming consciousness) (Faw, 2009); (x) *transitive* and *state* consciousness with *conscious*[23] intentional and/or qualitative properties, and higher-order thoughts (Rosenthal, 2009); and (xi) thoughts (such as imagination/creative thinking), emotions (such as pain, pleasure, thirst, fear, anger, and happiness), decision/voluntary action, (Pereira Jr. & Ricke, 2009).

Non-conscious functions are those functions that are not conscious functions; for example, functions related to pre-conscious, subconscious and unconscious domains, slow-wave dreamless deep-sleep, coma, vegetative, and anesthetized state. Non-conscious functions can include functions related to long-term memory, paradoxical awareness or awareness without being aware, such as subliminal perception and related *state* consciousness (Rosenthal, 2009), implicit memory, and blindsight (listed in Table 1 of (R. L. P. Vimal, 2009d)).

One could ask: What is the difference between *non-conscious functions* and *non-conscious experiences*? Would both reduce to proto-experiences? The meanings attributed to the term 'consciousness' have been categorized in to functions and experiences (R. L. P. Vimal, 2009d). Functions are related to third person objective measurements related to the function of the system, whereas, experiences are first person subjective observations. Since *non-conscious experiences* are those experiences that are not *conscious experiences*, they are indeed proto-experiences in the PE-SE framework. However, since *non-conscious functions* are those functions that are not *conscious functions*, it would be more appropriate to call them *proto-functions*. I agree that the difference between *non-conscious experiences* and related *non-conscious functions* is very little, which not clear.

Material functions and robotic consciousness: A *material function* is a part of *non-conscious functions*[24] and is the function of the material aspect of an entity, for example, the function of thermostat, the break of a car, spectrometer, and so on. However, in Idealism, one can argue that the *material functions* are the properties of mind or mind-like entities, and hence they are mental

[23] To avoid circularity, the term '*conscious*' refers to 'conscious experiences' as defined before.

[24] This claim implies, with the use of Elementary Logic ("If A → B then non-B → non-A") that conscious functions are not material. This is correct because, by definition, *functions* and *experiences* are mental (non-material) entities.

functions. Panpsychists argue that some – not necessarily all – fundamental states of Nature are mental. This view also implies that mental states are material. In panpsychism, (Skrbina, 2009b) argues that even a matter such as a rock has a mind. In *holoworld* framework (Globus, 1995; Globus, 1998), SEs are eliminated; instead, the experiences are denoted by the properties/qualities of objects (such as the red color of a ripe tomato) (Byrne & Hilbert, 2003; Globus, 1995; Globus, 1998).

In this article, we consider the qualities of objects as a part of *material functions*, which is considered as a part of *non-conscious functions*. In the dual-aspect-dual-mode PE-SE framework with hypothesis H_1, the mental aspect of an inert matter is a *carrier* of superposed SEs/PEs in unexpressed form and hence conscious experience is inactive; therefore, the *material function* is the *function* of the material aspect of the inert matter. However, (i) if neural networks, such red-green V4/V8/VO-neural-network, along with *necessary* ingredients of SEs are implemented in a robot, (ii) if the robot satisfies these necessary conditions and if it can perform all the *functions* as a human being can, and (iii) matching and selection mechanisms are active, then that robot may be considered conscious.

In addition, I concisely discuss 'qualia' as a related issue. According to (Beaton, 2009), qualia are "properties of sensory experience broadly construed to include states such as seeing, hallucination, sensory memory, sensory imagination, and so on". In general, one could argue that *qualia* are (a) properties of *conscious experiences* (such as phenomenal *redness*) (Beaton, 2009; Byrne, 2008; Pereira Jr. & Ricke, 2009) and/or (b) the properties/qualities of objects (such as the red color of a ripe tomato) (Byrne & Hilbert, 2003; Dretske, 1995; Globus, 1995; Globus, 1998).[25]

My view is that qualia are not equal to conscious states/processes, but rather they are properties of consciousness. For example, an experience of a bulging red tomato has the qualia (phenomenal qualities) of phenomenal bulginess and phenomenal redness. Especially (but not only) because a single experience of the world can have multiple qualia (qualities), it does not sound right to say that qualia are experiences, even though qualia are properties (arguably, the characteristic, defining properties) of consciousness experiences.

However, one might ask: when we think about qualia, are we really thinking about properties of experience? Or are we thinking about the power of objects to cause certain properties of experience (secondary qualities)? In addition, how do we address the conscious experience of an achromat (whose experience is equivalent to grayness) versus that of a trichromat (whose experience is redness) for the same ripe tomato?

Some authors, such as (Byrne & Hilbert, 2003), might claim that phenomenal bulginess and phenomenal redness are properties of actual tomatoes in the world; whereas other authors, such as (Beaton, 2009; Byrne, 2008; Pereira Jr. & Ricke, 2009), claim them as 'phenomenal' or 'qualitative' character of conscious experience. For most views, *qualia* are <u>either</u> properties of conscious experiences <u>or</u> the properties of objects.

[25] I differentiate the term 'redness' from 'red'. The term 'redness' is 'phenomenal redness' (less open to misinterpretation) or SE redness, whereas, the term 'red' is the property of object.

However, in Idealism, matter emerges from consciousness. This implies tomatoes themselves are properties of experiences in Idealism. In addition, in dual-aspect-dual-mode PE-SE framework (with hypothesis $\mathbf{H_1}$) (R. L. P. Vimal, 2009g; Vimal, 2010), SEs are superposed (in unexpressed form) in the mental aspect of inert matter (both internal and external to brain). A specific SE is expressed during matching and selection process in a specific neural-network when it satisfies the necessary ingredients of consciousness (R. L. P. Vimal, 2009f). This framework implies that both neural-networks and objects are involved in qualia.

Moreover, according to (Shoemaker, 1994), "the phenomenal character of the experiences consists in a certain aspect of its representational character, i.e., in its representing a certain sort of property of objects, namely "phenomenal properties" [qualia] that are constitutively defined by relations to our experience." This implies that the phenomenal character of experiences have a sort of relationship with the properties of objects for qualia. These views do not contradict with the hypothesis that qualia are both properties of experiences and properties of tomatoes. To sum up, the logical conjunction 'and/or' or equivalently symbol ⊕ can be used for a *general* definition that encompasses most views; for example, see Eq. (3) of Section 2.4 for qualia.

