Necessary and sufficient conditions for consciousness: Extended Dual-Aspect Monism framework

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Abstract

We investigate the necessary and sufficient conditions for consciousness. Consciousness is defined as the mental aspect of a state of brain-system or brain-process from first person perspective. Consciousness has two sub-aspects: conscious experience and conscious function. The *necessary* conditions for consciousness are those conditions that must be satisfied in order to have consciousness, i.e., if any of them is missing then the entity is not conscious. The *sufficient* conditions for consciousness are conditions, if satisfied, guarantee that the entity is conscious. The *necessary* conditions for *access* (reportable) consciousness are as follows: (1) the formation of neural-networks; (2) wakefulness; (3) reentrant interactions among neural populations; (4) fronto-parietal and thalamic-reticular-nucleus attentional signals that modulate consciousness; (5) integrated information (Φ) at or above threshold level; (6) working memory; (7) E=h/t for Orch OR; (8) stimulus contrast at or above threshold; and (9) neural-network proto-experiences that are superposed *potential* subjective experiences (SEs) embedded in a neural-network as precursors of SEs. The *necessary* conditions for *phenomenal* (non-reportable) consciousness are (1)-(3) and (5)-(9), i.e., the same as *access* consciousness except attention. Furthermore, structure, function, and SE are linked and the experiments to investigate the *necessary* and *sufficient* conditions of consciousness are proposed.

Key words: Access and phenomenal consciousness, necessary conditions of consciousness; arousal system; reentry; attention; memory; segregation and integration (or binding) of information; executive functions; proto-experiences; subjective experiences; Red-Green channel; neural correlates of consciousness; neural-network; fMRI; psychophysics

1. Introduction

1.1. Consciousness: meanings, definitions, and types (phenomenal and access consciousness)

Meanings: In (Vimal, 2009), there are about forty meanings attributed to the term 'consciousness', which were identified and categorized according to whether they were principally about *function* or about *experience*. The possibilities for reaching any single, agreed, theory independent definition of *consciousness* thus appear far-off. Therefore, we must define consciousness before using it to avoid confusion.

Definitions: A *general* definition of consciousness (that accommodates most views) may be: *consciousness is the mental aspect of a beable ontological dual-aspect state of the mind-brain-system or a mind-brain-process, which has two sub-aspects: a conscious experience, a conscious function, or both depending on the context from the 1st person perspective*, where the term '*context*' refers to metaphysical views, constraints, specific aims, and so on (Vimal, 2010b). The *optimal* definition (that has the least number of problems) of consciousness is: *consciousness is the mental aspect of a beable ontological dual-aspect state of a mind-brain-system or a mind-brain-process, which has two sub-aspects: a conscious experience and a conscious function from the 1st person perspective* (Vimal, 2010b). In other words, consciousness has functional and experiential aspects and includes subjective experiences (SEs) including functions, thoughts, and experiences related to subject (self), objects, emotions, and *Samādhi* state. This *special* beable ontological dual-aspect state has specific consciousness (1pp-mental aspect) when 'viewed' from the 1st person perspective 1pp and has its *inseparable* physical aspect (a correlated specific NN and its activities) when the same information is 'viewed' from the 3rd person perspective (3pp). Furthermore, this state is selected after matching the stimulus-dependent feed forward (FF) signal with cognitive feedback (FB) signals from the related long-term memory when the following necessary conditions are satisfied: the formation of the related neural-network, wakefulness, reentry, attention for the *access* (reportable) consciousness, information integration, working memory, stimulus contrast at or above a threshold, potential experiences embedded in neural network and so on. Attention is not necessary for the *phenomenal* (non-reportable) consciousness. Here, a beable ontological dual-aspect state is defined as the dual-aspect state of a mind-brain-system or a mind-brain-process that really exist and we can empirically measure it using psychophysical methods (for the 1pp-mental aspect) and neurophysiological methods such as fMRI/EEG (for the 3pp-physcal aspect).

Types: There are two types of consciousness: *access* (constitutively cognitive-accessible and reportable) and *phenomenal* (constitutively cognitive-inaccessible and non-reportable) consciousness (Block, 2005, 2007; Lamme, 2003).

1.2. Specific aims

The specific aims of this article are as follows:

(A) To investigate the *necessary* conditions of consciousness with an example of the experience of colors through the Red-Green color channel (Section 2.1),

(B) To investigate how to link/unify/integrate the three aspects in a conscious system, namely structure, function, and SE (Sections 2.1.3, 2.2.1, and 3), and

(C) To propose an experimental design to investigate the *necessary* and *sufficient* conditions of consciousness (Section 2.3).

We will focus on visual consciousness, such as SEs *redness* to *greenness* that arise in Red-Green channel related neural-network. The terms 'consciousness', 'visual consciousness', 'SE', and 'experience' are interchangeably used unless noted.

2. Results and Discussion

2.1. Necessary conditions of consciousness

We found that the necessary conditions of consciousness for access (reportable) consciousness are the formation of neural-networks, wakefulness, reentry, attention, integrated information above threshold, working memory, and so on as elaborated below in Sections 2.1.1-2.1.13. For phenomenal consciousness, attention and ability to report are not necessary.

2.1.1. Formation of neural-networks

The formation of neural-networks during development is necessary for consciousness. Neural-networks are necessary physical structures for neural correlates of consciousness (NCC) (Crick & Koch, 2003b; Tononi & Koch, 2008). Otherwise, consciousness cannot occur because there would not be proper physical infrastructure where consciousness (subjective experiences (including feelings, emotion- and thought-related experiences) and functions) can be supported.[1]

For the formation of neural-networks and for consciousness, living organisms (that are *complex adaptive* systems) follow biological laws of organization and functioning. Our framework is an extended dual-aspect monism (eDAM) (Vimal, 2008b, 2010a, 2013, 2015d) and is consistent with biological laws (Nurse, 2008), such as:

(i) Life is based on cells,
(ii) All life has genes,
(iii) The "evolution of the species by [natural] selection and mutation, the doctrines of molecular biology, the principle of physiology, and so on" ((Chauvet, 2004).p.36),
(iv) All life occurs through biochemistry,
(v) Biology as an organized system,
(vi) Self-replication and self-organization,
(vii) Mendelian inheritance laws (such as law of segregation and law of independent assortment: (Stern & Sherwood, 1966)) and
(viii) The thermodynamic non-equilibrium (Pereira Jr., Vimal & Pregnolato, 2015; Prigogine, 1977; Schrödinger, 1944).

In addition, the two fundamental properties of the elementary functional interaction between two *biological* entities (such as two neurons) are:

(i) "the non-symmetry of the action from source to sink, which implies a local transformation in the sink" ((Chauvet, 2004).p.262) and

(ii) "the non-locality of the action in space, which arises from the hierarchical structure" ((Chauvet, 2004).p.262). Here, the term 'non-locality' does *not* mean that the speed of information transfer is more than speed of light c or an entity is present simultaneously at many places. Rather, 'non-locality' is used in the sense of long-range interaction within brain (speed of information transfer v << c). A non-local phenomenon is "observed here and now has to be deduced from what happened faraway from here and perhaps quite time ago" ((Chauvet, 2004).p.28).

Both the properties of biological non-symmetry and biological non-locality "lead to the structuring of the biological system in the form of hierarchical levels of organization of the physiological functions" ((Chauvet, 2004).p.29). However, for non-biological physical systems, the functional interaction between two *physical* entities are symmetrical (in the sense of exchanging the two charges in Coulomb's law) (Chauvet, 2002, 2004).

(Northoff, 2014) proposes the followings:

1. The spatiotemporal structure of brain's resting-state [intrinsic] activity is also a necessary condition for consciousness related to different phenomenal features in space and time, their unification, self, intentionality, and qualia (p.*xii*).[2]
2. Brain and its particular design *predispose* consciousness and its phenomenal features by "relating brain's intrinsic activity and its spatiotemporal structure to the form [spatiotemporal structure, organization] of consciousness" (p.xviii-xix). This association of "purely neuronal resting state and stimulus-induced activity" (physical entity) with "consciousness and its phenomenal features" (mental entity) seems to be an effort to address the serious association problem of interactive substance dualism. On the other hand, the phrase "we can understand how the brain's neural activity generates consciousness by default only by considering form as its third dimension" seems to be based on materialism. Therefore, metaphysics is unclear.
3. Consciousness has three dimensions: content, arousal level, and form (p. xix).[3] This implies a specific NCC for a specific content, a specific level, and a specific form.
4. "The concept of NCC describes the neural mechanisms that are sufficient for the occurrence of consciousness ((Chalmers, 2000; Crick & Koch, 1998; Koch, 2004; Tononi & Koch, 2008) (Chalmers, 2010); and see a more detailed account of the concept of NCC and its distinction from neural predispositions, neural prerequisites, and neural consequences in the second Introduction; see also de Graaf et

al. 2012; (Aru, Bachmann, Singer, & Melloni, 2012; Northoff, 2013))"(p.xix-xx).

5. As per (Tsuchiya, Wilke, Frässle, & Lamme, 2015), " Thus, given the currently available evidence, activation and structural integrity of the frontal areas seems neither necessary nor sufficient for conscious perception. [...] The neural correlates of consciousness is the minimal set of neuronal mechanisms jointly sufficient for any one specific conscious percept".

In Neural Darwinism, the neuronal group selection theory (Edelman, 1993) consists of three components:

(i) In the brain, anatomical connectivity occurs through selective mechanochemical events, which take place epigenetically during development. This process creates a diverse structural primary repertoire by differential reproduction.

(ii) Once structural diversity is established anatomically, a second selective process creates a diverse secondary repertoire by differential amplification. This selective process arises through epigenetic modifications in the strength of synaptic connections between neuronal groups during postnatal behavioral experience.

(iii) Then the spatiotemporal continuity in response to real-world interactions is accomplished through reentrant signaling between neuronal groups.

However, there are two criticisms against Neural Darwinism:

(i) One could argue that neuronal groups do not undergo blind variation; rather they are instructed by the environment.

(ii) Neural Darwinism is a selectionist (not truly Darwinian) framework and does not have a mechanism to explain how information can be transferred between neuronal groups (Fernando, Szathmary & Husbands, 2012).

As specific neural-network is formed via Neural Darwinism (Edelman, 1993), the specificity of the neural-network for SEs also increases.

In our eDAM framework (Vimal, 2008b, 2010a, 2013, 2015d):

(i) A system like the brain can have both biological and mental properties,

(ii) Biological properties can supervene upon the physical properties,

(iii) Biological properties apply only to living matter (not dead matter like a rock that follows physical laws, such as thermodynamic equilibrium (Pereira Jr., Vimal & Pregnolato, 2015; Prigogine, 1977; Schrödinger, 1944), so rock is obviously not conscious),

(iv) Biological properties follow biological laws, and

(v) If we lesion a physical structure, related biological, functional, experiential, and other mental properties also disappear which entails monism. Supervenience is a structure-dependent weakly emergent process where the results can be traced back, *a posteriori,* to the structure.

(vi) Our framework is also consistent with psychophysical laws (laws connecting psychological or mental states with physical states: (Johnson, Hsiao

& Yoshioka, 2002)) and physical laws); this makes our framework consistent with psychology, neuroscience, biology, chemistry, physics and so on.

2.1.2. Wakefulness and Arousal system

Neural networks must be in wakeful state for consciousness to occur. The neural source for the arousal system is the ascending reticular activating system (ARAS) in the brain stem, which brings the thalamocortical neural networks to wakeful state as a baseline for consciousness to occur. This means that retina cannot be awake because it has no projection from ARAS. In (MacGregor & Vimal, 2008), we have elaborated (a) the origination of signals related to cortical arousal in the cholinergic cells of brain stem reticular formation peribrachial nuclei, and (b) the signals that modulate the arousal (sleep and waking) states such as serotonergic, noradrenergic, and dopaminergic signals in other brain stem nuclei. In the anterior hypothalamus, the suprachiasmatic nucleus (SCN: the biological clock) synchronizes the sleep-wake cycle with the day-night cycle and plays an important role in the activation of sleep and arousal system with the help of melatonin; its high level in night leads to sleep and low level in the morning leads to arousal. Our fMRI study suggests that the BOLD activations of the SCN and that of the primary visual cortex vary in their response to light as a function of the time of day; however, the direction of change is opposite between these two regions (Vimal et al., 2009). Under deep sleep and deep anesthesia, signals for wakefulness and attention are missing; in dreams, the inputs for subjective experiences are endogenously generated, but are different from subjective experiences during wakefulness (Vimal, 2008a).

2.1.3. Reentry process

According to Edelman, reentry is (i) a continuing process of 'recursive signaling' in neural-networks and (ii) a selection process that occurs in parallel (Edelman, 2003). In addition, reentry links, binds, and dynamically alters the activities of distributed multiple brain areas for generating consciousness in the context of thalamocortical 'dynamic core'. In 'dynamic core', a group of neurons that were not present are included in the core at the next moment, whereas some of the neurons that were present leave the core. Reentry process in a neural network binds various stimulus attributes such as location and features (color, motion, orientation) and entails consciousness (Edelman, 2003; Hamker, 2005).

However, as per (Tsuchiya & van Boxtel, 2010), "we doubt if recurrent processing is either necessary or sufficient for [phenomenal] consciousness. A gist of a scene may be consciously perceived by purely feedforward, without recurrent, processing."

2.1.4. Attention

There are multiple meanings assigned to the term 'attention' by various authors; five of them are elaborated in (Vimal, 2008a). Some of the other assigned meanings are as follows: (i) "Attention is the behavioral and cognitive process of selectively concentrating on a discrete aspect of information, whether deemed subjective or objective, while ignoring other perceivable information. Attention has also been referred to as the allocation of limited processing resources. (Anderson, 2004)" (Wikipedia, 2015). (ii) "[A]ttention can serve as a kind of 'gatekeeper' for working memory, by biasing the encoding of information toward the items that are most relevant to the current processing goals" (Awh, Vogel & Oh, 2006). (iii) "[A]ttention can be identified with the processes that allow information to be encoded in working memory. When a stimulus is attended, it becomes available to working memory, and if it is unattended, it is unavailable" (Prinz, 2011). In other words, attention makes perceptual representations available to working memory. These assigned meanings can be categorized into three groups of approaches (Wu, 2014): (1) In function-centered approach, attention: (i) *filters* "information for further processing" (Wu, 2014), (ii) binds "features for object representation and awareness", (iii) *acts* "as a *spotlight* (perhaps *zoom-lens*), highlighting its target", and (iv) *selects* "targets for memory, consciousness, or action". (2) In mechanism-centered approach, attention: (i) *modifies* "neural signals", (ii) *alters* "the area of space to which a neuron responds", (iii) *emerges* "from competition for limited resources", and (iv) *acts* "as the preparation of a motor response". (3) In phenomenology-centered approach, (i) "we consider attention as a distinctive mode of consciousness", (ii) "what attention is subjectively like", (iii) "attention is not a consciousness with its own characteristic phenomenology, but is a state that affects consciousness", and (iv) attention acts "as the gatekeeper of consciousness" (Wu, 2014).

In our eDAM framework (Vimal, 2008b, 2010a, 2013, 2015d), attention can be defined as neural signal that modifies the feed forward stimulus dependent main signal ((Vimal, 2008a)'s fifth definition). Attention could be the results of reentry and competitive interactions (Hamker, 2005), which modulates the stimulus related feed forward signal. This modulating signal could be in forward (bottom-up) direction or mostly in backward (top-down) direction. Attention could be at foveal or peripheral targets for long (sustained) or short (transient) duration. The 'sources' of attention may be thalamic reticular nucleus (TRN) for bottom-up or frontal cortex for top-down direction. In our example, the 'target' of visual attention is 'V8/V4/VO' (color area) for the Red-Green channel.

Visual attention can be defined as a neural signal (including reentrant signal such as FEF ↔ V4) that modulates the main feed forward pathways (ventral pathway: retina → LGN ↔ V1 ↔ V2 ↔ 'V8/V4/VO' ↔ IT ↔ GF and dorsal pathway: retina → LGN ↔ V1 ↔ V2 ↔ V5/MT/MST ↔ IPL/PPC); see also (Vimal, 2008a). Here, LGN is lateral geniculate nucleus; IT is inferior

temporal cortex related to object recognition; GF is fusiform gyrus face area; IPL is intraparietal lobule and PPC is posterior parietal cortex; PFC is prefrontal cortex, which has two parts: dorsolateral PFC (DLPFC) and ventrolateral PFC (VLPFC). Furthermore, as an example, attention modulates the activity of V2 and V4 neurons. Reentrant interactions among neural populations entail consciousness, whereas attention modulates consciousness (Edelman, 2003).

Furthermore, visual attention tasks can be grouped into five forms, namely, (i) foveal short-sustained, long-sustained, and vigilance attention tasks, (ii) covert attention task, (iii) divided attention task, (iv) selective (or focused) attention task, and (v) switching attention task; these five aspects of visual attention are detailed in (Vimal, 2008a).

To sum up, there are two types of reentry processes: one related to attention and other that is not related to attention (such as in binding process). These two types of reentry processes should be separated using appropriate psychophysical tasks and fMRI. For example, attention related reentry areas could be separated first and then areas related to non-attentional reentry could be investigated by subtraction method (see Section 2.3). Furthermore, areas common to all five attentional tasks and areas specific to a specific task should be investigated (see Section 2.3). From the meta-analysis of above studies and the consistency among studies, we argue that attention is another *necessary* ingredient for consciousness. Furthermore, we argue that attention is not *sufficient* for *access/reportable* consciousness because *other necessary conditions* (such as the formation of neural-networks, wakefulness, working memory, and so on) are also needed for it.

2.1.5. Segregation, differentiation, integration and autonomy of information

This is discussed in (Vimal, 2015d). Briefly, there are two steps:

(i) The segregation of information for the analysis of specific stimulus attribute and then

(ii) The integration of information for the synthesis of all attributes (related to dimension such as redness, sub-mode such as color, and mode such as vision), which results unified consciousness. As per (Northoff, 2014), "Re-entrant circuits integrate information from different sources as associated with neural activity in different regions and networks" (p.*xx*).

In other words, the first stage of processing is the segregation of information (such as the information related to physical and conceptual attributes), which are analyzed and processed for preciseness and specificity in different specialized neurons of related brain areas. Then, the second stage of processing is the integration of information (or binding of attributes) (related to different functions, concepts, experiences and so on) in various neural-network-complexes, which results unified consciousness. The term 'differentiation' signifies that there are a large number of possible functions and *potential* experiences; this leads to higher effective information (Tononi, 2004).

To sum up, one of the necessary conditions of consciousness is that the measure or degree of integrated information (Φ) (Balduzzi & Tononi, 2009; Tononi, 2004, 2008, 2012) in a 'complex' of neural-network must be higher than the critical threshold value ($\Phi_{critical}$).

As per (Tegmark, 2015), the autonomy of information processing is also a necessary condition of "consciousness as a state of matter", where the dynamics of the processing of information is dominated by internal forces.[4]

Furthermore, both global workspace (Baars, 1988) and higher-order global states (HOGS) (Van Gulick, 2015) models imply the integration of information into a larger unified state. Therefore, integrated information is a necessary (but unclear if it is sufficient) condition of access consciousness. It is unclear if integrated information is also necessary for phenomenal consciousness because it takes time to integrate, whereas the gist can be experienced significantly shorter time (Sperling, 1960).[5]

As per (Van Gulick, 2015), "Tononi's theory also commits him to a form of panpsychism [...] But overall it [IIT] does not seem plausible as a reductive proposal to provide necessary and sufficient conditions for consciousness in terms of nonconscious forms of unity and integration. [...] Moreover, as noted above, even if a certain type of integration is not strictly necessary for consciousness or for phenomenal unity and is absent (or very limited) in some special cases, it may nonetheless play a major role in explaining the function and value of consciousness. [...] Indeed, one can extend the argument to show that such representational unity is a necessary condition for conscious experience itself".

2.1.6. Memory

There are four types of memory:

(i) *Iconic (or sensory) memory*: It refers to the visual image a subject holds onto after briefly looking at an object. Iconic memory is by nature fleeting. The site of visual iconic memory might be visual areas (Lamme, 2003), which appears to be essential for retaining information for *phenomenal* consciousness (Rowlatt, 2009) because there is not enough time for the top-down attention to act on it.

(ii) *Fragile short-term memory*: (Vandenbroucke, Sligte & Lamme, 2011) suggested 'fragile' short-term memory (with large capacity and a lifetime of several seconds) between iconic memory (with high capacity but short time-scale) and short-term memory (with small capacity but long time-scale). It is easily overwritten by new stimulation. This may be used by the *phenomenal* consciousness.

(iii) *Short-term (or working) memory*: It stores information that is needed to recall in the subsequent seconds, minutes, or hours. The site of visual short term memory might be frontal (such as PFC), parietal, and also visual areas (Lamme, 2003). The working memory maintains internal representations to guide actions. This memory appears to be essential for retaining information

for *access* (reportable) consciousness (Rowlatt, 2009). One could argue that global workspace with working memory is also necessary for *access* consciousness (Baars, 1988).[6] The capacity of visual working memory (or active memory) is roughly four items or less; at a neural level, it is coded in the active firing of neurons; it ceases when that neuronal firing ceases. Whereas, structural memory depends on changes in the neural hardware itself, for example change in strength of synapses (Block, 2007).

(iv) *Long-term memory* (LTM): LTM stores salient information that is recalled after a day to years. Attention plays an important role in the formation of LTM; LTM is useful but does not appear to be necessary for *access* or *phenomenal* consciousness.[7] The site of LTM might be medial temporal lobe system and hippocampal area.

To sum up, the iconic or fragile memory is necessary condition for *phenomenal* consciousness whereas working memory is that for *access* consciousness.

2.1.7. Reentry, attention, memory, and consciousness

In general, reentry interactions can be grouped in two categories: (i) attention related reentry (or simply 'attention') and (ii) consciousness and binding related main reentry (or simply 'reentry') signals. Attention along with reentry process may solve the binding problem by linking together different features at the attended location. Memory retains the information for consciousness. Working memory and attention are closely related cognitive processes (Kastner & Ungerleider, 2000). Attention may play an essential role in transferring stimuli from iconic memory to working memory and then to long-term memory. Conversely, feature binding enables structuring representations coherently, perceptual integration, attention, and working memory, and seems necessary for unified consciousness (Engel, Fries, Konig, Brecht, & Singer, 1999; Engel & Singer, 2001; Hardcastle, 1999).

2.1.8. Stimulus level

The stimulus should be at or above threshold for conscious experience. Otherwise, it would be at subconscious level. This is consistent with the "Activation Hypothesis" elaborated in (Baars, 1988). Stimuli could be external or internal. For detection, discrimination, and recognition, the contrast of external stimulus should be at or above threshold contrast. Here, threshold level is defined as the critical stimulus-contrast at which the percent correct response is 50%; one could raise it to 75% depending on methods used (Vimal, 1997, 1998a, 1998b, 2000, 2002a). Suprathreshold contrast is obviously better for consciousness. Our psychophysical experiments related to detection and discrimination (Vimal, 1997, 1998a, 1998b, 2000, 2002a) validates this hypothesis. Internal stimuli could be endogenously generated such as in

thought processing, day-dreaming, imagery, dreams, phosphenes (Vimal & Pandey-Vimal, 2007), and so on.

As per (Atmanspacher, 2011), "The *activation* of a neuronal assembly is necessary to make the encoded content consciously accessible. This activation is considered to be initiated by external stimuli. Unless the assembly is activated, its content remains unconscious, unaccessed memory. According to Umezawa, coherent neuronal assemblies correlated to such memory states are regarded as vacuum states; their activation leads to excited states with a finite lifetime and enables a conscious recollection of the content encoded in the vacuum (ground) state. The stability of such states and the role of external stimuli have been investigated in detail by Stuart *et al.* (1978, 1979)."

As per (Naccache, 2005), "These results demonstrate that ventral pathway activation constitutes a necessary but not sufficient condition to perceive consciously visual stimuli."

2.1.9. Neural-network proto-experiences

What are the proto-experiences (PEs), exactly? PEs are precursors of subjective experiences, as detailed in (Vimal, 2010a). Subjective experiences are first person conscious experiences that are expressed (i.e., that are not covert or unexpressed as PEs are). In other words, a basis- or eigen-state related to a proto-experience is the state of a *potential*/possible subjective experience; the mental aspect of a state of an entity (such as neural-network) contains the superposition of these multiple possible eigen-states. This is embedded in neural-network. A specific subjective experience is selected from neural-network proto-experiences using matching process as described in (Vimal, 2010a), and then this selected subjective experience becomes a specific expressed subjective experience. The neural-network-PEs are a set of potential/possible relevant SEs embedded and stored as memory traces in the neural-network by the processes involving *neural Darwinism*.

2.1.10. Higher-order thoughts as necessary and sufficient condition of consciousness

As per (Rosenthal, 2005), "[HOTs] do not transfer the property of being conscious from themselves to their targets; indeed, they don't induce any changes whatever in those targets [p.185 …] A mental state's being conscious is not strictly speaking a relational property of that state. A state's being conscious consists in its being a state one is conscious of oneself as being in. Still, it's convenient to speak loosely of the property of a state's being conscious as relational so as to stress that it is in any case not an intrinsic property of mental states" (p.211).

As per (Wilberg, 2010), "a mental state is conscious if and only if it is accompanied by the [suitable] HOT that one is in that state [p.618 …]. It seems that the [suitable] HOT must represent, at least roughly accurately, the

individuating features of that state. [p.619 …] Consciousness as a property of token mental states [p.625]".

As per (Berger, 2014), "Rosenthal's version of HOT [higher-order thought] theory, according to which a suitable HOT is both necessary and sufficient for consciousness … consciousness is best understood as a property of individuals, not a property of states. […] Rosenthal's higher-order thought ("HOT") theory of consciousness, which holds that one is in a conscious mental state if and only if one is aware of oneself as being in that state via a suitable HOT (see, e.g., (Rosenthal, 2005)). [p1…] Consciousness is, as Rosenthal often emphasizes (e.g., 2009, p. 166), a matter of how one's mental life appears to one. But appearance and reality can in general diverge. [p2…] Although many theorists do assume that consciousness is a property of states, this assumption is questionable. Indeed, Rosenthal himself has been explicit that consciousness is not a property conveyed by HOTs to first-order states (2005, p. 185). […] The fundamental motivation for HOT theory is the claim that one is in a conscious state only if one is aware of oneself as being in that state. Rosenthal has called this fact about consciousness the "Transitivity Principle" (TP) because it explains what is for one to be in a conscious state in terms of one's transitive [transitional, intermediate] awareness of being in that state (2005, pp. 3–4). It is clear, however, that the TP offers a necessary, but not sufficient, condition for consciousness. […] According to HOT theory, suitable HOTs are the states in virtue of which there are these subjective impressions. A suitable HOT is an occurrent intentional state that asserts the content that I am in some state. […] Since a targetless HOT does not accurately represent any state, there is no state to exhibit consciousness. In such a case, one only seems to be in a conscious state. Hence Wilberg proposes his No Consciousness Account of targetless HOTs. On Wilberg's view [(Wilberg, 2010)], HOTs are necessary, but not sufficient, for consciousness. […] But because Wilberg maintains that a state's being conscious involves its acquiring the property of consciousness, he denies that the subjective appearance of being in a certain state is sufficient for consciousness. On Wilberg's view, one is in a conscious state if and only if it appears to one that one is in a state via a suitable HOT and, in addition, one is in that state. So while consciousness does concern mental appearance, Wilberg maintains that it is a 'matter of (rough) correspondence between appearance and reality' (2010, p. 630). […] If one reports seeing a red apple, such a report signals that it appears to one that one sees a red apple—and all there is to a conscious state, we think, is the subjective appearance that one is in some state. Since appearances in general need not correspond to reality, it is implicit in our folk conception of consciousness that consciousness is a matter of mental appearance, whether or not those appearances are accurate. […] To accurately capture our ordinary conception of consciousness, then, HOT theory should maintain that a suitable HOT is not only necessary but also sufficient for consciousness—and this is the version of HOT theory that Rosenthal defends. On Wilberg's No Consciousness version of HOT theory, by contrast, the mere subjective appearance of a state is

insufficient for consciousness. For Wilberg, if one has a targetless HOT that one sees a red apple, seems to see a red apple, and on that basis reports that one sees a red apple, one's report does not indicate that one consciously sees the apple. In severing the connection between verbal reports and consciousness, Wilberg's view violates a feature central to both our commonsense and experimental approaches to consciousness. [...] There is thus independent reason to think that consciousness is not a property of existing first-order states conveyed to them by HOTs. [...] Again, all that matters for consciousness is a suitable impression that one is in a state. According to HOT theory, HOTs are the states in virtue of which one has the subjective impression that one's mental life is some way. And HOTs are, of course, states of individuals. It is thus compatible with the folk conception of consciousness that consciousness is not a property of states, but a property of individuals—namely, the property of being aware of oneself as being in a state. [...] So though it is acceptable shorthand to say that one is in a conscious state only if one is aware of that state, it is more accurate to say that one is in a conscious state only if one is aware of oneself as being in that state. This way of casting the TP yields a version of HOT theory according to which one is in a conscious state if and only if one is aware of oneself as being in that state via a suitable HOT. This explains why the content of a suitable HOT is that I am in a particular state, not merely that there is such a state. [...] On Rosenthal's view, by contrast, what a HOT makes one aware of is, strictly speaking, oneself. So if one has a suitable HOT, one's HOT always renders one aware of something that exists—namely, oneself.13 If one has a HOT, then one exists; as Descartes said, a thought requires a thinker [...] Sometimes one is aware of oneself as being in a state that exists (when one's HOT is accurate) and sometimes one is aware of oneself as being in a state that does not exist (when one's HOT is targetless). [...] One way to unpack Rosenthal's claim would be to hold that when one has a suitable HOT, one exhibits the property of being-in-a-conscious-state, wherein this is understood to be the property of an individual who is suitably aware of being in some state.15 [if HOT theory holds that consciousness is a property of an individual's representing itself, then the theory is not really a higher-order theory of consciousness at all ... HOTs render individuals aware of themselves as being in states. ...] What [consciousness] might seem to be a property of a state is actually a property of an individual's representing itself as being in a state. [...] Conscious states are whatever states one is subjectively aware of oneself as being in. So there is, after all, a way in which we can comfortably describe consciousness as attaching to states, even in cases of targetless HOTs. If we do so, as Rosenthal proposes, we apply the property of consciousness to notional states. But this too is accommodated by HOT theory. We often apply properties to notional objects. And it is unclear what evidence could be brought to bear upon the decision between the view that consciousness is a property of notional states and the view that it is a property of actual individuals representing themselves as being in those notional states. [...] What it is for one to be in a conscious state is for one to have the suitable

appearance of a state, whether or not one is in that state. This is not to say that consciousness does not exist or that it is only a matter of appearances. HOTs and the appearances that they reflect are real, though it is the individuals, and not the states, that are conscious."

It seems that first we need to investigate the necessary and sufficient conditions for HOT and then investigate if these conditions are the same as that for consciousness.

As per (Northoff, 2014), "Other cognitive theories of consciousness emphasize the central role of higher-order cognitive functions like memory, executive functions, metacognition, metarepresentation, and so on, in constituting consciousness […] higher-order thought theories of consciousness…consciousness is here determined not by the contents themselves, but rather by the awareness of those contents as contents … reflective consciousness [enabled by cognitive functions such as attention or working memory]… This amounts to a "cognitive-based accounts of consciousness" [others are resting state based and a stimulus-bound accounts]" (p.*xxi*).

2.1.11. Executive functions

Executive functions include:

(i) The initiation of and the overall control of goal directed behavior, such as suppressing the activation of irrelevant information, creating and maintaining goal-related behaviors, and temporally sequencing behavior,

(ii) The initiation of and the overall control of the execution of deliberate actions;

(iii) Strategic planning,

(iv) Decision making,

(v) Effortful and flexible organizational skill,

(vi) Future-oriented behavior,

(vii) Self-regulation,

(viii) Attention, and

(ix) Working memory (Burgess, Alderman, Evans, Emslie, & Wilson, 1998; Fine, Lumsden & Blair, 2001).

(x) *Necessary and sufficient conditions for self-consciousness:* As per (Wüstholz, 2015), "For instance, we might observe that a given species is capable of social cognition, planning and mirror self-recognition, but not mindreading. … We might argue that the presence of these three abilities is sufficient for attributing self-consciousness because such an explanation would be more theoretical parsimonious and unified—a brand of Ockham's razor. […] Bennett & Hacker are also defenders of the view that language is necessary for self-consciousness [(Bennett & Hacker, 2003), p. 334]." In other words, social cognition, planning, mirror self-recognition and language are

necessary and perhaps sufficient conditions for self-consciousness (Bennett & Hacker, 2003; Wüstholz, 2015).

It is critical to recognize that most of these functions are the phenomena of distributed neural processing. Some of areas involved in EFs are (a) DLPFC for initiation and execution of deliberate actions, (b) anterior cingulate cortex (ACC) for monitoring the consequences of actions (Ito, Stuphorn, Brown, & Schall, 2003), and (c) cerebellum for coordinating movement. Attention and working memory, which are *necessary* for consciousness, are also the parts of EFs. Areas PFC and ACC are also activated in attention tasks.

One can ask the following questions: Are other components of EFs also *necessary* for experiential aspect of consciousness? Is motor action (for generating reports for *access* consciousness) also *necessary* element for the experiential aspect of consciousness? If EFs and motor action are also *necessary* for experiential aspect of consciousness, then fMRI experiments should be designed to isolate the components of EFs, such as (i) to (vii) and motor action, similar to attention and working memory.

Various components of EFs are certainly involved in certain functional aspects of consciousness. Furthermore, some areas are activated by multiple processes. For example, DLPFC supports EFs such as attention, memory, planning, and possibly other functions. DLPFC is a large area; some part of DLPFC may be assigned to working memory, some to attention, and some to planning function. Alternatively, whole of DLPFC may support multiple functions; if so, the underlying mechanism for each of them could be separated. Otherwise, one can ask if mechanisms are also the same for the functions that a group of neurons support. To address these questions, further research is needed.

2.1.12. Investigation of necessary and sufficient conditions of consciousness

The *necessary* conditions for consciousness are those conditions that must be satisfied in order to have consciousness, i.e., if any of them is missing then the entity is not conscious. The *sufficient* conditions for consciousness are conditions, if satisfied, guarantee that the entity is conscious. We ask if the *necessary* conditions of consciousness are *sufficient* for consciousness. Future research should address this question. The term 'sufficient' is used in the sense that no other ingredients of consciousness are needed. The neural correlates of consciousness might include brainstem mechanisms in addition to the thalamocortical system because there is some evidence of consciousness without a cerebral cortex (Merker, 2007). In that case, fMRI study may separate brainstem areas from thalamocortical areas for the *necessary* conditions of consciousness. However, we need to investigate if the degree of information integration (Φ) in brainstem or any neural-network complex under

consideration is above critical threshold for consciousness; otherwise, they are not directly necessary for consciousness although they may be needed as input/output.

2.1.13. Color subjective experiences and necessary conditions of consciousness

For subjective experiences (such as *redness* to *greenness*) related to the Red-Green channel, the internal representation of color stimulus is needed in 'V8/V4/VO R-G neural-network'. This neural-network needs to be awake, attentive, and re-entrant and needs to have working memory and stimulus should be at or above threshold level for having a reportable SE of color. The retina (a) does not appear to have projections from ARAS system, (b) does not have reentry from LGN and higher level, and (c) does not have attentional feedback; therefore, the retina is not awake, not reentrant, and not attentive and hence cannot have consciousness. However, the retina participates in the essential stimulus related feed forward visual processing for all three psychophysical visual entities: Red-Green, Yellow-Blue and luminance channels. Without retina, normal visual system and its consciousness will be completely shut down. For color, the feed-forward stimulus dependent signal needs to interact at 'V8/V4/VO' color area with fronto-parietal attentional feedback signal to generate consciousness of color through matching and selection mechanisms (Vimal, 2010a) of our framework.

2.2. Red-Green Channel and Visual consciousness

There are three aspects (triad) in a conscious system, which need to be linked: structure, *function*, and *experience*. A computational framework (Wray & Edelman, 1996) or a framework based on other standard models of neuroscience and cognition correlates structure and function well. However, they fail to link experience with structure-function. Our framework (a novel concept in neuroscience) links all those three aspects (Sections 2.1.3, 2.2.1, and 3) and addresses the 'hard problem' (Vimal, 2015d). Thus, our framework and the standard neuroscience frameworks are complementary to each other. We take color experiences and its NCC to link the triad.

2.2.1. Psychophysics of color vision

A *psychophysical* entity is an abstract mathematical construct derived by modeling the experimental data related to psychophysics and neurophysiology. This *psychophysical* entity (such as the R-G channel) provides a link between first-person data (*phenomenal or mental aspect,* such as *redness* to *greenness*) and third-person data (*physical aspect,* such as 'V4/V8/VO R-G color neural-network'). 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 color area in humans (Tootell, Tsao & Vanduffel, 2003). VO is ventral-occipital cortex.

The effect of divided attention is less at fusiform gyrus (GF: for face recognition) level than that at 'V4/V8/VO' level in the dual-task paradigm of (Reddy, Wilken & Koch, 2004). Thus, *phenomenal* consciousness could also be associated with higher stages of ventral system. This hypothesis can be tested using fMRI.

2.2.2. A neural-network for a specific function and experience

Our framework **predicts** that the formation of a specific neural-network for a specific function (such as red-green color detection and discrimination) and for a specific experience (such as redness or greenness) is necessary; otherwise, the specific SE will never be experienced. This prediction is **verified** by lesion experiments: the lesion of parvocellular pathway (V4/V8/VO-neural-network) leads to the loss of color vision (Merigan, 1989; Merigan, Katz & Maunsell, 1991; Schiller, Logothetis & Charles, 1990).