Therefore, an *optimal* definition is: *consciousness is a mental aspect of a system or a process and is consists of conscious experience and conscious function.* This definition is based on the dual-aspect-dual-mode PE-SE framework, which is *optimal* because it has the least number of problems.[26]

2.2. *General* definition of consciousness

A more *general* definition requires that most views and the *context* in which the term 'consciousness' is used should be included in the definition. For instance, it is well-known that the definition of consciousness varies with different metaphysical views. Therefore, a more *general* definition would be '*consciousness is a mental aspect of an entity (system or process), which is a conscious experience, a conscious function, or both depending on the context and particular bias (e.g. metaphysical assumptions)*'. This definition tries to accommodate most views. This is because any investigator's finding related to consciousness has to be a *conscious function, conscious experience* or both depending on the context and particular bias (e.g. metaphysical assumptions) dominant in the investigation. For example: (i) If the dominating view is a Materialist/Functionalist one, then consciousness is likely to be considered as *conscious function.* (ii) If the dominating view is Dualist/Idealist, consciousness is more likely to be considered as pure *conscious experience.* (iii) If the dominating view is Dual-Aspect, Panpsychist, Panprotopsychist, Panexperientialist or Panprotoexperientialist, consciousness is likely to be considered as both *conscious experience and conscious function.* And (iv) if the dominating view is the *Holoworld* framework, consciousness is likely to be associated with the qualities of objects.

[26] The only problem is the brute fact of justifiable dual-aspect view; the justification is that SEs (superposed in the mental aspect) are fundamental, irreducible, and inherent in normal waking state of mind-brain.

One could argue that *pure awareness* or *consciousness-as-such,* claimed by the Mystic, lacks subjectivity. However, I argue that it is still a *conscious experience* though it occurs at *samadhi* state.

Furthermore, according to epiphenomenalists (Type E) "physical states cause phenomenal states, but not vice versa" (Chalmers, 2003); here, perhaps, they are discussing the *conscious experience* aspect of consciousness.

One could also critique using Daniel Wegner's *free Will*: (Wegner, 2002) showed that the experience of *free Will* has no direct connection with actuality. However, one could argue that his conception of *free Will* also addresses *conscious experienc*e or *conscious function* aspects of consciousness; it must have some *function* otherwise natural selection would have selected out our *free Will*. For example, according to (Wegner, 2004), "Experiences of conscious will thus arise from processes whereby the mind interprets itself--not from processes whereby mind creates action"; here the term 'processes' indicates *function,* as defined in (R. L. P. Vimal, 2009d).

According to (Stapp, 2009), "*In orthodox quantum mechanics, no elements of quantum randomness enter into man's choice*. Nor is man's choice fixed by the deterministic aspect of quantum mechanics: that aspect enters only via process 2. Von Neumann's process 1 human choice is, in this very specific sense, "free": it is von Neumann's representation of Bohr's "free choice of experimental arrangement for which the quantum mechanical formalism offers the appropriate latitude" ((Bohr, 1958).p.51). Human choices enter orthodox quantum mechanics in a way not determined by a combination of the deterministic and random elements represented in the theory. " This seems like *semi-free Will* and is a *conscious experience*. However, Nunn argues that *free Will* could be an epiphenomenon, a type of *spandrel* (personal communication). If that is the case, then it is still a *conscious experience* as argued just above. Furthermore, one could criticize that there is enough evidence for a range of similar disjunctions in the psychological literature. Therefore, it is not plausible that in such cases *conscious experience* and *conscious function* could be aspects of the same 'mental entity'. This may be correct, but this mental entity, *free Will*, in a *general* definition, is not necessarily being both (*conscious function* **and** *conscious experience*); rather it could be *conscious function* **or** *conscious experience* depending on the *context and metaphysical bias*.[27] Thus, the *genera*l definition of consciousness accommodates most views.

2.3. Are optimal and general definitions of consciousness consistent with the criteria of definitions?

[27] Nunn commented, "This is correct in relation to 'mental entity', but unless the entity is consciously experienced, it is surely not 'conscious' from any ordinary perspective – it is only 'conscious' if one injects some theoretical (pan-psychist or whatever) notion of consciousness into it." This is true, but goal is to include most views in the *general* definition.

It would be interesting to investigate if our definitions meet the criteria discussed in (Allen, 2009). I provide a brief account of why or how these definitions meet these criteria as follows: The *optimal* and *general* definitions of consciousness (i) are neither too rigid not too detailed. (ii) They are part of a theory that facilitates some empirical prediction and explanation. (iii) They reveal 'real' features and also inter-relations. (iv) They are useful for scientific or philosophical applications. (v) They are definitive or unrevisable in that they reveal its "essential nature" but they are *working definitions* as well in that they can be modified based on future research. And (vi) they are *a posteriori* definitions because they are derived from observations made so far and from the categorization of all definitions in two aspects (R. L. P. Vimal, 2009d): *functions* (third person perspective, such as consciousness is a (multidimensional) physical/neurobiological processes (Baars, 1988; Edelman, 2003; James, 1977; Searle, 2000; Vimal, 2008a; R. L. P. Vimal, 2009f)) and *experiences* (first person perspective) that are linked with brain *structures* (neural networks). Thus, our definitions meets the (Allen, 2009)'s criteria.

In (Søgaard & Østerskov Søgaard, 2009), the format of a definition suggested by (Suppe, 2000) is discussed for consciousness. For example, (I) "A system is conscious iff [if and only if] it can interrupt or change a planned action in the absence of external stimuli" or (II) "A process is conscious iff there is a (higher order) thought about it". In this format, (i) (Nagel, 1974)'s definition (consciousness of a system S is "what it is like to be S") can be re-written as: A system (S) is conscious iff it has "what it is like to be S". (ii) (Pereira Jr. & Ricke, 2009)'s definition can be re-written as: A process is conscious iff it occurs in a subject & the subject has an experience & the experience has reportable informational content. (iii) The *optimal* definition of consciousness (Section 2.1) can be re-written as: *a system or a process is conscious iff its mental aspect is conscious experience and conscious function.* The *general* definition of consciousness (Section 2.2) that accommodates most views can be re-written as: *a system or a process is conscious iff its mental aspect is composed of conscious experiences, conscious functions, or both depending on the context and particular bias (e.g. metaphysical assumptions).* It should be noted that these are not circular definitions because the terms 'conscious *experience*' and '*conscious function*' are already defined in Section 2.1.

2.4. Equations for consciousness, qualia, mind, and awareness

In summary, one can then write the following equations, where symbol ⊕ represents 'and/or':

Experiences = (conscious experiences) ⊕ (non-conscious experiences) (1)

Functions = (conscious functions) ⊕ (non-conscious functions) (2)

Qualia = (properties of conscious experiences) ⊕ (properties/qualities of objects) (3)

Consciousness (*optimal*) = (conscious experiences) and (conscious functions) (4)

Consciousness (*general*) = (conscious experiences) ⊕ (conscious functions) (5)

Mind = (consciousness (general)) ⊕ (non-conscious experiences) ⊕ (non-conscious functions) (6)
= (conscious experiences) ⊕ (non-conscious experiences) ⊕

(conscious functions) ⊕ (non-conscious functions) (7)

= experiences ⊕ functions (8)

Awareness = consciousness (general) ⊕ (non-conscious experiences) ⊕
(pre- and/or sub-conscious functions) (9)

= (conscious experiences) ⊕ (non-conscious experiences) ⊕
(conscious functions) ⊕ (pre- ⊕ sub-conscious functions) (10)

= experiences ⊕ (conscious functions) ⊕ (pre- ⊕ sub-conscious functions) (11)

One can argue that the term 'consciousness' should include only conscious entities, such as *conscious experiences* and conscious functions as in Eqs. (4) and (5). In other words, non-conscious entities such as *non-conscious experiences* and *non-conscious functions* should not be included in the definitions of consciousness; rather they could be a part of *mind* as in Eqs. (6)-(8). According to (Carruthers, 2004), mindedness requires capacities for at least perception, belief, and desire. This can be further elaborated as, "[h]aving a mind means being a subject of perceptual states, where those states are used to inform a set of belief states which guide behavior, and where the belief states in turn interact with a set of desire states in ways that depend upon their contents, to select from amongst an array of action schemata so as to determine the form of the behavior" (Carruthers, 2004).

According to a panpsychist (Skrbina, 2009b), *mind* contains two *essential* components/sub-aspects: (i) the inward-directed experiential and qualitative aspect and (ii) the outward-directed relational/representational/intentional aspect. This is not inconsistent with Eq. Eq. (8) if the experiential component is the sub-aspect *experience* and if the intentional component is the sub-aspect *function*. This is because the intentionality or the directedness towards the objects of external world has representation, which might be associated to the *function* of the related *structure*.

In addition, the specificity to SEs in the dual-aspect-dual-mode PE-SE framework (Vimal, 2008b, 2010) may be somewhat related to the dimensionality/complexity of the mentality in panpsychism (Skrbina, 2009b).[28] The 'consciousness (*optimal*)' is equivalent to '*total* consciousnesses' because it includes all *conscious experiences* and *conscious functions* (Skrbina, personal communication). According to (Rosenthal, 2009), "States need not themselves be conscious to result in our being aware of things." Therefore, perhaps, *awareness* has more components than consciousness (*general*) but less than *mind*, which is shown by Eqs. (9)-(11). This is because it may not be acceptable to everybody that a rock has awareness but it may be acceptable that a rock has non-conscious functions (such as interacting with its environment via continuous exchange of energy (Skrbina, 2009b)) and hence has mind-like properties as in panpsychism. Perhaps, some of the non-conscious functions (such as unconscious functions) are excluded from the definition of *awareness*, but are included in the definition of *mind*. However, panpsychists might argue that *awareness* = *mind*.

[28] For example, the non-specificity of electron to high specificity of a specific neural-network (such as V4/V8/VO-neural-net specific to color) in the dual-aspect-dual-mode PE-SE framework may be related to extremely low dimensionality/complexity of the mentality of electron to high dimensionality/complexity of the mentality of a specific neural-net in panpsychism. It should be noted the panpsychism has seven problems (Section 2). The continuity from unconscious state into conscious state rather than discreteness (Skrbina, 2009b) is an interesting hypothesis but needs further research.

3. Conclusions

1. It would be difficult to arrive at any single, widely acceptable, definition of consciousness because of the multiplicity of meanings attributed to the term 'consciousness' (R. L. P. Vimal, 2009d). Any attempts to define cosnciousness often lead to confusion and circular discussion. While this is true for the *theory-independent definition of consciousness*, the quest for the definition(s) of consciousness, at least *theory-dependent definition of consciousness*, continues. We have made such an attempt while accommodating most views that are categorized in (Chalmers, 2003) and discussed further in (Vimal, 2008b; R. L. P. Vimal, 2009d).

2. The dual-aspect-dual-mode proto-experience/subjective experience (PE-SE) framework is an *optimal* framework because it has the least number of problems: the only problem is the brute fact of dual-aspect, which is justified because SEs appear fundamental, irreducible, and inherent in normal wakeful state of mind-brain.

3. *Experiences* can be conscious experiences, non-conscious experiences, or both; and *functions* can be conscious functions, non-conscious functions that include qualities of objects, or both.

4. The *optimal* definition of consciousness, that has the least number of problems, is '*consciousness can be optimally defined as a mental aspect of an entity (system or process) that has dual-aspect: conscious experience and conscious function*. In other words, *a system or a process is conscious iff its mental aspect is conscious experience and conscious function.* However, this is for the optimal dual-aspect-dual-mode PE-SE framework.

A more *general* definition can be '*consciousness is a mental aspect of an entity (system or process) that is a conscious experience, a conscious function, or both depending on the context and particular bias (e.g. metaphysical assumptions)*,' where the context or metaphysical view of investigation is an important factor. In other words, *a system or a process is conscious iff its mental aspect is composed of conscious experiences, conscious functions, or both depending on the context and particular bias (e.g. metaphysical assumptions)'.* These definitions, I hope, may guide us how to design *subjective* and *objective* experiments and how to investigate theoretically to link *structure*, *function,* and *experience*.

5. Based on this above premises, (i) *qualia* are properties of *conscious experiences* and/or *qualities* of objects, (ii) *mind* includes *experiences, functions,* or both, and (iii) *awareness* includes *experiences, conscious functions,* and/or pre- and sub-conscious *functions*.

6. The above definitions are *a posteriori* definitions. This is because they are based on observations and the categorization of various definitions in two aspects (R. L. P. Vimal, 2009d): *functions* (third person perspective, such as consciousness is a (multidimensional) physical/neurobiological processes) and *experiences* (first person perspective: such as consciousness is '*something that it is like* to be a (conscious) subject').

Acknowledgments

The work was partly supported by VP-Research Foundation Trust and Vision Research Institute research Fund. I would like to thank anonymous reviewers, Chris Nunn, David Skrbina, Michael Beaton, Peter Carruthers, David Rosenthal, Harald Atmanspacher, Serge Patlavskiy, Anders Søgaard, Manju-Uma C. Pandey-Vimal, Vivekanand Pandey Vimal, Shalini Pandey Vimal, and Love (Shyam) Pandey Vimal for their critical comments, suggestions, and grammatical corrections. The quotes and/or comments related to personal communication are from email correspondences with (a) Nunn in September 2008, (b) Skrbina in April 2009, (c) Beaton in March and April 2009, and (d) Carruthers in May 2009. Thanks to JCS online group (http://tech.groups.yahoo.com/group/jcs-online) for critiques and discussions.

References

Allen, S. (2009). The Definition of Consciousness: are triviality or falsehood inevitable? *Journal of Consciousness Studies: Special Issue on Defining consciousness (Ed. Chris Nunn), 16*(5), 127-138.

Armstrong, D. M. (1968). *A Materialist Theory of the Mind*. New York: Humanities Press; second revised edition, London:

Routledge & Kegan Paul, 1993.

Atmanspacher, H. (2007). Contextual Emergence from Physics to Cognitive Neuroscience. *Journal of Consciousness Studies, 14*(1-2), 18–36.

Baars, B. J. (1988). *A cognitive theory of consciousness*. New York: Cambridge University Press.