From the review (Nassi & Callaway, 2009) (see also (Dacey, 2004; Milner & Goodale, 2008)):

(i) One could hypothesize that the pathway 4Cβ → interblobs (layer 2/3) of V1 → thin stripes of V2 ↔ 'V4/V8/VO' might play role perhaps in the processing of the saturation and brightness aspects of color, whereas 4Cβ → blobs → thin stripes of V2 ↔ 'V4/V8/VO' may be for the hue aspect of color processing; this hypothesis needs to be tested.

(ii) The visual area 'V4/V8/VO' processes color information (Bartels & Zeki, 2000; Conway, Moeller & Tsao, 2007; Hadjikhani et al., 1998; Tootell, Tsao & Vanduffel, 2003; Wandell, 1999).

One could hypothesize that this 'V4/V8/VO' network consists of:

(i) The main color processing network in the ventral pathway (retina → parvocellular layers of the LGN ↔ cytochrome oxidase-rich blobs (and also interblobs) of the layer 2/3 of V1 ↔ thin stripes of V2 ↔ 'V4/V8/VO') ↔ IT ↔ GF,

(ii) The attentional network such as [fast (retinotectal: retina → superior colliculus → pulvinar → intraparietal lobule (IPL)/parietal cortex) and slow (geniculostriate: retina → LGN → V1 → V2 → 'V5/MT/MST' → IPL/parietal cortex)] → frontal cortex/PFC (such as FEF) ↔ 'V4/V8/VO',

(iii) Other auxiliary networks such as emotion, face, and color related network such amygdala system ↔ GF ↔ IT ↔ 'V4/V8/VO', location and color related dorsal network such as parietal cortex ↔ FEF ↔ 'V4/V8/VO', and so on,

(iv) The ARAS arousal system that sends projections to thalamocortical neural-networks to bring them to wakefulness as a baseline for

consciousness to occur,

(v) The memory related areas such as PFC, parietal and visual areas (Lamme, 2003; Pasternak & Greenlee, 2005), and

(vi) Self related areas (Bruzzo & Vimal, 2007; Northoff et al., 2006).

The areas up to V2 are involved in processing local aspects of color vision (Lennie, Krauskopf & Sclar, 1990). The visual area V4 is involved in more global processing such as contextual information in color constancy, color induction, and color discrimination (Hurvich & Jameson, 1957; Kaiser & Boynton, 1996; Wray & Edelman, 1996; Zeki, 1983a, 1983b). The IT is involved in color vision (Komatsu, Ideura, Kaji, & Yamane, 1992), but its functional role is not clear.

2.2.3. Event-related brain potential measurements and consciousness

The event-related brain potential (ERP) measurements in EEG study showed that visual *phenomenal* consciousness initially emerged independent of selective attention and earlier than selective attention (Koivisto, Revonsuo & Salminen, 2005): The earliest part of visual consciousness negativity (VAN) (130–200 ms) at occipital sites was independent of attention, suggesting *phenomenal* consciousness. The late positive amplitude enhancement (LP) is associated with *access* (reportable) or *reflective* consciousness, which includes updating of working memory, reporting, identification, categorization, naming the stimulus (Block, 2001; Donchin & Coles, 1988).

To sum up, for subjective experiences (SEs) (such as *redness* to *greenness*) related to the Red-Green channel, the internal representation of color stimulus is needed in 'V4/V8/VO R-G neural-network'. This neural-network needs to be awake, attentive, and re-entrant and needs to have working memory and stimulus should be at or above threshold level for having a SE of color. For color, the feed-forward stimulus dependent signal needs to interact at 'V4/V8/VO' color area with fronto-parietal attentional feedback signal to generate visual consciousness of color.

Moreover, there are three main levels for unfolding the attributes of the Red-Green channel: (i) psychophysical level (such as spatial frequency, temporal frequency, orientation, and wavelength-tuned mechanisms), (ii) neurophysiological level (such as 'V4/V8/VO'-neural-network, and (iii) consciousness level (such as the subjective experiences *redness* to *greenness*). We have tried to integrate psychophysical, neurophysiological, and consciousness research for the Red-Green Channel; however, further research is needed to clearly link all these levels. In our framework, one could argue that the psychophysically derived three channels and mechanisms in each channel have two aspects: (i) mental aspect, such as visual consciousness or subjective experiences *redness* to *greenness* related to the Red-Green channel, and (ii) physical aspect, such as its neural correlates 'V4/V8/VO-neural-network'.

Thus, the specific aim (B) is accomplished by linking the three aspects of a conscious system, namely, structure, function, and SE (Sections 2.1.3, 2.2.1, and 3).

2.3. Future directions

For specific aim (C), a few simple experimental designs related to the Reddish-Greenish cardinal color channel are proposed (a) to separate areas for attention, reentry, wakefulness, and memory, (b) to separate *access* and *phenomenal* consciousness, and (c) to investigate the *necessary* and *sufficient* attributes of visual consciousness. To define equiluminant Reddish-Greenish cardinal color channel for each subject, one needs to isolate (a) the chromatic channels from the achromatic channel by estimating equiluminance ratios (Vimal, 1997, 1998a, 1998b, 2000, 2002a, 2002b) and (b) the Reddish-Greenish cardinal channel from Yellowish-Bluish cardinal channel (Krauskopf, Williams & Heeley, 1982; Webster & Mollon, 1994). The Reddish-Greenish pattern is generated by making the greenish pattern in spatial antiphase with the reddish pattern using the result of this isolation process.

2.3.1. Separating areas for attention, reentry, wakefulness, and memory

In order to investigate neural correlates of consciousness (NCC), activities in thalamocortical dynamic core need to be measured at various level of consciousness (such as deep sleep, deep anesthesia, dream, and conscious wakeful state). In addition, activity correlated with stimulus needs to be separated from that with conscious percepts (such as in binocular rivalry) at both cortical and thalamic levels (Edelman, 2003). Furthermore, we need to separate the areas for the *necessary* conditions of *access* consciousness: areas for attention, areas for reentry processes excluding attention, areas for wakefulness, and areas for memory. The test stimulus can be color pattern for the Red-Green channel (such as reddish-greenish equiluminant pattern) (Vimal, 1997, 1998a, 1998b, 2000, 2002a, 2002b). Attention could be at high and low levels. The 'targets' of attentional signal depend on the test stimulus. For example, the 'targets' of attention may be the visual area 'V4/V8/VO' for color test stimulus.

In (Vimal, 2008a), we have detailed a fMRI experimental protocol to separate attentional areas from '*other*' areas. Here, we will concisely describe it. '*Other*' areas consist of those areas that not the attentional areas, but they are also activated by visual attention tasks depending on the stimuli used. For example, '*other*' areas may include:

(i) Visual areas (such as V1 and V2) for both color and luminance contrasts,

(ii) Visual areas (such as 'V8/V4/VO') for 'only color contrast' and color identification,

(iii) Areas involved in working memory (such as PFC),
(iv) Areas for iconic memory, long term memory, task performance, thought processing, perceptual categorization, reasoning, planning, evaluation of alternatives, decision-making, rational control of action,
(v) Areas for wakefulness,
(vi) Areas involving non-attentional reentry, and
(vii) Remaining areas as detailed in (Vimal, 2008a). Some of these areas may be involved in reentry process and other executive functions (Section 2.1.11).

For separating attentional areas from non-attentional or '*other*' area, we need three conditions (Vimal, 2008a):

(1) Fixation condition (**F**): 'looking at white fixation light on dark background', (2) non-attentional condition (**N**): 'fixation at the center without attention to the test stimulus', and (3) attentional condition (**A**): 'fixation at the center and high level of attention to the test stimulus'. Our psychophysical studies (Vimal, 1997, 1998a, 1998b, 2000, 2002a, 2002b) were performed with high degree of attention. The activated areas for these three conditions are adapted from the Eqs. (1)-(3) of (Vimal, 2008a) as follows:

$$\mathbf{F} = \mathbf{A_f} + \mathbf{O_f} \quad \mathbf{(1)}$$

$$\mathbf{N} = \mathbf{A_f} + \mathbf{O_f} + \mathbf{A_n} + \mathbf{O_n} \quad \mathbf{(2)}$$

$$\mathbf{A} = \mathbf{A_f} + \mathbf{O_f} + \mathbf{A_h} + \mathbf{O_h} \quad \mathbf{(3)}$$

In the left side of above equations, **F**, **N**, **A**, represent fixation, non-attentional, and attentional conditions, respectively; in the right side, 'A' and 'O' indicate attentional and '*other*' areas, respectively. The subscripts 'f', 'n', and 'h' on the right side represent foveal, *no*-attention, and high-attention conditions, respectively. One can assume that the activation A_n is small, $A_n << A_h$, and $O_n \sim O_h$. The attentional areas can be separated from the subtraction map $(A - N) \sim (A_h - A_n) \sim A_h$. The '*other*' areas can be separated from the subtraction map $[(A - F) - A_h] \sim O_h$. We have used subtraction method successfully in (Vimal et al., 2009; Vimal et al., 2006).

Furthermore, if we need to separate color area as well, then '*other*' areas will include areas mentioned in (i) and (iii)-(vii). Accordingly, more conditions need to be included in above equations leading to tasks that are more complex for subjects. One can simplify if multiple sessions with simple tasks are included in the design. For example, Eqs. (1)-(3) will separate attentional areas from non-attentional areas; another set of three conditions can be set up for separating memory areas from non-memory areas in another session, and so on. In other words, experimental designs should balance between a few long tiring difficult session versus a large number of short sessions with different tasks. Furthermore, the areas involved in wakefulness may include ARAS system such as brain stem reticular formation peribrachial nuclei and hypothalamus as discussed in Section 2.1.2. This can be verified using whole brain sagittal scan that includes brain stem areas. John's work (John et al.,

2001) may be useful in separating the areas involved in wakefulness. Moreover, neural network model, such as an extension of Hamker's model (Hamker, 2005), can be useful in detailing how the mechanisms of wakefulness, reentry, attention, and memory lead to visual consciousness.

2.3.2. Separating areas for access and phenomenal consciousness

The above groups of experiments in Section 2.3.1 can be extended to address the separation of *phenomenal NCC* from *access NCC* (Block, 2005; Lamme, 2003; Sperling, 1960). Attention is necessary for *access* (reportable) consciousness but not for *phenomenal* consciousness (Lamme, 2003), although they are still controversial (Baars & Laureys, 2005; Fell, 2004; Kentridge, Heywood & Weiskrantz, 2004; Tallon-Baudry, 2004).

As per (Block, 2007), "Sperling [1960] found the same results whether he made the exposure of the grid as short as 15 ms or as long as 500 ms. […] The idea that one does in fact phenomenally register many more items than are (in a sense) accessible […] the explanation is that the 'capacity' of phenomenology, or at least the visual phenomenal memory system, is [8-32 items] greater than that of working memory [3-4 items] [see (Sligte, Lamme & Scholte, 2006; Sperling, 1960)] […] there is phenomenology [phenomenal consciousness] without accessibility (Block 1995a) […] the Sperling [1960] experiment directly shows the existence of phenomenal states that are not cognitively accessible. [Overflow argument is that] the machinery of phenomenology does not contain the machinery of cognitive accessibility. […] [Block proposes] a distinct state of 'phenomenal consciousness' prior to global access [as demonstrated in (Sligte, Lamme & Scholte, 2006; Sperling, 1960)'s experiments […] The main point is that as the main control area for working memory, this [dorsolateral] prefrontal area is the main bottleneck in working memory, the limited capacity system that makes the capacity of working memory what it is. So the first half of my brain-oriented point is that the control of working memory is in the front of the head. The second half is that, arguably, the core neural basis of visual phenomenology is in the back of the head [V1-V5-V1 loop with recurrent activity is the core neural basis for motion]."

One can test the hypothesis that (a) *phenomenal NCC can be separated from the access NCC and (b) access NCC = phenomenal NCC + attention* needed for cognitive global access in the working memory (Block, 2005, 2007; Lamme, 2003). The iconic memory (not durable and erased quickly) does not need attention, so it may be related to *phenomenal* NCC (Block, 2001; Sperling, 1960). Therefore, the above attention experiments can be performed with short (Block, 2001; Sperling, 1960) test-stimulus duration of 1 frame (8.4 msec for a LCD projector or a color monitor with the frame rate of 120 frames per sec). The test pattern in conditions N and A can be about 8.4 msec ON and 2991.6 msec OFF (for TR = 3000 msec), which can be repeated for 10 times. If frame-rate is increased by programming then the test-stimulus duration for 1 frame can be further decreased. At the end of experiment, subjects can be asked

about their subjective experiences (such as color, shape, contrast, brightness, sharpness and anything else they can tell) during N and A conditions. Although subjects can be instructed not to attend in condition N, some residual attention may still be present. With this limitation, one can test the possibility that the subtraction maps (N – F) for '*no*-attention' condition does not involve attentional-modulation areas but subjects may have *phenomenal* consciousness, whereas (A – N) may involve some transient attentional-modulation areas even though it is of short duration (Sperling, 1960). For this purpose, subtraction maps (N – F) and (A – N) for both short (Block, 2001; Sperling, 1960) (16.7 msec) and long (30 sec) stimulus-durations can be compared and examined further for testing the above hypothesis. As discussed in Section 2.2, the ERP methods are useful for separating *phenomenal* consciousness and *access* consciousness in temporal domain (Koivisto, Revonsuo & Lehtonen, 2006; Koivisto, Revonsuo & Salminen, 2005) and should be investigated further.

The data of above groups of experiments can also test the hypothesis that a part of *common* attentional areas will always be activated. This is because a conscious subject by definition has to be awake and hence must always be attending on 'something' (Fell, 2004) whether it is 'attention' or '*no* attention' condition. This can easily be rejected if one can find a single fMRI session (in which a subject is conscious) that does not activate this common area. Otherwise, this area must be a part of 'neural correlate of consciousness' (NCC) (Crick & Koch, 2003a). Self-related areas can be investigated using Northoff's paradigms (Northoff et al., 2006).

2.3.3 Investigation of necessary and sufficient conditions of visual consciousness

The *necessary* conditions for consciousness are those conditions that must be satisfied in order to have consciousness, i.e., if any of them is missing then the entity is not conscious. The *sufficient* conditions for consciousness are conditions, if satisfied, guarantee that the entity is conscious.[8] The necessary conditions might be context-dependent (Van Gulick, 2015): "what might be necessary for consciousness in one systemic context might not be required in another." As per (Allen, 2013), "Since consciousness is a subjective experience, there is no sufficient condition for consciousness that can be experimentally confirmed. The most we can hope for is agreement on the necessary conditions for consciousness."[9] As per (Baars, Franklin & Ramsoy, 2013), "we may know some necessary but not sufficient conditions for conscious contents (viz., (Baars, 1988))."

1. Is attention sufficient for consciousness?

The relation between attention and consciousness is controversial; there are 5 competing views/ hypotheses (De Brigard, 2010):

A. Attention is necessary but not sufficient for consciousness (Merikle & Joordens, 1997; Moran & Desimone, 1985; Rensink, O'Regan & Clark, 1997).

B. Attention is both necessary and sufficient for consciousness (De Brigard & Prinz, 2010). As per (Prinz, 2011), "[reportable] consciousness arises when and only when we attend". Here, consciousness is access or reportable (Block, 2005, 2007; Lamme, 2003) subjective experience ("there is something that it is like to be …" (Nagel, 1974)). And attention is not consciousness, rather attention makes perceptual representations available to working memory (Prinz, 2011), which is a 'self-sealing' definition of attention (Taylor, 2013).

C. Attention is neither necessary nor sufficient for consciousness, i.e., they are two different processes that sometime occur simultaneous but can occur separately under specific conditions (Koch & Tsuchiya, 2007; Koivisto, Revonsuo & Salminen, 2005; Lamme, 2003; Watanabe et al., 2011).

D. Consciousness is necessary for attention based on *commonsense psychology*, but attention is not necessary for consciousness (Mole, 2008): "one is conscious of everything that one pays attention to, but one does not pay attention to all the things that one is conscious of" (p. 86). One could also argue that 'experienced self' is a part of the 'stream of consciousness', which provides the background for the central focus of attention (Stapp, 2005). Consciousness during dream may have degraded attention (Sarter & Bruno, 1999). (De Brigard, 2010) offers an argument against this hypothesis: "there isn't such a thing as the view of commonsense psychology about the relation between attention and consciousness. In fact, I argue that people's use of these terms—and, presumably, of their corresponding concepts—seems to be context-dependent."

E. Consciousness is not necessary for attention (Kentridge & Heywood, 2001).

One could argue that these relationships between attention and consciousness depend on the contexts, stimulus conditions, and how the terms are defined. Here, we argue for the hypothesis-(I) with qualification. Our definition of the terms 'consciousness' is given in Section 1.1 and 'attention' in Section 2.1.4. Within the limits of these definitions, both exogenous and endogenous attentions are *necessary* but not *sufficient* for *access* consciousness (Kentridge, Heywood & Weiskrantz, 2004). However, as reviewed in (van Boxtel, Tsuchiya & Koch, 2010a), top-down endogenous selective attention is not necessary for phenomenal consciousness because they can be dissociated (Koch & Tsuchiya, 2007; van Boxtel, Tsuchiya & Koch, 2010a). Moreover, in a simplified view, consciousness primarily linked to the ventral stream and attention to the dorsal stream (Milner & Goodale, 2008), although there are strong and reciprocal interactions among these streams (Baizer, Ungerleider & Desimone, 1991).[10] For example, subjects can be aware of the pop-out in visual search or the gist of a scene without or very little top-down selective attention; on the other hand, in aftereffect and priming, subjects can attend but are not aware of invisible objects (Koch & Tsuchiya, 2007).

The examples of attention is *necessary* for consciousness are as follows: (i) Attending one visual stimulus may lead to temporary blindness to other unattended stimuli (Perry & Hodges, 2003). (ii) There seems to be no (report of) consciousness in the absence of attention (Lamme, 2003). Thus, '*no attention* means *no (reportable) consciousness'* appears to be a valid statement.

This needs further elaboration and qualification to make it more precise. Attention could be top-down voluntary endogenous (such as fronto-parietal signal in dorsal stream) or bottom-up (Itti & Koch, 2001)[11] involuntary exogenous (such as thalamic reticular signal in selective attention?). As mentioned in Section 1.1, there are two types of consciousness (Block, 2005, 2007; Lamme, 2003):

(i) *Phenomenal* consciousness is not reportable, which presumably occurs during less than 50 msec stimulus presentation, where top-down endogenous attention is not necessary, but bottom-up exogenous attention is needed. For example, Sperling type experiments (Sperling, 1960, 1971, 1983; Sperling, Budiansky, Spivak, & Johnson, 1971) and pop-out visual search, attention is either not needed or minimally needed. In other words, *phenomenal* consciousness can occur without top-down endogenous attention; and top-down endogenous attention can occur without *phenomenal* consciousness; for example, subjects can attend to perceptually invisible objects.

(ii) *Access* consciousness is reportable, for which top-down endogenous and also exogenous attentions are necessary; it takes longer time than *phenomenal* consciousness.

Furthermore, there are consistent reports that exogenous (reflexive, automatic. Bottom-up) attention with peripheral cues interacts with conscious perception and hence it is necessary condition for consciousness. Most of the dissociations are for endogenous (top-down voluntary) attention with central cues. However, if phasic alerting or bottom-up activation is increased enough then endogenous attention modulates consciousness. This implies that endogenous attention is also necessary condition for consciousness under this context (Botta, Lupianez & Chica, 2014). Exogenous attention has fast (quick rise at 150 ms) and transient response, and involves temporoparietal cortex and ventral frontal cortex region. Whereas, endogenous attention has slow (asymptote at about 300 ms) and sustained (several seconds) response, and involves dorsal posterior parietal and frontal cortex region.[12]

Attention is not *sufficient* for consciousness because:

(i) There is evidence of (exogenous) attentional capture without (phenomenal) consciousness. For example: (a) As per (McCormick, 1997), "exogenous cue presented below a subjective threshold of awareness captured attention automatically and without awareness." (b) Distractors can capture

attention but subjects are not aware of them (Theeuwes, Kramer, Hahn, & Irwin, 1998).

(ii) Other conditions such as stimulus above threshold level, wakefulness, reentry, working memory and so on are also needed for consciousness as elaborated in Section 2.1.1-2.1.11.

2. Is *neural synchrony necessary* for consciousness?

Furthermore, (Engel et al., 1999) proposed that (40-Hz) neural synchrony may be necessary for consciousness. However, (Hardcastle, 1999) argued that it is still unclear. Perhaps, it is more important to arousal, attention, working memory, structuring representations, and perceptual integration (Engel & Singer, 2001), which are necessary (but not sufficient) conditions for consciousness as elaborated in Sections 2.1.2, 2.1.4, 2.1.6, and 2.1.7.

As per (Northoff, 2014), "Neural synchronization [30-40 Hz] describes the temporal coordination and integration of neural activity changes across different brain regions. [...This] allows for binding together the neural activities of different neurons (and regions) across time so that they form a "neural coalition" [binding by synchronization ...] Since "binding" and "binding by synchronization" may be central for consciousness, Crick and Koch consider the gamma oscillations [30-40 Hz] as their underlying neuronal mechanisms to be sufficient conditions and thus neural correlates of consciousness (Crick, 1994; Crick & Koch, 2003a, 2003b, 2005). [NCC with content (not level, not form) as sufficient conditions of consciousness ...] how is a stimulus to be processed neuronally in order for it to become conscious? The answers consistent in re-entrant thalamo-cortical processing, globalized neuronal processing, and neuronal synchronization. One may thus speak of "stimulus-bound accounts of consciousness" that consider the brain's extrinsic activity, its stimulus-induced (or task-related) activities sufficient condition of consciousness, and this as NCC."

3. Is intrinsic (resting-state/DMN, difference-based encoding strategy) activity necessary for consciousness?

As per (Northoff, 2014), "One recent proposal suggests that the resting-state activity's slow wave fluctuations in the frequency ranges between 0.001 Hz and 4 Hz [duration of ON: (1/0.001)/2=500 s, (¼ s)/2=0.125 s] are central in yielding consciousness (He et al. 2008; He and Raichle 2009; Raichle 2009). Due to the long time windows of their ongoing cycles, that is, phase durations, the slow wave fluctuations may be particularly suited for integrating different information together. Such information integration may then allow for the respective content to become associated with consciousness [p.xxii ...]

[1 Slow wave vs. neuronal synchronization]

The assumption of information integration is supported by the origin of the slow wave fluctuations: they are generated in cortical layers I and II, where the

afferences from many different cortical layers and regions converge onto each other. This predisposes the slow wave fluctuations to integrate the different information from various afferences [p.xxiii…see also Fingelkurts et al. 2010 for such association…why two different kinds of substances/entities will associate? …] Moreover, the "slow-wave" [SW] hypothesis [0.001-4 Hz) can be regarded as complementary to the one on neuronal synchronization [NS: 30-40 Hz]. […] This question [link between SW and NS] may be central not only for understanding how intrinsic and extrinsic neural activity, i.e., resting state and stimulus-induced activity, are linked, but may need to interact in order to associate consciousness with the processed stimuli [p.xxiii…]

[2: Metabolic and energy demand]

The high metabolic and energy demand of the brain may be used to maintain a continuously high level of resting-state activity [(Logothetis, 2009], which seems to be essential for consciousness, while metabolic and energetic reduction seems to go along with a decrease in the level of consciousness and ultimately the loss of consciousness (as in anesthesia [(Sulman, 2012)]. [p.xxiii …]

[3: Modulation of 40 Hz oscillation in NREM-sleep, REM-sleep/dream, and awake states]:

Llinas (1998, 2002) …Conducting MEG studies, he observed that 40 Hz oscillations are present in both awake and sleeping (REM sleep) states. Both states differed from each other, however, in that a sensory stimulus could reset (and thus modulate) the 40 Hz oscillations only in the awake state but not during REM sleep state (where we dream). [p.xxiv…] The same was observed in NREM sleep that showed a similar nonreactivity to external stimuli. In addition, NREM sleep also exhibited reduced amplitude in the 40 Hz oscillations themselves, which distinguished it from REM sleep. […] This underlines the central importance of the resting state and especially if its interaction with stimuli, that is, rest-stimulus interaction … in yielding consciousness.

[4. Stimulus-onset relative to the ongoing spontaneous phase fluctuations]

The level of the ongoing spontaneous activity in fronto-parietal cortex may thus set a threshold and thereby gate whether the stimulus can induce neural activity changes and thus consciousness [(Dehane and Changeux 2005, 2011)]. Taken together, these [four] hypotheses point out the central relevance of the brain's intrinsic activity, its resting-state activity … for consciousness. One may thus want to characterize them as "resting state-based accounts of consciousness," which claim that the brain's intrinsic activity is somehow related to consciousness. [p.xxiv…]

Tentatively defined, the concept of "**neurophenomenal hypotheses**" describes suggestions for how particular neuronal mechanisms of the brain are related to specific phenomenal features of consciousness. … like qualia, first person perspective, intentionality, unity, and so on… I postulate that the form

(or structure or organization) of the brain's intrinsic activity makes possible the association of consciousness and its subjective nature with the otherwise purely objective neural activity of the brain. … How does the brain's intrinsic activity "subjectivize" its own neural activity? This is a hard nut to crack [p.xxv] But we currently know neither how the resting state controls the stimulus-induced activity, now how the latter brings forth and generates consciousness and its various phenomenal features. … In order to understand consciousness, we may need to go back to the brain itself, the resting-state activity and its intrinsic features and how these predispose and modulate stimulus-induced activity. [p.xxvi…]

If the **resting-state [intrinsic] activity** level is too low, we lose consciousness and end up in a vegetative state or, even worse, in a coma (disorder of consciousness as it is called in the context of the brain…). [p.xxvii …] "The problem of mechanism, then, can be put as follows: How do objective, physical changes in the brain generate subjective feelings and experiences? What is the mechanism which is responsible for the production of the 'what it is lke' aspects of our mental lives?" (Tye 2007, 27). [p.xxviii …] The brain's intrinsic features are the features that the brain itself provides to its own neural processing of extrinsic stimuli. [p.xxix-xxx …]

[5 Spatiotemporal structure of resting-state [intrinsic, default-mode-NN] activity:]

The resting-state activity can be characterized by both spatial and temporal dimensions. This is reflected in functional connectivity and low-frequency fluctuations. Functional connectivity describes the linkage between the neural activities of different regions across the space of the brain (see also Fingelkurts et al 2004a and b, 2005…), whereas low-frequency fluctuations concern the fluctuations in neural activity across time. … The encoding of neural activity across different discrete points in physical time and space makes possible the constitution of a spatiotemporal structure. Such spatiotemporal structure must be considered "virtual" and rather than "real." This is because the spatiotemporal structure is based on the encoding of temporal and spatial differences between stimuli rather than on the stimuli themselves and their respective physical features. [p.xxx …] The spatiotemporal structure is based on the encoding of the statistical frequency distribution of the stimuli across different discrete points in physical time and space, that is, the natural statistics of the encoded stimuli. Accordingly, this resting state's spatiotemporal structure is statistically based rather than physically based, which I postulate to be possible on the basis of difference-based coding as distinguished from stimulus-based coding [p.xxxi …]

[6. Statistical-based spatiotemporal structure and difference-based coding for resting-state/intrinsic activity:]

The resting state's spatiotemporal structure is not physically based because it does not reflect or correspond one to one to the stimuli's physical features at their specific discrete points in physical time and space. Instead, the resting

state's spatiotemporal structure may rather correspond to the spatial and temporal differences in the occurrences of the different stimuli's physical features across their different discrete points in physical time and space. I consequently characterize the resting state's spatiotemporal structure as difference- and statistically based rather than stimulus- and physically based. … It is still physical but, and that is important, it is no longer based on the single stimuli and their respective physical features themselves. Instead, the spatiotemporal structure is based on the statistical frequency distribution of the stimuli across their physically discrete points in time and space [in analogy to frequency Fourier transform of space and time]… Instead of encoding each stimulus' single discrete point in physical time and space by itself into neural activity, i.e., stimulus-based coding, the resting state encodes the spatial and temporal differences between different stimuli and their different discrete points in physical time and space, e.g., difference-based coding. [p.xxxii-xxxiii …]

[7. Spatiotemporal structure and environment-brain unity:]

(Lakatos et al. 2008; Stefanics et al. 2009) demonstrated that the resting state's low-frequency fluctuations (like delta oscillations in the range between 1 Hz and 4 Hz) can shift their phase onsets in order to align themselves to the onsets especially of rhythmic stimuli in the environment … The brain's resting state may thus align itself to the environmental activity by encoding the latter's statistical frequency distribution into its neural activity; that is, the phase onsets … such neural alignment suggests the resting state's spatiotemporal structure to extend beyond the brain to the environment (including one's own body) in a statistically based and thus "virtual" way. … the brain links us continuously to the environment by encoding its stimuli's statistical frequency distribution into its resting-state activity. [p.xxviii …]

[8. Environment-brain unity and consciousness:]

Either the intrinsic activity no longer aligns itself properly to the extrinsic stimuli, as may be the case in schizophrenia …or, alternatively, the resting-state activity itself may be altered, no longer having (for instance) sufficient energy and metabolism to properly encode the stimuli from the environment; this may be the case in the vegetative state. … Finally, the resting state may have sufficient energy, but it may be imbalanced leading to an abnormal spatiotemporal structure, which then also affect its relationship to the environment as may be the case in depression…Accordingly, the resting-state activity's spatiotemporally and statistically based structure and its extension toward the environment may predispose and thus make possible the subsequent association of extrinsic stimuli and their purely neuronal stimulus-induced activity with the phenomenal features of consciousness. The resting-state activity's spatiotemporal structure and its neural alignment to the stimuli in the environment may be regarded as what I will call "neural predisposition of consciousness" (NPC), a necessary neural condition of the possibility of consciousness [p.xxxiv …]

[9. Difference-based coding as the brain's encoding strategy…]

"code"…the most basic algorithm the brain applies to format and organize its neural activity, that is, any kind of neural activity during both resting-state and stimulus-induced activity …encoding concerns the generation of neural activity during the exposure to intero- and exteroceptive stimuli…decoding refers to the deciphering of the contents that are associated with processed by the neural activity. … "Difference-based coding" refers to the brain's general encoding strategy and thus the formal measure or metric the brain applies to generate its own neural activity during both resting state and stimulus-induced activity. More specifically, "difference-based coding" [may be considered as intrinsic feature of the brain] describes that the neural activity in the brain encodes the spatial and temporal differences between the same and/or other stimuli across their different discrete points in physical time and space. What is encoded into neural activity is the statistical frequency distribution of stimuli… [p.xxxv …]

[10. Difference-based coding and rest-stimulus and stimulus-rest interaction, stimulus-based coding, sparse-coding:]

any stimulus … exteroceptive stimuli from environment, interoceptive stimuli from the body, and "neural stimuli" describing the brain's intrinsic activity changes… the interaction between resting-state ad stimulus-induced activity is bilateral… Both rest-stimulus and stimulus-rest interaction are possible only on the basis of encoding the extrinsic stimulus in relation to the brain's intrinsic activity; that is, in terms of their statistically based spatial and temporal differences, this presupposing difference-based rather than stimulus-based coding. … "sparse coding" [presupposes difference-based coding]…there is no one-to-one correspondence between stimuli and neurons/regions, but rather a many-to-one relationship with many stimuli leading to the activation of one neuron or region. [p.xxxvi …]

[11. Coding hypothesis of consciousness (CHC), EHC and DHC:]

By encoding its own neural activity during rest-rest, rest-stimulus, stimulus-rest interaction in a difference-based rather than stimulus-based way, the brain predisposed the constitution of the various phenomenal features of consciousness. […] The CHC claims that consciousness is predisposed and thus possible only on the basis of a particular coding strategy that [the brain applies to all stimuli and its own neural activity, i.e.,]is applied by the brain to encode and generate its own neural activity during both resting state and stimulus-induced activity [CHC has two subsets: EHC (encoding hypothesis of consciousness) and DHC (difference-based coding hypothesis of consciousness) …] EHC describes a statistically rather than physically based encoding strategy of the brain. … Accordingly, the EHC is a neuronal hypothesis about the way or strategy the brain must use in encoding and thus generating its own neural activity in order to make possible consciousness and its various phenomenal features. […] The EHC is related to the encoding of stimuli into neural activity

on the basis of their spatial and temporal differences across the different discrete points in physical time and space, thus mirroring their statistical frequency distribution; i.e., natural statistics. That must be considered a neural predisposition of consciousness (NPC)…The DHC claims that neural activity changes during the various kinds of neural interactions in the brain, i.e., rest-rest, rest-stimulus, and stimulus-rest, are also coded in terms of differences. If the spatial and temporal differences encoded into neural activity are large enough, the respective neural differences will be associated with a phenomenal state, e.g., consciousness. The degree of the encoded neural differences thus be regarded as neural correlate of consciousness (NCC) … By encoding the spatial and temporal differences between both neural and intero- and exteroceptive stimuli rather than the isolated stimuli themselves, the brain makes possible the constitution of a statistically and spatiotemporally based virtual structure and its virtual extension to the environment (and the body). [p.xxxviii …]

[12. Content, state/level, and code-based hypotheses of consciousness:]

Theories on extrinsic stimulus-induced or task-related activity like neuronal synchronization, re-entrant loops, global workspace, and information integration …focus on the constitution of contents in consciousness rather than on consciousness itself; that is, the phenomenal features that are associated with the respective contents. These neuroscientific theories are thus what one may describe as "content-based hypotheses" of consciousness […] Rather than focusing on how the contents of consciousness are processed and related to neural activity, the CHC is interested in the neural activity itself: how neural activity by itself is encoded and generated, and how that impacts the processing of any subsequent contents, as during rest-stimulus and rest-rest interaction. [From Fig I-4b…] Rather than focusing on how the contents of consciousness and their underlying neuronal mechanisms, the CHC aims to search for how the brain's encodes that very same neural activity that the other theories take for granted and as given when they associate it with contents of consciousness. This implies that the CHC focuses on the encoding of neural activity rather than the decoding of contents from neural activity. This CHC is thus a "code-based hypothesis" and an "encoding-based hypothesis" rather than a "content-based hypothesis" and a "decoding-based hypothesis." Rather than on the level or state of consciousness itself, the CHC traces the level or state of consciousness back to the degree to which its form, the spatiotemporal structure of the brain's intrinsic activity, is recruited or activate during changes in neural activity. The CHC is thus a "form-based hypothesis" rather than a "level-based hypothesis" of consciousness. Finally, rather than being based on cognitive (or some other) function, the CHC claims a direct relationship between the brain's neural code and the phenomenal features of consciousness. This entails a "brain-based hypothesis" rather than a "cognition-based hypothesis" of consciousness. The focus on cognitive and, more generally, psychological functions is replaced by a focus on the brain's

phenomenal functions. Finally, the constructionist approach to the mind in psychology is replaced by a neuro-constructionist approach to the brain's neural activity, where the processes of the encoding and structuring and organizing of the brain's neural activity, rather than the brain's psychological functions, are the main focus. [p.xxxix …] As such, the CHC is a hypothesis about the brain's encoding of neural activity and how that predisposes consciousness, rather than a theory how the brain's neural activity processes contents. [RV: In my view, your main contribution appears to be that you provide the missing emphasis on encoding in the content-based theories. p.*xl* …]

[13. Decoding-based vs. encoding-bases hypotheses:]

Rather than focusing on the neuronal mechanisms how the brain encodes and generates its own neural activity, they search for the kind of contents and the level or state of arousal that are processed by brain's neural activity once it is encoded and generated. [RV: Intrinsic activity is more basic than ARAS activity that presumably predisposes the brain to consciousness. …] Therefore, the CHC chooses a starting point that precedes the starting points of the current approaches. The brain must encode and generate its own neural activity before it can process and associate it with information about content and level of consciousness. The CHC can thus be considered more basic and fundamental than the current approaches. […] The focus … is on how the brain's encoding of its own neural activity predisposes the various empirical dimensions (content, level, form) and phenomenal features (point of view, qualia, first-person perspective, etc.) of consciousness [p.xl…]

[14. Level-based vs. form-based hypotheses:]

As discussed earlier, several neuroscientific theories suggest a central role for the brain's intrinsic activity and its metabolism and information integration in consciousness. Besides the contents of consciousness, this also concerns the level or state of consciousness as it is predominantly investigated in the disorders of consciousness like vegetative state, anesthesia, or NREM sleep …Since they target the neuronal mechanisms underlying the level or state of consciousness, these approaches may be described as "level-based hypotheses" of consciousness. … I now postulate that the degree of difference-based coding is directly proportional to the degree and thus the level or state of consciousness: the larger the spatial and temporal differences that are encoded into neural activity during, for instance, intero- or exteroceptive stimuli, the more likely it is that the purely neuronal stimulus-induced activity will be associated with a particular level or state of consciousness … Why, however, does the degree of difference-based coding entail the modulation of the level or state of consciousness? This is, I postulate, possible only on the basis of the brain's intrinsic activity, and the spatiotemporal structure of neural activity, its form (or structure or organization) as the third dimension of consciousness … The CHC can therefore be considered a "form-based hypothesis" of

consciousness, rather than a "level-based hypothesis." By encoding larger degree of spatial and temporal differences into neural activity, the spatiotemporal structure of the brain's intrinsic activity will be activated, transferred, and carried over to the extrinsic stimulus and its stimulus-induced activity. Such a neuronal transfer of the intrinsic activity's spatiotemporal structures to the extrinsic stimulus-induced activity makes possible the association of the extrinsic (purely physical) stimulus with consciousness and its phenomenal features [p.xli …]

[15. "Cognition-based hypotheses" of consciousness:]

The focus on content in content-based hypotheses of consciousness is often linked to certain cognitive processes; namely, how the content is processed and which kind of processes and functions are involved. Therefore, many neuroscientific and philosophical theories target higher-order cognitive functions like memory, attention, or others. … This has recently been complemented by a shift toward medium- or even lower-order functions like neurosensory, neuromotor, and neuroaffective functions … Despite the focus on different functions, the different hypotheses nevertheless share the assumption that the processing of stimuli in terms of some kind of function (whether sensory, motor, affective, cognitive, or social functions) and their underlying neuronal mechanisms can account for consciousness and its phenomenal features. …one may describe them as neurocognitive or "cognition-based hypotheses" of consciousness. The "cognition-based hypotheses" of consciousness postulate that consciousness and its phenomenal features are dependent on the cognitive processes and their underlying neuronal mechanisms. This means that the link between brain and consciousness is here rather indirect via some mediating cognitive processes, the neurocognitive functions. This however leaves open how consciousness can be linked in a more direct way to the brain. [p.xli-xlii …]

[16."Cognition vs. brain-based hypotheses" of consciousness:]

The CHC postulates that the brain's intrinsic features themselves predispose, and thus make necessary or unavoidable, the generation of consciousness. If the brain were characterized by different intrinsic features, a different encoding strategy, and/or an intrinsic activity without a spatiotemporal structure, consciousness would be altogether impossible. There would be no longer be any phenomenal features. … Such "neurophenomenal link" is direct rather than indirect and does therefore not require the mediation by any other function, including neurosensory, neuromotor, neuroaffective, or neurocognitive functions. [p.xlii]

[RV: However, working memory and attention are necessary condition of consciousness. The "cognition-based hypotheses" of consciousness entails neural activity → cognition (working memory, attention) → consciousness (selection of a specific experience during matching and selection mechanism).

On the other hand, the "brain-based hypotheses" of consciousness entails neural activity → consciousness (selection of a specific experience during matching and selection mechanism) → cognition (working memory, attention); this implies consciousness is necessary conditions of cognition. What do empirical evidences say?]

[17. "Priority of phenomenal function" vs. "priority of psychological function" and "Theory of brain activity" vs. "Theory of brain function": ...]

phenomenal functions precede psychological functions. … The concept of "priority of phenomenal function" describes that the phenomenal functions of the brain are more basic and fundamental than its psychological functions—the sensory, motor, affective, cognitive, and social functions. In short, phenomenology comes first, and psychological second. [p.xlii …] The concept of "priority of psychological function" describes that psychological functions are more basic and must there precede the phenomenal functions. […] The "priority of psychological function" considered consciousness and its phenomenal features to be dependent on the various psychological functions. When applied to the brain, the "priority of *psychological* function" presupposes a "theory of brain function" that investigates how the brain and its neural activity generate the various psychological functions … Rather than a "theory of brain function," the "priority of phenomenal function" presupposes a "theory of brain function" that investigates the neuronal mechanisms of how the brain encodes and thus generates its own neural activity … the generation of neural activity precedes the generation of function; code precedes content; and consciousness precedes cognition.

[18. "Faculty psychology" vs. "constructionist approach" to the mind:]

cognitive functions like working memory, attention, episodic memory, etc., have been suggested to be such different faculties. … The different psychological faculties were assumed to be related to separate and distinct regions and networks in the brain. [p.xliii …] That, however, turned out to be problematic, as the different functions or faculties show extensive overlapping in their respectively recruited regions and neural networks… This has led some researchers to psotualte … "constructionist approach"…replace the old "faculty psychology"…Rather than suggesting different faculties and the respective functions in the brain, this "constructionist approach" searches for some basic psychological processes, operations, and mechanism that "construct" the different psychological functions … like perceptions, memories, attention, and emotions (including their various subdivisions) are then no longer considered "ready-made and given" categories or entities. Instead, they are supposed to result from constructing processes that involve some basic psychological operations. Such construction of the various psychological functions presupposes some very basic ingredients, the sensation from the world, the sensation from the body, and the prior experiences. These basic ingredients are

combined in various ways, which leads to the construction of the different psychological functions. Prior knowledge and associations are used here to assign meaning to the different contents—this is called "situated conceptualization" [p.xliii-xliv …]

[19. "Constructionist approach" to the mind's psychological functions vs. " neuroconstructionist approach" to the brain's neural activity:]

The constructionist approach in psychology does not focus on the localization of psychological functions in the brain, "where," but rather on their "how," that reflects the underlying psychological processes and ingredients. […] I postulate that the brain constructs its own neural activity by applying a particular encoding strategy; namely, difference-based coding. […] The interoceptive stimuli from the body, the exteroceptive stimuli from the body, and the brain's intrinsic or spontaneous activity are the three basic ingredients on the basis of which the brain constructs and thus encodes its own neural activity in a difference- rather than stimulus-based way […] The concept of a "neuroconstructionist approach" suggests that neural activity … must be generated and thus constructed … brain itself has a strong impact on the construction of its own neural activity by applying its particular neural code and its intrinsic activity. [p.xliv …] focus…on the brain's construction of its own neural activity prior to any function. The constructionist approach to psychology assumes that consciousness is constructed by some basic psychological ingredients and their underlying neuronal mechanisms. … My neuroconstructionist approach suggests that consciousness and its phenomenal features directly results from the its phenomenal features directly result from the construction of the neural activity by the brain itself and its particular encoding strategy. [p.xlv …]

[20. The "code-based hypothesis" of consciousness (CHC):]

By determining a particular encoding and coding strategy, namely, difference-based encoding and coding strategy, namely, difference-based coding, the CHC targets the necessary neural conditions of possible consciousness including both contents and level or states. Thus amounts to …the neural predispositions of consciousness (NPC)…that make possible and thus predispose both level/state and contents of consciousness … the NPC target the ground or the floor upon which most of the current neuroscientific and philosophical theory of consciousness stand when focusing on the sufficient rather than necessary conditions of actual rather than possible consciousness. … neural-mechanisms allows brain to generate the various phenomenal feature of consciousness, the phenomenal heterogeneity, and their essentially subjective nature.[p.xlv …]

[21. Intrinsic features of consciousness:]

I propose that the brain's intrinsic features predispose exactly those features that define consciousness [C] as consciousness; that is, its intrinsic [empirical, conceptual, and phenomenal] features. [… **Empirical-contents of**

C:] Our consciousness is always about contents like events, persons, or objects in the environment. […] Neuroscientific research on consciousness has focused mainly on the contents of consciousness, the phenomenal contents (as distinguished from unconscious, i.e., nonphenomenal contents). Neuronally … phenomenal contents have been associated with contents have been associated with various neuronal mechanisms, including cyclic thalamo-cortical reentrant processing (Edelman, 2003, 2005), information integration (Tononi 2004; Tononi an dKoch 2008; Seth et al. 2006, 2011), global neuronal workspace (Baars 2005; Dehaene and Changeux 2011; Dehaene et al. 2006), pre-stimulus resting-state activity (see Kelinschmidt et al. 2012), and neuronal synchronization (Fried et al. 2001; Fries 2005; Varela et al. 2001; Koch 2004; Singer 1999; Llinas et al. 1998; Llina 2002; Buzsaki 2006; John 2005) [p.xlvii 47…]

[22. Fig. II-1a-c: Multidimensional view of consciousness:]

The figure illustrates the three dimensions of consciousness, content (x-axis), level (y-axis), and form (z-axis) and their involvement in different conditions ([fig]a), the interplay between extrinsic stimuli and intrinsic activity with the latter providing the form for the former ([fig]b), and the conceptual, neuronal, and pathological characterization of the three dimensions of consciousness ([fig]c).

(a) The figure illustrates the three dimensions of consciousness—form, content, and level—in a three-dimensional view. The different cylinders reflect the changes of the three dimensions in different conditions: awake state in healthy subjects (awake); REM sleep in healthy subjects (REM: reduced level); NREM sleep in healthy subjects (NREM: reduced level and content); regional brain lesions (Brain lesions: reduced content); minimally conscious state (MCS: reduced level and form); vegetative estate (VS: stronger reduced level [&] form); coma (Coma: extremely reduced content, form, and level); and psychiatric disorders link schizophrenia (and depression, not shown) (Schizophrenia: reduced form);

(b) The figure illustrates how the intrinsic activity and its spatiotemporal continuity provide the form for the extrinsic stimuli and their organization in consciousness. … upper part of ..shows the occurrence of different extrinsic stimuli … at different discrete points in the physical time and space. … *Middle part*: Independently of the extrinsic stimuli themselves, the intrinsic activity constitutes spatiotemporal continuity in its neural activity by linking different discrete points in time and space which by itself can be experienced in the gestalt of "inner time and space consciousness." The spatiotemporal continuity of the brain's intrinsic activity provides a grid, matrix, or template that is imposed upon and aligned to the extrinsic stimuli and their different discrete points in physical time and space. *Lower part* …shows how the intrinsic activity's spatiotemporal continuity (light grey) is imposed upon the extrinsic stimuli and their discrete points in physical time and space (black) and how

that yields contents (dark grey) in consciousness as part of the continuous flow of consciousness, the "stream or dynamic flow of consciousness."

(c) The figure shows the three dimensions of consciousness (left row), their role in consciousness (left middle row), their underlying neuronal mechanism (right middle row), and their alterations in corresponding disorders (right row).

The concept of *content* refers to the persons, objects and events in consciousness, the *phenomenal contents* as philosophers say. The contents are the main focus in the various neuroscientific suggestions for the neural correlates of consciousness (NCC). They imply stimulus-induced activity and are altered in patients with selective brain lesions.

The concept of *level* refers to the different degrees of arousal and awakeness and thus to the state of consciousness. The level or state of consciousness is related to global metabolism and energy supply which are found to be impaired and highly reduced in disorders of consciousness like vegetative state and coma. Moreover, neural activity in brain stem and midbrain is supposed to play an essential role in maintaining arousal. This reflects what is described as "enabling conditions" and "neural prerequisites" of consciousness.

The concept of form describes the spatiotemporal organization and structuring ("putting together") of the contents in consciousness. As such, form or organization and their underlying neuronal mechanism signify the neural predisposition of consciousness (NPC) which I propose to be related to the resting state and the spatiotemporal continuity of its neuronal activity. The resting state itself and thus the neural predisposition of consciousness themselves seem to be abnormal in psychiatric disorder like depression or schizophrenia.[p.xlviii 48…]

[23. Content-based and level-based NCC:]

The NCC describe the search for those minimally neuronal conditions that are jointly sufficient for any one being specifically conscious, that is, the distinct phenomenal content that we can experience … Hohwy (2009) … distinguishes between the minimally sufficient neural conditions of the contents of consciousness, that is, "content-based NCC," and the minimally sufficient neural conditions of the level or state of consciousness, that is, "level/state-based NCC" [p.*l-li* 50 …]

[24. From consciousness to unconsciousness:]

"Enabling conditions" or "neural prerequisites" are those neuronal mechanisms that are necessary to yield consciousness, while they remain unable to generate consciousness by themselves independent of some additional sufficient neural condition. […] The "enabling conditions" are necessary prerequisites, e.g., "neural prerequisites" for setting the sufficient neural conditions of consciousness, the neural correlate or neural substrate of consciousness, into motion. These in turn may then be followed by some neural events, the neural consequences of consciousness, that can occur only on the basis of the preceding neural substrate or neural correlate of consciousness […] For instance, neural activity in brainstem and midbrain is

often considered an enabling condition that needs to be met in order for thalamo-cortical connections to yield consciousness (see Koch 2004; …Damasio 2003). […] Whether such enabling conditions, or neural prerequisites, can be equated with the neural conditions underlying the level (rather than the content) of consciousness and thus the level-based NCC remains open at this point. [p.*li* 51…]

[25. From NCC to NPC (neural predisposition of consciousness:]

Rather than searching for the neural correlates and prerequisites of consciousness itself as distinguished from the unconscious, we are now targeting the neural conditions underlying those features of the unconscious itself that distinguishes it from the non-conscious[13] and therefore make possible its transformation into a conscious state. Since these neural conditions predispose the principal (or possible) transformation of the unconscious into a conscious state, one may want to speak of neural predispositions of consciousness (NPC) (See Northoff 2013). […] The concept of the neural predispositions of consciousness (NPC) refers to those neural conditions that make it necessary or unavoidable for the unconscious to be possibly transformed into consciousness (in the "right' circumstances like the presence of "right" neuronal mechanisms). In contrast to the unconscious, the non-conscious can well avoid of being transformed into either unconscious or consciousness.

[26. Form of consciousness—temporal continuity]

[Form of consciousness means:] The contents of consciousness have to be put together, ordered, structured, and ultimately organized in a certain way. Such "putting together" requires a certain form or organization … which is well manifest on the level of subjective experience and thus on the phenomenal level. … Experience of contents in consciousness presupposes a dynamic and continuous flow of time extending from the past over the present to the future all crystallized and condense in the present moment … James (1890) … "specious present" or "dynamic flow." … describes the organization of time as a continuum rather than as a discontinuum in consciousness … any content we experience in consciousness is integrated and embedded within this "dynamic flow" of time [James] [or "phenomenal time" (E. Husserl)] and becomes thereby part of the ongoing stream of consciousness [like boat in river]. .. One content goes and the next one comes, each at distinct and discrete point in physical time … we nevertheless experience a temporal continuum, a transition, between the different contents. [*p.lii-liii* 52-3…]

[27. Form of consciousness—spatial continuity]

Analogously to time, the contents in consciousness are not experienced at their discrete points in physical space. Onstead, they are embedded and integrated into a sptail continuum with multiple transitions between the different discrete points in physical space. As in the case of time, the contents are woven into a spatial grid or template that emphasizes continuity and

transition over discontinuity and segregation … The spatiotemporal continuity in the phenomenal realm of consciousness as distinguished from the spatiotemporal discontinuity in the realm of physical time and space. [*p.liii 53…*]

[28.Form of consciousness— third dimension: form]

The contents we subjectively experience in consciousness are always already interwoven in consciousness into an underlying spatiotemporal grid or template that provides some continuity between the different discrete points in physical time and space. … The level or state of consciousness describes the degree of arousal or awakeness that does not imply any reference to the spatiotemporal continuity itself. … I propose that the spatiotemporal continuity structures and organizes the content in consciousness by putting their discrete points in physical time and space into a spatial and temporal continuum … "form" of consciousness … [which] concerns the organization and structuring of the contents of consciousness in space and time and, more specifically, the integration of their discrete points in physical time and space into a spatial and temporal continuum. Such underlying spatiotemporal continuum provides the form of consciousness which … is constructed by the brain's intrinsic activity itself and its spatiotemporal structure. [p. *liii-liv 53-4 …*]

[29.Form of consciousness— Psychiatric disorders]

hypothesis of the brain's intrinsic activity as the designer of the spatiotemporal continuity of consciousness… schizophrenia or depression patients often experience abnormal time and space in their consciousness, that is, inner time and space consciousness… schizophrenic patients experience disruption and thus temporal discontinuity rather than a temporal continuum in their consciousness. This in turn affects their experience of the still somehow intact contents as manifest in delusions and hallucinations … patients with depression still experience a temporal continuum in their consciousness, which though is abnormally shifted toward the past at the expense of the future … Due to their preserved contents in their consciousness, the latter are abnormally associated with the past rather than present and future…the brain's intrinsic activity, its resting-state activity (Logothetis et al. 2009…), to be abnormal in psychiatric disorders like depression and schizophrenia…as "resting-state disorders"… we need to understand how the brain's intrinsic activity can yield the aforementioned spatiotemporal continuity as the template or grid for the contents of consciousness. That may be possible if, for instance, the intrinsic activity itself constitutes a particular spatial and temporal structure on the basis of its own neural activity. … toward understanding the kind of neuronal features that predispose the unconscious to be converted into a conscious state… (NPC) [*p.liv 54 …*]

[30.Form of consciousness—the intrinsic activity's spatiotemporal structure provides the form of consciousness:]

The intrinsic activity's spatiotemporal structure may provide the spatiotemporal grid or template within which the various contents of contents are integrated, structured and organized …[floor=level of C, furniture =contents of C, the way the furniture is set and organized by the designer in the living rooms, e.g., space and time = form or organization of consciousness…] Who … is the designer in the case of consciousness? We currently do not know. One suspect, as it will turn out, is the brain itself and more specifically its intrinsic activity by means of which the brain itself may act as the designer of its own living room in which the extrinsic stimuli and their associated contents are processed. More concretely, it is the brain itself and its intrinsic activity that may constitutes the spatiotemporal continuity as the form of consciousness. [*p.lv 55 …*]

[31.Neuroconceptual remark: Intrinsic features of the brain and consciousness: …]

Tye also emphasized that its [brain's] intrinsic features may predispose the brain to associate consciousness with its own neural activity in the same way the crystal's intrinsic features predispose the crystal to brittleness. […] intrinsic features of the brittle object, its irregular alignment of crystals, without which the effects of the extrinsic force cannot be understood. […] The exact features of the brain's intrinsic activity that predispose it to associate the extrinsic stimuli and their purely neuronal and objective stimulus-induced activity with consciousness and its phenomenal and subjective features remain unclear, however. […] What is the corresponding "irregular alignment of crystals" in the case of the brain's intrinsic activity? We currently do not know.

[32.Neuroconceptual remark: Actual vs. possible consciousness: …]

The NCC concerns the sufficient neural conditions of consciousness as it is manifest, that is, actual consciousness. While the necessary neural conditions of actual consciousness may be touched upon with the concepts of "enabling conditions" … and "neural prerequisite" (as distinguished from "neural substrate," "neural causes" and "neural consequences" … these may, for instance, concerns the involvement of subcortical structures like the brainstem that may remain insufficient by themselves to yield consciousness… Psychologically arousal or vigilance may be regarded an "enabling" and thus necessary nonsufficient condition of consciousness … Besides the necessary and sufficient (neural and psychological) conditions of actual or manifest consciousness, we may also need to distinguish those neural conditions that predispose consciousness. … we need to understand those featured of the unconscious itself that predispose its possible conversion into a conscious state. … the irregular alignment of the crystal does not by itself simply any shattering; which would require some external force, Therefore, the irregular alignment of the crystal concerns and disposes only "possible shattering"

rather than "actual shattering". Analogously, one may distinguish those conditions that predispose "*possible* consciousness" from those that are necessary and sufficient for "*actual* consciousness." [the necessary and sufficient conditions of actual consciousness are the NCC and the neural prerequisite of consciousness] I ..propose…that what I described as the neural predisposition of consciousness, the NPC, reflect the necessary neural conditions of possible consciousness and more specifically of those features of the unconscious that makes possible its principle transformation into consciousness. [p. *lvi-lvii* 56-7…]

[33.Neuroconceptual remark: from possible consciousness to neural predispositions of consciousness (NPC): …]

We are searching for the brain's analogue to the "irregular alignment of crystals" that predisposes the crystal's possible shattering of the brittle object. That is analogous to the predisposing role of the brain's intrinsic features for the possible association of stimuli and their purely neuronal stimulus-induced activity with consciousness and its phenomenal features. … actual consciousness [as in the NCC] … to be distinguished from the NPC that concerns the unconscious as distinct from the non-conscious. [*p.lvii/*57…]

[34.Neuroconceptual remark: from neural predispositions of consciousness (NPC) to the brain's intrinsic features: …]

The brain's intrinsic features are those features that the brain itself provides; i.e., its own [previous?] neural processing of extrinsic stimuli in the brain. They thus reflect the brain's active contribution, that is, its specific neuronal input, to its own neural processing of the intero- and exteroceptive inputs from body and environment. Two such active contributions of the brain and its intrinsic features were identified…: the spatiotemporal structure of the brain's intrinsic activity and the neural code the brain applies to encode and thus generate its neuronal activity. … I therefore postulated … that the resting state's spatiotemporal structure predisposes possible consciousness—the resting state's spatiotemporal structure can therefore be regarded as a neural predisposition of consciousness (NPC). While the brain's specific way of coding rest-stimulus and stimulus-rest interaction, more specifically the degree of difference-based coding, can be regarded as a sufficient neural condition of actual consciousness and thus as a neural correlate of consciousness (NCC) Accordingly, what we empirically described as different intrinsic features of the brain, its spatiotemporal structure and coding strategy, can now be aligned with two different conceptual characterizations, NPC and NCC, in the search for the neuronal mechanisms underlying consciousness. [*p. lviii-lix/*58-9…]

[35.Conceptual characterization of consciousness 1a: concept of unconsciousness—preconscious and dynamic unconscious:]

Unconscious states have been characterized by hidden characteristics if a person's self (fate, temperament, soul, character) that need to be inferred and cannot be accessed directly. Such hidden characteristics were distinguished

from those that were believed to be distinguished from those that were believed to be transparent, experienced directly, open to introspection, and thus accessible to consciousness (Uleman 2005; Northoff 2011, 2012a,b). …Searle ((Searle, 2004), 165-172) distinguishes among different types of unconsciousness… "preconscious," which refers to a state that is on the verge of becoming conscious though not yet conscious by itself; as such, it resembles what …Freud described as "system preconscious." Another concept of the unconscious concerns the "dynamic unconscious": "unconscious mental states function causally, even when unconscious" ((Searle, 2004), 167). Unlike in the case of the preconscious, the state is here not on the verge of becoming conscious but remains unconscious by itself. This corresponds to some degree to what Freud referred as "dynamic or repressed unconscious" where the contents are actively repressed in order to avoid their entrance into consciousness. Important, though, even the dynamically unconscious state has at least the potential or principal possibility of becoming conscious. … the "subliminal" is supposed to describe neural processing where the stimulus remains unconscious [Dehanene at ela,2006; Kouider and Dehanene 2009, D and Changeux 2011)]. In this case, the stimulus cannot enter consciousness because it is simply too weak to induce the "right" kind of neural processing, like the suggested "ignition" of neural activity in a large-scale frontal-parietal network …This is different in the case of the "preconscious," where the stimulus itself is strong enough while the fronto-parietal network is not ready because it is occupied with other stimuli (see … "global neuronal workspace theory" (GNW)… [p. *lix-lx*/59-60 …]

[36.Conceptual characterization of consciousness 1a: concept of unconsciousness—deep unconscious and non-conscious:]

"deep unconscious [mental?]." Here the unconscious mental state cannot only factually be brought into consciousness, as in the "dynamic unconscious," but even stronger it remains also principally impossible to do so. Following Searle, this is so because what is unconscious here is not "the sort of thing that can form the content of a conscious intentional state" (Searle 2004, 168). … Hence rules that guide the acquisition of language (or for instance our construction of perception in the retina and the visual cortex) are simply not the sort of things we can become conscious of at all. … The concept of the non-conscious refers to neurobiological phenomena that remain non-conscious [non-mental?] and cannot become instances of conscious at all. … "… the secretion of serotonin at the synaptic cleft is simply not a mental phenomenon. Serotonin is important for several kinds of mental phenomena…but there is no mental reality to the behavior of serotonin as such. Let us call these sorts of cases the "non-conscious." There are other examples of the non-conscious that are more problematic. So, for example, when I am totally unconscious, the medulla will still control my breathing. This is why I do not die when I am unconscious or in a sound sleep. But there is no mental reality to the events in the medulla that keep me breathing even when unconscious. I am not

unconsciously following the rule "Keep breathing"' rather, the medulla is just functioning in a nonmental fashion in the same way that the stomach functions in a nonmental fashion when I am digesting food. (Searle 2004, 168)" [*p.lx*/60…]

[37.Neuro of consciousness 1a: concept of principal non-conscious and principal conscious, right code:]

In short, wrong code and wrong format makes you non-conscious. The concept of the "principal non-consciousness" [Searle's deep unconscious and non-conscious] describes that a particular state can in principle not become conscious at all because its intrinsic features like its format or code (principally) prevent its association with consciousness. [*p.lxiii…*] Hence, the concept of the "principal consciousness" is based on the "right" kind of intrinsic features like the coding or formatting that therefore includes what we earlier described as *possible* and *actual* consciousness … As such, the concept of the "principal consciousness" provides a wide umbrella term for the various forms of unconscious that is, preconscious, dynamic unconscious, cognitive unconscious, as well as the different forms of consciousness like access consciousness, phenomenal consciousness and so on […] The concept of the principal consciousness describes that a particular state can in principle becomes conscious because its intrinsic features like its format or code make principally possible its association with consciousness and its phenomenal features. … [*p.lxiv*/64…]

I determine the conceptual range and scope of the neuronal hypothesis by postulating specific definition of consciousness as "principal consciousness." […] What, then, is my first neurophenomenal hypothesis? I hypothesize the brain's particular coding strategy, difference-based coding, to provide "right" kind of code and format that predisposes and makes possible the association of the brain's otherwise purely neuronal resting state and stimulus-induced activity with consciousness and its phenomenal features. Accordingly, I propose difference-based coding to provide the "right" code or format that allows it to distinguish the "principal consciousness" from the "principal non-consciousness." [p.*lxv* …]

[40.Neurophenomenal hypothesis of consciousness 1c: difference-based coding and biophysical-computational spectrum of principal consciousness:]

I suggest the degree of the spatial and temporal differences encoded via difference-based coding to account for the difference between consciousness and unconsciousness within the realm of the "principal consciousness." I hypothesize that the encoding of larger differences entails a higher probability of consciousness, while lower differences may favor unconsciousness … I consequently propose the difference between consciousness and unconsciousness (within the realm of the "principal consciousness") to be, not a principal one, that is, all-or-nothing, but rather a continuous or gradual, that is, more-or-less, distinction … Consciousness and unconsciousness may thus

be distinguished from each other by the degree of spatial and temporal differences that are encoded into neural activity on the basis of difference-based coding … [*p.lxvi …*]

[41.Neurophenomenal hypothesis of consciousness 1c: difference-based coding and hard problem of consciousness:]

Why is there consciousness at all rather than non-consciousness? And how is consciousness possible? This addresses the "hard problem" … I provide both a conceptual and an empirical answer. In contrast, I will leave open the metaphysical [ontology] problem of how to characterize the existence and reality of consciousness as distinguished from its conceptual definition and empirical mechanisms. I also leave open epistemological issues that concern the difference in our knowledge of brain and consciousness (which is often thematized in the explanatory gap argument in philosophy…). [Conceptual, empirical, and phenomenal approaches vs. epistemological and metaphysical/ontology approaches to address the hard problem] My conceptual answer consists in the distinction between the concepts of "principal consciousness" and the "principal unconsciousness." By subsuming both actual and possible consciousness under the umbrella of the "principal consciousness" and by distinguishing it from the "principal non-consciousness," we can provide a conceptual answer. Why is there consciousness rather than non-consciousness? Because our brain predisposes us to obtain "principal consciousness" rather than "principal non-consciousness." How about my empirical answer to the "hard problem"? I propose that the "right" kind of code or format, namely, difference-based coding, provides an empirical answer to the "hard problem." (as it occurs in the nature world (as it is relevant for neurophilosophy) while my hypothesis leaves open the answer to the "hard problem" in the logical world as it is dealt with in philosophy). By generating and encoding its own neural activity in terms of statistically based spatial and temporal differences, that is difference-based coding, the brain predisposes the association of its otherwise purely neuronal and objective resting state and stimulus-induced activity with consciousness, including its various phenomenal features and their essentially subjective nature. According, the question of why and how there is consciousness rather than non-consciousness can be answered empirically by referring to difference-based coding as the "right" code or format for predisposing and thus making possible consciousness. The direct reference to the "hard problem" distinguishes my coding hypothesis of consciousness (CHC) and its focus on difference-based coding from the many current neuroscientific suggestions for the NCC. As explicated above, they target the distinction between consciousness and unconscious rather than the one between consciousness/unconsciousness and non-consciousness. Therefore, those theories remain within the realm of the "principal consciousness" [PC] itself, rather than addressing the latter's [PC] distinction from the "principal non-consciousness." The current neuroscientific (and many philosophical) theories

of consciousness remain consequently unable to provide an empirical (and conceptual) answer to the "hard problem," i.e., why there is consciousness rather than non-consciousness. [*p.lxvii …*]

[42.Phenomenal characterization of consciousness 1: a. spatiotemporal continuity with inner time and space consciousness, b. qualia and unity:]

one may consequently want to speak of a spatiotemporal continuity as center feature of our experience of time and space, that is, "inner time and space consciousness" [p. *lxviii …*] **Figure II-4a and b Phenomenal features of consciousness and the brain.** … I propose that the brain itself applies a particular encoding strategy as its neural code, namely, difference-based coding, in order to generate neuronal activity within the range of its underlying biophysical-computational spectrum … This makes possible the constitution of a statistically based "virtual" spatiotemporal structure in the resting state … That in turn predisposes the constitution of consciousness, including the spatiotemporal organization of its phenomenal features … during the encounter and difference-based coding of extrinsic stimuli … The resting state's spatiotemporal structure can consequently be characterized as pre-phenomenal, as distinguished from both phenomenal and non-phenomenal states [p. *lxix …*] There is a distinction between the pages of the book as the figure and the table as the background in your experience. However, you nevertheless experience them as unity, as a homogeneous unified field of which both book and table are distinct aspects or parts.

[43.Phenomenal characterization of consciousness 1: c. Intentional organization:]

What is important here is not the physical presence but the presence of some kind of object, even, or person whether mentally or physically toward which the experience that is consciousness is directed and targeted. Such directedness towards or aboutness structures and organizes our consciousness which therefore can be characterized by intentionality, or *intentional organization* [*p.lxx…*]

[44. Part VIII Spatiotemporal Quality and consciousness]

I propose these spatiotemporal structures of the resting state to pre-dispose and this make possible the association of any subsequent changes in neural activity with consciousness, including the various phenomenal features. … The resting-state activity's spatiotemporal structures are proposed to predispose consciousness, thus being a necessary [though not sufficient neural] condition of its possibility [rather than actuality]. … As such they [… the resting-state activity's spatiotemporal structures] may be considered necessary though not sufficient [NCC] neural conditions of possible (rather than actual) consciousness. I have characterized them as neural predisposition of consciousness (NPC). […] My subsequent assumption is that rest-stimulus interaction that its neuronal mechanisms are central in providing the

transition from the resting state's prephenomenal structures to the full-blown phenomenal state of consciousness. Accordingly, we have to discuss the neuronal mechanisms underlying rest-stimulus interaction in order to become to get a grip on the NCC. [p.409…ch28:] the neuronal mechanisms underlying the level or degree of consciousness … closely related to the one of the sufficient neural conditions of consciousness, i.e., the NCC. … content, form, and level/degree of consciousness, are closely related to and thus interdependent on each other … converge in … qualia … loss of consciousness in vegetative state (VS) as …example [p410…ch29:] the "nonlinearity hypothesis of consciousness" … points out the central role of supposedly GABA-ergic-mediated non-linearity during rest-stimulus interaction for the initiation of consciousness. [p411…ch30:] Both nonlinearity and GABAergic-mediated neural inhibition are proposed to make possible the carryover and transfer of the resting state's prephenomenal structures to the stimulus and its associated stimulus–induced activity. … the carryover and transfer make possible the association of stimulus-induced activity with phenomenal features of qualia by changing and modulating the resting-state activity and its phenomenal features. […ch31] I consequently consider the subcortical regions to be sufficient neural conditions of consciousness, albeit in a spatially and temporally restricted way. [p411…ch32] I propose the same res-stimulus interaction like difference-based coding, nonlinearity, and GABAergic-mediated neural inhibition to hold in the insula too. Rest-intero interaction [interoceptive awareness of our own body) in this sense allows the carryover and transfer of the resting state's prephenomenal structures to the interoceptive stimulus, which in turn makes possible the interoceptive stimulus' association with qualia and thus consciousness. [p411…]

[45. Ch28: Resting-State Activity and Qualia…]

The degree of differences encoded into neural activity on the basis of difference-based coding may therefore be regarded as a sufficient condition and thus neural correlate of consciousness (NCC). [p413…] the resting-state activity's spatiotemporal structures are necessary but not sufficient neural conditions of possible consciousness and thus what I describe as neural predispositions of consciousness (NPC) … We now though want to move on, and reveal the neural mechanisms that underlie the manifestation of actual consciousness itself, that is, its actual realization. This is the question for the sufficient neural conditions of actual consciousness, the neural correlate of consciousness (NCC). [p414…]

the default-mode network (DMN) [:] Strong functional connectivity was observed in the neural network between anterior midline regions (perigenual anterior cingulate cortex, ventromedial prefrontal cortex, subgenual anterior cingulate cortex, and dorsomedial prefrontal cortex), posterior midline regions (posterior cingulate cortex [PCC], precuneus, and retrosplenial cortex), medial temporal (hippocampus and parahippocampus), and the bilateral tempoto-parietal junction. [PCC and precuneus have strongest functional connectivity

indices p415…] [The degree of DMN functional connectivity: normal, ~LIS (lock-in-syndrome), $\sim_{\text{effective(causal interaction)}}$, $>_{\text{functional(mere temporal correlation)}}$ MCS (minimally conscious state), >>VS (vegetative state), >coma] In addition to the DMN, the thalamus seems to have an essential role in resting-state functional connectivity [to anterior and posterior medial and lateral cortical regions p416…] neural activity seems to remain simple, local, and short in VS [p417…] decreased spatial and temporal spread of neural activity in VS. [p421…]

The decreased changes in neuronal measures like functional and effective connectivity and high-frequency oscillations may result from the resting state's reduced neuronal reactivity or propensity to change its activity level and pattern. … They can thus be considered a *sufficient* neural condition; that is, a neural correlate of actual consciousness. In contrast, they do not explain why there is such reduced propensity or reactivity and therefore cannot be considered a *necessary* non-sufficient neural condition, i.e., a neural predisposition of possible consciousness. [p423…]

The closer the resting state activity level to its maximal and minimal biophysical-computational limits, the higher the threshold for the induction of activity changes during subsequent rest-rest or rest-stimulus interaction […] This entails an inverted U-curve in the relationship between the resting state's position within its underlying biophysical-computational spectrum [bd=brain death,cs=comatose state,vs,mcs,hs=healthy subject: 0-max]] on the one hand and its propensity for the change on the either […]

[Metabolism:] If, for instance, metabolism and energy supply are decreased the resting state's threshold for possible change may rise and consequent make activity change more difficult and thus less likely. [p424…Biophysical] The reduced energy supply has two major consequences: (i) it leads to a reduction of activity levels in the resting state itself; and by that means, (ii) it elevates the resting state's threshold for any subsequent activity change. [The degree (đ) of manifestation of mental aspect of a state of an entity varies with level, content, and form of consciousness and context. For example, the đ varies from close to 1 at wakefulness to <1 in deep sleep to <<1 at vegetative state to <<<1 at coma to close to zero at brain death to zero (latent) at death. The đ is proportional to metabolism and energy supply; or proportional to Tononi's integrated information Φ; or approximately proportional to $\text{degree}_{\text{content}} * \text{degree}_{\text{level}} * \text{degree}_{\text{form}}$) (Northoff, 2014).p.*xlviii*.Fig.*IIa*):

$đ \sim [100(\text{degree}_{\text{content}} * \text{degree}_{\text{level}} * \text{degree}_{\text{form}})/đ_{hs}]$

$0 = đ_{dead} < đ_{bd} < đ_{cs} << đ_{NREMsleep} < đ_{vs} < đ_{dream} < đ_{mcs} < đ_{hs} \leq 1$

$0 = đ_{dead} < đ_{bd} < (đ_{cs} = 0.3\%) << đ_{NREMsleep} = 4\% < đ_{sch} = 7\% << đ_{vs} = 17\% < đ_{REM/dream} = 25\% < đ_{mcs} = 38\% < đ_{brainLesion} = 43\% << đ_{hs\_awake} = 100\%]$

Table of level, content, and form

mm in Fig from origin of (Northoff, 2014).p.*xlviii*.Fig.*IIa*	Level	content	form	Level * content * form	đ (%)
Coma	5	5	5	125	0.3

NREM	10	7.5	25	1875	4
Schizophrenia	38	42	2	3192	7
VS	16	42	12	8064	17
REM/dream	10.5	42	27	11907	25
MCS	26	42	17	18564	38
Brain lesion	36	23	25	20700	43
Awake	36	42	32	48384	100

This leads me to postulate the following neurometabolic hypothesis: the lower the degree of global metabolism, the less energy the energy the resting-state activity receives, the lower its activity level, and the higher its threshold for subsequent activity changes. [p427…]

How does all that relate to the data in VS described above? I showed that VS can be characterized by reduced global metabolism and energy supply. If my hypothesis is correct, reduced metabolism and energy supply should lead to a reduced activity level in the resting state itself, for instance, in its functional connectivity and the low-frequency fluctuations. […]

This leads me to suggest the following hypothesis about the level of consciousness. I postulate that the highest level or state of consciousness is possible when the resting-state activity operates in the middle of rather than toward the minimal and maximal ends of the brain's underlying biophysical-computational spectrum. This leads me to what I describe as the "biophysical spectrum hypothesis of consciousness." [p427…] I thus propose decreased degrees of difference-based coding and increased degrees of stimulus-based coding in VS. [p430…RV: Does this imply that brain used both types of coding? Yes. NCC (rest-stimulus interaction) is sufficient and NPC (neural predisposition of consciousness: resting-state activity & rest-rest interaction) as necessary condition of level-based C] One may consider the degree of spatial and temporal differences that are (or can be) encoded into neural activity via difference-based coding a sufficient neural condition of consciousness. If sufficiently large spatial and temporal differences are encoded during rest-rest or rest-stimulus interaction, then newly resulting neural activity level is associated with a high level or state of consciousness. … I propose the resting-state activity's degree of difference-based coding and the subsequent encoding of sufficiently large spatial and temporal differences into neural activity during rest-rest or rest-stimulus interaction to be a sufficient neural condition of the level or state of consciousness and thus a level-based NCC.[p435…] the degree of qualia [SEs] to be directly dependent upon the degree of spatial and temporal differences that are encoded into neural activity. If the degrees of spatial and temporal differences are themselves dependent upon the statistical frequency distributions of either the stimuli or the resting-state activity that their natural and neuronal statistics, one would characterize qualia as a both spatiotemporally and statistically based. Qualia as spatiotemporally and

statistically based are then ultimately based and predisposed by the brain's particular encoding strategy, difference-based coding as statistically based encoding strategy. [p436…] Phenomenally, the resting state's ongoing party is manifested in your thoughts' wandering … "mind wandering" [p437…]