Bartels, A., & Zeki, S. (2000). The architecture of the colour centre in the human visual brain: new results and a review. *Eur J Neurosci, 12*, 172–193.

Beaton, M. (2009). Qualia and Introspection. *Journal of Consciousness Studies: Special Issue on Defining consciousness (Ed. Chris Nunn), 16*(5), 88-110.

Blackmore, S. J. (1996). Near-death experiences. *J R Soc Med, 89*(2), 73-76.

Block, N. (1990). Consciousness and accessibility. *Behav. Brain Sci., 13*, 596–598.

Block, N. (1992). Begging the question against phenomenal consciousness. *Behav. Brain Sci., 15*, 205-206.

Block, N. (1995). On a confusion about a function of consciousness. *Behav. Brain Sci., 18*, 227-247.

Block, N. (2001). Paradox and cross purposes in recent work on consciousness. *Cognition, 79*(1-2), 197-219.

Block, N. (2005). Two neural correlates of consciousness. *TRENDS in Cognitive Sciences, 9*(2), 47-52.

Block, N. (2007). Consciousness, Accessibility, and the Mesh between Psychology and Neuroscience. *Behavioral and Brain Sciences, 30*(5-6), 481-499; discussion 499-548.

Bohr, N. (1958). *Atomic Physics and Human Knowledge*. New York: Wiley.

Bruzzo, A. A., & Vimal, R. L. P. (2007). Self: An adaptive pressure arising from self-organization, chaotic dynamics, and neural Darwinism. *Journal of Integrative Neuroscience (Available: http://sites.google.com/site/rlpvimal/Home/2007-Bruzzo-Vimal-self-JIN-p541-566.pdf), 6*(4), 541-566.

Byrne, A. (2008). Inverted Qualia. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy (Winter 2008 Edition)*: Available: <http://plato.stanford.edu/archives/win2008/entries/qualia-inverted/>.

Byrne, A., & Hilbert, D. R. (2003). Color realism and color science. *Behav Brain Sci, 26*(1), 3-21; discussion 22-63.

Carruthers, P. (2000). *Phenomenal Consciousness: A Naturalistic Theory*. Cambridge: Cambridge University Press.

Carruthers, P. (2004). On being simple minded. *American Philosophical Quarterly, 41*, 205-220. Available: Articles on animals:

http://www.philosophy.umd.edu/Faculty/pcarruthers/.

Carruthers, P. (2007). Higher-Order Theories of Consciousness. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy (Spring 2009 Edition)* (pp. Available:<http://plato.stanford.edu/archives/spr2009/entries/consciousness-higher/>).

Carruthers, P. (2009). How we know our own minds: the relationship between mindreading and metacognition. *Behav Brain Sci, 32*(2), 121-138; discussion 138-182.
Chalmers, D. J. (1996). *The Conscious Mind: in Search of a Fundamental Theory*. New York: Oxford Univ. Press.
Chalmers, D. J. (2003). Consciousness and its Place in Nature. In S. Stich & F. Warfield (Eds.), *Blackwell Guide to Philosophy of Mind*: Blackwell. Also in (D. Chalmers, ed) Consciousness and its Place in Nature (Oxford University Press, 2002).
Damasio, A. R. (1999). *The feeling of what happens: Body and emotion in the making of consciousness*. New York: Harcourt Brace.
Dennett, D. C. (1991). *Consciousness Explained*. Boston: Little, Brown and Company.
Dretske, F. (1995). *Naturalizing the Mind*: MIT Press.
Duvall, S., & Wicklund, R. A. (1982). *A Theory of Objective Self-Awareness*. New York: Academic Press.
Edelman, G. M. (2003). Naturalizing consciousness: a theoretical framework. *Proc Natl Acad Sci U S A, 100*(9), 5520-5524.
Eerikäinen, A. (2000). *Time and Polarity: The Dimensional Thinking of Karl Heim.* University of Helsinki, Helsinki: Yliopistopaino.
Faw, B. (2009). Cutting 'consciousness' at its joints. *Journal of Consciousness Studies: Special Issue on Defining consciousness (Ed. Chris Nunn), 16*(5), 54-67.
Feigl, H. (1967). *The `Mental' and the `Physical', The Essay and a Postscript*. Minneapolis: University of Minnesota Press. See also, The `mental' and the `physical'. Minnesota Studies in the Philosophy of Science, 2, 370-497.
French, C. C. (2005). Near-death experiences in cardiac arrest survivors, *Progress in Brain Research: The Boundaries of Consciousness: Neurobiology and Neuropathology; Chapter 25* (Vol. 150, pp. 351-367): Elsevier B.V.
Globus, G. (2006). The Saltatory Sheaf-Odyssey of a Monadologist. *NeuroQuantology, 4*(3), 210-221.
Globus, G. (2009). Halting the descent into panpsychism: A quantum thermofield theoretical perspective (Chapter 3). In D. Skrbina (Ed.), *Mind that abides: Panpsychism in the new millennium* (pp. 67-82). Amsterdam: John Benjamins.
Globus, G. G. (1995). *Forget qualia, zombies and zimboes*. Available: http://www.imprint.co.uk/online/Globus.html.
Globus, G. G. (1998). Self, Cognition, Qualia and World in Quantum Brain Dynamics. *Journal of Consciousness Studies, 5*(1), 34-52.
Globus, G. G. (2005). The being/brain problem. *NeuroQuantology, 4*, 256-263.
Globus, G. G. (2007). Mind, Matter, and Monad. *Mind and Matter, 5*(2), 201-214.
Glover, S. (2004). Separate visual representations in the planning and control of action. *Behav Brain Sci, 27*(1), 3-24; discussion 24-78.
Hadjikhani, N., Liu, A. K., Dale, A. M., Cavanagh, P., & Tootell, R. B. (1998). Retinotopy and color sensitivity in human visual cortical area V8. *Nat Neurosci, 1*(3), 235-224; Comment in: Nat Neurosci 1998 Jul;1991(1993):1171-1993. Comment in: Nat Neurosci 1998 Sep;1991(1995):1335-1996.
Hameroff, S., & Penrose, R. (1996). Conscious events as orchestrated spacetime selections. *Journal of Consciousness Studies, 3*(1), 36-53.
James, W. (1977). In J. J. McDermott (Ed.), *Writings of William James* (pp. 169-183). Chicago: Univ. of Chicago Press.
Kant, I. (1929). *Critique of Pure Reason* (N. K. Smith, Trans.). London: McMillan. See also http://en.wikipedia.org/wiki/Idealism, http://en.wikipedia.org/wiki/Critique_of_Pure_Reason, and http://www.marxists.org/reference/subject/ethics/kant/reason/ch01.htm.
Klemenc-Ketis, Z., Kersnik, J., & Grmec, S. (2010). The effect of carbon dioxide on near-death experiences in out-of-hospital cardiac arrest survivors: a prospective observational study. *Critical Care, 14:R56 (Available: http://ccforum.com/content/pdf/cc8952.pdf*, (in Press).
Kosslyn, S. (1994). *Image and Brain*. Cambridge, MA: MIT Press.
Kriegel, U., & Williford, K. (Eds.). (2006). *Self-Representational Approaches to Consciousness*. Cambridge, MA: MIT Press.
Lamme, V. A. (2003). Why visual attention and awareness are different. *Trends Cogn Sci, 7*(1), 12-18.
Laws, V., & Perry, E. (2010). Near Death Experiences: A New Algorithmic Approach to Verifying Consciousness Outside the Brain. *NeuroQuantology* <*http://www.neuroquantology.com/journal/index.php/nq/article/view/280/278* > <*Reprint request: valaws@yahoo.co.uk*>, *8*(2), 142-154.
Levin, J. (2006). What is a Phenomenal Concept? In T. Alter & S. Walter (Eds.), *Phenomenal Concepts and Phenomenal Knowledge. New essays on Consciousness and Physicalism*. Oxford: Oxford University Press.
Levin, J. (2008). Taking Type-B Materialism Seriously. *Mind & Language, 23*(4), 402-425.
Levine, J. (1983). Materialism and qualia: The explanatory gap. *Pacific Philosophical Quarterly, 64*, 354–361.
Loar, B. (1990). Phenomenal states. *Philosophical Perspectives, 4*, 81-108.
Loar, B. (1997). Phenomenal states. Revised edition. In N. Block & O. Flanagan & G. Güzeldere (Eds.), *The Nature of Consciousness*: MIT Press. Second preprint version is available at http://www.nyu.edu/gsas/dept/philo/courses/consciousness97/papers/loar.html.
Lycan, W. G. (1996). *Consciousness and Experience*. Cambridge MA: MIT Press.

MacGregor, R. J., & Vimal, R. L. P. (2008). Consciousness and the Structure of Matter. *Journal of Integrative Neuroscience, 7*(1), 75-116.
Millikan, R. G. (1989). In Defense of Proper Functions. *Philosophy of Science, 56.2*, 288-302.
Milner, D., & Goodale, M. (1995). *The Visual Brain in Action*. Oxford: Oxford University Press.
Nagel, T. (1974). What is it like to be a bat? *Philosophical Review, 83*, 435-450.
Nixon, G. (2007). The Continuum of Experience: Non-Conscious Experience. *Karl Jaspers Forum TA95A*, available at http://www.kjf.ca/95A-TANIX.htm.
Northoff, G., & Bermpohl, F. (2004). Cortical midline structures and the self. *Trends Cogn Sci, 8*(3), 102-107.
Northoff, G., Heinzel, A., de Greck, M., Bermpohl, F., Dobrowolny, H., & Panksepp, J. (2006). Self-referential processing in our brain--a meta-analysis of imaging studies on the self. *Neuroimage, 31*(1), 440-457.
Papineau, D. (1993). *Philosophical Naturalism*. Oxford: Blackwell.
Papineau, D. (1993). Physicalism, consciousness, and the antipathetic fallacy. *Australasian Journal of Philosophy, 71*, 169-183.
Papineau, D. (2006). Phenomenal and Perceptual Concepts. In T. Alter & S. Walter (Eds.), *Phenomenal Concepts and Phenomenal Knowledge. New Essays on Consciousness and Physicalism*: Oxford University Press. http://www.kcl.ac.uk/ip/davidpapineau/Staff/Papineau/Papineau.html.
Pereira Jr., A., & Ricke, H. (2009). What is Consciousness? Towards a Preliminary Definition. *Journal of Consciousness Studies: Special Issue on Defining consciousness (Ed. Chris Nunn), 16*(5), 28-45.
Perrett, R. W. (2003). Intentionality and Self-Awareness. *Ratio, 16*(3), 222-236.
Prakash, R., & Caponigro, M. (2009). Inner Light Perception as a Quantum Phenomenon-Addressing the Questions of Physical and Critical Realisms, Information and Reduction. *NeuroQuantology, 7*(1), 188-197.
Prakash, R., Haq, Z. U., Prakash, O., Sarkhel, S., & Kumar, D. (2009). Inner Light Perception of Vihangam Yogis A Qualitative Study. *Journal of Consciousness Studies, 16*(2-3).
Primas, H. (2002). Hidden determinism, probability, and time's arrow. In H. Atmanspacher & R. C. Bishop (Eds.), *Between Chance and Choice* (pp. 89-113). Exeter: Imprint Academic.
Primas, H. (2003). Time-entanglement between mind and matter. *Mind and Matter, 1*, 81-119.
Prosser, S. (2007). The Two Dimensional Content of Consciousness. *Philosophical Studies, 136*, 319-349.
Rao, K. R. (1998). TWO FACES OF CONSCIOUSNESS: A Look at Eastern and Western Perspectives. *Journal of Consciousness Studies, 5*(3), 309-327.
Rao, K. R. (2005). Perception, Cognition and Consciousness in Classical Hindu Psychology. *Journal of Consciousness Studies, 12*(3), 3-30.
Rosenthal, D. (2009). Concepts and definitions of consciousness. In P. W. Banks (Ed.), *Encyclopedia of Consciousness* (pp. Available at davidrosenthal1.googlepages.com/elsevier.pdf). Amsterdam: Elsevier.
Rowlatt, P. (2009). Consciousness and Memory. *Journal of Consciousness Studies: Special Issue on Defining consciousness (Ed. Chris Nunn), 16*(5), 68-78.
Seager, W. (1995). Consciousness, information and panpsychism. *Journal of Consciousness Studies, 2*(3), 272–288.
Searle, J. R. (2000). Consciousness. *Annu Rev Neurosci, 23*, 557-578.
Shoemaker, S. (1994). Phenomenal Character. *Noûs, 28*(1), 21-38.
Skrbina, D. (2003). Panpsychism as an Underlying Theme in Western Philosophy. *Journal of Consciousness Studies, 10*(3), 4-46.
Skrbina, D. (2005). *Panpsychism in the West*. Cambridge, MA: MIT Press.
Skrbina, D. (2009a). Minds, objects, and relations: Toward a dual-aspect ontology (Chapter 19). In D. Skrbina (Ed.), *Mind that abides: Panpsychism in the new millennium* (pp. 361–382). Amsterdam: John Benjamins.
Skrbina, D. (2009b). Transcending consciousness: Thoughts on a universal conception of mind. *Journal of Consciousness Studies: Special Issue on Defining consciousness (Ed. Chris Nunn), 16*(5), 79-87.
Søgaard, A., & Østerskov Søgaard, S. (2009). On definitions of consciousness. *Journal of Consciousness Studies: Special Issue on Defining consciousness (Ed. Chris Nunn), 16*(5), 46-53.
Sperling, G. (1960). The information available in brief visual presentations. *Psychological Monographs, 74*(11), 1-29.
Stapp, H. P. (2009). Quantum reality and mind. *Journal of Cosmology, 3*, Published Online: http://journalofcosmology.com/QuantumConsciousness105.html.
Stapp, H. P. (2010). The Effect of Mind upon Brain. In S. Koutroufinis (Ed.), *Life and Process: Towards a Whiteheadian Biophilosophy*: Ontos-Verlag. Available from http://www-physics.lbl.gov/~stapp/stappfiles.html.
Suppe, F. (2000). Definitions. In W. H. Newton-Smith (Ed.), *A companion to the philosophy of science* (pp. 76-78). Malden: Blackwell.
Tootell, R. B. H., Tsao, D., & Vanduffel, W. (2003). Neuroimaging Weighs In: Humans Meet Macaques in "Primate" Visual Cortex. *The Journal of Neuroscience, 23*(10), 3981–3989.
Torrance, S. (2009). Contesting the concept of consciousness. *Journal of Consciousness Studies: Special Issue on Defining consciousness (Ed. Chris Nunn), 16*(5), 111-126.