[46. Ch29: Rest-Stimulus interaction and Qualia…]

I propose that such neuronal-phenomenal dissociation between stimulus-induced activity and consciousness can ultimately be traced back to the purely neuronal dissociation between resting-state activity and stimulus-induced activity. In order to understand the loss of phenomenal state, i.e., consciousness, in VS, we therefore need to go back to the neuronal mechanism underlying the stimuli's interaction with the resting-state activity; that is, rest-stimulus interaction … [which] can be characterized as nonlinear and nonadditive , implying interactive and integrative processing between resting-state activity and stimulus. I now propose the degree of nonlinearity during rest-stimulus interaction to be directly related to the degree of consciousness. This is what I describe as the "nonlinearity hypothesis of consciousness." How is such nonlinearity mediated on the neuronal level? GABA-ergic mediated neural inhibition seems to be central here. [p439…] [RV: VS data rejects that phenomenal consciousness is based on cognition functions (cognition-based C) and maintains that it is based on phenomenal functions of the brain such as rest-rest and rest-stimulus interactions. P440…]

[(Northoff, 2014)'s "neuronal-phenomenal dissociation"(p.446-452) for vegetative subjects (VS) does not prove separability in my reading. This is because functional aspect of consciousness (cognition, such as imagining, mental navigation, self-referencing in VS) still have neural basis intact. The dissociation may be simply between resting state activity and stimulus-induced activity. This does not reject inseparability hypothesis. Is this correct?] [14]

[47. Ch30. Neuronal Transfer and Qualia

Consciousness comes in different dimensions, including content, level, and form. The *contents* concern the objects, persons, or events of which we are conscious. The *level* or *state* of consciousness refers to the degree of arousal, while the *form* of consciousness describes the spatiotemporal organization of the contents in subjective experience … What are the neural predispositions [necessary conditions] and neural correlates [sufficient conditions] of the contents, level, and form of consciousness? … The low-frequency fluctuations and their phase-power and phase-phase coupling to the high-frequency fluctuations can therefore be considered the necessary neural conditions of possible contents in consciousness and thus as their neural predispositions [p461-2…]

Table 30-1 Neural predispositions [necessary conditions of contents, level, and form of consciousness] and correlates [sufficient conditions of contents, level, and form of consciousness] of the three dimensions of consciousness

	Neural predisposition	Neural correlate
Content	*Phase duration of low* frequency fluctuations and their *phase-power/phase-phase coupling* with *high* frequency fluctuations in the resting state	*Gamma* frequency fluctuations and their modulation of "*binding*" and "*binding-by-synchronization*" during rest-stimulus interaction
Level	Degree of *spatial and temporal differences* that can possibility be encoded into neural activity as threshold by the resting state	Degree of *spatial and temporal differences* that are *actually* encoded into neural activity during rest-stimulus interaction
Form	Different layers of the intrinsic activity's *spatiotemporal organization and structure* in the resting state	Degree of transfer of the intrinsic activity's *spatiotemporal organization* and structure to the *extrinsic* stimulus during res-stimulus interaction

The "biophysical-computational spectrum hypothesis of consciousness" describes that the position of the brain's actual operation relative to its underlying biophysical-computational spectrum disposes its possible degree of difference-based coding; the degree of difference-based coding in turn predicts the possible degree of the level or state of consciousness that can be associated with the brain's neural activity [….] GABA-ergic-mediated neural inhibition increases the degree of spatial and temporal differences that can possibly be encoded into neural activity, which makes it likelier that the changes in neural activity will become associated with consciousness. […] Therefore, I consider both the "biophysical-computational spectrum hypothesis of consciousness" and the "nonlinearity hypothesis of consciousness" to describe the necessary neural conditions of the possible level or state of consciousness. Accordingly, both hypotheses concern what I refer to as "neural predispositions of the level of consciousness" (NPC) [as necessary conditions of consciousness]. [p.463…]

The "difference-based coding hypothesis of consciousness" postulates that the degree of spatial and temporal difference that are (or can be) encoded into neural activity determines the actual degree of the level or state of consciousness. The degree of the actually encoded spatial and temporal differences can thus be regarded as a sufficient neural condition of the level or state of consciousness and thus as a neural correlate of the level of consciousness (NCC). […] The concept of the 'form' of consciousness refers to how the contents in consciousness are structured and organized in spatial and temporal terms [p464…] Therefore, I postulate that the neuronal transfer of the intrinsic activity's spatiotemporal organization and structure to the extrinsic stimulus during rest-stimulus interaction is a sufficient neural condition, and

thus neural correlates, of the form of consciousness. […] I postulate that what I described empirically as the form of consciousness is manifested on the phenomenal level of consciousness in the gestalt of qualia. […] There is spatiotemporal continuity and unity to qualia in our subjective experience. Moreover, qualia are self-perspectival and intentional. [p465…] I postulate that this "something additional" [stimulus gets during rest-stimulus interaction] consists of the different layers of the intrinsic activity's spatiotemporal structures. The linkage and integration to the spatiotemporal structures of the brain's intrinsic activity strongly affect and modulate the stimulus itself. […] The stimulus is now integrated and embedded into the spatiotemporal continuity, the spatiotemporal unity, and the self-specific and preintentional organization of the resting state's neural activity. This means that the stimulus becomes spatially and temporally structured and organized. [p466…] I thus suggest that the "statistically based homogeneity" on the neuronal level resurfaces … on the phenomenal level in "non-structural homogeneity." [p.470…] I therefore characterize qualia s spatiotemporal, and even more strongly state that they are intrinsically spatiotemporal by default. … There would be no qualia in the absence of spatiotemporal structure of the brain's intrinsic resting-state activity and its neuronal transfer to extrinsic stimulus during rest-stimulus interaction. … In contrast, it leaves open the possibility of non-spatiotemporal qualia I a purely logical world. [p473…]

[**Spatiotemporal transparency as a neurophenomenal bridge concept**:] In other words, my coding-based account of phenomenal transparency makes the introduction of a concept that mediates between the neuronally encoded spatial and temporal differences on one hand, and the phenomenal concept of transparency in the context of qualia on the other. The novel concept of spatiotemporal transparency does not belong to either the phenomenal or neuronal level and can therefore be regarded as a "neurophenomenal bridge concept." In the same way one cannot get from one side of the river to the other without a bridge, we will not be able to bridge the gap between the neuronally encoded spatial and temporal differences on one hand and the phenomenal level of transparency on the other. For that we heed a bridge, and that bridge is provided by the concept of spatiotemporal transparency. [p477…]

[Necessary and sufficient conditions: NPC and NCC] The concept of biophysically based subjectivity describes the spatiotemporal stance of humans within the physical world on the basis of our brain's species-specific biophysical equipment. I propose that such biologically based subjectivity and its underlying neural mechanisms to provide a necessary, non-sufficient biophysical (and neural) condition of possible consciousness, e.g., [the resting-state activity's spatiotemporal structure ac be regards as] neural predisposition of consciousness (NPC). As such, biophysically based subjectivity must be distinguished from the concept of "phenomenally based subjectivity" that refers to the subjective nature of consciousness, that is, the manifestation of subjectivity in the phenomenal states … "Phenomenally based subjectivity" is a phenomenal concept that can be considered a sufficient condition and thus a

phenomenal correlate of consciousness; its underlying neuronal mechanism may thus signify the sufficient neural condition of actual consciousness, i.e., [the neuronal transfer of the intrinsic activity's spatiotemporal organization and structure to the extrinsic stimulus during rest-stimulus interaction is] the neural correlate of consciousness (NCC). [p478…]

[Resting state approach to qualia vs. stimulus-based approach: explanatory gap:] Unlike the "*resting state* approach to qualia," a "stimulus-based approach to qualia" considers the stimulus-induced activity by itself to be both necessary and sufficient neural condition of qualia. Qualia are exclusively associated with the extrinsic stimulus and its stimulus-induced activity, while the brain's intrinsic resting-state activity, let alone its spatiotemporal structure, are completely neglected. This seems to be the case in most current neuroscientific accounts of qualia (see for instance, Orpwood, 1994, 2007, 2010; Feinberg 2009, 2011; Tononi 2004, 2008) … thus "stimulus-based approaches to qualia" in general, can provide neuronal hypotheses about qualia. However, they leave unexplained why and how these neuronal mechanisms are associated with qualia rather than non-qualia. This means that these approaches fail to show the necessity of qualia: why stimuli and their stimulus-induced activity are necessarily and unavoidably associated with qualia by default. In other words, there remains a gap between the neuronal mechanisms of the brain on the one hand and the phenomenal features of qualia on the other in "stimulus-based approaches to qualia," an "explanatory gap" as it is called in current philosophy of mind. [p481…] I now postulate that such "spatiotemporalization" of extrinsic stimuli by their encoding into neural activity during rest-stimulus interaction makes necessary and unavoidable their association with the phenomenal features of qualia [not of qualia but the features of stimulus-related neural signals]. I demonstrated this for different phenomenal and qualitative features of qualia: "non-structural homogeneity," "transparency," and "ipseity [selfhood; individual identity]." The statistically based "spatiotemporalization" of stimuli can thus not avoid becoming manifest or "resurfacing" (as I said earlier) in the "non-structural homogeneity," the "transparency," and the "ipseity" of qualia. [p.482…]

[How the resting state-based approach to qualia can avoid the explanatory gap:] I postulate that the statistically rather than physically based encoding strategy of the brain's neural activity makes necessary or unavoidable the association of the resulting stimulus-induced activity with the phenomenal features of qualia. This means that my statistically and spatiotemporally based account of qualia can avoid the problem of the "explanatory gap" altogether by choosing the "right" starting point. Due to the choice of the "right" starting points, the brain's encoding strategy and the spatiotemporal structure of its intrinsic activity, the question of the "explanatory gap" cannot even be raised anymore. This is exactly what I suggested in my "resting state-based approach to qualia," which therefore is not prone to the problem of the "explanatory gap." [However, the explanatory gap remains in the *resting state* approach to qualia as well. This is because rest-stimulus interaction elaborates only 3pp-physical

aspect. The statistically-based "encoding strategy of the brain's neural activity makes necessary or unavoidable the association of the resulting stimulus-induced activity" with the features of stimulus-related neural signals in feed forward pathway, not that with "the phenomenal features of qualia". The subjective experiences *somehow* arise when matching between spatiotemporal structures of intrinsic and extrinsic activities is perfect in relational ontology. For example, the subjective experience redness of ripe-tomato exists (if it exists) in the "spatiotemporal nestedness or relation" between the ripe tomato (world) and brain. In other words, once the match is perfect, the experience redness just pops up. Voila! The rabbit is magically out of the relationship hat! This seems as a brute-fact (that's just the way it is!) of relational ontology.] [p.482-3…]

[48. Ch31 Subcortical regions and qualia]

[thalamus, subcortical midline regions, lower brain-stem regions: cranial nerves nuclei, locus coerulus, raphe nuc, ventral tegmental area (VTA), nuc basalis Mrynert, superior and inferior colliculus, basal ganglia, tectum, periaqueductral gray (PAG), dorsomedial thalamus (DMT), p.487-8…] Qualia in the context of the subcortical regions were characterized as affective; I therefore spoke of *affective qualia*. [As per (Panksepp, 2007, 2011) primary/anoetic consciousness; (anoetic: a state of mind consisting of pure sensation or emotion without cognitive content); affects and feelings; we subjectively experience what Panksepp describes as "raw experience; ;raw emotional feelings that do not involve any explicit knowledge about the world or about the self, pre-reflective; James "free water of consciousness as the free water that flows around; affective signifies most basic emotional feelings; concerns mainly automatic and unexperienced processing in the brain's neural activity that is not yet associated with a particular object or content;] …

The concept of *secondary consciousness* refers to cognitive consciousness and related cognitive functions, including learning, attention, memory, etc. As such, secondary consciousness involves knowledge about the world and can therefore be described as noetic [of or relating to the mind, esp to its rational and intellectual faculties] consciousness.

Finally, *tertiary consciousness* describes thoughts about one's own thoughts and feelings and may therefore be characterized by knowledge about one's own self *as* self; this is described as *reflective* and *autonoetic consciousness.* […]

The term "existential feeling" is a phenomenal concept that describes the experience and feeling of one's own existence, one's own body and one's relationship to and standing in the world. [p503-4…: is this Nagel's what it is like?…] I now postulate that the experience of existential feelings (or the "raw experiences," as Panksepp would say) reflects this "invisible spatiotemporal grid or template spanning between brain and environment." […] The point of view may be considered the very basis of our existence, or better, our existence by itself, independent of any particular content. […] I now postulate that this basic self comes closed to what I described as the "point of view," itself which is

not yet superseded by contents as they are predominantly mediated by cortical regions. [...] Panksepp postulates that affective qualia "lie" directly at the interface between neuronal and phenomenal states, that is, where both are transformed into each other. [...] By linking affect and qualia, the feeling signifying the former—that is, affect—is transferred and carried over to the latter, the qualia. ... However, the reverse also holds. Qualia are transferred to the affect and emotions. ... Whitehead ... speaks of a "basic affective tone" tht underlies all our consciousness: "the basis of experience is emotional." [p505...] A defining and thus intrinsic feature of qualia is subjectivity and its determination by a point of view ...Qualia are the subjective and qualitative features of our experience. ... The subjectivity and hence qualia are now first and foremost manifested in affect and emotions. But they are also manifested in our perceptions, in our cognitions, and in all of our behavior. And there may also be many instances where qualia do not go along with affect, as for instance in perceptual qualia. [p506...] I consider the brain's neurophenomenal functions to be more basic and fundamental than its neuroaffective, neurocognitive, neurosensory, and neuromotor functions. [qualia can have cognitive functions and affective functions; both can have phenomenal qualitative feeling as is often signified by "what it is like." p507...]

[49. Ch32 Body and qualia]

[Exteroceptive stimulus = external stimulus, relating to, being, or activated by stimuli received by an organism from outside; external-stimulus-induced activity. Interoceptive=body: of, relating to, or being stimuli arising within the body and especially in the viscera. p509...] I distinguished an "interoceptive baseline" in the inner ring's regions (i.e., the regions centered around ventricles) from the "exteroceptive baseline" in the outer ring's regions (i.e., the regions at the outer surface of the brain). ... bilateral intero-extero interaction turned out to be a trilateral one, rest-intero-extero. ... Due to the interoceptive input from our continuously present body, any exteroceptive stimulus will encounter not only brain's resting-state activity but also interoceptive stimuli from one's own body. [p510...] These cognitive functions are still often deemed to be central for consciousness to occur. Yes, they are. Certainty so. But they may not be as central for phenomenal consciousness but rather for the awareness or consciousness of phenomenal consciousness, that is, access or reflective consciousness" [p.511...] I consider the encoding of spatial and temporal differences into neural activity as necessary conditions of the possible association of stimulus-induced activity with consciousness, independently of where in the brain the differences are encoded and generated. [p520....]

xxxx

[50. Epilogue: Keyholes in the brain's door to consciousness]

Consciousness turns life into an experience, the experience of life. ... Long ago philosophers thought the key was found in a mind: a mind different from

both body and brain, a mind purely mental. Now we know better. It is rather the brain and its neuronal states that are the door to consciousness … from the loss of consciousness in … vegetative state … we do not know the neuronal mechanisms that make consciousness [C] possible and thus predispose it. Nor do we know where the keyhole in the door, the brain, can be found. […]

Various neuronal mechanisms [keys to C] have been proposed as being reflected in the … NCC: neural synchronization, re-entrant circuits, information integration, global workspace, global metabolism, slow cortical potentials, cognitive functions like attention and working memory, affective functions as in emotions, and sensorimotor functions pertaining to the body. … none [are] … keys [brain's extrinsic features such as neural mechanisms…p532]… the brain's keyhole must consist of some intrinsic feature that defines the brain *as* brain. [p.532-3…] I identified two such intrinsic features of the brain in volume I, its resting-state activity and its encoding strategy. [p.533…]

"rest-rest interaction." I thought such rest-rest interaction to constitute a statistically-based, virtual spatiotemporal structure: an organization of its neuronal activities in spatial and temporal terms that ranges across the different regions and their different frequency fluctuations. … I demonstrated how the resting-state activity constitutes spatiotemporal continuity on neuronal activity across different discrete points in physical time and space …

Finally, self-perspectival organization and intentionality in consciousness seem to be predetermined by the testing state's self-specific and preintentional organization of its neural activity. Taken together, these various yet "dormant" prephenomenal features reflect different ways that the brain's resting state structures and organizes its own neuronal activity in spatiotemporal terms during both resting state and stimulus-induced activity. [p.533…]

Applying a particular [difference-based] encoding strategy to generate its own neural activity makes it possible for the brain to actively impact, i.e., to structure and organize the changes in its own neural activity as triggered either by the extrinsic stimulus or by the dynamic changes in the resting state itself. The impact of the extrinsic stimuli is especially thereby contained, so that they "can no longer do whatever they want" in the brain and its intrinsic activity. Since it constraints the processing of extrinsic stimuli, the brain's encoding strategy is of high neuronal relevance for the brain itself.

If extrinsic stimulus induces the "right" kind of changes, namely, non-linear changes in the hitherto "dormant" intrinsic activity of the brain, the latter "wakes up," "opens up," and thereby transfers and carries its prephenomenal spatiotemporal structures over to the extrinsic stimulus and its associated stimulus-induced activity. This makes possible the association of extrinsic stimulus and its otherwise purely neuronal stimulus-based activity with consciousness and its phenomenal features [p.533…]

What, then, is consciousness? The answer is very simple. Taken in an empirical perspective, consciousness ultimately comes down to a statistically-based matching or fitting process between the spatiotemporal features of the

extrinsic stimulus and those of the brain's intrinsic activity: If both fit and match well, the extrinsic stimulus and its otherwise purely neuronal stimulus-induced activity are associated with consciousness, its various phenomenal features and their essentially subjective nature. If, in contrast, extrinsic stimulus and the brain's intrinsic activity do not fit well, the stimulus will be processed at best in an unconscious, or at worse in a non-conscious, mode (or not at all) and thus not be associated at all with consciousness. [p.533…] The relation between the brain's intrinsic activity and the extrinsic may very much resemble the relationship between keyhole and key: both must fit and match with each other to associate the extrinsic stimulus with consciousness, than thus to open the door, that is, the brain, to consciousness. [p.533…] Because the brain's keyhole, its intrinsic features, can tell us what the key (i.e., the neuronal mechanisms related to the extrinsic stimuli) must look like in order to open the brain's door to consciousness.

Are the brain's resting-state activity and its encoding strategy really the keyholes of the brain, the intrinsic features that define the brain *as* brain? We currently do not know. Even worse, we also do not know how the extrinsic stimuli from body and environment, the keys, must interact with brain's keyhole, its intrinsic activity, in order to open the brain's door to consciousness. All I can do at this point in time is to develop empirically, phenomenally, and conceptual plausible hypotheses about the relationship between neuronal and phenomenal features. This has resulted what I describe as "neurophenomenal hypotheses." [p.533…]

In the case of good fit or match, the Brian's door unlocked. The result is that which, we, as outside observers, call *consciousness*. In case of a bad fit or match, the brain's door remains closed to consciousness. [p.534]"

Vimal: [1] We may need to add spectral feature in addition to spatiotemporal features for matching between the features of the extrinsic stimulus and those of the brain's intrinsic activity. In other words, the statistically-based matching or fitting process should be between the spatiotemporal-spectral features of the extrinsic stimulus and those of the brain's intrinsic activity.

[2] As per (Northoff, 2014), "The relation between the brain's intrinsic activity and the extrinsic may very much resemble the relationship between keyhole and key: both must fit and match with each other to associate the extrinsic stimulus with consciousness, than thus to open the door, that is, the brain, to consciousness. [Vol.2.p.533…]". This seems to imply that consciousness pre-exists outside of the door; when the door is opened, consciousness can enter through the door. Consciousness includes subjective experiences. Do subjective experiences *actually* pre-exist in Nature outside the door?

4. Is proto-self necessary for consciousness?

[Phenomenal characterization of consciousness 1: c. the self, d. self-perspectival organization:] As per (Northoff, 2014), "Consciousness is always already tied to the perspective of a particular self like your specific self that provides the particular perspectival point, from which you experience the reading of this book… The individual first-person perspective. Panksepp [(1998a,b; Northoff and Panksepp 2008)]… and Damasio [2010] … propose what they describe as "protoself," which cannot yet be experienced as such (thus remaining what I will describe later as prephenomenal … This "protoself" is supposed to be empirically associated with neural activity in subcortical regions (brainstem, midbrain) and, important in our context, considered necessary for the occurrence of consciousness. […] The "protoself" is often supposed to provide some kind of point of view or perspective from which experiences can be made. One can thus characterize the "protoself" as "perspectival point." You can experience the world only from the point of view of your own self…In contrast, you remain unable to take the point of view of another person's self, let alone the one of another species, for instance, the bat when experiencing and perceiving this book. You experience is thus centered around your point and the perspective associated with it. Such organization of consciousness as centered around your point of view and perspective has been described by what philosophers call "*self-perspectival organization*" … Besides these phenomenal feature, others like subjectivity and first-person perspective have been described (can Gulick 2004). Consciousness implies a point of view and is therefore essentially subjective and must as [*p.lxx*] such be distinguished from the brain, which has no point of view and is therefore objective. Thereby the objective character of the brain and its neuronal states is often linked to observation in third-person perspective. In contrast, the subjective character of consciousness is associated with the first-person perspective since it characterizes our experience, that is consciousness. This makes it particularly difficult to link consciousness and brain: How can we link and relate something as subjective as consciousness and its point of view to the brain's neural activity that is by definition objective and shows no point of view? This also raises the question of how the subjective-objective distinction is related to the one between first- and third-person perspective, as the two distinctions are often associated with each other in the current discussion [*p.lxxi* …]

[Neurophenomenal hypotheses and spatiotemporal structure of the phenomenal features of consciousness, :] The neurophenomenal hypotheses …aim to reveal the neuronal mechanisms that predispose the otherwise purely neuronal resting state and stimulus-induced activity to become associated with consciousness and its various phenomenal features by default. "Neurophenomenal hypotheses" in this sense refer to the brain's intrinsic features, its neural code, and particularly the encoding of its own neural activity as well as to the spatiotemporal structure of its intrinsic activity …

direct link between neuronal and phenomenal features, the "neurophenomenal link" […] the first neurophenomenal hypothesis concerned the predisposition of "principal consciousness" by difference-based coding as the "right" code [p. *lxxi…*] I proposed the resting state to constitute a statistically based virtual spatiotemporal structure that spans between environment and brain. … different phenomenal features of consciousness signify different forms of spatiotemporal organization. Therefore, it is important to note that spatiotemporal organization does not refer to the notions of a purely physical and objective space and time, but rather to phenomenal and more subjective space and time; that is, the kind of time and space that provide the template or grid for our subjective experience. In short, the here suggested spatiotemporal organization implies the phenomenal rather than the physical level. [*p.lxxii …*]

[Neurophenomenal hypotheses of consciousness: spatiotemporal relationship between intrinsic activity and phenomenal features:] [The second N hypothesis:] Let us specific this neurophenomenal hypothesis in empirical and thus neuronal terms. I propose that the spatial and temporal neuronal measures of the brain's intrinsic activity, like low-frequency fluctuations and functional connectivity, are structured and organized in such way that they cannot but predispose, e.g., necessarily and unavoidably, the organization of the subsequent extrinsic stimuli and their associated contents along the lines of the phenomenal features and their spatiotemporal structures [but it is still 3pp-physical aspect]… This means that statistically based spatiotemporal virtual structure of the resting state's neural activity on the one hand, and the phenomenal features and their spatiotemporal structure on the other, may be structured and organized in a more or less related or corresponding way [is this isomorphism? …] [*p.lxxii*]

[**Need for activity change as argument against neurophenomenal isomorphism:]** In addition to the resting-state activity's spatiotemporal structure as constituted by its low-frequency fluctuations and functional connectivity, the latter also need to undergo some kind of change to yield sufficiently large spatial and temporal differences in order to make possible their association with consciousness. Such a change is usually triggered by extrinsic stimuli [or spontaneous activity during dream …] second neurophenomenal hypothesis proposes some degree of relationship or correspondence between the spatiotemporal structures of the brain's intrinsic activity and that of the phenomenal features of consciousness. However, such spatiotemporal correspondence does not amount to one-to-one correspondence between neuronal and phenomenal features. The neuronal and phenomenal features thus do not need to map one-to-one onto each other. To suggest that would be to neglect the need to induce large enough spatial and temporal differences in the brain's intrinsic activity in order to assign its neural activity with phenomenal features, that is consciousness [C]. [RV: We do not need to neglect it for 1-1 because larges changes in activity correspond to large changes in C] One can thus not speak of … "spatiotemporal or neurophenomenal isomorphism" between the brain's intrinsic activity and the

phenomenal features of consciousness [but see Roy and Llinas, 2008 and Fingelkurts et al 2010 for suggesting such as neurophenomenal isomorphism …] [*p.lxxiii …*]

[Resting-state activity is neither phenomenal nor non-phenomenal, but pre-phenomenal:] The resting state's spatiotemporal grids or templates may not yet be ready by themselves to be associated with consciousness (except in dreams…). They are not yet fully phenomenal by themselves since for that, usually (except in dreams) an extrinsic stimulus from wither body or environment is needed that can induce the encoding of sufficiently large spatial and temporal differences into the resting state's neural activity. [p. *lxxiii*] …the extrinsic stimuli may trigger sufficiently large changes in the testing-state activity to "wake-up" its "dormant" spatiotemporal structure. … If the concept of *nonphenomenal* implies the absence of any kind of relationship to the phenomenal features and thus to consciousness, the intrinsic activity cannot be characterized as nonphenomenal. .. there must be some "dormant" feature in neuronal activity of the resting-state activity itself that reacts to change in such a way that it makes possible the association of these activity changes with consciousness. … The concept of prephenomenal describes that the resting state's spatiotemporal structure makes possible, e.g., necessary and unavoidable, the association of the purely neuronal resting state or stimulus-induced activity, with consciousness and its phenomenal features. [p. *lxxiv*] … an extrinsic stimulus (or some large rest-rest interaction as in dreams or auditory hallucinations) must trigger sufficiently large enough neural activity changes in the resting-state activity itself to allow it to associate the newly resulting neural activity level with a full-blown consciousness and its phenomenal features.

[Neurometaphorical comparision: sleep and brain or 'the dormant intrinsic activity':] the brains intrinsic activity is transformed by the extrinsic stimulus as its alarm clock that triggers it to associate phenomenal features and thus consciousness with its otherwise purely neuronal resting state and stimulus-induced activity. […] I do not discuss the various cognitive features like awareness, attention, willful modulation, [memory?] reporting, access, and volition that are often associated with consciousness …neurophenomenal rather than neurocognitive (or neuroaffective, neurosensory, neuromotor or neurosocial) […] I aim to search for what can be called the brain's "neurophenomenal functions." The concept of "neurophenomenal functions" refers to the neuronal mechanism that are related to the various phenomenal features of consciousness [p. *lxxv* …]".

5. Are feature and binding necessary for consciousness?

Feature binding is necessary for unified consciousness and is a part of integration for information (Section 2.1.5).

As per (Baars, Franklin & Ramsoy, 2013):

(i) Frames (or contexts) are defined as visual arrays such as the egocentric and allocentric visuotopic arrays of the parietal cortex. They do not give rise to conscious experiences, but frame binding is necessary "to specify spatial knowledge within which visual objects and events become conscious."

(ii) "In vision the dorsal 'framing' stream and 'feature-based' ventral stream may combine in the medial temporal cortex (MTL) [...] In sum, normal conscious experiences need both traditional feature binding and frame binding".

(iii) "(Baars, 1988) proposed that self-other access is a specific variety of framing (contextualizing), and that it is a necessary condition for conscious contents. [...] Cortical BOLD fading after training is a robust fact, indicating that conscious (reportable) events evoke widespread adaptation at multiple levels, from single neurons to entire brains (Baars, 1988; Gomezetal., 2009). Adaptation to novelty has been proposed to be one of a small set of necessary conditions for conscious experience (Baars, 1988, Chapter12). [...] We postulate that conscious involvement is necessary for non- trivial acquisition of knowledge and skills, and that the period of conscious access enables permanent memory traces to be established."

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Future research should address if the *necessary* conditions of visual consciousness are *sufficient* for consciousness. If not, then other components of executive functions (EFs), motor action, and other plausible conditions should be included one at a time to address this question by analyzing if the added component is necessary. Functional MRI experiments should be designed to isolate the other components of EFs, such as (i) to (vii) of Section 2.1.11 and motor action, similar to attention and working memory.

According to Merker, the neural correlates of consciousness might include brainstem mechanisms in addition to the thalamocortical system because there is some evidence of consciousness without a cerebral cortex (Merker, 2007). In that case, fMRI study may separate brainstem areas from thalamocortical areas for the *necessary* conditions of visual consciousness.

These types of experimental design could test the hypothesis that the *necessary* conditions are also *sufficient* for consciousness. This could be an interesting area of research related to consciousness.

2.3.4. Whitehead: Is a state of a process (an experiencing subject), that entails an occasion of experience, a dual-aspect entity?

A state of Leibnitz's monad (Edwards, 2014) or that of Whitehead's process (Whitehead, 1929/1978) needs to be a dual-aspect entity to explain the two (1pp and 3pp) sources of information.

As per (Whitehead, 1929/1978), "The process is nothing else than the experiencing subject itself [that has 'occasions of experience']. In this

explanation it is presumed that an experiencing subject is one occasion of sensitive reaction to an actual world. Science finds religious experiences among its percepta; and religion finds scientific concepts among the conceptual experiences to be fused with particular sensitive reactions. [p16...] 'Actual entities'-also termed 'actual occasions'—are the final real things - of which the world is made up. [...] The final facts are, all alike, actual entities; and these actual entities are drops of experience, complex and interdependent. [p18...] The analysis of an actual entity into 'prehensions' is that mode of analysis which exhibits the most concrete elements in the nature of actual entities. [Prehension is an interaction of a subject with an event or entity that involves perception but not necessarily cognition; the act of seizing or grasping, mental apprehension. ...] a prehension is only a subordinate element in an actual entity. ...With the purpose of obtaining a one-substance cosmology, 'prehensions' are a generalization from Descartes' mental 'cogitations,' and from Locke's 'ideas,' to express the most concrete mode of analysis applicable to every grade of individual actuality. ... the prehensions are real, individual, and particular.[p18-20 ...]

'Creativity,' 'many,' 'one' are the ultimate notions involved in the meaning of the synonymous terms 'thing,' 'being,' 'entity.' These three notions complete the Category of the Ultimate and are presupposed in all the more special categories. [...] 'Creativity' is the universal of universals characterizing ultimate matter of fact. It is that ultimate principle by which the many, which are the universe disjunctively, become the one actual occasion, which is the universe conjunctively. It lies in the nature of things that the many enter into complex unity. 'Creativity' is the principle of *novelty*. [...] 'Together' is a generic term covering the various special ways in which various sorts of entities are 'together' in any one actual occasion. Thus 'together' presupposes the notions 'creativity,' 'many,' 'one,' 'identity' and 'diversity.' The ultimate metaphysical principle is the advance from disjunction to conjunction, creating a novel entity other than the entities given in disjunction. The novel entity is at once the togetherness of the 'many' which it finds, and also it is one among the disjunctive 'many' which it leaves; it is a novel entity, disjunctively among the many entities which it synthesizes. The many become one, and are increased by one. In their natures, entities are disjunctively 'many' in process of passage into conjunctive unity. This Category of the Ultimate replaces Aristotle's category of 'primary substance.'

Thus the 'production of novel togetherness' is the ultimate notion embodied in the term 'concrescence/ These ultimate notions of 'production of novelty' and of 'concrete togetherness' are inexplicable either in terms of higher universals or in terms of the components participating in the concrescence [growing together]. The analysis of the components abstracts from the concrescence. The sole appeal is to intuition. [p21-2...]

(v) Eternal Objects, or Pure Potentials for the Specific Determination of Fact, or Forms of Definiteness. [...] The eternal objects are the same for all actual entities. [...]

(vii) That an eternal object can be described only in terms of its potentiality for 'ingression' [act of going in and out] into the becoming of actual entities; and that its analysis only discloses other eternal objects. It is a pure potential. The term 'ingression' refers to the particular mode in which the potentiality of an eternal object is realized in a particular actual entity, contributing to the definiteness of that actual entity. [as bliss in Samadhi? Or potential V in sch eq]

[p23...]

a remainder for the decision of the subject-superject of that concrescence. [A superject is an individual or an actual entity that progressively emerges through feelings and the attainment of satisfactions <for the philosophy of organism, a subject emerges from the world a superject rather than a subject — A. N. Whitehead>] [p28 ...]

Actual occasions in their 'formal' constitutions are devoid of all indetermination. Potentiality has passed into realization. They are complete and determinate matter of fact, devoid of all indecision. [SEs potentially co-exist as PEs with respective 3pp-NN..p29...]

'Creativity' is another rendering of the Aristotelian 'matter,' [Kant's matter-in-itself[15]] ... Aristotelian 'matter' is without a character of its own. [p31...]

Newtonian cosmology, emphasized the [109] 'receptacle' theory of space-time, and minimized the factor of potentiality. Thus bits of space and time were conceived as being as actual as anything else, and as being 'occupied' by other actualities which were the bits of matter. ... And thence arise certain prejudices, for the removing of which, it will be convenient to distinguish them into absolute and relative, true and apparent, mathematical and common. [p70...] Newton is presupposing four types of entities which he does not discriminate in respect to their actuality: for him minds are actual things, bodies are actual things, absolute durations of time are actual things, and absolute places are actual things. He does not use the word 'actual'; but he is speaking of matter of fact, and he puts them all on the same level in that respect. The result is to land him in a clearly expressed but complex and arbitrary scheme of relationships between spaces inter se; between durations inter se; and between minds, bodies, times and places, for the conjunction of them all into the solidarity of the one universe. [In relationship between A and B, we compare A and B and find non-matching attributes. For example, A=actual entity=redness; and B=potentiality, i.e., surrounding and background colors.] [p71...] appearance is to be distinguished from reality. ... [Newton's sensible objects are actual entities] ...

This is a theory of monads; but it differs from Leibniz's in that his monads change. In the organic theory, they merely *become*. Each monadic creature is a mode of the process of 'feeling' the world, of housing the world in one unit of complex feeling, in every way determinate. Such a unit is an 'actual occasion'; it is the ultimate creature derivative from the creative process. [p80...]

Descartes in his own philosophy conceives the thinker as creating the occasional thought. The philosophy of organism inverts the order, and

conceives the thought [who creates a thought then?] as a constituent operation in the creation of the occasional thinker. The thinker is the final end whereby there is the thought. In this inversion we have the final contrast between a philosophy of substance and a philosophy of organism. The operations of an organism are directed towards the organism as a 'superject,' and are not directed from the organism as a 'subject.' The operations [thoughts?] are directed from antecedent organisms and to the immediate organism. They are Vectors in that they convey the many [229] things into the constitution of the single superject. The creative process is rhythmic: it swings from the publicity of many things to the individual privacy; and it swings back from the private individual to the publicity of the objectified individual. The former swing [public to private?] is dominated by the final cause, which is the ideal; and the latter swing [private to public?] is dominated by the efficient cause, which is actual. [p151]

In this last statement the philosophy of organism is in agreement with Kant; but for a different reason. It is agreed that the functioning of concepts is an essential factor in knowledge, so that 'intuitions without concepts are blind.' But for Kant, apart from concepts there is nothing to know; since objects related in a knowable world are the product of conceptual functioning whereby categoreal form is introduced into the sense datum, which otherwise is intuited in the form of a mere spatio-temporal flux of sensations. Knowledge requires that this mere flux be particularized by conceptual functioning, whereby the flux is understood as a nexus of 'objects.' Thus for Kant the process whereby there is experience is a process from subjectivity to apparent objectivity. The philosophy of organism inverts this analysis, and explains the process as proceeding from objectivity to subjectivity, namely, from the objectivity, whereby the external world is a datum, to the subjectivity, whereby there is one individual experience. Thus, according to the philosophy of organism, in every act of experience there are objects for knowledge; but, apart from the inclusion of intellectual functioning in that act of experience, there is no knowledge.

... In it the [237] development of cosmology has been hampered by the stress laid upon one, or other, of three misconceptions:

(i) The substance-quality doctrine of actuality.
(ii) The sensationalist doctrine of perception.
(iii) The Kantian doctrine of the objective world as a construct from subjective experience.
[p156-7]

In another sense, a 'nexus' falls under the meaning of the term 'contrast'; though we shall avoid this application of the term. What are ordinarily termed 'relations' are abstractions from contrasts. A relation can [p228] be found in many contrasts; and when it is so found, it is said to relate the things contrasted. The term 'multiple contrast,' will be used when there are or may be more than two elements jointly contrasted, and it is desired to draw attention

to that fact. A multiple contrast is analyzable into component dual contrasts. But a multiple contrast is not a mere aggregation of dual contrasts. It is one contrast, over and above its component contrasts. This doctrine that a multiple contrast cannot be conceived as a mere disjunction of dual contrasts is the basis of the doctrine of emergent evolution. It is the doctrine of real unities being more than a mere collective disjunction of component elements. This doctrine has the same ground as the objection to the class-theory of particular substances. The doctrine is a commonplace of art.