Van Gulick, R. (2004). Higher-order global states (HOGS): an alternative higher-order model of consciousness. In R. Gennaro (Ed.), *Higher-Order Theories of Consciousness*. Amsterdam/Philadelphia: John Benjamins Publishing Co.

Velmans, M. (2009). How to define consciousness and how not to define consciousness. *Journal of Consciousness Studies: Special Issue on Defining consciousness (Ed. Chris Nunn), 16*(5), 139-156.

Vimal, R. L. P. (2008a). Attention and Emotion. *The Annual Review of Biomedical Sciences (ARBS), 10*, 84-104.

Vimal, R. L. P. (2008b). Proto-experiences and Subjective Experiences: Classical and Quantum Concepts. (Available: http://sites.google.com/site/rlpvimal/Home/2008-Vimal-PE-SE-classical-quantum-JIN-0701-P49.pdf). *Journal of Integrative Neuroscience, 7*(1), 49-73.

Vimal, R. L. P. (2009). Dependent Co-origination and Inherent Existence: Dual-Aspect Framework. *Vision Research Institute: Living Vision and Consciousness Research [Available: http://sites.google.com/site/rlpvimal/Home/2009-Vimal-Coorigination-LVCR-II(vii).pdf], 2*(7), 1-50.

Vimal, R. L. P. (2009a). Derivation of Subjective Experiences from a Proto-experience and three *Gunas* in the Dual-Aspect-Dual-Mode Framework. *Vision Research Institute: Living Vision and Consciousness Research [Available: http://sites.google.com/site/rlpvimal/Home/2009-Vimal-Guna-LVCR-II(v).pdf], 2*(5), 1-140.

Vimal, R. L. P. (2009b). Dual Aspect Framework for Consciousness and Its Implications: West meets East for Sublimation Process. In G. Derfer & Z. Wang & M. Weber (Eds.), *The Roar of Awakening. A Whiteheadian Dialogue Between Western Psychotherapies and Eastern Worldviews.* (Vol. 3 of Whitehead Psychology Nexus Studies, pp. 39-70. Longer and corrected version is available: http://sites.google.com/site/rlpvimal/Home/2009-Vimal-Consciousness-and-its-implications-recent-version-LVCR-II(xi).pdf). Frankfurt / Lancaster: Ontos Verlag.

Vimal, R. L. P. (2009c). Interpretation of Empirical Data of Samadhi State and the Dual-Aspect Dual-Mode Optimal Framework. *Vision Research Institute: Living Vision and Consciousness Research [Available at http://sites.google.com/site/rlpvimal/Home/2009-Vimal-Samadhi-LVCR-II(iii).pdf], 2*(3), 1-130.

Vimal, R. L. P. (2009d). Meanings attributed to the term 'consciousness': an overview. *Journal of Consciousness Studies: Special Issue on Defining consciousness (Ed. Chris Nunn), 16*(5), 9-27. See also http://sites.google.com/site/rlpvimal/Home/2009-Vimal-Meanings-LVCR-II(x).pdf.

Vimal, R. L. P. (2009e). The Most Optimal Dual-Aspect-Dual-Mode Framework for Consciousness: Recent Development. In M. Weber (Ed.), *Chromatikon: Yearbook of Philosophy in Process* (pp. 295-307. Available: http://sites.google.com/site/rlpvimal/Home/2009-Vimal-Most-Optimal-Consciousness-Framework-Summary-II(xii).pdf).

Vimal, R. L. P. (2009f). Necessary Ingredients of Consciousness: Integration of Psychophysical, Neurophysiological, and Consciousness Research for the Red-Green Channel. *Vision Research Institute: Living Vision and Consciousness Research [Available at http://sites.google.com/site/rlpvimal/Home/2009-Vimal-Necessary-Ingredients-Conciousness-LVCR-II(i).pdf], 2*(1), 1-40.

Vimal, R. L. P. (2009g). Subjective Experience Aspect of Consciousness Part I - Integration of Classical, Quantum, and Subquantum Concepts. *NeuroQuantology [Available: http://sites.google.com/site/rlpvimal/Home/2009-Vimal-PE-SE-SQ-Part1-LVCR-II(viii).pdf], 7*(3), 390-410.

Vimal, R. L. P. (2009h). Subjective Experience Aspect of Consciousness Part II: Integration of Classical and Quantum Concepts for Emergence Hypothesis. *NeuroQuantology [Available: http://sites.google.com/site/rlpvimal/Home/2009-PE-SE-Emergence-Part2-LVCR-II(ix).pdf], 7*(3), 411-434.

Vimal, R. L. P. (2009i). Towards a Theory of Everything: Unification of Consciousness with Fundamental Forces in Theories of Physics. *Vision Research Institute: Living Vision and Consciousness Research [Available: http://sites.google.com/site/rlpvimal/Home/2009-Vimal-TOE-LVCR-I(xi).pdf], 1*(11), 1-100.

Vimal, R. L. P. (2010). Matching and selection of a specific subjective experience: conjugate matching and subjective experience. *Forthcoming in June issue of Journal of Integrative Neuroscience [Longer version is available at http://sites.google.com/site/rlpvimal/Home/2009-Vimal-Matching-Selection-LVCR-III(i).pdf], 8*(2).

Vimal, R. L. P., & Davia, C. J. (2008). How Long is a Piece of Time? - Phenomenal Time and Quantum Coherence - Toward a Solution. *Quantum Biosystems (Available: http://www.quantumbionet.org/admin/files/QBS2%20102-151.pdf), 2*, 102-151.

Vitiello, G. (1995). Dissipation and memory capacity in the quantum brain model. *International Journal of Modern Physics, B9*, 973–989.

Wandell, B. A. (1999). Computational neuroimaging of human visual cortex. *Annu. Rev. Neurosci., 22*, 145-173.

Wegner, D. M. (2002). *The illusion of conscious will*. London and Cambridge MA: The MIT Press.

Wegner, D. M. (2004). Precis of the illusion of conscious will. *Behav Brain Sci, 27*(5), 649-659; discussion 659-692.