[p229…]

. The process of the feeling involves negative prehensions which effect elimination. [p231…]

The pattern of intensities is not only the variety of qualitative elements with such-and-such intensities; but it is also the variety of qualitative elements, as in such-and-such an abstract qualitative pattern, with such-and-such intensities. Thus the two patterns are not really separable. It is true that there is an abstract qualitative pattern, and an abstract intensive pattern; but in the fused pattern the abstract qualitative pattern lends itself t to the intensities, and the abstract intensive pattern lends itself to the qualities. [p233-4]

[p236…Initial datum is external stimulus that entails/causes FF 3pp-signals (W calls it objective datum); its inseparable 1pp is phenomenal consciousness (PC: Whitehead calls it physical feeling), no attention, no reporting and iconic memory. Then attention, WM/LTM, and previous feelings are injected in it leading to access consciousness (AC). W would call PC as subject of stimulus, AC as subject of PC]

But it is equally true to say that a simple physical feeling is the most primitive type of an act of perception [detection?], devoid of [access?] consciousness. The actual entity which is the initial datum is the actual entity perceived, the objective datum is the 'perspective' under which that actual entity is perceived, and the subject of the simple physical feeling [362] is the perceiver. […]

A simple physical feeling has the dual character of being the cause's feeling re-enacted for the effect as subject. But this transference of feeling effects a partial identification of cause with effect, and not a mere representation of the cause. It is the cumulation of the universe and not a stage-play about it. In a simple feeling there is a double particularity in reference to the actual world, the particular cause and the particular effect.

[…] It [simple physical feeling] is a feeling *from* the cause which acquires the subjectivity of the new effect without loss of its original [p237…]. In virtue of these feelings time is the conformation of the immediate present to the past. Such feelings are 'conformal' feelings.

The novel actual entity, which is the effect, is the reproduction of the many actual entities of the past. But in this reproduction there is abstraction from their various totalities of feeling. […] The other feelings are dismissed by

negative prehensions, owing to their lack of compliance with categoreal demands.

A simple physical feeling enjoys a characteristic which has been variously described as 're-enaction,' 'reproduction,' and 'conformation.'

But there is reproduction; and hence the permanence which is the result of order, and the cause of it. And yet there is always change; for time is cumulative as well as reproductive, and the cumulation of the many is not their reproduction as many.[p238] transferred in definite quanta. [p239…]

Conceptual feelings and simple causal feelings constitute the two main species of 'primary' feelings. […] In each concrescence there is a twofold aspect of the creative urge. In one aspect there is the origination of simple causal feelings; and in the other aspect there is the origination of conceptual feelings. These contrasted aspects will be called the physical and the mental poles of an actual entity. No actual entity is devoid of either pole; though their relative importance differs in different actual entities. Also conceptual feelings do not necessarily involve consciousness; though there can be no conscious feelings which do not involve conceptual feelings as elements in the synthesis.

Thus an actual entity is essentially dipolar, with its physical and mental poles; and even the physical world cannot be properly understood without reference to its other side, which is the complex of mental operations. The primary mental operations are conceptual feelings. [p239]

[RV: This is eDAM with inseparable physical and mental aspects and the degrees of their manifestations vary with entity.]

[…] Immanence and transcendence are the characteristics of an object: as a realized determinant it [367] is immanent; as a capacity for determination it is transcendent; in both roles [p239] it is relevant to something not itself. [p240] , a conceptual feeling is a feeling whose 'datum' is an eternal object. Analogously a negative prehension is termed 'conceptual' when its datum is an eternal object. In a conceptual feeling there is no necessary progress from the 'initial data' to the 'objective datum.' The two may be identical, except in so far as conceptual feelings with diverse sources of origination acquire integration.

Conceptual prehensions, positive or negative, constitute the primary operations among those belonging to the mental pole of an, actual entity. [p240…]

Whenever there is consciousness there is some element of recollection. It recalls earlier phases from the dim recesses of the unconscious. Long ago this truth was asserted in Plato's doctrine of reminiscence. No doubt Plato was directly thinking of glimpses of eternal truths lingering in a soul derivate from a timeless heaven of pure form. Be that as it may, then in a wider sense consciousness enlightens experience which precedes it, and could be without it [experience] if considered as a mere datum. [p242…] [RV: This seems to imply that experiences (1pp-mental aspect] are excitations of universal potential consciousness.]

According to the philosophy of organism, a pure concept does not involve consciousness, at least in our human experience. [Access] Consciousness

arises when a synthetic feeling integrates physical and conceptual feelings. [p243...] Physical feelings form the non-conceptual element in our awareness of [372] nature. Also, all awareness, even awareness of concepts, requires at least the synthesis of physical feelings with conceptual feeling. [...] Conceptual feeling is the feeling of an unqualified negation; that is to say, it is the feeling of a definite eternal object with the definite extrusion of any particular realization. [p244...]

According to the ontological principle there is nothing which floats into the world from nowhere. Everything in the actual world is referable to some actual entity. It [an entity] is either transmitted from an actual entity in the past, or belongs to the subjective aim of the actual entity to whose concrescence it belongs. [...] God is the principle of concretion; namely, he is that actual entity from which each temporal concrescence receives that initial aim from which its self-causation starts. [p244...]

The general doctrine of the previous section requires an examination of principles regulating the transmission of feelings into data for novel feelings in a new concrescence. Since no feeling can be abstracted from its subject, this transmission is merely another way of considering the objectification of actual entities. A feeling will be called 'physical' when its datum involves objectifications of other actual entities. In the previous chapter the special case of 'simple physical feelings' was discussed. A feeling belonging to this special case has as its datum only one actual entity, and this actual entity is objectified by one of its feelings. All the more complex kinds of physical feelings arise in subsequent phases of concrescence, in virtue of integrations of simple t physical feelings with each other and with conceptual feelings. But before proceeding to these more complex physical feelings, a subdivision of simple physical feelings must be considered.

Such feelings are subdivided into 'pure physical feelings' and 'hybrid physical feelings/ In a 'pure physical feeling' the actual entity which is the datum is objectified by one of its own physical feelings. Thus having regard to the 're-enaction' which is characteristic of the subjective form of [p245] a simple physical feeling, we have—in the case of the simpler actual entities—an example of the transference of energy in the physical [376] world. When the datum is an actual entity of a highly complex grade, the physical feeling by which it is objectified as a datum may be of a highly complex character, and the simple notion of a transference of some form of energy to the new subject may entirely fail to exhaust the important aspects of the pure physical feeling in question.

In a 'hybrid physical feeling' the actual entity forming the datum is objectified by one of its own conceptual feelings. Thus having regard to the element of autonomy which is characteristic of the subjective form of a conceptual feeling, we have—in the case of the more complex actual entities—an example of the origination and direction of energy in the physical world. In general, this

simplified aspect of a hybrid physical feeling does not exhaust its role in the concrescence of its subject.

The disastrous separation of body and mind, characteristic of philosophical systems which are in any important respect derived from Cartesianism, is avoided in the philosophy of organism by the doctrines of hybrid physical feelings and of the transmuted [to completely change the form, appearance, or nature] feelings. In these ways conceptual feelings pass into the category of physical feelings. Also conversely, physical feelings give rise to conceptual feelings, and conceptual feelings give rise to other conceptual feelings[…][RV: This is similar to the eDAM framework, where information from 3pp-physical aspect is translated immediately to the 1pp-mental aspect and vice-versa.]

One important characteristic of a hybrid feeling is the intensity of the conceptual feeling which originates from it, according to the Category of Subjective Valuation. […]

A hybrid physical feeling originates for its subject a conceptual feeling with the same datum as that of the conceptual feeling of the antecedent subject. But the two conceptual feelings in the two subjects respectively may have different subjective forms.

There is an autonomy in the formation of the subjective forms of conceptual feelings, conditioned only by the unity of the subject [p246…]
[W's God is the primal entity with all potentiality/possibility as in the eDAM].

Category IV. The Category of Conceptual Valuation. From each physical feeling there is the derivation of a purely conceptual feeling whose datum is the eternal object exemplified in the definiteness of the actual entity, or oft [often; frequently] the nexus, physically felt.

This category maintains the old principle that mentality originates from sensitive experience. It lays down the principle that all sensitive experience originates mental operations. It does not, however, mean that there is no origination of other mental operations derivative from these primary mental operations. Nor does it mean that these mental operations involve consciousness, which is the product of intricate integration.

The mental pole originates as the conceptual counterpart of operations in the physical pole. The two poles are inseparable in their origination. The mental pole starts with the conceptual registration of the physical pole. This conceptual registration constitutes the sole datum of experience according to the sensationalist school. Writers of this school entirely neglect physical feelings, originating in the physical pole. Hume's 'impressions of sensation' and Kant's sensational data are considered in terms only applicable to conceptual registration. … Every actual entity is 'in time' so far as its physical pole is concerned, and is 'out of time' so far as its mental pole is concerned. [p248…]

Category V. The Category of Conceptual Reversion. There is secondary origination of conceptual feelings with data which are partially identical with, and partially diverse from, the eternal objects[16] forming the data in the primary phase of the mental pole; the determination of identity and diversity depending on the subjective aim at attaining depth of intensity by reason of contrast.

Thus the first phase of the mental pole is conceptual [381] reproduction, and the second phase is a phase of conceptual reversion. [p249…]

[RV: We can interpret it in the eDAM framework as follows: Integrated unified experience (1pp-mental aspect) arise from (i) the integration of physical information in neural signals (3pp-physical aspect, such as physical neural information related to color and shape of ripe-tomato) as the primary origination/source and using the *inseparability doctrine* to reflect in 1pp-mental aspect and (ii) from the integration of mental information of each micro-experiences (such as redness and ovalness in ripe-tomato) as a secondary source, which in reverse manner using the inseparability doctrine is reflected in 3pp integrated neural signals. Materilists may be more comfortable with from 3pp to 1pp and idealists with from 1pp to 3pp.]

Also the eternal object may be the datum of a reverted conceptual feeling, only indirectly derived from the members of the original nexus. In this case, the transmuted feeling of the nexus introduces novelty; and in unfortunate cases this novelty may be termed 'error.' But all the same, the transmuted feeling, whatever be its history of transmutation, is a definite physical fact whereby the final subject prehends the nexus. For example, considering the example of presentational immediacy, colour-blindness may be called 'error'; but nevertheless, it is a physical fact. A transmuted feeling comes under the definition of a physical feeling. [p253…]".

1. SEs potentially co-exist with respective NCCs in Nature as PEs: This hypothesis is consistent with Whitehead's "givenness" and Hume's interpolation

As per (Whitehead, 1929/1978), "For the organic doctrine the problem of order assumes primary importance. No actual entity can rise beyond what the actual world as a datum from its standpoint—its actual world—allows it to be. Each such entity arises from a primary phase of the concrescence of objectifications which are in some respects settled: the basis of its experience is 'given.' Now the correlative of 'order' is 'disorder.' There can be no peculiar meaning in the notion of 'order' unless this contrast holds. Apart from it, 'order' must be a synonym for 'givenness.' But 'order' means more than 'givenness,' though it presupposes 'givenness'; 'disorder' is also 'given.' Each actual entity requires a totality of 'givenness,' and each totality of 'givenness' attains its measure of 'order.' … Four grounds of 'order' at once emerge: (i) That 'order' in the actual world is differentiated from mere 'givenness' by introduction of adaptation for the attainment of an end. [p83…] In each case there is an ideal

peculiar to each particular actual entity, and arising from the dominant components in its phase of 'givenness.' This notion of 'dominance' will have to be discussed later in connection with the notion of the systematic character of a 'cosmic epoch' and of the subordinate systematic characters of 'societies' included in a cosmic epoch. … The notion of a dominant ideal peculiar to each actual entity is Platonic. [p84…]

[As per Hume's *Treatise*,] "*That all our simple ideas in their first appearance, are derived from simple impressions? Which are correspondent to them, and which they exactly represent.*" It must be remembered that in the organic philosophy the 'data of objectifications' are the nearest analogue to Hume's 'simple impressions.' Thus, modifying Hume's principle, the only lure to conceptual feeling is an exact conformation to the qualities realized in the objectified actualities. But Hume (*loc. cit.*) notes an exception which carries with it the exact principle which has just been laid down, namely, the principle of relevant potentials, unrealized in the datum and yet constituent of an 'objective lure' by proximity to the datum. The point is that 'order' in the actual world introduces a derivative 'order' among eternal objects. Hume writes: ["]

> There is. however, one contradictory phenomenon, which may prove, that it is not absolutely impossible for ideas to go before their correspondent impressions. I believe it will readily be allowed, that the several distinct ideas of colours, which enter by the eyes, or those of sounds, which are conveyed by the hearing, are really different from each other, though, at the same time, resembling. Now, if this be true of different colours, it must be no less so of the different shades of the same colour, that each of them produces a distinct idea, independent of the rest. … Suppose, therefore, a person to have enjoyed his sight for thirty years, and to have become perfectly well acquainted with colours of all kinds, excepting one particular shade of blue, for instance, which it never hast been his fortune to meet with. Let all the different shades of that colour, except that single one, be placed before him, descending gradually from the deepest to the [133] lightest; it is plain, that he will perceive a blank, where that shade is wanting, and will be sensible that there is a greater distance in that place, betwixt the contiguous colours, than in any other. Now I ask, whether it is possible for him, from his own imagination, to supply this deficiency, and raise up to himself the idea of that particular shade, though it had never been [p86] conveyed to him by his senses? I believe there are few but will be of opinion that he can; and this may serve as a proof, that the simple ideas are not always derived from the correspondent impressions; though the instance t is so particular and singular, that it is scarce worth our observing, and does not merit that, for it alone, we should alter our general maxim. ["] [p86-87…]

The analysis of concrescence, here adopted, conceives that there is an origination of conceptual feeling, admitting or rejecting whatever is apt for feeling by reason of its germaneness to the basic data. The gradation of eternal objects in respect to this germaneness is the 'objective lure' for feeling; the

concrescent process admits a selection from this 'objective lure' into subjective efficiency. This is the subjective 'ideal of itself which guides the process. Also the basic data are constituted by the actual world which 'belongs to' that instance of concrescent process. Feelings are 'vectors'; for they feel what is there and transform it into what is here.

The term 'potential difference' is an old one in physical science; and recently it has been introduced in physiology with a meaning diverse from, though generically allied to, its older meaning in physics. The ultimate fact in the constitution of an actual entity which suggests this term is the objective lure for feeling. In the comparison of two actual entities, the contrast be-[134]tween their objective lures is their 'potential difference' [p87…]

The 'objectifications' of the actual entities in the actual world, relative to a definite actual entity, constitute the efficient causes out of which that actual entity arises; the 'subjective aim' at 'satisfaction' constitutes the final cause, or lure, whereby there is determinate concrescence … The 'objectifications' of the actual entities in the actual world, relative to a definite actual entity, constitute the efficient causes out of which that actual entity arises; the 'subjective aim' at 'satisfaction' constitutes the final cause, or lure, whereby there is determinate concrescence … Thus an actual entity has a threefold! character: (i) it has the character 'given' for it by the past; (ii) it has the subjective character aimed at in its process of concrescence; (iii) it has the superjective character, which is the pragmatic value of its specific satisfaction qualifying the transcendent creativity. [p87…]"

These are consistent with eDAM.

2. *Whitehead's metaphysics is a version of dual-aspect monism with relational ontology*

As per (Whitehead, 1929/1978), "The process is nothing else than the experiencing subject itself. In this explanation it is presumed that an experiencing subject is one occasion of sensitive reaction to an actual world. [p16…] 'Actual entities'-also termed 'actual occasions'—are the final real things - of which the world is made up. […] The final facts are, all alike, actual entities; and these actual entities are drops of experience, complex and interdependent. [RV: This seems to imply that a process/subject is one actual occasion/entity of experience] [p18…]

The summary statement of this discussion is, that the mental pole determines the subjective forms and that this pole is inseparable from the total *res vera*. [p70…] [RV: This seems to imply that mental pole is inseparable from physical pole; both poles together defines the total *res vera*: this is similar to the eDAM.]

Each actuality is essentially bipolar, physical and mental, and the physical inheritance is essentially accompanied by a conceptual reaction partly conformed to it, and partly introductory of a+ relevant novel contrast, but always introducing emphasis, valuation, and purpose. The integration of the

physical and mental side into a unity of experience is a self-formation which is a process of concrescence, and which by the principle of objective immortality characterizes the creativity which transcends it. So though mentality is non-spatial, mentality is always a reaction from, and integration with, physical experience which is spatial [p108…]

All metaphysical theories which admit a disjunction between the component elements of individual experience on the one hand, and on the other hand the component elements of the external world, must inevitably run into difficulties over the truth and falsehood of propositions, and over the grounds for judgment. [RV: Thus, Whitehead rejects interactive substance dualism…] There is a togetherness of the component elements in individual experience [RV: This is in analogy to dual-aspect monism]. This 'togetherness' has that special peculiar meaning of 'togetherness in experience.' It is a togetherness of its own kind, explicable by reference to nothing else. For the purpose of this discussion it is indifferent whether we speak of a 'stream' of experience [(Pred, 2005)], or of an 'occasion' of experience. With the former alternative there is togetherness in the stream, and with the latter alternative there is togetherness in the occasion. In either case, there is the unique 'experiential togetherness.' [p189…] The contrary doctrine, that there is a 'togetherness' not derivative from experiential togetherness, leads to the disjunction of the components of subjective experience from the community of the external world. This dis-[289]junction creates the insurmountable difficulty for epistemology. For intuitive judgment is concerned with togetherness in experience, and there is no bridge between togetherness in experience, and togetherness of the non-experiential sort. [p190…]

In each concrescence there is a twofold aspect of the creative urge. In one aspect there is the origination of simple causal feelings; and in the other aspect there is the origination of conceptual feelings. These contrasted aspects will be called the physical and the mental poles of an actual entity. No actual entity is devoid of either pole; though their relative importance differs in different actual entities. Also conceptual feelings do not necessarily involve consciousness; though there can be no conscious feelings which do not involve conceptual feelings as elements in the synthesis.

Thus an actual entity is essentially dipolar, with its physical and mental poles; and even the physical world cannot be properly understood without reference to its other side, which is the complex of mental operations. The primary mental operations are conceptual feelings. [p239…]

[RV: This is eDAM with inseparable physical and mental aspects and the degrees of their manifestations vary with entity.]

Whenever there is consciousness there is some element of recollection. It recalls earlier phases from the dim recesses of the unconscious. Long ago this truth was asserted in Plato's doctrine of reminiscence. No doubt Plato was directly thinking of glimpses of eternal truths lingering in a soul derivate from a timeless heaven of pure form. Be that as it may, then in a wider sense

consciousness enlightens experience which precedes it, and could be without it [experience] if considered as a mere datum. [p242…]

[RV: This seems to imply that experiences (1pp-mental aspect] are excitations of universal potential consciousness.]

The mental pole originates as the conceptual counterpart of operations in the physical pole. The two poles are inseparable in their origination. The mental pole starts with the conceptual registration of the physical pole. [p248…]

[RV: This is clearly consistent with the eDAM, where physical and mental aspects are inseparable.]

Consciousness arises when a synthetic feeling integrates physical and conceptual feelings. […] Also, all awareness, even awareness of concepts, requires at least the synthesis of physical feelings with conceptual feeling. […] Conceptual feeling is the feeling of an unqualified negation; that is to say, it is the feeling of a definite eternal object with the definite extrusion of any particular realization. [p243…]

[RV: Whitehead's consciousness is Block's access consciousness.]

The bare character of mere responsive re-enaction constituting the original physical feeling in its first phase t is enriched in the second phase by the valuation accruing from integration with the conceptual correlate. In this way, the dipolar character of concrescent experience provides in the physical pole for the objective side of experience, derivative from an external actual world, and provides in the mental pole for the subjective side of experience, derivative from the subjective conceptual valuations correlate to the physical feelings. The mental operations have a double office. [p277…]

[There is] the classification of eternal objects into two species, the 'objective' species [physical aspect], and the 'subjective' species [mental aspect]. An eternal object of the objective species can only obtain ingression in the first mode, and never in the second mode. [RV: this seems to imply that the cross causality between aspects are forbidden.] [p291…]".

To sum up, in relational ontology, for a specific relation, a state of Leibnitz's monad (Edwards, 2014) and Whitehead's process/'experiencing subject'/'actual entity'/'actual occasion' (Whitehead, 1929/1978) need to be a dual-aspect entity to explain the two (1pp and 3pp) sources of ~~information~~ empirical data.

Alfredo Pereira (1/13/16): I am not a historian of philosophy. Your comments make sense to me, but they are a bit superficial. It seems that nobody discussed Whitehead's concept of feeling deeply.

3. Can we link relational ontology and the eDAM ontology?

As per (Stratton, 2000), "The relational nature of reality is expressed in two ways: (1) a relational, rather than a receptacle [container], view of space-time, and (2) the importance of field theories in modern physics.

Relativity theory understands the space-time continuum to be relational in nature in contrast to the old receptacle view of space. In the receptacle model, space and time are conceived as a huge container which holds all the objects that exist and events that occur. In the relational model envisioned by Einstein and Torrance [(Torrance, 1969/2005)], space is not empty but filled with matter and energy with time as an inalienable [indisputable] ingredient in the relations between particles and the events affecting their configurations. Space and time are not containers but relations intrinsic to the ongoing process of the universe. […] Field theories also demonstrate the relational character of reality. An emphasis on fields, or relations between bodies, is an important part of Torrance's approach, and he derives much of his treatment of fields from Polanyi, Maxwell, and Einstein, whose theory of general relativity is a field theory.

Torrance understands field theory to be at the heart of modern science. According to Torrance, modern science rejects the dualism of previous scientific eras and understands nature in terms of "continuous invisible fields in a multi-leveled universe." Furthermore, Torrance holds that field theories are needed in all sciences, not just physics. Biology, for example, needs to give up its tendency to apply mechanistic explanations to living systems and investigate "the fields set up by living force." Biology needs organic thinking in which structures are set up which do not abrogate [abolish] the laws of nature expressed by physics and chemistry but are coordinated with them at their boundary conditions which the laws of physics leave underdetermined. Torrance calls for a "biologic" that grasps the dynamic laws of living organisms, and he follows Polanyi in arguing that the DNA molecule transcends explication merely in terms of physics and chemistry [p179]."

Edwards (personal communication on 1/12/16) argued, "To talk of 'invisible fields' is to lay bare a confusion about what is being analysed. Biology should not be thought of in terms of fields unless events are being considered at the quantum field level. Most of the time it should be thought of in classical aggregate terms because it is aggregates."

Vimal: However, fields are used in classical physics as well, such as EM field, water wave, fundamental and harmonics using Fourier analysis as sometimes done in EEG, and so on. They can be used for classical aggregates. McFadden used field in *consciousness electromagnetic information field (Cemi field) theory* (McFadden, 2002a, 2002b, 2006).[17] For classical fields, do we need quantum field theory?

Edwards (1/13/16): Fields are just arrays of values in space and time - hardly more special than rulers. QFT is something very specific.

Vimal: OK. Then how do we use QFT in understanding how redness arises when we view a ripe-tomato? This requires information transfer from light to photoreceptors to other retinal cells to LGN to V1/V2 to V8 as FF signals, which interacts with cognitive (such as memory) FB signals to match the modes. I guess, each cell has its own QFT-mode from retina to cortex. In relational ontology, a specific subjective experience (such as redness) is a product of the relation between a brain and the external world, where world is an object (such as ripe-tomato) relative to its environmental surrounding (such as background light and other surrounding objects). This is consistent with the eDAM ontology because it is related to the function detection/discrimination of object relative to its surrounding and related to (SE such as redness of ripe-tomato).

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3. Critical Discussion

3.1. Vimal (11/11/15): Fragile short-term memory

Is fragile short-term memory (between iconic and working memory) necessary for (non-reportable) phenomenal consciousness?

Jobe, T.H. (11/12/15: Discussion at Research Gate)

There may also be an "imaginative" form of working memory that interacts with recall working memory. You might want to check out Andrey Vyshedskiy's book, On the Origin of the Human Mind. His concept of "mental synthesis" might also help if you are not already aware of it. A concept such as imaginative working memory might bridge the gap between phenomenal and working memory.

Vimal (11/12/15)

It seems that we have working or short term-memory (WM: with small capacity but long time-scale), which stores information needed to recall in the subsequent seconds, minutes, or hours. WM can be used for various purposes, such as mental imagery (which I guess, you are referring as imaginative form of WM). As per (Vyshedskiy, 2014), visual-recall activates a mental image of the object (his Fig 1.4, Section 1.3). WM is for *access* consciousness, which is reportable; it needs time to process information.

Iconic (or sensory) memory (IM: with high capacity but short time-scale) refers to the visual image a subject holds onto after briefly looking at an object. Iconic

memory is by nature fleeting. The site of visual iconic memory might be visual areas (Lamme, 2003), which appears to be essential for retaining information for *phenomenal* consciousness (Rowlatt, 2009) because there is not enough time for the top-down attention to act on it.

However, recently (Vandenbroucke, Sligte & Lamme, 2011) suggested 'fragile' short-term memory (FM: with large capacity and a lifetime of several seconds) between iconic memory (with high capacity but short time-scale) and WM (with small capacity but long time-scale). It is easily overwritten by new stimulation. This may be used by the non-reportable *phenomenal* consciousness.

There is still debate between IM vs. FM for the non-reportable *phenomenal* consciousness. My question is: which kind of memory (IM or FM) is used for the phenomenal consciousness.

Jobe (11/12/15)

I have enjoyed following your important work. I am not really up on the consciousness research enough to be of much help. My thought would be that iconic memory would be used for phenomenal consciousness because of the very short time duration and large capacity. I will think more about it however.

Vimal (11/12/15)

There is a reason for considering fragile memory (FM) for non-reportable phenomenal consciousness. Some of the data do not fit in with iconic memory (IM). Perhaps, we need to design a few experiments that clearly reject one of them (IM or FM).

Alfredo Pereira Jr. (11/13/15)

Your comments assume that cognitive processing as STM is necessary for consciousness, but non-reportable phenomenal consciousness does not have to be cognitive - for instance, you have a vague feeling that a headache is coming (the "aura") - how is STM necessary for this conscious experience?

Vimal (11/13/15)

I agree with you that cognitive processing such as (a) STM working memory (WM-STM) with small capacity but long time-scale and (b) both endogenous and exogenous attention (along with other conditions) are necessary for reportable *access* consciousness. I also tend to think that non-reportable phenomenal consciousness should not involve cognitive processing. However, it is controversial if (a) IM/FM and (b) exogenous attention are necessary for phenomenal consciousness (such as "there is something that it is like to be …"

(Nagel, 1974)). It is unclear if IM involves cognitive processing. FM is considered as a part of STM. Perhaps, FM-STM and exogenous attention involve cognitive neural processing. What do you think?

Alfredo Pereira Jr. (11/13/15)

In my view all these processes are cognitive and largely unconscious. What makes them conscious (or not) is a feeling that is (or is not) attached to the cognitive process. Our cells exchange signals unconsciously. You can call these signals iconic or fragile WM (or sensory memory - information about stimuli that is processed in primary sensory regions). Only when they elicit a feeling they become conscious.

Vimal (11/13/15)

To avoid confusion, I should first define a few terms: The *necessary* conditions for consciousness are those conditions that must be satisfied in order to have consciousness, i.e., if any of them is missing then the entity is not conscious. The *sufficient* conditions for consciousness are conditions, if satisfied, guarantee that the entity is conscious.

Implicitly, I guess, you are implying that how consciousness finally arises depends on a foundational (metaphysical) framework. From your Triple-Aspect Monism (TAM: (Pereira Jr., 2013)), a necessary condition for consciousness is that a related feeling (or subjective experience) must *somehow* be attached with related cognitive process (call it 'attachment mechanism' or you may like to use more appropriate term). Is this correct? Is this also sufficient condition for consciousness?

Furthermore, other conditions are also needed, even if processing is unconscious.

So far, in the extended Dual-Aspect Monism (eDAM) (Vimal, 2008b, 2010a, 2013, 2015c, 2015d), my working hypothesis is as follows:

The *necessary* conditions for *access* (reportable) consciousness are as follows:

(1) The formation of neural-networks (Crick & Koch, 2003b; Tononi & Koch, 2008);
(2) Wakefulness (MacGregor & Vimal, 2008);
(3) Reentrant interactions among neural populations (Edelman, 2003; Hamker, 2005);
(4) Fronto-parietal and thalamic-reticular-nucleus attentional signals that modulate consciousness (Prinz, 2011);
(5) Working memory (Rowlatt, 2009);
(6) Integrated information (Φ) at or above threshold level (Vimal, 2015d);

(7) Stimulus contrast at or above threshold (Atmanspacher, 2011; Naccache, 2005; Vimal, 1997, 1998a, 1998b, 2000, 2002a);
(8) Neural-network proto-experiences that are superposed *potential* subjective experiences (SEs) embedded in a neural-network as pre-cursors of SEs (Vimal, 2008b);
(9) Self (the experiencer/agent of a system) and self-related neural network for generating intuition for the system being conscious (Arico, Fiala, Goldberg, & Nichols, 2011) and for feeling a specific subjective experience (SE); and
(10) Matching (between feed forward signals and cognitive feedback signals) and selection mechanisms for selecting a specific SE (Vimal, 2010a) that is experienced by the self.

The *necessary* conditions for *phenomenal* (non-reportable) consciousness are (1)-(3) above, (4') exogenous attention, (5') iconic/fragile memory, and (6)-(10) above.

In the eDAM framework, condition-(10) makes the unconscious processing conscious. In your TAM, the condition-(10) would be "a related feeling (or subjective experience) must *somehow* be attached with related cognitive process." Other conditions for eDAM and TAM are same or similar. What do you say?

I am still working on the followings:
1. Is neural synchrony (Engel et al., 1999) necessary for consciousness?
2. Is intrinsic (resting-state) activity (Northoff, 2014) necessary for consciousness?
3. Is proto-self (Northoff, 2014) necessary for consciousness?

3.2. Vimal (11/15/15): Exogenous attention

Is exogenous (reflexive, automatic, bottom-up) attention with peripheral cues necessary for (non-reportable) phenomenal consciousness?

Pereira Jr., Alfredo. (11/15/15)

The De Brigard (2010) taxonomy is too complicated for my taste. How could my position (below) be classified in his taxonomy?

a) Access consciousness is phenomenal; IOW access consciousness is a kind of phenomenal consciousness, not a separate category;

b) Cognition can occur without consciousness (IOW consciousness is not necessary for cognition);

c) Consciousness is cognition with feeling (IOW feeling is necessary for consciousness);

d) Attention is a function of feeling on cognition (IOW feeling highlights/selects cognitive contents and this operation is called *attention*).

Vimal

a) If (De Brigard & Prinz, 2010) and (Prinz, 2011) consider phenomenal = access consciousness, attention is both necessary and sufficient for consciousness. I disagree with them. There is enough evidence that phenomenal consciousness ("there is something that it is like to be …" (Nagel, 1974)) is non-reportable and endogenous attention is not needed; only exogenous attention is required; it does not need working memory; it requires only iconic/fragile memory (IM/FM).

b) If cognition means endogenous attention and working memory (WM), then yes, both are not necessary for phenomenal consciousness, but they are needed for access consciousness as per available evidences.

c) As you know there are over 40 meanings attributed to the term consciousness as elaborated in (Vimal, 2009), which were identified and categorized according to whether they were principally about function (cognition can be considered as functional aspect of consciousness) or about experience. However, for phenomenal consciousness, exogenous attention and IM/FM parts of cognition are necessary. What is the difference between feeling and experience; feeling is a sort of emotional experience: is this correct?

d) Kindly define your term 'feeling'. Do you mean that feeling such as "happiness" selects cognitive contents (such as the content of endogenous/exogenous attention) and this operation is called attention with the feeling of happiness and then attention leads to experience? I thought happiness is an emotional experience.

Lisbeth Nilsson (11/15/15)

Your question and the copy of your current manuscript is very interesting. I find neuroscience helpful to understand my observations in research practice. From my experiences with people with stroke and visuo-spatial neglect, my answer to your question is Yes!

People with stroke and visuo-spatial neglect are attentive and their access consciousness inform them there is no problem with how they perceive their surroundings. Typically it is not working very well to discourse or inform them about the neglect via their endogenous attention (top-down) as their experience is that their visuo-spatial perception is OK.

However, in my studies of this population I found that if clients during practice in the powered wheelchair got peripheral cues (crashing into something they did not perceive) their exogenous attention (bottom-up) was alerted and if the cue was immediately followed by a discourse connecting their endogenous attention (top-down) to what happened, why and how to avoid - they quite quickly adapted their perceptual behaviour to their visuo-spatial

neglect (turning their head towards the neglected space and thereby perceiving obstacles and avoiding crashing into things). Quite quickly could mean from 40 minutes to a couple of sessions. The clients typically had not access consciousness of their changed perceptual behaviour.

Peripheral cues alert exogenous attention (bottom-up) but need to be combined with reasoning at a higher cortical level - involving endogenous attention (top-down) to result in adaptation to the perceptual deficit. Still the client might not have access consciousness about their changed approach to context - but phenomenal consciousness is enough as the client avoids crashing and is able to perform tasks safely.

Neuroscience is a fascinating topic and the search for answers to different questions is most interesting. Best wishes for your work!

Vimal (11/15/15)

Thanks Lisbeth. I agree with you that first exogenous attention with phenomenal consciousness and then endogenous attention with access consciousness are needed in our (both normal and patient subjects') daily lives. You may like to read the eDAM framework (Vimal, 2008b, 2010a, 2013, 2015c, 2015d) and let me know your comments and questions.

Pereira Jr. (11/15/15)

some clarifications:

1) Alfredo: I did not write that De Brigard & Prinz consider phenomenal = access consciousness. I wrote that for me access consciousness is part of phenomenal consciousness;

2) You wrote "There is enough evidence that phenomenal consciousness ("there is something that it is like to be …" (Nagel, 1974)) is non-reportable"... Alfredo: This statement is not convincing, because what is reported in access consciousness is a content of phenomenal consciousness;

3) "For phenomenal consciousness, exogenous attention and IM/FM parts of cognition are necessary"

Alfredo: You still have to argue for this thesis, it seems not plausible to me;

4) Alfredo: Feeling is what makes a cognitive content conscious; it is the feeling of the meaning of the information processed in the brain/body; it encompasses all kinds of experience, it is not restricted to conscious emotion; for instance, knowing is considered to be "true justified **belief**": this belief is a feeling;

5) "Do you mean that feeling such as "happiness" selects cognitive contents (such as the content of endogenous/exogenous attention) and this operation is called attention with the feeling of happiness and then attention leads to experience? I thought happiness is an emotional experience."

Alfredo: You are confusing feeling with emotional experiences. Feeling encompasses all conscious experiences, it is **the state of the subject** who has

the experiences (about something), for instance: feelings of hot and cold, hunger and thirst, pleasure and pain, happiness and sadness, believing or doubting, knowing or not knowing, anger or admiration, a visually perceived object being black or white or any other color, a heard sound being a note, a chord, harmony in music, etc etc.

More generally, consciousness has a subjective and an objective sides; the feeling is the subjective side (the state of the experiencer) and the cognitive content is the objective side (the represented entity that the feeling is about)

Vimal (11/15/15)

1) Thanks for clarifications. Sorry, I misunderstood. For you access consciousness is part of phenomenal consciousness: do you mean both are reportable?

I am using the definitions from (Block, 2005, 2007; Lamme, 2003): there are two types of consciousness

(a) *Phenomenal* consciousness is not reportable, which presumably occurs during less than 50 msec stimulus presentation, where top-down endogenous attention is not necessary. For example, Sperling type experiments (Sperling, 1960, 1971, 1983; Sperling et al., 1971) and pop-out visual search, attention is either not needed or minimally needed. In other words, *phenomenal* consciousness can occur without top-down endogenous attention; and top-down endogenous attention can occur without *phenomenal* consciousness; for example, subjects can attend to perceptually invisible objects.

(b) *Access* consciousness is reportable, for which top-down endogenous and also exogenous attentions are necessary; it takes longer time than *phenomenal* consciousness.

2) I agree with you that what is reported in access consciousness is a content of phenomenal consciousness. However, there is not enough time to process information to recognize its content and then report in 15-50 msec. Perhaps, only gist is experienced, not the details.

3) Once you accept the division then perhaps it might make sense. In addition, this information is derived from (Botta, Lupianez & Chica, 2014; Koch & Tsuchiya, 2007; van Boxtel, Tsuchiya & Koch, 2010a).

4+5) It seems that you are defining terms based on your Triple-Aspect Monism (TAM): physical aspect (aspect-1), non-conscious mental aspect (aspect-2), and conscious mental aspect (aspect-3). The conscious mental aspect has two sub-aspects: subjective feeling (experiences) and objective cognitive content. Is this correct?

In the eDAM, consciousness is the mental aspect of a state of mind-brain system. Consciousness has two sub-aspects: experiential sub-aspect and functional sub-aspect. Feelings are the same as experiences related to emotions. We can have non-emotional experiences as well such neutral experiences. There can be many gradations between unconscious and non-conscious states, which are indicated by the degree of the manifestation of mental aspect. Consciousness has three dimensions: content, arousal level (such as sleep, dream, wakefulness), and form ((Northoff, 2014).p. xix). Brain and its particular design *predispose* consciousness and its phenomenal features by "relating brain's intrinsic activity and its spatiotemporal structure to the form [spatiotemporal structure, organization] of consciousness" ((Northoff, 2014).p.xviii-xix). This implies a specific NCC for a specific content, a specific level, and a specific form.

As per (Northoff, 2014), "deep unconscious [mental?]." Here the unconscious mental state cannot only factually be brought into consciousness, as in the "dynamic unconscious," but even stronger it remains also principally impossible to do so. Following Searle, this is so because what is unconscious here is not "the sort of thing that can form the content of a conscious intentional state" (Searle 2004, 168). … Hence rules that guide the acquisition of language (or for instance our construction of perception in the retina and the visual cortex) are simply not the sort of things we can become conscious of at all. … The concept of the non-conscious refers to neurobiological phenomena that remain non-conscious [non-mental?] and cannot become instances of conscious at all. … "… the secretion of serotonin at the synaptic cleft is simply not a mental phenomenon. Serotonin is important for several kinds of mental phenomena…but there is no mental reality to the behavior of serotonin as such. Let us call these sorts of cases the "non-conscious." There are other examples of the non-conscious that are more problematic. So, for example, when I am totally unconscious, the medulla will still control my breathing. This is why I do not die when I am unconscious or in a sound sleep. But there is no mental reality to the events in the medulla that keep me breathing even when unconscious. I am not unconsciously following the rule "Keep breathing"' rather, the medulla is just functioning in a nonmental fashion in the same way that the stomach functions in a nonmental fashion when I am digesting food. (Searle 2004, 168)" (*p.lx*).

Lisbeth Nilsson (11/16/15)

To Alfredo: Thank you for shedding light on the neuroscientific meaning of feelings, as I also wondered about how feelings and emotions are related. I suppose you know of this article written by Damasio & Carvalho, 2013, The nature of feelings: evolutionary and neurobiological origins. It also added drive to feelings and emotions and helped to expand my insights of what make us do what we do.
http://www.nature.com/nrn/journal/v14/n2/full/nrn3403.html

[Nature Reviews Neuroscience 14, 143-152 (February 2013) | doi:10.1038/nrn3403: The nature of feelings: evolutionary and neurobiological origins, Antonio Damasio & Gil B. Carvalho: Abstract: Feelings are mental experiences of body states. They signify physiological need (for example, hunger), tissue injury (for example, pain), optimal function (for example, well-being), threats to the organism (for example, fear or anger) or specific social interactions (for example, compassion, gratitude or love). Feelings constitute a crucial component of the mechanisms of life regulation, from simple to complex. Their neural substrates can be found at all levels of the nervous system, from individual neurons to subcortical nuclei and cortical regions.

Pereira Jr. (11/16/15)

Lisbeth, my concept of feeling is close to Damasio´s, but a bit different too. I made a RG question on this subject. Please join that discussion if you are interested!

Pereira Jr. and Vimal (11/16/15-11/17/15

Ram: For you access consciousness is part of phenomenal consciousness: do you mean both are reportable?

Alfredo: Yes, access cness is the phenomenal cness that is reported, while other kinds of phenomenal cness can be reported if we have words or other signs available for intersubjective communication of it.

Ram: Confusion may be because of different meanings assigned to terms. You are implicitly assuming that duration of presentation of stimuli is longer than 50 msec and we are able to access working memory and able to broadcast the information (Baars' GWT), and both exogenous and endogenous attention are employed. This is called access consciousness as per (Block, 2005, 2007; Lamme, 2003). What about if the duration is 15-50 msec and there is not enough time to process information? This is called phenomenal consciousness as per (Block, 2005, 2007; Lamme, 2003).

Alfredo: This is not consciousness at all. It is sub-threshold unconscious cognitive processing. For the correct meaning of "phenomenal consciousness", please take a look at Max Velmans` (2009) book Understanding Consciousness.

Ram: However, Sperling's subjects are conscious of the presentation, although cannot report everything what they saw (Sperling, 1960, 1971, 1983; Sperling et al., 1971).

Alfredo: I attended to Lamme´s talk at ASSC in Brighton, 2012, and what he told there (about the clock experiment) is that after a 50ms (or less, I do not remember exactly) presentation of the stimulus the subjects reported **not seeing** the pointers, but were able to guess their position in a forced choice task. If they did not see, there was no conscious experience of it! There was only an unconscious cognitive process that helped the guess in the forced choice task. It is like blindsight: there is only an **unconscious** cognitive process for the visual blind spot. IOW, in both cases there is no phenomenal experience of the stimuli.

Ram: If that is the case, then I agree with you. However, transient and sustained mechanisms in our visual system are well established both psychophysically and neurophysiologically.

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Ram: I am using the definitions from (Block, 2005, 2007; Lamme, 2003): there are two types of consciousness
(a) Phenomenal consciousness is not reportable, which presumably occurs during less than 50 msec stimulus presentation, where top-down endogenous attention is not necessary.

Alfredo: This is not phenomenal cness, it is subliminal or implicit cognition.

Ram: In day time, close your eye and open it; whatever you see in 15-50 msec is a phenomenal experience, which is above critical threshold. To me, subliminal cognition is below this critical threshold (detection is less than 50% of presentation of stimuli) and it is not a conscious experience when I am not able to see it (for more than 50% of presentations).

Alfredo: It is not phenomenal experience; it is just a snapshot on modality-specific information processing that may or may not become part of a conscious episode.

Ram: As long as it is above threshold and subjects are able to see then it is experience.

Alfredo: In the temporal window of 50 ms the subjects do not see and therefore do not have conscious experience of the stimuli. For conscious experience to occur, according to Global Workspace and related theories, it is necessary for the stimuli to be globally broadcasted. In the biological version of the GW, it takes 300ms for the visual stimulus to reach the prefrontal cortex, and only in this case it is seen. Event-Related Potentials are good indicators of the time that is necessary for different stimuli to reach consciousness. Besides this time, the construction of a meaningful episode requires more processing,

forming cycles of around 2 seconds. I have a paper on this issue, but unfortunately it was rejected by ASSC people and now I am in the process of submitting to a journal that is not controlled by them.

Ram: I agree with you that we need enough time for "what it is like to be...". Therefore, we are certain for access consciousness which is based on sustained mechanism. However, transient phenomenal consciousness cannot be rejected; the necessary duration for this depends on the context.

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Ram: Phenomenal consciousness can occur without top-down endogenous attention

Alfredo: This is nonsense to me. For me, what is needed for phenomenal consciousness is the feeling of the information being cognitively processed. This is the "endogenous feedback" that I think is necessary for consciousness. In my modeling, this feedback is given by the astroglial network on the information processed in the neuronal network. Attention is a **result** of the endogenous feedback.

Ram: This is access consciousness for (Block, 2005, 2007; Lamme, 2003). I guess you are not appreciating the two sub-aspects of consciousness based on time: transient vs. sustained. They have presumably different neural processing.

Alfredo: Yes, I do not buy Block's distinction the way that Lamme uses it. The temporal distinction I make is between modality-specific cognitive processes (in the range of milliseconds) and conscious episodes (in the range of seconds; around 2 or 3 seconds, according to Poppel). If there is consciousness, in any temporal window, then it is phenomenal (in the sense of Velmans, Chalmers, classical phenomenologists and gestaltists). Reports occur when the contents of (phenomenal) consciousness are transmitted to other conscious systems by means of language or another media.

Ram: OK, but see my argument above, related to transient and sustained mechanisms.

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Ram: and top-down endogenous attention can occur without phenomenal consciousness; for example, subjects can attend to perceptually invisible objects.

Alfredo: This is again nonsense to me; attention is attention to something. When attention occurs, the object of attention is already formed as a map or representation in the neuronal network and the conscious feeling of it is already formed as a wave in the astroglial network; therefore, attention requires some degree of phenomenal consciousness.

Ram: You are mixing access and phenomenal consciousness division of (Block, 2005, 2007; Lamme, 2003). If you separate them then we are not in contradiction.

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Ram: Access consciousness is reportable, for which top-down endogenous and also exogenous attentions are necessary; it takes longer time than phenomenal consciousness.

Alfredo: It is a kind of phenomenal consciousness that reaches the effector systems and therefore requires more processing time than other types of phenomenal cness that do not reach the effector systems.

Ram: Perhaps, to avoid confusion, we need better terms for the two divisions of temporal consciousness:

(1) Transient phenomenal (or simply phenomenal) consciousness:
- (i) The duration of this type of consciousness is 15-50 msec (Sperling, 1960, 1971, 1983; Sperling et al., 1971);
- (ii) It has exogenous attention not endogenous attention (Botta, Lupianez & Chica, 2014; Koch & Tsuchiya, 2007; van Boxtel, Tsuchiya & Koch, 2010a);
- (iii) It uses iconic/fragile memory, not working memory;
- (iv) It is non-reportable (Botta, Lupianez & Chica, 2014);
- (v) It satisfies (Nagel, 1974)'s "there is something that it is like to be …")
- (vi) It is part of Kant's "phenomenon" (Kant, 1961).

(2) Sustained phenomenal (or access) consciousness:
- (i) The duration of this type of consciousness is larger than 50 msec; perhaps in seconds (Sperling, 1960, 1971, 1983; Sperling et al., 1971);
- (ii) It has both exogenous and endogenous attention (Botta, Lupianez & Chica, 2014; Koch & Tsuchiya, 2007; van Boxtel, Tsuchiya & Koch, 2010a);
- (iii) It uses working memory (Baars, 1988; Lamme, 2003; Rowlatt, 2009; Vandenbroucke, Sligte & Lamme, 2011)(Baars, 2005; Dehaene et al., 2006);
- (iv) It is reportable (De Brigard & Prinz, 2010; Prinz, 2011).
- (v) It satisfies (Nagel, 1974)'s "there is something that it is like to be …")

(vi) It is part of Kant's phenomenon.

Alfredo: It is pure nonsense. The "what it is like to be" [(1).(v)] requires at least one conscious episode to occur. Who could come to know what it is like to be human having his/her experience restricted to temporal windows of 50 ms??

Ram: You mean that "what it is like to be" is related to "sustained phenomenal (or access) consciousness" because enough time for processing is needed.

Alfredo: It is ordinary phenomenal consciousness, not "sustained" or "access" consciousness. Consciousness theory is about our everyday phenomenal experience, not about artificial controlled laboratory conditions.

Ram: Transient stimuli, such as lightening, are also for natural experiences although it is less frequent.

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Ram: I agree with you that what is reported in access consciousness is a content of phenomenal consciousness. However, there is not enough time to process information to recognize its content and then report in 15-50 msec. Perhaps, only gist is experienced, not the details.

Alfredo: In 50 ms there is only unconscious or implicit cognition, not consciousness. If there is cness, it is phenomenal. If the phenomenal content is reported, then there was sufficient time to reach the motor or endocrine systems, and what is reported is a phenomenal content (otherwise it is not a conscious report, but a reflex-guided or automatic action that is not mediated by the endogenous feedback - the feeling).

Ram: See my arguments above

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Ram: It seems that you are defining terms based on your Triple-Aspect Monism (TAM): physical aspect (aspect-1), non-conscious mental aspect (aspect-2), and conscious mental aspect (aspect-3). The conscious mental aspect has two sub-aspects: subjective feeling (experiences) and objective cognitive content. Is this correct?

Alfredo: Yes, thanks for the comment!

Ram: (...) the unconscious mental state cannot only factually be brought into consciousness, as in the "dynamic unconscious," but even stronger it remains also principally impossible to do so. Following Searle, this is so because what is unconscious here is not "the sort of thing that can form the content of a conscious intentional state" (Searle 2004, 168). ... Hence rules that guide the

acquisition of language (or for instance our construction of perception in the retina and the visual cortex) are simply not the sort of things we can become conscious of at all. … The concept of the non-conscious refers to neurobiological phenomena that remain non-conscious [non-mental?] and cannot become instances of conscious at all. … "… the secretion of serotonin at the synaptic cleft is simply not a mental phenomenon. Serotonin is important for several kinds of mental phenomena…but there is no mental reality to the behavior of serotonin as such.

Alfredo: The physiological unconscious state itself cannot be brought to consciousness, but the **information content** of it is brought to consciousness. All conscious states are constructed from signals, which are processed in brain physiology. Serotonin carries a message that becomes a conscious feeling. This is the correct **Monist** view; otherwise we fall into Chalmers' Property **Dualism** or Searle's Causal **Dualism.**

Ram: I agree.

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Ram: When I am totally unconscious, the medulla will still control my breathing. This is why I do not die when I am unconscious or in a sound sleep. But there is no mental reality to the events in the medulla that keep me breathing even when unconscious. I am not unconsciously following the rule "Keep breathing"' rather, the medulla is just functioning in a nonmental fashion in the same way that the stomach functions in a nonmental fashion when I am digesting food. (Searle 2004, 168)" (p.lx).

Alfredo: I disagree with you and Searle again. For me, all information processes are mental processes. They do not need to become conscious to be considered mental processes. A calculating machine or a digital computer perform mental operations (e.g., to add or subtract quantities). Every living cell performs many mental functions.

Ram: Do you accept dual-aspect information?

Alfredo: This is an artifact of Chalmers' lack of solution for his Hard Problem! I claim that information is intrinsically unconscious. What makes it conscious is not more information, or information referenced to the system that computes the information (informational self-reference). What makes it conscious is a feeling. A feeling is not information, but the effect of the content (the message) on matter/energy structures. It is a change in the form of the energy waves (ionic waves in the brain) induced by the message.

Ram: Do you mean that feelings do not have any information? But feeling of sadness has information related to sadness. Since feeling encompasses

experiences, then whatever we are 'seeing' right now, has lots of information in it if we include the content. Perhaps, the term 'feeling' is confusing. Does 'feeling' co-exists with its 3pp-NN in nature? If it does then you need 'attachment' mechanism to attach a feeling with a system to make the system conscious. What does this attachment mechanism is?

Note: You are using TAM concepts as if it well accepted by everybody. That is why it appears to contradict others who are materialists such Block, Lamme, and so on. We need to qualify our sentences and terms with our frameworks such as TAM (for you) or eDAM (for me). For example, in the TAM framework, feeling is not information, information is intrinsically unconscious, what makes it conscious is a feeling, and so on. This is essential; otherwise, it will be very confusing. I should do the same, when I use concepts from eDAM. I try to mention it, but I also forget. For example, in the eDAM framework, information is dual-aspect entity, feeling and experience are the same, and so on. Then readers will understand us what we are trying to say. Since I am aware of TAM, so I understand what you are trying to say, but not everybody knows TAM or eDAM. Similarly, since you are aware of eDAM, you might understand what I am trying to say from the eDAM point of view. Similarly, Block, Lamme, Baars, and so on are materialists; they are saying from materialism point of view; they do not explicitly mention this because materialism is still dominant in science and it is default if metaphysics is not explicitly mentioned. Unfortunately, we need to qualify our writing explicitly until eDAM and TAM are well known. What do you say?

Alfredo: TAM uses the same language of Psychology (and Philosophy of Psychology), which was very well reviewed in Velmans' book. This is the mainstream. Unfortunately, ASSC people bought Block´s distinction of types of consciousness and Lamme - an excellent neuroscientist, but using poor philosophy - uses the terminology for experiments in artificial Lab settings that have nothing to do with real life phenomenal experiences. I tried to explain my ideas on feeling and the putative function of the astrocyte network to Lamme, but he was not interested (about astrocytes, he told me he had similar ideas when he was an undergraduate student...). As they have rejected all my submissions to their journal without an adequate discussion, now I am more inclined to criticize their misguided Philosophy of Psychology and their sophisticated experiments that address the wrong issues. Please note that these criticisms are not directed to Baars; he gave attention, for instance, to the works of Roy John and Walter Freeman, which are fundamental for a neuroscientific psychophysiological view of consciousness.

Ram: Excellent; I will also join you. Unfortunately we are struggling in the world of materialists at present time. So it will take time. However, you may like to look at transient and sustained system carefully. I will also work on it.

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Ram: Cortical structures and related activities have information; can we call it physical information from third person perspective (3pp)? Our experiences also have information; can we call it mental information from first person perspective (1pp)?

Do you accept that a state of our brain-mind system is dual-aspect: the information is precisely the same in both 1pp-mental aspect and *inseparable* 3pp-physical aspect of the state of our mind-brain system; it is just different perspectives (1pp vs. 3pp) for "looking" the same information?

Alfredo: This is an epistemological interpretation of the duality of aspects. I have proposed an ontological interpretation: there are three aspects of activity in the brain-mind system: matter/energy, form/information and feeling/consciousness. Only the second aspect is informational. The first is physical and the third is an effect of the second on the first.

If you accept the above, then Searle might be talking about physical information. Please note that Searle may or may not accept TAM as your argument is based on TAM.

3.3. Is transient and sustained phenomenal consciousness dichotomy valid?

Vimal: The transient and sustained mechanisms are well established in psychophysics and neurophysiology (Ferrera & Wilson, 1985);(Courtney, Ungerleider, Keil, & Haxby, 1997);(Kulikowski & Tolhurst, 1973);(Mechler, Victor, Purpura, & Shapley, 1998);(Battelli, Cavanagh, Martini, & Barton, 2003);(Nakayama & Mackeben, 1989);(Yeshurun, 2004);(Carrasco, Talgar & Cameron, 2001);(Ling & Carrasco, 2005);(Konishi et al., 1998);(Schluppeck, Curtis, Glimcher, & Heeger, 2006);(Wolf & Lusty, 1994);(Fox, Snyder, Barch, Gusnard, & Raichle, 2005);(Kim & Johnson, 2010);(Yeshurun & Hein, 2011).

Can we have such dichotomy in phenomenal consciousness, which is defined as “there is something that it is like to be …” (Nagel, 1974))?

3.4. What are the necessary and sufficient conditions for HOT?

Berger (11/3/15)

As Rosenthal conceives of it, HOT theory holds that a mental state is conscious if and only if one has a suitable HOT about it. Now, there is some debate about what 'suitable' means. Rosenthal claims, at least, that the HOT must arise in a way that does not seem to be the product of inference or observation. But there may be other conditions that need to be met.

Vimal (11/3/15)

You and Rosenthal seem to claim that HOT is the necessary and sufficient conditions for consciousness. However Wilber seems to claim that HOT is the necessary but not sufficient conditions for consciousness. Your wrote, "the TP offers a necessary, but not sufficient, condition for consciousness".

"Rosenthal claims, at least, that the HOT must arise in a way that does not seem to be the product of inference or observation. But there may be other conditions that need to be met."

From this it is not clear to me what the necessary and sufficient conditions for HOT are. What is the origin of thought and HOT?

My understanding about necessary and sufficient conditions is as follows: "The *necessary* conditions for consciousness are those conditions that must be satisfied in order to have consciousness, i.e., if any of them is missing then the entity is not conscious. The *sufficient* conditions for consciousness are conditions, if satisfied, guarantee that the entity is conscious." (Vimal, 2015c).

Could you please elaborate it in detail as much as you can?

Berger (11/4/15)

You're right that Rosenthal and I think that a suitable HOT is necessary and sufficient for consciousness, whereas Wilburg argues that such a HOT is only necessary. I try to make the case for why Wilburg is mistaken in the paper I sent you.

As I say there, the TP (which is the motivation for HOT theory) only specifies a necessary condition for consciousness: namely, a mental state is conscious only if you're aware of it somehow. But being aware of a mental state isn't sufficient for consciousness because, after all, I can become aware of a mental state of yours, but that need not--and indeed cannot--make it conscious.

So Rosenthal tries to generate a theory of consciousness--HOT theory--that not only captures the TP, but also specifies what kind of awareness is both necessary and sufficient for consciousness. And this is what we capture by saying that the HOT, in virtue of which a state is conscious, has to be "suitable."

As Rosenthal argues (e.g., on p. 27 of that book), a mental state need not be conscious if we are aware of it in a way that seems to be mediated by inference or observation. If you tell me that I'm happy, and I really am happy, my state of happiness still need not be conscious. My state of happiness is conscious if

and only if I'm aware of it *and* it doesn't seem to me that I'm aware of it because of inference or observation. That isn't to say that I am not in fact aware of it because of inference or observation, only that it doesn't seem that way to me. So at least one part of what it is for a HOT to be suitable is for it not to seem to arise as a product of inference or observation. In other words, you have to seem to be directly aware of it.

Does that help?

Vimal (11/5/15)

[I] An individual (consists of body, brain and mind) has innumerable states including conscious, unconscious, and non-conscious states. Therefore, it is more precise to consider a specific state of an entity.

[II] Let us interpret the HOT theory of consciousness in the least problematic extended dual-aspect monism framework (eDAM) (Vimal, 2008b, 2010a, 2013, 2015c, 2015d), where a state of an entity has *two inseparable* aspects: 1pp-mental aspect and 3pp-physical aspect. [1pp: first person perspective and 3pp-third person perspective.]

In the eDAM framework, the *optimal* definition (that has the least number of problems) of consciousness is: *consciousness is the mental aspect of a state of a brain-mind system or a brain-process from the first person perspective; consciousness has two sub-aspects: conscious function and conscious experience* (Vimal, 2010b).

As per (Berger, 2014), "Rosenthal's higher-order thought ('HOT') theory of consciousness, which holds that one is in a conscious mental state if and only if one is aware of oneself as being in that state via a suitable HOT (see, e.g., (Rosenthal, 2005))."

In the eDAM, a self is the subjective experience (SE) of a subject (from first person perspective) (Bruzzo & Vimal, 2007), which is different from the objective experience of the subject (from third person perspective). The former includes inner feeling of 'I"-ness, whereas the latter is the experience of her/his own body as an object similar to that of any object.

Therefore, in the eDAM, Rosenthal's HOT theory holds one is in a conscious mental state if and only if one is aware of 'the subjective experience of the subject' as being in that state via a *suitable* HOT.

In the eDAM framework, the suitable HOT entails the relationship between three kinds of signals: the self-related neural-network signal interacts with the result of the interaction/matching between stimulus-dependent feed forward (FF) signals and cognitive feedback (FB) signals. Here, stimulus could be either exogenous (external target stimuli) or endogenous (internal stimuli without external target, internal target could be internally generated target as in dreams, imaginations etc.).

In the eDAM, the first-order state is the state related to "the interaction/matching between stimulus-dependent feed forward signals and cognitive feedback signals", which is not conscious yet; it needs some entity to

experience the matched specific experience; and that entity is the self. The self is the SE of the subject, which is the 1pp-mental aspect of the self-related state of the mind-brain system; the 3pp-physical aspect of this state is the self-related neural-network and its activities. Thus, a HOT theory is consistent with the eDAM framework.

To sum up, if suitable HOT is the necessary and sufficient condition for consciousness, then the necessary and sufficient conditions for the suitable HOT are the same as that for consciousness.

"The *necessary* conditions for *access* (reportable) consciousness are as follows: (1) the formation of neural-networks; (2) wakefulness; (3) reentrant interactions among neural populations; (4) fronto-parietal and thalamic-reticular-nucleus attentional signals that modulate consciousness; (5) integrated information (Φ) at or above threshold level; (6) working memory; (7) stimulus contrast at or above threshold; and (8) neural-network proto-experiences that are superposed *potential* subjective experiences (SEs) embedded in a neural-network as pre-cursors of SEs. The *necessary* conditions for *phenomenal* (non-reportable) consciousness are (1)-(3) and (5)-(8), i.e., the same as *access* consciousness except attention." (Vimal, 2015c).

[III] Once we accept a *suitable* HOT then the eDAM addresses the difference between Rosenthal's/your and (Wilberg, 2010)'s views and controversy related to *external* targetless HOTs. It seems that, for Wilberg, target means external stimulus only. Target needs to be precisely defined as it could be internal or external stimulus. This is because we can have experiences or HOT in our imagination (e.g., I can imagine red apple that will create a state) or in our dream for endogenous stimuli/targets even if there is no external target. A state related to this is can be thought of state for the endogenous/internal target without external target; this is what I understood by targetless HOT, where a target is an external stimulus. The state of the tip-of-tongue related to author's name need to involve self to make the HOT as a suitable HOT.

[IV] There are over 40 meanings assigned to the term 'consciousness', which were categorized in to two groups: functions and experiences as elaborated in (Vimal, 2009). Rosenthal and you seem to include experiences related to both internal and external targets for consciousness; whereas, Wilberg seems to use only external target in his definition of consciousness. Thus, different meanings are assigned to the term "consciousness" leading to further confusion.

Thus, Rosenthal and you seem to defend the view by implicitly using internal target also in consciousness, whereas Wilberg seems to use only external target and hence conclusions appear contradictory, although in reality there is no contradiction. Misunderstanding arose because of the lack of the precise definitions of target and consciousness and their use.

[V] To sum up, as long as self is involved in interactions, i.e., all three kinds of signals (self, FF and FB) interact, then the self should be able to experience the specific experience; otherwise, a first-order state will be created via the interaction/matching of FF and object related FB signals, but there is no entity

(such as self) to experience it. This explanation addresses the controversy between first-order and high-order frameworks.

What are your comments on the above view?

[VI] Queries: [1] What are the origins of thoughts? Our thoughts could be due to intrinsic activities and/or because of extrinsic stimuli. Is this correct?

[2] Thoughts, HOTs, attention, memory are included in cognition. Cognition is a functional sub-aspect of consciousness, whereas our subjective experiences are the experiential sub-aspect of consciousness. If a suitable HOT (functional sub-aspect of consciousness) is necessary and sufficient condition for the experiential sub-aspect of consciousness, then this is consistent with the hypothesis of 1-1-1 correspondence between function, related experience, and related neural correlates. Do you agree?

Berger/Vimal (11/10/15)

[II]

Berger: I'm not sure if this is entailed by eDAM, but my version of HOT theory does not hold that the 1pp mental appearances of consciousness are distinct from the 3pp physical features of their brains. I think mental appearances are just brain activity that a creature is aware of in the right kind of way. So we have two perspectives, the 1pp and 3pp, on the same thing. It may not seem like the same thing, but it is.

Vimal: The eDAM also says that the information is precisely the same for both aspects/perspectives; in addition, they are inseparable, except HOT bases on problematic materialism (consciousness is generated by non-conscious matter such as brain) and eDAM bases on the least problematic dual-aspect monism.

Berger (11/19/15): I obviously don't think that materialism is problematic--I think it's reasonable to think that consciousness can be generated by non-conscious matter. This is especially clear if you grant a HOT model on which thoughts can occur nonconsciously (and so are unproblematically material) and that consciousness is just a product of certain kinds of thoughts.

Vimal: There are over 40 meanings attributed to the term 'consciousness' as elaborated in (Vimal, 2009), which were identified and categorized according to whether they were principally about function (thoughts can be considered as functional aspect of consciousness) or about experience. If you attribute the product of certain kinds of thoughts as consciousness then perhaps there is not much problem. However, the experiential aspect of consciousness (what it is like to be …) is different and materialism has serious well-known explanatory gap problem as elaborated in (Vimal, 2010b, 2013).

[IV]

Berger: I agree that the term 'consciousness' is highly ambiguous. And your idea that Wilberg and I are just talking past each other because we're using

different notions of it is an interesting one. But I'm not sure that's what's going on. On my view, a conscious state is a state that it (suitably) seems to you that you're in--and I think Wilberg agrees. And we both agree that, whenever it seems to you that you're in a state, there is something that exists--namely, the HOT in virtue of which it seems to you that way. What we disagree about is whether or not the state that it seems to you you're in must exist for there to be consciousness. I say it doesn't: You can be in a conscious state that doesn't exist--which is to say that it can seem to you that you're in a state that you're not in fact in. Wilberg disagrees. He thinks that if it seems to you that you're in a state, but you're not in that state, you're not in a conscious state. I think he's wrong because consciousness isn't a property of the target state (the state you're aware of being in, but might not be in), but a property of you--to be in a conscious state is to be aware of yourself as being in a state. So in that way we disagree about what the predicate 'conscious' applies to. I say it applies to creatures; Wilberg says it applies to the target of a HOT. Perhaps that's what you had in mind? As I say in the paper, though, we often do apply 'conscious' to the target states, and that's fine as far as it goes. It's just that it is, in a way, misleading and a kind of loose talk.

Vimal: So difference is: you claim that consciousness is property of a creature to resolve the problem of targetless HOT; whereas, Wilberg claims that consciousness (C) is the property of a state (S) of the creature. Since a creature can have innumerable states, one of them may be conscious of seeing redness of ripe tomato, i.e., (S_1, C_1), second may be related to the taste of the sugar, i.e., (S_2, C_2), third may be listening to music, i.e., (S_3, C_3), etc. If you assign consciousness to the creature then it should be the same experience in all states of the same creature, which is obviously not true in this example. Therefore, a specific experience/consciousness should be assigned to a specific state.

Berger (11/19/15): That's a nice argument. But I don't think it shows my view is problematic. I think that when we say that "a creature C is in a conscious state S" we mean that the creature has a certain property--namely, the property of being aware of itself as being in S. But that means that the creature can be in many different kinds of conscious states at once--that is, the creature has many kinds of properties. The creature might be aware of itself as being in state S, state S_1, state S_2, etc. And being in those conscious states are all distinct properties of the creature.

Vimal: Yes, S is a unified state as the superposition of S_1, S_2, etc. Does Wilberg claim that micro-consciousness C_i is the property of i^{th} state S_i of the creature? If this is true, then macro-consciousness C is the property of unified macro-state S of the creature at that moment, which is the same as saying C is the property of the creature. Thus, there is no contradiction. Now, let ripe-tomato is missing, then (S_1, C_1) will be missing also. However, the creature can now imagine ripe-tomato from her memory; this will create S'_1, with corresponding C'_1. Again, I do not see any contradiction.

[VI]

[1] *Berger*: I think so. Sometimes I am caused by extrinsic stimuli to have a thought. An apple causes me to see the apple and that causes me to think that there's an apple. But sometimes I can just "bring up" a thought myself endogenously. I just sit here and think that Paris is in France. How I do that, however, is something that is still unclear to me.

[2] I'm not sure I agree. For one thing, I think much thinking (and cognition generally) occurs without being conscious. According to HOT theory, a mental state is conscious iff one is aware of it via a HOT--but those HOTs need not be, and typically aren't, themselves conscious. So cognition is not a functional sub-aspect of consciousness, it's the other way around. And on my view, the expression 'subjective experience' just means conscious mental state. So while I agree that you can't have a mental function without some neural activity (because mental functions just are neural activities), I don't think you have to have experience--some mental activity occurs without consciousness. Indeed, that is what HOT theory is trying to account for: the difference between conscious mental states and mental states that occur outside of consciousness. Does that help?

Vimal: Well, I guess, I was not clear. If you want to pick up a coffee, then function is picking up, experience is where the cup is, and the structure is all related anatomy and physical activities. In this example, structure : function (cognition) : experience (consciousness) :: 1:1:1 and this triad is inseparable for a specific time, specific space, and specific condition; otherwise, if there is any mismatch then you will not able to pick up the cup.

Berger (11/19/15): I agree that our cognition and experience is often wrapped up. But one of the key motivations for HOT theory is that many kinds of mental activity, including thought, can occur without experience at all. There are many commonsense and experimental examples of unconscious thinking and arguably even unconscious acting that do not require the creature to be aware of itself as thinking or acting. If so, then experience isn't inseparable from action. It often accompanies it, but it need not. Or at least that's what I think.

Vimal: In that case experience is missing, but function (unconscious thinking) and related structure must remain intact. Missing does not mean *separable*; it means experience is latent because once you become conscious then experience, function, and structure return back to be inseparable. This example does not violate the *doctrine of inseparability* of aspects and sub-aspects.

Pimiskern, Joachim (11/20/15)

It sounds very philosophical. What's the main statement, in one or two sentences?

Vimal

As per (Wilberg, 2010), “a mental state is conscious if and only if it is accompanied by the [suitable] HOT [high order thought] that one is in that state” “A state’s being conscious consists in its being a state one is conscious of oneself as being in” (Rosenthal, 2005). As per (Berger, 2014) argues that consciousness a property of individuals, not a property of states as Wilberg claims. My question is: if a suitable HOT is both necessary and sufficient for consciousness as Berger claims, then what are the necessary and sufficient for a suitable HOT?

Pimiskern (11/21/15)

An intimate relationship exists between consciousness and working memory. Working memory has a certain capacity and empirical observation suggests that there is no way to extend this capacity. That allows a variety of conclusions, thought experiments. What you can't do is to extend WM using consciousness: ok, I store 7 items in my WM, 7 items in my consciousness, that adds up to a total of 14 items I'm able to store at will. That obviously doesn't work. BTW, the same is true for considering modalities and WM. You can store e.g. 7 colors in WM and you can store e.g. 7 syllables or sounds in WM, but all of these don't add up to a WM capacity of 14. It is like an addition theorem for WM, that the total capacity is limited to about the Miller Number, however big its real value might be. That leads us to the conclusion that the content of consciousness is yet one more modality. WM can't store analog values. Otherwise you could encode lots of phone numbers in a single number and have many phone numbers at once in WM. Nobody has observed such. The conclusion is: items stored in WM are symbolic. Conscious thoughts are patterns of symbols that reside in the present in working memory.

Vimal

Are you trying to say that WM is a necessary condition of HOT? If so, I agree with you. You may like to look at other 9 necessary conditions of consciousness in the RG-post Vimal (11/13/15). Let me know if you agree that they are also true for a suitable HOT. Next question is what are the sufficient conditions for HOT?

Edwards, Jonathan (11/22/15)

I think these discussions just go around in circles because they invoke concepts that can have no place in a scientific or mechanistic analysis. Thus: 'that one is in that state” “a state one is conscious of oneself as being in” 'consciousness a property of individuals, not a property of states' are statements that cannot be used in an analysis that tries to break consciousness down into neural mechanisms because they have no power to lead to useful predictions, unless 'one' or ‘individual' or 'being in' or even 'state' are defined. My own impression after listening to Rosenthal and discussing with him is that he has identified certain very plausible aspects of what may be

required for us to discuss consciousness but that the HOT concept can never get anywhere because it is couched in these unusable terms. I agree with Joachim that a discussion of short term and working memory is much more productive.

Vimal

Thanks. Your single neuron consciousness is interesting but it would be for micro-consciousness; for example, V8/V4/VO cell for color. Then there should be binding of all attributes of stimuli. You may like to look at other 9 necessary conditions of consciousness in the RG-post Vimal (11/13/15). What are your comments? Do you like to add any other necessary and sufficient conditions?

Edwards, Jonathan (11/22/15)

No, Ram, my single neuron consciousness would not be for micro-consciousness because that is not what the theory is. I can see no evidence for there being micro-consciousnesses or proto-consciousnesses. How could one test for their existence? How would they 'combine'? They cannot be scientific concepts I think. What we have as part of our science is full experience or consciousness - it is the observation that tests the prediction. Postulating micro-versions is, I think, vacuous.

I am not sure what to make of your list of conditions to be honest. What is the formation of a neural network? There are neurons and they are connected in ways we partially understand in brains. But what would define a subdomain as a 'network'. And what would a 'self' be?

I am afraid I am a practical cell biologist at heart and need things to be defined in terms of specific causal relations or events rather than 'systems' or 'selves'.

Vimal

[1] The formation of neural-networks (NNs) during development is necessary for consciousness. Neural-networks are necessary physical structures for neural correlates of consciousness (NCC) (Crick & Koch, 2003b; Tononi & Koch, 2008). Otherwise, consciousness cannot occur because there would not be proper physical infrastructure where consciousness (subjective experiences (including feelings, emotion- and thought-related experiences) and functions) can be supported. If the V8-NN is deleted, subject becomes achromat.

[2] Self (the experiencer/agent of a system) and self-related neural network for generating intuition for the system being conscious (Arico et al., 2011) and for feeling a specific subjective experience. If we delete this, then subject will have no consciousness.

Oliver, Alan 4/9/16

Alan: I have come to the conclusion that we cannot separate the two kinds of memory from Samapatti and eDAM and I will write a bit about that later today. I am becoming more aware of just how much I live in what Patanjali referred to as the first kind of memory where the process and instrument of apprehension is primary.

Ram: Very interesting. I have attached Swami Vivekananda's (my ideal yogi) commentary of Patanjali YogaSutra; please write me page numbers where Patanjali discusses two kinds of memory, you mentioned.

Alan: Almost everyone I know operates in the second kind of memory in which the object of apprehension is primary. For years friends and colleagues would be exasperated by my shorthand answers, requiring further questions to get a comprehensive description or statement from me. That is of course because I use the first kind of memory which is obviously a narrative without any physical correlates such as emotion and psychophysical sense. So when I have an experience of the bliss state the memory of that experience is only the narrative, which you would call the second person perspective. In other words, the 'observer' or Buddhi level of Consciousness. Thus, the physical/brain memory does not contain the experience of bliss despite the fact that the experience was factual.

Ram: In the eDAM, there are 4 kinds of brain-based memories as elaborated in section 2.1.6 of (Vimal, 2015f). In my view, Samapatti has NCC, so are all kinds of memories. Let us practice 'real' science (reproducible evidence + logic); logic-based pseudo-science is not very useful.

Hari, Syamala 4/9/16

Dear Ram,

Please see http://www.swamij.com/yoga-sutras-10511.htm for a clear description of two kinds of memory.

Dear Alan,

The book on Patanjali Yoga Sutras you have been reading was written by somebody, who I do not think has done much effort for spiritual progress. He is a scholar, who simply translated the Sanskrit text by Vyasa without an insight. What this process and instrumentation is he does not say. This process is involvement of the ego/self/'I', desires, emotions, past experiences, and memory. This is explained in the Vivekananda's commentary in Yoga Sutras as well as in the link above. Vivekananda does not however, explicitly mention the two kinds of memory you have been referring to.

As I said before, J.Krishnamoorthy and Buddhist Philosophers have discussed at length, the two kinds of memory you often talk about.