[I] As per (Laws & Perry, 2010), "Quantum mechanics arose to explain 'wobbles' in predicted effects of Newtonian physics, such as the stability of electron orbitals. Similarly, scientifically

verified phenomena in the field of neuroscience which contradict known theories of brain function, could give weight and credibility to neuroquantology, stimulating new research and discovery. The existence of consciousness outside the physical brain, often recounted anecdotally in various forms, if verified, could be such a phenomenon. […] 'Out of Body Experiences' (OBEs) are episodes, during which a person's consciousness seems, according to their subjective recall afterwards, to 'leave' the body, and therefore the physical brain, remaining aware of physical surroundings. Reports have accumulated over the years and across many cultures. They often incorporate 'Near Death Experiences', (NDEs), which seem to transcend physical surroundings and enable subjects to perceive an 'after life' scenario. Such experiences are usually linked to extreme stress, emotional or physical, factors such as drug intoxication, or actual short periods of 'brain death' or flat lining. […] OBE/NDEs are reported in increasing numbers, due to improved technology for resuscitation of patients who may now return to tell their stories after suffering from previously lethal injuries and conditions. […] We choose to focus on OBEs during flatlining or emergency procedures, as NDEs are less open to fraud, delusion, or contamination by sensory input during minimal consciousness, but the study of other forms of 'out of body' consciousness (eg survival after death, shamanic journeys, telepathy) could also be moved forward if this approach bears fruit. […]

OBE/NDEs commonly include the sensation of 'rising' out of one's body, and actually being able to 'hover' above it and look down on it, being still visually and aurally aware of surroundings even if unconscious, from a viewpoint outside the physical body, somehow independent of physical eyes or ears. Sometimes this disembodied consciousness moves to another room or place, even outside. Especially if the subject is in extremis, in a coma or flatlining, the experience may then go on to the classic NDE. The subject moves through a dark tunnel, with a light at the end. They may 'see' their life history, the 'life review' feature. They emerge into this light, to awareness of feelings of peace, happiness, an awareness of a benign intelligence, a state they would wish to stay in. Typically, they encounter loved ones who have previously died, who explain to the subject, that they can't stay but must return to their body until the time is right. These experiences occur in many cultures, indeed, sometimes a culture- or religion specific figure is present, but generally, the experiences do not conform to the taught dogmas of the subject's religion or culture. There is often a 'boundary' between the subject's state and that of their loved ones, which may be culturally determined, eg a river, a line, a wall, that must not be breached. Instead, the subject is guided or sent back into the body. The conscious subject typically recalls their experience as very clear, detailed, and coherent. The individual commonly reports this as a life-changing experience, with feelings of peacefulness, lack of fear of dying, and happiness which remain with them and shape the rest of their lives. It has to be said that sometimes the experience of the OBE/NDE is not so positive. Frightening, 'warning' experiences are also reported. There is a tendency to associate these with would-be suicides, being 'warned' against self-slaughter, or drug fuelled states, but there are some instances of negative NDEs not associated with these states. These instances are not so often cited, for obvious reasons. We'd all like to think that if consciousness survives death, of which those who have NDEs become subjectively convinced, it will be a pleasant experience. This feature of 'wishful thinking' can become a distorting factor, in the Chinese Whispers effect. […]

(Greyson, 2000) found that amongst 98 self-reported NDE's (compared to 38 coming close to clinical death reporting no NDE) these were associated with ' dissociative experiences' (which include amnesia, periods of time unaccounted for, feeling unfamiliar with one's surroundings or even one's own body) consistent with a non-pathological response to stress as opposed to a psychiatric disorder. In a later paper, Greyson (Lange, 2004) refers to his NDE scale published in 1983 and 1990. In this survey, with increasing intensity, NDEs reflect 'peace, joy and harmony' and provide new insights. […] as quantum theory tells us that the observer influences, even determines, the observed; so the notion of the truly detached independent scientist/observer is already challenged. […]

(French, 2005) reviewed some possible explanations of NDEs: spiritual - consciousness detaches from neural substrate of brain providing glimpse of afterlife; psychological – defense mechanism in extreme danger; biological - cerebral hypoxia, anoxia, hypercarbia., causing release of endorphins and other brain neurotransmitters inducing hallucinations and temporal lobe hyperactivity. […] A brain, which shows no measurable activity, 'flatlining' for example, cannot undergo experiences involving sensory impressions, except from physiological effects of hypoxia/anoxia. The fact that similar experiences can be artificially induced by electromagnetic stimulation of the brain, drugs such as Ketamine, extreme fatigue, etc, means that those resulting from clinical death after cardiac arrest or similar, are not 'real' either. They are hallucinations, induced in a damaged brain. […] Hypoxia is characterised by mental confusion and yet NDEs/ OBEs are characterised by great clarity of thought, recall, and ordered narrative. […] So the question should surely be, is there a possibility of consciousness outside the brain, which is suggested by a verifiable account of an NDE/OBE? Then, we can ask, how does it come about? […] The commonly reported features: peaceful 'out of body' experience, the tunnel, the wonderful light holding 'god' like intelligence and love, deceased loved ones waiting for us, the life review, the feeling that everything that happens actually makes sense: all this is very seductive. In a Japanese study (Yamamura, 1998), 14 of 48 consecutive patients admitted to hospital in a deep coma subsequently reported an NDE. Features included flying in a dark void with a light ahead, encountering relatives and friends, and returning to the world in response to a voice calling. […]Subjects however, they found, assumed more 'sincere values' afterwards, and viewed death as a peaceful calm experience. In a Taiwan study (Lai, 2007), 45 out of 710 dialysis patients reported NDEs with women, younger patients and those participating in religious ceremonies being more likely to be in the NDE group. Out of body, precognitive visions and tunnel experiences were included in the reports and after effects included 'being kinder to others' and being more motivated. This might suggest NDEs have a real psychological or even evolutionary advantage, regardless of their intrinsic reality. […] your deceased mother is actually there waiting for you … A sense that something good's waiting for them at the end. […] OBEs and NDEs are reported in cases of extreme stress, such as traumatic childbirth, or the use of shamanic plants, drugs, meditation … Subjects, sometimes after undergoing fleeting 'brain death', say that they could 'see' people, light, rivers, walls… how could someone 'see' without functioning physical eyes, let alone a functioning cortex? […] if some form of consciousness operates outside the body, possibly it perceives in more dimensions than our usual three (as string theory has postulated there are ten dimensions). We cannot step outside our brain to examine such a possibility. We are 'of' three dimensions; mathematical points and lines, supposedly in one and two dimensions, are actually three dimensional models of notional one and two dimensional concepts … perhaps the returning patient's brain 'translates' what was perceived 'outside' three dimensional perception, into 'normal' three dimensional terms, using their own culturally influenced imagery: we naturally think metaphorically. […] a few seconds have encompassed a mental odyssey! […] If the NDE is purely a construct of the brain, perhaps the patient was clinically dead and totally devoid of consciousness or awareness, until just coming out of the unconscious state, and the whole NDE happened in the seconds as consciousness returned? As the brain tried to make sense of the hiatus in self-awareness? Sceptics could argue it might be a tendency of the afflicted brain, developed through natural selection, to help the species live less traumatised lives after major trauma. That argument does not take into account, that very few would ever have come back before modern technology and resuscitation, and that the very many more who experience less drastic but severe trauma and pain, respond with PTSD, which is often disabling and life-threatening. […] Indeed, it's suggested that the brain itself uses quantum processes, possibly measured in femtoseconds, as well as currently detectable functioning on a 'slower' scale. […]