Vimal

I guess, Yoga Sutra 1.11 implies long term memory with or without subjective biases.[18]

It seems that Patanjali wrote Yoga Sutras in problematic *Prakṛti* and *Puruṣa* of *Sāṃkhya* (1000–600 BCE or even before *Gīta:* 3000 BCE) metaphysics (interactive substance dualism). In *Sāṃkhya*, *Puruṣa* (consciousness) and *Prakṛti* (matter) are two fundamental substances although they can interact. Therefore, all interpretations also have problems. We need to re-interpret Patanjali's *Yoga Sutras* in the eDAM framework.

As per my reading, Patanjali did not propose two kinds of memory (is 4th *Vrttis*), rather he proposed two kinds of recall: (i) with subjective bias (in which *manas/mana, buddhi*, and *Ahamkara*/ego and three other *Vrttis* (*Viparya*/false substitution, *Vikalpa*/verbal delusion, sleep & dream) bias the pure long memory)[19] and (ii) pure long term memory without any bias.

Syamala

Ram: As per my reading, Patanjali did not propose two kinds of memory (it is 4th *Vrttis*), rather he proposed two kinds of recall.

Syamala: By that if you mean that bias is being created or not, while reactivating the stored neural trace, the effect is the same from the point of view of what Oliver is saying; in other words, one may say there is two kinds of recall, one is biased and one is factual. But to find out what is responsible for that difference is what is interesting and that is something to do with past experiences, which cognitive scientists call episodic memory.

Ram: As per Wikipedia, "Researchers do not agree about how long episodic memories are stored in the hippocampus. Some researchers believe that episodic memories always rely on the hippocampus. Others believe the hippocampus only stores episodic memories for a short time, after which the memories are consolidated to the neocortex. The latter view is strengthened by recent evidence that neurogenesis in the adult hippocampus may ease the removal of old memories and increase the efficiency of forming new memories.[10]". This seems to imply that short episodic memory might be short term memory (working memory) and long episodic memory might be long term memory

Syamala: Another point, is in Sanskrit books, sometimes the word manas is used as one of the four components of the Antahkarana Chatushtayam, and sometimes collectively for the mind in English which stands collectively for all thoughts, ego, experiences, desires, etc. We have to understand the word from the context. Similarly, chitta is used as a synonym for manas sometimes.

Ram: I agree that Antahkarana (Internal Instrument) has 4 components: Ahamkara/Ego, Buddhi/Intellect, Manas, and Chitta. Please provide reference for the latter where manas = western term 'mind'. As per (Rao, 1998), "The *manas* is the central processor which selectively reflects on the material provided by the senses and determines its character by assimilation and discrimination" (p.319). In my view (Vimal, 2012), the western/scientific term 'mind' is different from eastern term '*manas*' or '*mana*', which is a subtle matter, the central processor, and is liaison between *Puruṣa* and *Prakṛti*. This western scientific term 'mind' includes all mental entities (such as cognition, functions, experiences/appearances, self/soul, *Brahman/Parmātman/*God).

Syamala (to Alan): I do not think that the predominantly narrative nature of your memory causes difficulties for anybody. On the other hand, unprejudiced, unbiased, factual speech and actions avoids conflicts and complications in life. Sometimes people may take nonattachment for insensitivity but they will eventually understand your true nature. The unbiased true nature of all of us is compassionate not insensitive.

Alan Oliver

Alan: The difficulty arising from my narrative memory stems from their inability to join the dots so to speak. My thinking causes similar problems because there does not appear to be any discernible linkage (or time) between their question and my immediate answer.

Anyway, enough of that. What Ram's response tells me that we are on different planets. With all due respect Ram, I think that you and most of science are preoccupied with deconstructing simple statements into lengthy discussions about what a word can mean and what Patanjali might have intended by these words from centuries past. I can only say what I have experienced in simple terms, which is why, for me, the narrative memory relates to the position of the detached observer. What you, and science makes of that is your right, and probably your problem. I have put forward my contribution and that is as far as I can go.

Ram: I was just trying to write what I understood by reading Sutra 1.11 and relating it to 'real' science. By the term 'narrative memory' do you mean, your 'self' (Alan) is detached from your long term episodic memory encoded in Alan's Long-term-memory area (such as hippocampus) of his brain? You as detached observer just narrate it as if another person is narrating your long term episodic memory. Do I understand correctly?

I also do not understand why you become insensitive to the pain of others in Samapatti state, whereas my understanding is that Samadhi state gives us godly virtues such as compassion, love, and humility, which is just opposite to what you get. Do I understand correctly? My understanding of detachment is NOT being insensitive as a passive process; rather first you get attached and then detach yourself, which is active process and needs lots of effort to do in

mundane life. For example, if one is attached to one's family member with lots of love, then detaching from him/her needs lots of effort.

3.5. Discussion with Sehgal, Vinod Kumar (Oct. 22, 2016)

The following comments are for Section 2.1.4.

3.5.1. Sources of attention and dichotomy of consciousness

1. Sehgal

Most of the definition of attention defines attention either in terms of functions it performs or effects it cast upon the perceptual or cognitive information. None of the definition traces the source of attention and its ontology. For example, attention "described as a cognitive and behavioral process of selectivity and concentrating on discrete information" indicates a specific process done on discrete information. But what is the ontological reality which does this process and what is the source of that ontological reality?

However, under phenomenology centered approaches, attention has been described NOT as a state of consciousness with characteristics of phenomenal consciousness but that one which affects the state of consciousness. Though this description of attention seems to give some clue about source and ontology of attention but it seems to miss the target. But under the same category, attention as a distinctive mode of consciousness happens to hit the target in terms of source and ontology of attention.

2. Vimal

As elaborated in Section 2.1.4, the sources of attention could be exogenous (bottom up) stimuli for phenomenal (non-reportable) consciousness and endogenous (top-down) stimuli for access (non-reportable) consciousness. From neurophysiology point of view, the 'sources' of attention may be thalamic reticular nucleus (TRN) for bottom-up or frontal cortex for top-down direction. "Attention as a distinctive mode of consciousness" is elaborated further in (Wu, 2014).

3. Sehgal

Consciousness does exist without exogenous and endogenous stimuli for attention also. So why to make a distinction between reportable and phenomenal consciousness? In other words, consciousness does exist regardless of the fact whether attention (both exogenous and endogenous) exist or not. But the reverse of this being not true. Exogenous attention appears to be another name for perceptual attention. Endogenous attention is another name for cognitive internal attention. Consciousness is required in building both types of attention. Dichotomy of consciousness in reportable and non-reportable categories for exogenous and endogenous is artificial.

4. Vimal

There are at least two types of cells and also two types of psychophysical temporal mechanisms: transient and sustained. One could argue that the distinction related to phenomenal (non-reportable, transient, attention not needed) and access (reportable, sustained, attention is necessary) facilitates the understanding of brain processing better. The ongoing debate between attention and consciousness is briefly elaborated in Section 2.3.3.1.

3.5.2. Exogenous and endogenous attention

3.5.2.1. Is attention necessary for feed-forward signals?

1. Sehgal

In the eDAM, you have described attention as the neural signal that modifies the feed forward (FF) signal. But I am doubtful if without attention, feed forward signal is built at all, leave away modulation. I think without attention, stimulus-related feed forward signal is not born at all. It is the attention which creates the feed forward signal before it enters retina.

2. Vimal

In my view, the FF signals are stimulus dependent, where stimulus could be exogenous or endogenous. This is because if there is no external or internal stimulus then there is no attention and no experience.

3. Sehgal

I am not disputing that FF signals are stimulus dependent -- both external and internal. My argument is that without attention, FF signal is not even built up let alone modulating it.

4. Vimal

As elaborated above if there is no stimulus, there is no attention. This means that the root cause of stimulus-dependent FF signals is stimuli, i.e., attention is not the root cause.

3.5.2.2. Sources of endogenous and exogenous attention

1. Sehgal

You have described fronto-parietal cortex as the source for top-down (endogenous) attention and TRN for bottom up (exogenous) attention respectively. I assume these are the neurological sources for the visual color attention. Are other perceptual stimuli having same source for attention or different one? Similarly, attention arising out from cognitive stimuli viz. memory, imagination should also be having specific sources. Please confirm about the sources of attention towards different perceptual and cognitive targets.

2. Vimal

All types of reportable consciousness need attention because extra processing is needed; however, phenomenal consciousness does not need attention. Cognitive stimuli are related to endogenous (top-down) sources and external stimuli are related to exogenous (bottom-up) sources as elaborated above in Section 3.5.1.

3. Sehgal

My query was: Understood that cortex and TRN are sources of top-down and bottom-up VISUAL attention respectively. However, whether other perceptual and cognitive attentions have different sources of attention or same as one for visual attention? If different, what are those sources? There are innumerable perceptual and cognitive stimuli corresponding to which there will be innumerable categories of attention. Have scientists pinned down sources for each category of the innumerable type of attention? You seem to imply as if consciousness exists by virtue of attention. If it is so, then it is wrong. It is the attention which exists by virtue of consciousness but not the converse one. However, in the case of external (perceptual) and internal (cognitive), we may call consciousness by different names such as reportable or non-reportable. By using different names or semantics, reality does not change.

4. Vimal

Yes, similar sources of other than visual attention should be present but their NNs might be different; my interest is mostly on visual system; if you are interested then you need to search literature. In my view, attention is one of the necessary conditions of access (reportable) consciousness and not for the phenomenal (non-reportable) consciousness; justification is given in Section 2.3.3.1; however, this is an ongoing debate.

3.5.2.3. Attention and two pathways: ventral pathway for 'what' is the information and dorsal pathway for 'where is the information

1.Sehgal

You have traced out the pathways of visual attention in quite graphical manner thru two ventral and dorsal pathways. I don't know much about the neural and brain Science, therefore, unable to comment upon this. However, visual perception might be a naive phenomena, it would not have been much difficult to trace this path. But for cognitive (endogenous) attention say for a target from imagination or memory, tracing the path shall not be so easy. Have attention paths traced out for cognitive targets also? Please confirm. I can't understand why two paths have been traced out for visual attention? In reality, how can attention operate thru two different paths? Up to V2, the path is common but after that, it branches out in two different directions.

2. Vimal

Yes, there are many researches on both exogenous (external) and endogenous (cognitive, internal) stimuli related attention; see references in Sections 2.1.4 and 2.3.3.1. From visual area V2, signals bifurcate one goes to ventral areas for 'what' information is being held (such as color related information) and other dorsal areas for 'where information' is being held (such as motion for the information processing say 'rightward moving red ball') as elaborated in above Sections. As per Deric Bownds, "Some cells fire while 'what' information is being held, others fire while 'where' information is being held, and still others register a combination of 'what' and 'where' activity. [(Rao et al, 1997)]".

3. Sehgal

(i) Should it mean that as on date, pathways for cognitive (endogenous) attention have not been traced out and researches are still going on to find the same? (ii) If the stimulus is a still (without any motion) colored source, even then will it be branched out in dorsal areas?

4. Vimal

(i) There are many researches already done and still going on. (ii) Yes, ventral and dorsal pathways are well worked out. Some references are given but you need to search literature if you are interested further.

3.5.3. Reentrant signals and attention

1. Sehgal

"Reentrant interactions among neural populations entail consciousness, whereas attention modulates consciousness (Edelman, 2003)." Above seems to be a materialistic interpretation of consciousness. What has it to do with the eDAM?

2. Vimal

Yes, Nobel laureates Edelman and Crick were materialists, but their colleagues/students Tononi and Koch's view is somewhat close to the eDAM; see (Vimal, 2015d) for detail. Materialistic models (a) explain well the information processing in NN (the physical aspect), (b) the information is the same in both aspects, only viewing-perspectives are different, and (c) it is immediate translation to 1pp language for subjective experiences without loss of information. Therefore, it is justified to include them for describing the physical aspect in the eDAM framework. Similarly, I have included idealism based models such as (Kastrup, 2016) for describing the mental aspect. For example, all possible SEs are the excitations of Universal Potential Consciousness (UPC) (the mental aspect of the dual-aspect unmanifested state of primal entity (*Brahman*)), in analogy to the ripples of an ocean.

3. Sehgal

Please consider your last line above. The eDAM starts with sub-strata of discrete QFs having dual physical and mental aspects of unmanifested state of the primal entity from the primal stage. These QFs are already excitations. There is no concept a unified whole holistic ocean of any primordial energy. Discrete QFs do emerge out from an empty vacuum. So the analogy of UPC akin to an ocean is misplaced. These could be excitations if instead of empty vacuum; the eDAM would have postulated an ocean of primordial energy as source of QFs. Furthermore, I would like to make a few queries related to neuroscience. (i) When stimuli from different exogenous and endogenous sources enter the FF pathway of a brain, they do affect respective distinct areas of the brain. In other words, visual stimuli affect visual areas and audio stimuli affect audio area of the brain. (ii) By affecting the respective areas by specific stimuli implies neurons of that specific area form (build) an NN. (iii) It means neurons of different areas of the brain sensitive to a stimulus should possess some distinct features to enable them to build an NN as a response to the particular stimuli. (iv) Now my queries are: (a) Whether Scientists have identified and delineated distinct features of neurons for different areas of the brain (as sensitive to different stimuli) (b) Apart from distinct features of neurons, are there some other factors also to make neurons of any specific area of brain sensitive to particular stimuli?

4. Vimal

My working hypothesis related to co-evolution of aspects and the emergence of CM, QM, and deeper level physics is given in Section 3.5.1.6 of (Vimal, 2016),[20] where I have proposed that the fundamental sub-strata is the pre-BB (quantizable) dual-aspect vacuum (*Śunyatā*) field with QFs. In the quantum field theory, quanta are modes related to the excited states of a field. Therefore, this vacuum field can be considered like a unified/holistic field. QFs are virtual quanta of very high Planck-energy in very brief Planck-time from the 3pp. Corresponding to QFs, the excitations/fluctuations of UPC are from the 1pp so it is a part of mental aspect of unmanifested state of primal entity (*Brahman*). Information is the same in both aspects; it is just viewing the same information from two different perspectives. Vacuum means there are no matter in it, but QFs are fluctuations of energy and it is in pre-BB stage. Ocean needs physical space; but at pre-BB stage there is no physical space; it is an abstract space. Physical space-time starts after BB. The analogy is just for understanding given by (Kastrup, 2016); one should go beyond that. (i) Yes. (ii) The anatomy of a NNs and pathways are already physically built and are adult-like during co-development and sensorimotor co-tuning by age 18. However, stimulus related signals flow in FF pathways during stimulus presentation and necessary neurons are recruited in the respective NNs to build a specific NN. (iii) Yes. (iv) (a) Yes. (b) Yes, attention can make the stimuli more sensitive, i.e., the critical threshold contrast decreases and sensitivity increases.

3.5.4. Building a conscious state and attention

3.5.4.1. Sehgal

At the end, it has been concluded that attention is a necessary (but not sufficient) condition along with other necessary conditions of wakefulness, conscious state, working memory for building any neural network. Now, in the context of the eDAM, I am raising the key query on which entire section is silent. From the 3pp, attention has been described as some neural signal as sourced out from fronto-parietal cortical areas (endogenous/top-down source) or TRN (exogenous/bottom-up source of attention). As per eDAM, attention at 1pp level is the automatic translation of the information of NN of attention because information is the same in both aspects. However, here an unresolved dilemma is that the NN (including that one for attention) cannot be built *without the attention from the 1pp. So how will attention from the 1pp manifest from its NN when for building its NN, attention itself is required as an essential condition?* The Same logic is applicable to other essential conditions of eDAM for creating any NN viz. conscious state, intention, working memory. In general how essential conditions will manifest from the 1pp for the manifestation of their related NN when these conditions are prior to creating any network for such conditions.

(Oct. 23, 2016): I understood all the things and agree with most of the concepts but the article is silent on one key issue. *The key issue has been if attention, consciousness, intention at 1pp level are essential conditions for built up of NN (3pp) for the manifestation of any SE(1pp), how and from where these elements appear at 1pp levels since NNs for these elements should also require these elements as pre-conditions.* This has been a very important aspect of eDAM which needs to be explained.

3.5.4.2. Vimal

Now you implicitly started thinking from *Sāṅkhya* and/or idealism/*Advaita* point of view unknowingly because they are engraining in your mind-brain system and you are fully in the grip of these metaphysics. Let us take an example of a visual system. The steps of the building of a conscious state are: (a) ARAS signals make the related NN awake (as elaborated in Section 2.1.2), then (b) stimulus dependent signals above threshold level travel from retina to LGN and activate the source of exogenous attention TRN, (c) then the signals from TRN activate bottom-up exogenous type attention. We can view this attention from either 1pp or 3pp does not matter because information is the same and aspects are *inseparable*. Idealists prefer to view it from 1pp and materialists from 3pp. Please note that aspects are *inseparable*, which entails that there is immediate translation of information between the two aspects. Therefore, if idealism based information (such as attention is from 1pp) is

immediately translated to neural information in its 3pp-physical aspect or vice-versa. Thus your argument is not tenable.

3.5.4.3. Sehgal-Vimal (Oct. 24, 2016)

1. Are a conscious state and attention needed for built-up of a specific NN

Sehgal

For the built up of any NN for any SE, the presence of a conscious state of mind and attention from the 1pp level is an essential condition? YES/NO?

Vimal

Since information is the same in both aspects and aspects are inseparable, 1pp or 3pp does not matter in the eDAM because of the immediate translation; you view the same information from 1pp or 3pp; the eDAM is neither idealism/*Advaita*, nor *Sāṅkhya*. A conscious state is created after matching FF-signals and FB-signals is complete and all necessary conditions (including attention) are satisfied. Therefore, YES for attention and NO for conscious state.

2. Is NN required for consciousness and attention?

Sehgal

When a person will come in the state of consciousness or attention, from out of unconsciousness of deep sleep or from birth, should a 3pp-NN be required to build 1pp-consciousness/attention. YES/NO? As per eDAM, YES, for any 1pp, NN is required.

Vimal

YES.

3. Is consciousness and attention required for building a specific NN?

Sehgal

For building NN for consciousness and attention, should consciousness and attention be required or not since it is the essential condition for building any NN. YES/NO? (a) If YES, from where consciousness as an essential condition will manifest? (b) If NOT WHY no NN should be required for building NN for consciousness. Please stick to above logical sequence of reasoning and don't bring any other issue in between in order to not to lose focus on core problem.

Vimal

Your query is ill-posed for the eDAM framework; you are trying to ask from the idealism/*Advaita* or *Sāṅkhya* point of view, which is illegal in the eDAM. The formation of NN (Section 2.1.1), attention (2.1.4.) and other necessary

conditions (Section 2) along with matching and selection mechanisms are needed to build a dual-aspect conscious state. Attention modulates the FF and FB signals and threshold contrast level. This conscious state has the specific experiential and functional sub-aspects of consciousness as 1pp-mental aspect and its inseparable NN and activities as 3pp-physical aspect. Therefore, attention may be needed in 3pp-NN building if we want access (reportable) consciousness, but your query is ill-posed for 1pp-consciousness because they (1pp-cosnciousness and 3pp-NN) are inseparable 1pp-mental and 3pp-physical aspects and hence one cannot be derived from other in the eDAM.

Sehgal

You have indicated that ARAS signal makes the related NN awake. I don't know what you mean by ARAS. But if you want to convey that some NN for consciousness was built right from birth which is awakened by ARAS signal my next query shall be: How related NN for consciousness was built in the absence of consciousness?

Vimal

The ARAS (ascending reticular activating system) makes the NN awake and is one of the necessary conditions for consciousness as elaborated in Section 2.1.2. During co-development and sensorimotor co-tuning, physically NNs are already built and are fully adult-like by age 18 or so in general. However, to build a specific NN for specific stimuli with attention, online build up may be necessary. Again your query is ill-posed for the eDAM; it should be directed to the problematic idealism/*Advaita* or *Sāṁkhya*.

4. Postulates of the eDAM: How does a conscious state arise from the non-conscious state of mind-brain system?

Vimal: Postulates of the eDAM: The eDAM framework rests upon following central postulates:

(P1) The mental and physical aspects a state of an entity are inseparable with the same information. Since the information is the same in both aspects, any information 'viewed' from the first person perspective (1pp) at a conscious state is a specific SE (such as redness in the 1pp-mental aspect) and the same information 'viewed' from the third person perspective (3pp) is the correlated NN (such as redness related V8/V4 NN) and its activities. A specific ontological conscious state is selected (or manifested) when all necessary conditions (such as the formation of NN, attention, etc.) are satisfied and the matching and selection process is complete. The 1pp-mental aspect does not cause 3pp-physical aspect and vice versa in the eDAM framework.

(P2) The NNs are formed during co-development and sensorimotor co-tuning as elaborated in Section 2.1.1 and are adult-like after the respective critical period (such as age 18). The specific dual-aspect conscious state is selected after all

necessary conditions of consciousness (Section 2) are satisfied and matching is complete.

Sehgal-Vimal (Oct. 26, 2016)

I am rephrasing my query related to attention for making it clearer and understandable.

Now starting from zero stage of mind and brain (implying zero consciousness or non-conscious state, zero attention), how do the attention and consciousness (function and SE) arise from the first person perspective (1pp) for *the very first time* while adhering to above two central postulates of eDAM. One fact, which should not be lost sight of, is when there is no SE of any perceptual or cognitive stimuli (i.e. nil thoughts); our consciousness still persists upon as a self-awareness. In other words, my query is: how does a conscious state arise from the non-conscious state of a mind-brain system without violating the postulates P1 and P2?

Vimal

Consciousness is the tip of an iceberg (Kastner, 2015). Below this iceberg, a significant amount of information is processed non-consciously. Attention is related to reentry process as elaborated in Sections 2.1.3, 2.1.4, 2.1.7 and 2.3.3.1. For the very first time is when a baby is born. It is unclear if baby has any self-awareness; usually, babies cry if they are normal when they come to this world. That time, NNs are not matured; they go thru co-development and sensorimotor tuning for many years without violating any postulates of the eDAM. It is an excellent topic for further research; it is briefly sketched in (Vimal, 2008b) and (Vimal, 2010a). Briefly, on the first encounter of an external stimulus (say long wavelength light for stimulating the redness-related immature NN) to a baby after her birth, the stimulus-dependent FF signals do not have any match with cognitive FB system because LTM is empty, a novel ontological state related to this novel stimulus is stored in the LTM. However, the strength of the related memory-trace will extremely weak. After a large number of the encounter of this stimulus, the memory-trace will become stronger for easy recall thru FB system. When next time this stimulus is encountered then matching occurs and slowly it becomes adult-like. Similarly, the process goes on for innumerable types of stimuli until cognitive FB becomes an adult-like. Eventually, in an adult, when all necessary conditions of consciousness (Section 2) are satisfied, a non-conscious state becomes a conscious state without violating the postulates P1 and P2. Please note that attention is one of the necessary conditions for consciousness, not the other way around in my view, although, currently, it is an ongoing debate as elaborated in Section 2.3.3.1.

Sehgal (Oct. 27, 2016)

Thanks for putting forward your views on built up of a state of consciousness for the very first time from the state of unconsciousness.

[A]. I feel there is the need to re-examine the whole concept of 1pp and 3pp. Let us take an example of viewing a ripe-tomato. Suppose, in the eDAM terms, a specific dual-aspect ontological state as a my dual-aspect conscious state is selected after satisfying all necessary conditions of consciousness and after matching is complete. You can 'look' at my 3pp-NN from your 1pp, which the eDAM interprets as the information of the 3pp-physial aspect of my conscious state is 'viewed' is by you from your 1pp. But actually, it is your 1pp-mental aspect of your conscious state and attention (for access/reportable consciousness) 'views' and analyzes my 3pp-physical information. However, even though the information is the same in my both aspects, you cannot view my 1pp-information (my SE redness); what you will 'see' is my grey appearing 3pp-NN and its activities thru fMRI analysis.

But I have the liberty to view the same information from my 1pp and 3pp, namely, I will experience 'redness' from my 1pp and the 'grayness' of my 3pp-NN and its fMRI activities (using for example mirror system); these two views will appear entirely different from 1pp vs. 3pp. So, an attentive conscious state is required for both people -- for me who can view both aspects of information, physical and conscious & you or another person who can view only physical aspect of my 3pp-information. To sum up, whenever any conscious state is selected in the mind-brain system of a person,

(i) The conscious state has two aspects viz. 3pp-physical (NN) along with its activities and 1pp-conscious (SE).
(ii) The first person, in whose mind-brain system the conscious state is selected, can view both the aspects-- physical and mental.
(iii) The 3rd person (another person) can view only 3pp-physical aspect of information of the first person.
(iv) Both persons require an attentive conscious state (for access/reportable consciousness) to view any aspect of information.
(v) Though the information in physical and mental aspects is the same, they appear entirely different from the 1pp and 3pp.

[B] The Second postulate was different from your P2; mine was: For the development of any NN and SE, conditions of consciousness and attention are the essential one.

NNs, whether general one before the age of 18 or specific one after 18 years, arising out from reentry process, rest upon the very primary condition viz. presence of consciousness. So question arises, how does eDAM explain out built out of these general NNs in the absence of consciousness? You can't make

out an artificial dichotomy that general NNs need not adhere to the condition of presence of consciousness and specific one should require consciousness and attention. So to sum up:

(i) Before age 18, general NNs are formed during co-development and co-tuning. But there is no explanation in eDAM, from where consciousness appears for the built out of these general NNs?

(ii) If you want to extend the logic that consciousness is a manifestation of the built up of these NNs, this is also illogical since these general NNs should also require consciousness for built up.

(iii) After 18 years, specific NNs are built up which require both consciousness and attention.

[C] When a baby is born, it may or may not be having self awareness but definitely it is aware of environment. That is why a baby cries when gets hurt by something or feels hungry or thirsty. These are the symptoms of a conscious entity. How does eDAM explain this consciousness if it postulates that consciousness is the manifestation of NNs only? Leave at the time of birth, a baby demonstrate symptoms of consciousness even within womb. In the womb, a baby moves, requires food, digest the food and may also react unconsciously to some external signals. These are the signs of a conscious entity. Therefore, consciousness is present in baby even within womb. How does the eDAM explain the presence of this consciousness within womb in terms of built up of NNs?

[D] "That time, NNs are not matured; they go thru co-development and sensorimotor tuning for many years without violating any postulates of the eDAM." No, here the central postulate of eDAM that consciousness is the dual aspect of NNs is being violated. No NN of any kind, matured or immatured one, general or specific one, should take birth in the absence of consciousness -- as per central postulate of eDAM. And, in turn, consciousness can't take birth without its NNs. But NNs for consciousness can't be built up without consciousness. One can't limit one to the narrow perspective of consciousness viz. demonstrating free will, self awareness, and awareness of environment. General symptoms of different biological organism viz. motion, reproduction, digestion, a nervous system even at rudimentary level are also symptoms of conscious entities. To sum up:

(i) Central postulate of eDAM demands that any consciousness is the manifestation of NNs.

(ii) No NN can be formed in the absence of consciousness.

(iii) Built up of general NNs, arising out from co-development and sensori-motor co-tuning should also require consciousness.

(iv) Consciousness required for co-development and sensori-motor co-tuning, should also manifest from some NNs (as per central postulate of eDAM). NNs for consciousness itself can't take birth without consciousness.

(v) A baby at the time of birth and even during womb demonstrates signs of consciousness viz. awareness of environment (may be in rudimentary form), crying, smiling, motion, requirement of food, digestion etc which all are the symptoms of consciousness. So consciousness in one way or other is present in the baby at the time of birth as well as within womb.

(vi) However, eDAM fails to explain this consciousness, as indicated in (v) above, in terms of its central postulate viz. consciousness is the dual aspect manifestation of NNs.

Vimal

In your response, you have tried to reject the eDAM unsuccessfully by tacitly misconstruing it as materialism and tried to defend idealism forcefully without addressing the well known and widely accepted problems of idealism.

[A] I tried to rewrite your idealism-based query in terms of the eDAM. You use idealism phrases such as consciousness and attention (1pp-mental aspect as a cause) are needed to form NN (matter, 3pp-physical aspect, as the effect).

[B] Your second postulate also implies that consciousness and attention (1pp) cause NN (matter, 3pp), which is the problematic idealism. The idealism makes serious category mistake and has serious explanatory gap problem; this is not consistent with the eDAM. The correct one is the eDAM's postulate P2.

It is the stimulus that causes or initiates the activation and entails the selection of a dual-aspect conscious state after the matching between stimulus-dependent FF and cognitive memory-based signals is complete (for adult); its 3pp-physical aspect is a NN & its activities and its 1pp-mental aspect is SE; here, a category mistake is not made; 1pp attention and consciousness does NOT cause 3pp-NN and vice-versa. It is the idealism if you claim that 1pp attention and consciousness (mind) cause 3pp-NN (matter); its vice-versa is materialism; both make their own category mistake and have their own explanatory gap problem.

If matching is unsuccessful such as in the case when a baby encounters a stimulus for the first time, then FF signals activate the reentry process to build a phenomenal conscious state (that does not require attention) in the first entry in a FF pathway because of the stimulus and eventually a weak memory trace is built for the stimulus. This weak memory trace is used as FB signals for the matching when the baby is encountered the same stimulus for second time.

The related memory trace slowly becomes stronger with many encounters and eventually it becomes a part of LTM.

[C] A new born baby most likely has immature experiential sub-aspects of phenomenal consciousness and functional sub-aspect of consciousness, such as the movement of baby in the womb, the cry of a new born baby, and the digestion of food before and after birth as elaborated above in [B]. In the query "How does eDAM explain this consciousness if it postulates that consciousness is the manifestation of NNs only?" you are silently inserting materialism: the eDAM NEVER postulates "consciousness is the manifestation of NNs only" because this implies that 3pp-NN causes 1pp-consciousness. Please read carefully P1 and updated P2. The baby's consciousness is explained above in [B].

[D] Here, you go again: you are silently and tacitly inserting materialism in disguise of the eDAM. The central postulate of eDAM is NOT "consciousness is the dual aspect of NNs" because this misleadingly implies that consciousness (1pp-mental aspect) is caused by NNs (3pp-physical aspect). Instead, the central postulates of the eDAM are P1 and P2 as elaborated before, where consciousness is defined in Section 1.1. This ontological state is selected thru the processing of stimulus related signals and after matching as elaborated in above.

Then you are claiming "NNs for consciousness can't be built up without consciousness," which implies idealism (consciousness causes NN). The eDAM is neither materialism nor idealism. (i) is based on materialism. (ii) and (iii) are based on idealism. (iv) is based on materialism and idealism. (v) is true and the eDAM has explained it above in [C]. (vi) As argued above that the "consciousness is the dual aspect manifestation of NNs" is not the eDAM's central postulate and eDAM explains (v). To sum up, the eDAM does have any such problems, they are all your misconstruction of the eDAM; the eDAM is an elegant and least problematic framework, so far.

Sehgal-Vimal (Oct. 28, 2016)

[A-B] Sehgal: What I meant to convey had been that the eDAM prescribes presence of consciousness and attention (at 1pp level) as essential conditions for the built up of any NN whose dual aspect shall immediately manifest as a conscious SE. Do you agree with the above condition or still having some reservation?

Vimal: I disagree as elaborated before. It is mandatory that the necessary conditions must be satisfied before a state of our mind-brain system can have a dual-aspect conscious state. The matching between FF and FB signals must also be completed and then a specific dual-aspect ontological conscious state is selected out of many ontological states stored in the LTM.

[B-C] Sehgal: I agree that it is the stimulus which causes or initiates the selection of a dual aspect conscious state *but the added condition is the presence of conscious state of mind and brain and attention for the buildup of NNs*. This itself is one of the central postulates of eDAM.

Vimal: Attention is needed for consciousness, not other way around in the eDAM, although some researchers disagree as elaborated in Section 2.3.3.1. No, "*the presence of conscious state of mind and brain and attention for the buildup of NNs"* is misleading and hence it is not a central postulate of the eDAM. You have misunderstood. The central postulates are elaborated above in Section 3.5.4.3.4.

Sehgal: Here, you yourself are invoking materialism by stating that if matching is unsuccessful (in baby), reentry process is activated to buildup a phenomenally conscious state, Okay, I agree that it is not by any materialistic interaction process of neurons but it is on built up of some general NNs that phenomenal consciousness manifests. But the built up of general NNs should also adhere to the condition of the presence of some consciousness (if not attention), as is required for building any specific SE as in the case of adults. So a general principle of eDAM is that any NN, specific one in adults or general in babies, shall be built up in the presence of consciousness only. But in the case of babies, eDAM has tactfully remained silent on this condition. The important issue which I have been trying to highlight and somehow, you are losing sight of the same in garb of "isms", words and semantics is: Even in case of babies, no general NN can be built up without the presence of consciousness as in the case of adults. The Issue which eDAM is unable to explain, from where and how this consciousness appears? Please take note of following: It is illogical and arbitrary on part of eDAM to create an artificial dichotomy by putting the essential condition of presence of consciousness and attention for the built up of any specific NNs in adulthood and dispensing with this essential condition in case of built up of general NNs in the case of babies. This whole approach of eDAM is illogical and arbitrary one.

Vimal: NO. Consciousness is not a necessary condition for the buildup of any NN. It is other way around: the formation of NN is necessary for consciousness as elaborated in Section 2.1.1. This you misinterpret that NNs cause experiential sub-aspect of consciousness, which is the problematic materialism or the present of consciousness and attention are needed in the buildup of NN, which is idealism; I have already rejected both materialism and idealism. There is no inconsistency in the eDAM. In the eDAM, postulates P1 and P2 must be fully understood first. When we 'view' the 3pp-information from the 1pp, we experience, which is the experiential aspect of consciousness.

It is all you misconstruction that does not allow you understand the eDAM because you want the idealism based view that the presence of God/consciousness in necessary to build the NNs. Word and sentences of a writer must be written clearly to convey the meanings correctly to readers. I suggest, you should read all our conversation from very beginning.

[D] Sehgal: Now please see minutely. The eDAM is defining consciousness is the 1pp mental aspect of a *conscious state of a mind-brain system*. Here, the eDAM becomes a victim of its own conditions. You have already stipulated the condition *of the presence of the conscious state of mind/brain system* (*implying consciousness*) for defining consciousness. So the whole definition loses its logical relevance. The hard problem which eDAM is unable to explain while adhering to its postulates in a consistent and logical way is: How this conscious state of mind/brain system came into existence for the very first time?

Vimal: You have again misconstrued the definition of consciousness in the eDAM; it is now clearly defined in Section 1.1. I used the term 'conscious state' instead of simply 'state', which appeared circular to you and perhaps caused you to misinterpret. I have corrected it. However, the interpretation of the term 'conscious state' is that this special beable ontological dual-aspect state has consciousness (1pp-mental aspect) when viewed from the 1pp and has inseparable 3pp-physical aspect which is a specific NN and its activities when the same information is viewed from the 3pp. This does not mean that consciousness is needed for the formation of NN (as idealism proposes) or consciousness is defined using consciousness (making it circular); this would be misinterpretation and misconstruction of the eDAM. These are the reasons why I recommended you reading all my published articles to avoid misinterpretation.

[E] Sehgal: The Framework of eDAM rests upon following 3 types of consciousness, which is a part of 1pp-mental aspect.

(i) *Non-reportable consciousness*: I think another name for non-reportable consciousness is phenomenal consciousness. I also think that it derives its name non-reportable because of the fact that this is not focused on any specific stimuli; therefore, not reportable for any specific function.

(ii) *Reportable or access consciousness*: When consciousness is focused on some internal or external stimuli. The source of reportable consciousness should be non-reportable or phenomenal consciousness. In view of this, non-reportable consciousness should be more fundamental. We can visualize non-reportable and reportable consciousness akin to a reservoir of water and some streams of water branching out from the reservoir. Non-reportable consciousness is analogous to the reservoir while reporting consciousness akin

to streams of water branching out from the reservoir as and when some stimulus is presented before it. And that is how attention is built up for any specific stimulus.

(iii) In the presence of non-reportable consciousness (conscious state of mind/brain) and reportable consciousness (attention), when NN for any specific stimulus is built up, its 1pp aspect manifest as an SE which is also treated as a conscious state by eDAM. You have postulated that in babies some phenomenal consciousness is built up by reentrant mechanism of some signal implying some general NNs are built up for the manifestation of phenomenal consciousness. But for the built up of NNs for the manifestation of specific SE (in adults), the presence of phenomenal consciousness and attention are essential. So we can safely infer that no NN, whether general one in babies or a specific one in adults, should be built up in the absence of some phenomenal consciousness. *So a logical corollary of above is that even for built up of general NNs in the case of babies, presence of some phenomenal consciousness (not attention) is essential.* If the presence of phenomenal consciousness is not essential for building general NNs in babies why should it be an essential condition for building NNs for a specific SE in the case of adults? You may provide a counter-argument that in the case of specific SE in the case of the adults, if NIL presence of phenomenal consciousness (and attention) is postulated, there shall be NIL 1pp experience. Leave away 1pp experience for the time being i.e. there is no one to experience SE in absence of phenomenal consciousness (conscious state of mind/brain). But can NN for any SE built up from FF signal stimulus from any stimulus in the absence of phenomenal consciousness and attention? The Obvious answer is NO. *This fact itself proves that presence of phenomenal consciousness is imperative for the built up of NNs of any type -- specific one for adults and general for babies.*

Please don't interpret my above quotes that I am stating that NNs or SE is the effect of phenomenal consciousness (as you state as Idealism). *But despite the fact that the eDAM interpret any SE as dual aspect manifestation of related NNs, its NNs don't build up in the absence of some phenomenal consciousness* (*conscious state of mind/brain*) *and reportable consciousness* (*attention*). *This is an empirically verifiable fact. A logical extension of this fact is that in case of babies also, no NNs -- general one or a specific one in immature form should be producible without the presence of some phenomenal consciousness.*

The range of phenomenal consciousness is not limited up to babies in early years only but it extends even before. When a baby is born, on the very 1st hour, he/she cries when hurt by some object or pricked with fingers. Sometimes babies stare at us or smile on our gestures. This indicates that some awareness does exist in babies, in whatever rudimentary form it may be. This, in turn, proves that some phenomenal consciousness, in very rudimentary form exist in babies even from the very 1st day of birth.