Persinger and Koren (Persinger and Koren, 2007; Persinger et al., 2008) suggest that 'brain space could contain inordinately large amounts of information reflecting the nature of extraordinarily large increments of space and time.' […] Radin (Radin, 1997; Radin, 2006) has included quantum reality in his search for scientific explanations for psychic phenomena, while

Schwartz et al., (2005) have used quantum physics to set up a neurophysical model for mind-brain interaction. […] A chance, surely, too good to miss by merely dismissing all this human experience as wishful thinking. […] some of the NDEs and OBEs have involved remote viewing – such as rising out of the body and 'seeing' the doctors and nurses in the ICU. […] the most convincing state for a subject to have an OBE/NDE would be when they are in fact near death, and in surroundings where their life signs, brain function, consciousness etc can be monitored. Therefore, cases arising during clinical death before resuscitation, (e.g., cardiac arrest) when by orthodox thinking, no coherent thoughts or experiences can occur, would seem to be the best for closer study. There have been attempts at this, like placing objects or messages on high surfaces in operating rooms, to see if OBE/NDE subjects report seeing them. […] Subjects ideally should return to consciousness and report (the sooner the better) an OBE/NDE which includes physical events or details which other people witnessed – a doctor dropping something, a nurse's remark, which happened during the time they were clinically dead, or a feature of the room either high up or that they could not have seen when conscious, e.g., if they were outside the room when they regained consciousness. The more detailed and specific, the better, the less likely to be explicable by 'coincidence', that useful catchall for the unexplained. […]

The Pam Reynolds case, 1991, is often cited online and in discussions, lectures and books as an example of a convincingly genuine OBE/NDE, in a patient undergoing a 'standstill' procedure, in which the body is deeply chilled, the brain is drained of blood, the heart is stopped, for brain surgery to take place. Reynolds recovered, and recalled an OBE, observing (hearing instruments and conversations of medical staff, seeing procedures) her operation or part of it from outside her body. She described the bone saw, recalled remarks made on the smallness of her veins, described procedures, before she apparently moved into a classic transcendental NDE scenario. Michael Sabom (Sabom, 1998) described her case, and published a clear timeline of events in the operating room, and Reynolds's reported experiences. […] The actual 'standstill' and flatline period was only a few minutes. Sabom asserts as fact that Reynolds' NDE afterlife experience took place during flatline: there is no evidence that this is the case, nor can there be, except faith and hope. Further distorting the account, many believers assert as fact that her 'remote viewing' of her operation, bonesaw, etc, coincided with the standstill period, which is often quoted as much longer than it was. […] (Augustine, 2007) has explained Reynolds' hearing, as due to incomplete anaesthesia, and earplugs, which were not soundproof. […]Apparently during this period she had a detailed veridical near-death OBE. […] as if her whole OBE experience took place during flatline. […] Sceptic Gerald Woerlee goes on to claim that the spiritual and psychological after-effects often reported of NDE subjects, are due to brain damage during hypoxia! Pam Reynolds had a verifiable, or at least supportable by witnesses, timeable, out of body experience while under anaesthesia and not near death. […]facts (times, procedures, number of witnesses of events or sights, medical condition of patient). […]

Reynolds case would not get through the algorithm. It would not get beyond the first question as she was having elective surgery. Even if starting at Question 2, she was awake entering the operating room, so the case fails there too. […] If any cases exist now, or are reported in the future, of a patient who, eyes taped, saw an event, or some other verifiable sight, in an unseen room, which can be timed by observers to a period of the brain measurably flatlining or deeply unconscious, which the patient reported as soon as they woke up in the recovery room, and staff posted the report somewhere safely retrievable in its original form, then possibly a) the brain is actually conscious in some hitherto unmeasurable way when we believe it is not, If any cases exist now, or are reported in the future, of a patient who, eyes taped, saw an event, or some other verifiable sight, in an unseen room, which can be timed by observers to a period of the brain measurably flatlining or deeply unconscious, which the patient reported as soon as they woke up in the recovery room, and staff posted the report somewhere safely retrievable in its original form, then possibly a) the brain is actually conscious in some hitherto unmeasurable way when we believe it is not, and/or b), consciousness and perception can exist outside the brain, in which case, serious efforts can begin to find out, how? […] (Do neutrinos, a million

million of which go through your head while you read this sentence? Does memory? Does gravity, which acts at a distance and instantly?) [...] Or, equally significantly, we'd have to consider the possibility that the brain we thought was 'dead' or not showing any function, was actually functioning during clinical death, and that there are forms of consciousness at present undetectable (perhaps relating to quantum processes at subatomic levels or superfast speeds). After all, presently measurable phenomena such as gamma brainwaves were unknown fairly recently, until advances in technology allowed their detection. There would be implications for further refining definitions of life and death, including decisions of when to switch off life support machines. [...] If just one case can be verified, or not discredited at least, then all sorts of possibilities blossom. 'Death bed coincidences', in which family members some distance away, 'see' the loved one at the moment of death, and which are also widely reported: astral projection, telepathy, and all those other embarrassing, ne'er do well poor relations, will clamour for attention and a seat at the table of conventional wisdom, a disturbing prospect to those who like order and Newtonian certainty to prevail. But let's just find out, scientifically, whether there are biological equivalents of quantum tunnelling, the uncertainty principle, or string theory, which might just be here with us all along. [...] If we can show that perception is possible outside a conscious brain, we may find explanations for how it is possible, which prove, or disprove, the possibility of some of these other forms of out-of-body experiences, such as shamanic journeys, telepathy, and telekinesis, which do involve a functioning brain. In fact, scientific evidence, obtained as a result of experimental observation under carefully controlled conditions, already suggests there are small but statistically significant effects of mind on mind (Sheldrake, 2005: Schmidt, 2004), or mind on matter (Radin and Ferrari, 1991) which do not involve direct interactions (non local) and are not explicable in terms of currently understood mechanisms. However, most scientists are not aware of the evidence or, worse, refuse to accept it – mainly because there is no scientific explanation. Yet physicists accept the principle, indeed the inescapability, of 'the influence of the observer on the observed', as a cornerstone of quantum theory. One verifiable case of out of body consciousness could revolutionise biomedical science as quantum theory did to Newtonian physics".