During womb also, babies may show some signs of very rudimentary awareness which proves that some consciousness in rudimentary form should be present during womb also. At least, babies in womb reveal motion and requirement of food, digestion, and excretion. These are also the symptoms of the presence of some rudimentary consciousness even in the womb.

To sum up, a phenomenal consciousness does exist in all stages of the life of an organism from womb till death, whether in rudimentary form or fully developed form.

If the eDAM is an elegant science, as you state, how does it explains the existence and development of phenomenal consciousness as a manifestation of built up of NNs. But while explaining the manifestation of phenomenal consciousness as manifestation of NNs, eDAM should not overlook its central postulate which is also empirically verifiable that no NNs, general or specific one can be built up in the absence of some phenomenal consciousness or/and attention

Please don't misinterpret that I am saying that consciousness creates built up of NNs. I agree that NNs are caused by stimuli. But stimuli can't build up NNs in the absence of consciousness and/or attention. This is an empirically verifiable fact and there should no second thought for this fact.

Vimal: (i-ii) It is unclear if the phenomenal consciousness is more fundamental. This major difference is that access consciousness needs more processing time for attention. (iii) This is misconstruction; the presence of any type of consciousness is **NOT** needed to build NNs either in babies or adult. The 3pp-NN activities do not cause 1pp-mental aspect as in the materialism or vice versa as in the idealism. The phenomenal consciousness might be due to the first encounter of a novel stimulus by a new born baby, not by the many reentrant signals as used in attention for access consciousness (see Sections 2.21.3, 2.1.4, and 2.1.7). The formation of NNs is elaborated in Section 2.1.1; please carefully; the presence of any type of consciousness is NOT needed for the formation of NNs; it is just other way around, the formation of NN is one of the necessary conditions for consciousness as elaborated in Section 2.1 and 2.1.1.

It seems that you are misleadingly and silently introducing the presence of *Puruṣa* of *Sāṁkhya*, which is unnecessary.

Thus, the eDAM rests on the two types of consciousness (phenomenal and access consciousness) and 2 sub-aspects of consciousness (functional and experiential sub-aspects).

There are no such problems in the eDAM; they are your misconstruction of the eDAM.

4. Conclusions

[1] Our simple working hypothesis is as follows: Visual consciousness is the result of dynamic interactions between widely distributed neuronal groups (Edelman, 2003) in the visual neural-network of thalamocortical (that includes dorsal and ventral visual pathways and frontal cortex) system. In terms of our framework, interaction involves the matching between feed forward and feedback signals and then the selection of specific subjective experience (SE).

[2] The *necessary* conditions for *access* (reportable) consciousness (Sections 2.1-2.1.13) are the formation of neural-networks, wakefulness, reentry, attention, integrated information above threshold, and working memory. In addition, for consciousness, stimulus should be at threshold level for detection, and above threshold for discrimination and recognition (Section 2.1.8). Furthermore, neural-network proto-experiences (a set of precursors of SEs embedded in a neural-network) are also essential for consciousness (Section 2.1.9). Attention and ability to report are not *necessary* for *phenomenal* consciousness. We conclude that arousal system brings the thalamocortical neural networks to wakefulness as a baseline for consciousness to occur, reentrant interactions among neural populations entails consciousness, attention modulates the consciousness, and memory retains information for consciousness.

[3] Our framework (Vimal, 2008b, 2010a, 2013, 2015d) along with reentry links/integrates the three aspects of a consciousness system, namely, structure, function, and SE (Sections 2.1.3 and 2.2.1).

[4] An experimental design is proposed to investigate the *necessary* and *sufficient* conditions for visual consciousness (Section 2.3).

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Endnotes

[1] As per (Allen, 2013), "In addition to functional features, the sentient brain depends upon structure and architecture in order to be aware of 3-dimensional space, such as fractal geometry and the convolutions of the cerebral cortex, as il- lustrated by left-neglect disorder. This raises a ques- tion as to how "synthetic" a synthetic sentient brain could be."

[2] Personal communication with Northoff on 18 October 2015.

[3] As per wiki, "There are two common but distinct dimensions of the term *consciousness* [(Zeman, 2001)], one involving *arousal* and *states of consciousness* and the other involving *content of consciousness* and *conscious states*. To be conscious *of* anything the brain must be in a relatively high state of arousal (sometimes called *vigilance*), whether in wakefulness or REM sleep, vividly experienced in dreams although usually not remembered."

[4] As per (Tegmark, 2015), "Consciousness as a state of matter … another principle that conscious systems must satisfy: that of *autonomy*, *i.e.*, that information can be processed with relative freedom from external influence. Autonomy is thus the combination of two separate properties: *dynamics and independence*. Here dynamics means time dependence (hence information processing capacity) and independence means that the dynamics is dominated by forces from within rather than outside the system. Just like integration, autonomy is postulated to be a necessary but not sufficient condition for a system to be conscious".

[5] As per (Allen, 2013), "Time is crucial to waking consciousness. a) Time flows in the opposite direction that information flows. b) Neurological time is distinct from physical time. The neurological present lies in the physical past. The physical present lies in the neurological future. […] d) The neurological present is the only thing a person can perceive while awake. e) The affective content of a stimulus arrives in the neurological present before the stimulus itself, thus admitting to emotional precognition. This is because awareness of the stimulus itself is first processed by pre-conscious perception and an awareness filter."

[6] As per (Baars, 1988), "The Global Workspace model … is a distributed society of specialists that is equipped with a working memory, called a global workspace, whose contents can be broadcast to the system as a whole." (p.42). As per (Northoff, 2014), "The information and its contents processed in the brain [i.e., neural activity] must be globally distributed across the whole brain in order for them to become associated with consciousness [in a global workspace …] (Dehaene & Changeux, 2005, 2011) … *global neuronal workspace theory* (GNW) … postulate … that neural activity in the prefrontal-parietal cortical network has to be recruited by the single stimulus in order to link and recruit the different neural networks. That in turn makes possible the global distribution and processing of the stimulus, which is central for associating cosnciousness with the stimulus".

[7] As per (Allen, 2013), "learning and expansion of long-term memory are not necessary for consciousness. Individuals who have suffered permanent brain damage that precludes forming new long-term memories are nonetheless conscious [60-62]. For that matter, so are individuals whose ability to experience emotion is impaired [63-65], as suggested above. However, some pre-existing long-term memory is necessary [for *access* consciousness] since, as shown in Figure 3, it is interrogated by pre-conscious processing and the awareness filter that is necessary to conserve limited energy and prevent the brain from being overwhelmed with information. In this case, however, fixed long-term memory would play the same role as the hard-wired module that provides instinct, reflexes, and a somatic map."

[8] As per Hausman, "*A necessary condition for some state of affairs S is a condition that must be satisfied in order for S to obtain.* […] *A sufficient condition for some state of affairs S is a condition that, if satisfied, guarantees that S obtains.*" < http://philosophy.wisc.edu/hausman/341/Skill/nec-suf.htm> As per (Cunningham, 2000).p65, "A condition is *necessary* for something if it is impossible for that thing or event to be present without that condition being ful-filled. For example, it is necessary condition for the presence of water that the liquid contain oxygen. You cannot have water without oxygen. However, oxygen alone, while a necessary condition, is not *sufficient* for the presence of

water. Something more is needed; there must be hydrogen as well, and it must be combined with the oxygen in a precise ratio. A *sufficient* condition for something, on the other hand, is a condition that guanrantees the presence of the thing or event. So, for example, rain is a sufficient condtion for the presence of water. Note, however, that it is not necessary to have rain in order to have water but if you do have rain, that is sufficient to guarantee the presence of water. So, it is possible that a condition can be necessary without being sufficient, or it can be sufficient without being necessary. Obviously, the strongest set of conditions, the set that will offer a full definition or explanation of the thing you are trying to understand, is the set *of necessary and sufficient conditions*. These will specify both what is required for the thing to be what it is and what is adequate so that nothing else is required. In the case of water, hydrogen plus oxzygen (in proper relation) are necessary and sufficient."

[9] As per (Allen, 2013), "Certain rare neurological disorders that occur in conscious individuals eliminate certain mental capabilities as necessary for consciousness. Capabilities not necessary for consciousness include, without limitation: [...i] the ability to perceive pain, and [...ii] the ability to form new long-term memories. c) Since an unfeeling, immoral and non-learning brain may be sentient, it would be easier to engineer this type of synthetic brain. However, the result would be an artificial sociopath. Hence, such an effort should be avoided."

[10] As per (van Boxtel, Tsuchiya & Koch, 2010a), "Recent research has slowly corroded a belief that selective attention and consciousness are so tightly entangled that they cannot be individually examined. In this review, we summarize psychophysical and neurophysiological evidence for a dissociation between top-down attention and consciousness. The evidence includes recent findings that show subjects can attend to perceptually invisible objects. More contentious is the finding that subjects can become conscious of an isolated object, or the gist of the scene in the near absence of top-down attention; we critically re-examine the possibility of "complete" absence of top-down attention. We also cover the recent flurry of studies that utilized independent manipulation of attention and consciousness. These studies have shown paradoxical effects of attention, including examples where top-down attention and consciousness have opposing effects, leading us to strengthen and revise our previous views. Neuroimaging studies with EEG, MEG, and fMRI are uncovering the distinct neuronal correlates of selective attention and consciousness in dissociative paradigms. These findings point to a functional dissociation: attention as analyzer and consciousness as synthesizer. Separating the effects of selective visual attention from those of visual consciousness is of paramount importance to untangle the neural substrates of consciousness from those for attention.
[...*Introduction*] We use the term "attention" to imply selective attention, rather

than the processes that control the overall level of arousal and alertness. We focus on top-down, goal-directed endogenous attention and not on bottom-up, saliency-driven exogenous attention (Itti and Koch, 2001). We do so because top-down attention and consciousness can be independently manipulated without changing the visual inputs (e.g., (van Boxtel, Tsuchiya & Koch, 2010b)), while bottom-up attention, almost by definition, needs to be manipulated by changing the physical properties of a cueing stimulus, such as its visual features or its spatio-temporal relationship with a target stimulus. Thus, it is difficult to disentangle bottom-up attention from consciousness (but see Chica et al., 2010). By consciousness, we refer to the content of consciousness (sometimes also referred to as awareness), and not to states or levels of consciousness (e.g., wakefulness, dreamless sleep or coma). [...] We will equate consciousness for an object or event, say a stationary grating, with stimulus visibility. [...]

FUNCTIONAL CONSIDERATIONS IMPLY A DISSOCIATION Such attentional selection can be based on bottom-up, exogenous saliency-based factors or top-down, endogenous, goal-directed factors (James, 1890; Braun and Julesz, 1998; Duncan, 1998; Koch, 2004). Top-down attention, the focus of this review, selects a portion of the input defined by a circumscribed region in space (spatial or focal attention), by a particular feature (feature-based attention), or by an object (object-based attention) for further processing. Consciousness is surmised to have functions almost diametrically opposite to those of attention. It does not select information. Rather, proposed roles of consciousness include summarizing all relevant information pertaining to the current state of the organism and its environment and making this compact summary accessible to the planning stages of the brain, detecting anomalies and errors, decision making, language, inferring the internal state of other animals, setting long-term goals, making recursive models, and rational thought. This integrative aspect is emphasized by the Integrated Information Theory of consciousness (Tononi, 2004, 2008). These functions also suggest that consciousness may be important at longer timescales than attention is, and may not be operating at the same level in the visual hierarchy. From this viewpoint, we can regard selective, focal attention as an analyzer and consciousness as a synthesizer. To the extent that one accepts that attention and consciousness have different functions, one has to accept that they cannot be the same process, and anticipate dissociations between the two.

[...*2x2 design*...] For example, an unexpected and unfamiliar stimulus requires top-down attention in order to be consciously perceived. Otherwise, such a stimulus goes unnoticed, a phenomenon called inattentional blindness (Mack and Rock, 1998). [...] attention without consciousness (bottom-left) and consciousness without attention (top-right). ... While many scholars agree that attention and consciousness are distinct, it is popular to assume that attention is necessary for consciousness. For example, Dehaene et al. (2006) argue that without top-down attention, an event cannot be consciously perceived and

remains in a preconscious state.

[…*Evidence for a tight link between attention and consciousness*:] … even a very salient object, presented for a few seconds, sometimes goes unnoticed if it is not properly attended: *inattentional blindness* (Mack and Rock, 1998; Wolfe et al., 2005).

… Also, a major change between two subsequent images may go unnoticed if attention is not focused on the change: *change blindness* (Rensink et al., 1997; Tse, 2004; Wolfe et al., 2006). Visual sensitivity decreases when attention is distracted: *load-induced blindness* (Macdonald and Lavie, 2008). […] These studies show that when attention is not appropriately directed to an object, its conscious report can fail […] Sometimes, however, a relatively large stimulus or change can go unnoticed when attention is not properly directed, as mentioned above. We believe this is because subjects do perceive the gist of the image correctly, interfering detection of a less meaningful change in the scene as if it was filled in by the gist. In fact, when a stimulus or image change is related to the gist of the scene, attention-related blindness rarely occurs. […]We conclude that attentional reduction does not usually result in invisibility of an isolated object and that a large change can be missed as long as it does not alter the gist of the scene. Attention and consciousness may not be coupled as tightly as has been thought even in the above cases.

[…*Evidence for a dissociation between endogenous attention and phenomenal consciousness*:] Due to the recent surge in research on attention and consciousness, there is now ample evidence for a dissociation between the two processes. There are two sides to this story that are of particular interest: Can attention be deployed to a stimulus attribute, object or event without giving rise to consciousness of that attribute, object or event? (bottom-left quadrant in Table 1); and, can one be conscious of something without paying attention to it? (top-right attentionquadrant in Table 1). From the point of view of consciousness, the first question asks whether attention is sufficient to cause consciousness, while the second one asks whether attention is necessary to cause consciousness (or whether only attentionally selected items can enter into consciousness).

[… *Attention without consciousness*:] Can observers deploy attention to a stimulus that is not accessible to consciousness? The answer now seems quite definitely: yes, they can. The evidence comes from (1) the attentional manipulation of non-conscious priming and adaptation and (2) the effects of invisible stimuli on attentional cueing. […] Taken together, these studies demonstrate attention can be directed toward and away from a stimulus or one of its attributes without that stimulus or attribute ever being visible. [RV: This suggests that attention does not guarantee consciousness and attention is not sufficient condition for consciousness.]

[…*Open questiIons and the neuronal basis of attentiIon without consciousness*:] While top-down attention can operate without giving rise to consciousness, many open questions remain. For example, what is the nature

of attentional selection of invisible stimuli? Can the representation of an invisible "object" be modulated by any type of attention or only indirectly via temporal, spatial or feature-based attention, yet not object-based attention (De Brigard and Prinz, 2010; Prinz, 2010; Tapia et al., 2010)? Can attention bind features of an invisible object (Lin and He, 2009)? As to this last question, some evidence from a Balint's patient (Wojciulik and Kanwisher, 1998) suggest that consciousness is not required for binding [...] synchrony or coherence in a population of spiking neurons (Womelsdorf and Fries, 2007) may be responsible for the attentional selection of invisible stimuli but not for consciousness. Another critical question is why the attentional enhancement of neuronal activity is not sufficient for conscious perception (Braun, 2007). Insufficient stimulus strength is probably an important factor (Dehaene et al., 2006).

[*Consciousness without attention*:] If there is attention without consciousness, one can ask whether or not there exists consciousness without attention. Can a subject be conscious of an object or of an attribute of an object without attending to the object or its attribute? We focus on evidence in favor of that view obtained with the dual-task paradigm. Other lines of evidence, including pop-out, iconic memory, and partial reportability, have been reviewed extensively elsewhere (Block, 2007; Koch and Tsuchiya, 2007; Tsuchiya and Koch, 2008a,b; Lamme, 2010).Top-down attention is employed when there is competition among two or more nearby objects (Desimone and Duncan, 1995). [...] At the perceptual level, if a display contains only a single object in isolation, subjects become aware of it in any attentional state. This simple fact seems to undermine the argument that top-down attentional amplification from the frontal area is always necessary for consciousness (Dehaene et al., 2006). [...] This suggests that consciousness without attention develops in response to extensive experience with a particular class of images. [...] Even with a mere 30 ms exposure to natural scenes, followed by a mask, observers can clearly perceive their gist (Biederman, 1972; Fei-Fei et al., 2002) even in the absence of any expectation about what type of scene will be flashed. Within these 30 ms, top-down attentional bias could not have taken effect. [...] Conclusions from the dual-task experiments rest on one strong assumption about the nature of top-down attention: that attention is a unified and limited resource and all the tasks compete for it, to different degrees. [...] We concluded that attention to a stimulus or an attribute of this stimulus is neither strictly necessary nor sufficient for the stimulus or its attribute to be consciously perceived.

[...*Independent manipulation of attention and consciousness*:] The prime could signal the same behavioral response as the subsequent stimulus (a congruent trial) or an opposite behavioral response (an incongruent trial). When the prime was invisible and unattended, no priming effects were found. Compared to this baseline condition, both attention and awareness increased the priming effects. However, each manipulation contributed to the priming

effects in distinct ways: when attention was directed to the invisible prime, the reaction times for the congruent trials were speeded compared to neutral trials, while when visibility was increased for the unattended prime, the reaction times for the incongruent trials were slowed down compared to the neutral condition. In other words, *attention to invisible* stimuli and *visibility of unattended* stimuli both enhanced the priming effects, but via distinctive neuronal mechanisms. In visible and attended conditions, both the speeding up of congruent trials and the slowing down of incongruent trials occurred. [...] These effects did not interact with each other and suggest that attention and consciousness may have dissociable neuronal correlates.

[...*Studies that have shown detrimental effects of attention*:] In all of the above cases, the more subjects try to see some stimulus by paying attention to, the less visible it becomes! [...*Opposite effects of attention and consciIousneEss on perceptiIon but not on adaptation*:] van Boxtel et al. (2010) found that attention *decreased* the duration of the afterimage while awareness *increased* the duration of the afterimage. In other words: the effects of attention and awareness opposed each other at the level of perception ... There was no interaction between the effects of attention and consciousness. [...]Taken together Brascamp et al. (2010) and van Boxtel et al. (2010) showed that attention and consciousness can have opposing effects on visual *perception*, while still performing similar, yet not identical, operations at a *neural level*. [...] Attention primarily reduces the complexity of incoming input so that the brain can process it online and in real time. This might/could be the function of Milner and Goodale's (2008) dorsal visual stream for action. In fact, the "pre-motor" theory of attention (Rizzolatti et al., 1987) argues that visual attention evolved from the need to plan to move the eyes to one location. Overt eye movements and covert attention are closely related in both neural and functional ways. In terms of anatomical structure, front-parietal areas have been implicated in the control of attention (e.g., Corbetta and Shulman, 2002), which are, of course, part of the dorsal, vision-for-action pathway. On the other hand, the ventral, vision-for-perception pathway has been linked to consciousness (Milner and Goodale, 1993, 2008; Tong et al., 1998; Rees et al., 2002). As pointed out by Milner and Goodale (2008), the two streams interact intensely under most circumstances but they can be dissociated in neurological patients and in normal subjects with some illusions. A similar point could be made for attention and consciousness. From this perspective, many examples of attention without consciousness may be thought of as normal functioning of dorsal attention orienting system without proper/full ventral functioning (see e.g., Jiang et al., 2006; Lambert and Shin, 2010). The key here is that there are some recognition modules present in the dorsal pathways (e.g., shape sensitivity, Lehky and Sereno, 2007). An object, or location, may attract attention without giving rise to consciousness via this pathway (cf. Lambert and Shin, 2010). Likewise, consciousness without attention may be due to some ventral function without the help of attentional

amplification from the dorsal systems (as in dual-task paradigms, e.g., Reddy et al., 2007). This could be because, for example, a face module in FFA is effectively activated without the help of attentional system. Even though linking consciousness primarily to the ventral stream and attention to the dorsal stream is undoubtedly an oversimplification, especially in the light of known strong and reciprocal anatomical interactions among these streams (Baizer et al., 1991), as well as the variety in types of attention (e.g., endogenous versus exogenous, focused versus object-based), framing the attention/consciousness difference along these anatomical lines may help us better define future research directions. [... *Conclusion:*] Here, we reviewed additional evidence for a dissociation between top-down, selective attention and consciousness. We find that there exists considerable evidence for attentional deployment without consciousness, supporting the view that attention is not sufficient for consciousness. We also reviewed evidence for consciousness without attention, which indicates that attention is not necessary for consciousness. Yet many scholars find the evidence for this latter claim insufficiently compelling. We believe that psychophysical studies are not powerful enough to decide this question. In particular, it may never be possible to fully prevent subjects paying some attention to a stimulus on the basis of purely behavioral techniques. Currently, many assume that an important means by which top-down attention influence sensory processing is via cortico-cortical feedback connections (Macknik and Martinez-Conde, 2007). It may be possible to transiently, delicately, reversibly and specifically knock out all top-down cortico-cortical pathways, thereby preventing the subject, most likely a mouse or non-human primate, from exerting any sort of top-down attentional control. This could be achieved via molecular-biology tools, in particular *opto-genetics* (Han et al., 2009; Gradinaru et al., 2010). Unbraiding the complex relationship between attention and consciousness will ultimately depend on such powerful, interventionist tools."

As per (van Boxtel & Tsuchiya, 2015), "[**1. Introduction**:] In this chapter, we will use the word 'consciousness' to refer to the 'contents' of consciousness, rather than the state or level of consciousness (e.g., as opposed to coma, dreamless sleep or under anesthesia) (Laureys, 2005). Further, we assume that the ultimate goal of the study of consciousness is to reveal how objective, physical neural activity gives rise to subjective, phenomenal conscious experience (Block, 2005) (sometimes called the 'hard problem'; Chalmers, 1996), rather than revealing how we can make sense of the functional and externally observable aspects of consciousness (sometimes called access consciousness; Block, 2005). We mainly discuss the relationship between phenomenal consciousness and some psychological concepts, namely, attention, report and memory, which are intimately related to the concept of access consciousness. [...] Introspection involves three psychological mechanisms: to attend to subjective experiences, to hold them in memory and

to report on them later. [One could argue that introspection also analyzes and evaluates what we have done so far, what are our virtues and shortcomings, and what should we do to reach our goals of life. "Introspection is the examination of one's own conscious thoughts and feelings (Schultz & Schultz, 2012)."] The relationship between these mechanisms that allow access to the contents of consciousness — attention, report and memory — and phenomenal consciousness [C_p] remains unclear.

[… **2. De-confounding access consciousness from phenomenal consciousness**] [*2.1 Minimizing top-down attention with a demanding concurrent task*] we have argued that top-down attention and phenomenal consciousness may have different biological, functional purposes (van Boxtel et al., 2010a); attention allows the brain to "analyze" a selected location, feature and/or object by allocating resources to it, while consciousness allows it to "synthesize" a unified experience from past and present information with future planning. […] This synthesis happens by binding information across different sensory modalities represented in distant brain regions into a globally accessible workspace-like structure (Baars, 2005; Dehaene et al., 2006) to achieve maximally integrated information (Oizumi, Albantakis, & Tononi, 2014; Tononi, 2010).

[…*2.2 Neuronal effects of reports*] two potential confounds. The first is introduced by the act of report, which activates an array of neural mechanisms potentially unrelated to phenomenological consciousness. The second is a gap between what subjects actually experience and what experimenters assume the subjects experience based on the report. [*Separation of endogenous attention from C_p*:] Future studies of the neural correlates (or neural constituents; Miller, 2007; see Miller, this volume) of phenomenal consciousness would need to rule out the confounding effects of top-down attention, for example, by independently manipulating the (1) amount of top-down attention via a concurrent demanding attentional task and (2) visibility of the stimulus, in a 2 × 2 design […*Separation of report from C_p*:] two potential confounds. The first is introduced by the act of report, which activates an array of neural mechanisms potentially unrelated to phenomenological consciousness. The second is a gap between what subjects actually experience and what experimenters assume the subjects experience based on the report. […2.2.1. *Effects of reports on local field potentials and firing rate*:] Currently, spiking activities are considered to reflect mainly the output from a brain area while LFPs [local field potentials], especially at the low frequency bands such as alpha (9–14 Hz) to beta (15–30 Hz) range, are considered to reflect mainly the input into the brain area (Logothetis, 2002). […] Thus, the low-frequency LFPs in the pulvinar were likely to be produced by the act of report itself and unlikely to be a neural constituent of phenomenal consciousness, while neuronal firing in the pulvinar may be a constituent of phenomenal consciousness. […] Given these findings, it will be important for future studies to check if the proposed neural correlates or neural constituents continue to be observed even if subjects do not overtly

report the percept. [...2.2.2. *Reports fail to capture what subjects really experience*:] Taken together, the activity in the frontal areas may not be critical in perceptual transitions. These studies underline the importance of de-confounding co-occurring processes (such as response inhibition during discrete reports of a perceptual experience that is more gradual) from the neural constitution of phenomenal consciousness. [...] To summarize, the first case (Frässle et al., 2014; Wilke et al., 2009) showed a possibility that even within a given area, different neural measures may or may not be sensitive to the phenomenology itself or influenced by the act of report itself. The second case (Knapen et al., 2011) reminds us of the importance of taking subjective reports seriously, and providing report options (and replay conditions) that more closely resemble the perceptual experience.

[*2.3 Separation of memory from C_P: Memory confound: Amnesia or blindness?*:] Memory is traditionally divided into different types: iconic memory, short-term (or working) memory, and long-term memory. Recently, Lamme and colleagues (Vandenbroucke, Sligte & Lamme, 2011) suggested there is yet another category of memory, which they term 'fragile' short-term memory, which sits between iconic and short-term memory. Because currently the debate on the link between conscious perception and memory is mainly focused on iconic and fragile memory [...*Possible memory confounds in inattentional and change blindness*:] In sum, it is still debated whether inattentional and change blindness are really cases of loss of phenomenal consciousness (but see Cartwright-Finch & Lavie, 2007). They might rather reflect loss of memory. Also, it is still unclear how these phenomena are related to gist perception, which seems to be largely immune to attentional distraction. ... there is a need to consider the possible confound of memory in the study of consciousness. [...*Iconic memory and phenomenal consciousness: Sperling's experiment*:] These findings suggested that subjects somehow stored at least nine letters in the partial report condition, while they were able to report only four of them in the full report condition because of interference that operated when they reported the whole array from memory. The result of Sperling's experiment has been taken to imply that a large capacity iconic memory system exists with a limited capacity to read out from it. That is, sometime after the stimulus disappeared and when the subject was asked to report on it, information in iconic memory was lost. [...] First, memory is fragile. Even if the question regarding the stimulus array is asked right after the array disappeared, iconic memory can be overridden by new visual information (Coltheart, 1980a, 1980b; Lamme, 2010). Second, an observer's ability to retrieve information from memory is limited. [...] we can revisit focused objects ... In that respect, the world can be considered as our memory device that resides outside of our brain (O'Regan, 1992; O'Regan & Noe, 2001).

[...*Iconic memory and phenomenal consciousness: The contents of iconic memory*:] The authors proposed that the feeling of seeing the entire array emerges from the interplay between partially accessible information and

expectations, and that the conscious experience is not as rich as usually assumed. [...] Thus, this study indicates that some aspects of iconic memory (i.e., the gist) are very rich indeed and that there are some aspects of the letter array that are consciously perceived even without attention being directed there by a cue. [...] The second line of studies investigated the nature of the contents of iconic memory using a change blindness paradigm (Landman, Spekreijse, & Lamme, 2003; Phillips, 2011; Sligte, Scholte, & Lamme, 2008; Vandenbroucke, Barrett, Seth, Fahrenfort, & Lamme, 2014; Vandenbroucke et al., 2011). Subjects were briefly shown a set of 4–32 stimuli, which was followed by a blank period of up to several seconds, and a second set of stimuli (Figure 4b). Subjects had to report if a cued item had changed. Subjects were relatively poor at this task when they relied on working memory via a cue presented after the onset of the second stimulus (which erased the fragile memory trace of the previous stimulus), and they were of course very good when the item was cued at the moment the first set of items was shown. However, subjects were also remarkably good when the item was cued in between the two sets of stimuli, even when retinal afterimages were erased, which presumably forces subjects to rely on fragile memory. Based on this and other findings, Lamme and colleagues (Vandenbroucke, Sligte & Lamme, 2011) proposed that phenomenal consciousness is closely related to the contents of a fragile memory system that lasts longer than iconic memory but has a larger capacity than short-term (or working) memory. Fragile memory is more stable than iconic memory, in that it is only erased by a new visual input when that input is at the same location (Pinto, Sligte, Shapiro, & Lamme, 2013). It is also notable that the representation in fragile memory is introspectively accessible to the same degree as working memory, as is measured via the accuracy of metacognition (Vandenbroucke et al., 2014).

[...**3. On sufficiency and necessity**: *3.1.1.*] Here, we consider necessity and sufficiency of reports — or more precisely, the access to reportable information — for phenomenal conscious perception. Currently, this is a topic under intense discussion (Block, 2007). We believe that reports are neither necessary nor sufficient to experience most forms of phenomenal consciousness. [NO, this is because many items are perceived but lot less can be reported; so the report will not tell us anything about items more than 4 as in (Sperling, 1960).]

3.1.2 Is a report sufficient to cause conscious experience? Is a report sufficient for phenomenal consciousness? Does the presence of report guarantee the presence of phenomenal consciousness? Clearly, when employing a strict approach the answer is no. Not every report will guarantee a conscious experience of the reported percept, for example when someone is lying. However, there are some cases that suggest that the act of reporting itself might cause one to truly consciously see something that was not physically present.

3.1.3 Is a report necessary for conscious experience? It is possible, however, that language allows one to elaborate on an experience, which might facilitate

categorization ability and endow the observer with a finer phenomenal conscious experience. Thus, we do not deny a possibility that some forms of phenomenal consciousness might rely on reportability. [...] vivid consciousness seems to be experienced by locked-in syndrome patients (Bauby, 1997) and by some of vegetative or minimally conscious patients (Monti et al., 2010; Owen et al., 2006), both of whom have lost almost all motor modalities to report. [...] In sum, we believe reports are not necessary to experience at least some form of phenomenal consciousness. If reports are not necessary for consciousness, we need to try to de-confound them when we try to study the neural mechanisms of phenomenal consciousness. [...]

3.2 Iconic and/or fragile memory Some researchers claim that we are conscious of all the contents of iconic memory, making it a de facto carrier of consciousness (Lamme, 2010). Others believe that only those objects in iconic memory that are attended to are stored in short-term (or working) memory and are consciously perceived (Rensink, 2002). This latter framework assumes that attention and the memory system are tightly coupled, which has been supported by both empirical and modeling work (Deco & Rolls, 2005; Henderson & Hollingworth, 1999; Jonides et al., 2008; Oberauer, 2002). In section 2.3.3 we discussed studies that investigated the contents of iconic memory. The overall data supports the idea that iconic memory can contain a large amount of visual data, but is perhaps not limitless. Interestingly, iconic memory seems to capture the gist of an unattended scene as well as the specific information in an attended stimulus (see section 2.3.3; de Gardelle et al., 2009). Does the fact that one has an iconic memory of stimulus S, guarantee that he or she consciously perceives that stimulus S? We do not know the answer to this question, and the sufficiency of iconic memory for phenomenal consciousness is currently hotly debated (Block, 2011; Brown, 2011; Lamme, 2010; Phillips, 2011; Vandenbroucke et al., 2014). [...]

3.2.2 Necessity of iconic memory for consciousness [...] Would a person with a lesion that prevents him/her from having an iconic memory be unable to have phenomenal consciousness? Can we knock down iconic memory with TMS without interfering with phenomenal consciousness? Iconic memory, induced by external stimulation, is clearly not necessary for consciousness, as is exemplified by vivid phenomenal consciousness experienced in visual imagery and dreaming. These types of conscious experiences may rely on episodic memory system and top-down attentional access to mnemonic [something intended to assist the memory, as a verse or formula] representations, but they do not necessarily rely on the iconic memory mechanisms (Keogh & Pearson, 2011). While the relationship between visual imagery and short-term memory (e.g., Cattaneo, Vecchi, Pascual-Leone, & Silvanto, 2009) or visual imagery and working memory (e.g., Keogh & Pearson, 2011) has been studied, the interaction between visual imagery and iconic memory seems difficult to study. [...]

4. Conclusion There are widespread changes in the brain associated with

changes in conscious visual perception, involving early and late visual areas and beyond, such as fronto-parietal areas. [...] Attention research has shown us that there are different types of attention: focal/spatial attention, feature-based attention and object-based attention. Are there any such subdivisions we could make for consciousness? In this chapter we have employed one of the possible divisions, namely the division of consciousness in phenomenal and access consciousness. This division is relatively well supported, but not universally accepted (Dehaene et al., 2006; Lau & Rosenthal, 2011). [...] A potentially stronger case can be made for a distinction between gist consciousness and attention-driven consciousness. [...] Indeed, it seems that we need very little, if any, attention to perceive the gist of a scene [...] Consistent with these findings, psychophysical studies suggest we may be aware of simple stimulus features without attention (gist consciousness), but that they may be misbound, and that recurrent attention-related activation is necessary for binding of features (Koivisto & Silvanto, 2011; Treisman & Schmidt, 1982) — i.e., attention-driven consciousness."

[11] As per (Itti & Koch, 2001), "Five important trends have emerged from recent work on computational models of focal visual attention that emphasize the bottom-up [, saliency-driven exogenous attention], image-based control of attentional deployment. First, the perceptual saliency of stimuli critically depends on the surrounding context. Second, a unique 'saliency map' that topographically encodes for stimulus conspicuity over the visual scene has proved to be an efficient and plausible bottom-up control strategy. Third, inhibition of return, the process by which the currently attended location is prevented from being attended again, is a crucial element of attentional deployment. Fourth, attention and eye movements tightly interplay, posing computational challenges with respect to the coordinate system used to control attention. And last, scene understanding and object recognition strongly constrain the selection of attended locations. Insights from these five key areas provide a framework for a computational and neurobiological understanding of visual attention."

[12] As per Wikipedia, "**Voluntary vs. Automatic Shifts in Attention**: Attention can be directed either voluntarily, also referred to as endogenous control, or automatically, which is referred to as exogenous or reflexive attention. In endogenous control, attention is directed toward the stimulus voluntarily, usually by interpreting a cue that directs one to the target, whereas in exogenous control, attention is automatically drawn towards a stimulus (Yantis, 2000). The neural mechanisms in the brain have been shown to produce different patterns of activity for endogenous and exogenous attention (Gazzaniga, Ivry & Mangun, 2002).

Separate neural mechanisms: Corbetta and Shulman, who are proponents of

the belief that separate neural systems exist for endogenous and exogenous control, conducted a meta-analysis of multiple studies showing brain activation due to either of the two attentional processes. Specifically, the dorsal posterior parietal and frontal cortex region are mainly implicated with voluntary attention, while activity is transiently shown in the occipital region. The endogenous mechanisms are thought to integrate previous knowledge, expectations and goals to voluntarily decide where to shift attention. On the other hand, neural areas involved in reflexive attention are believed to have the purpose of focusing attention on events or objects that stand out in the environment. The temporoparietal cortex and ventral frontal cortex region, particularly in the right brain hemisphere, have shown involvement with reflexive [exogenous] attention (Corbetta & Shulman, 2002). [...]

Neural overlap for voluntary and reflexive attention: There appears to be agreement that multiple areas of the brain are involved in shifts of attention, however research is not quite as conclusive regarding the amount of overlap evident with voluntary versus reflexive attention. Rosen *et al.*'s study found a fair amount of overlap between endogenous and exogenous shifts of attention. Both conditions showed activation in the dorsal and parietal premotor areas. However, the voluntary condition also showed activation in the right dorsolateral prefrontal cortex, which did not appear in the reflexive condition. As this area has been shown to be associated with working memory, it may indicate that working memory is engaged voluntarily. The subcortical global pallidus region was also activated only in the voluntary condition. Additionally, the activation shown in the temporoparietal junction [TPJ] was slightly different in both conditions, with the endogenous condition showing more spreading to the lateral, anterior and superior regions. Although these differences did exist, overall there was a lot of overlap demonstrated for voluntary and reflexive shifts of attention. Specifically both showed activations in the dorsal premotor region, the frontal eye field area, and the superior parietal cortex (SPC), although, the SPC exhibited greater activation in the endogenous condition (Rosen et al., 1999). Attention can be guided by top-down processing or via bottom up processing. Posner's model of attention includes a posterior attentional system involved in the disengagement of stimuli via the parietal cortex, the shifting of attention via the superior colliculus and the engagement of a new target via the pulvinar. The anterior attentional system is involved in detecting salient stimuli and preparing motor responses."

As per (Botta, Lupianez & Chica, 2014), "Recent studies have consistently demonstrated that conscious perception interacts with exogenous attentional orienting, but it can be dissociated from endogenous attentional orienting (Chica Lasaponara, et al., 2011; Wyart & Tallon-Baudry, 2008). It has been hypothesized that enhanced conscious processing at exogenously attended locations results from a synergistic action of spatial orienting, bottom-up

activation, and phasic alerting induced by the abrupt onset of the exogenous cue (Chica, Lasaponara, et al., 2011). Instead, as endogenous cues need more time to be interpreted, the phasic alerting they produce may have dissipated when the target appears. Furthermore, endogenous cues presumably elicit a weak bottom-up activation at the cued location. Consistent with these hypotheses, we observed that endogenous attention modulated conscious perception, but only when phasic alerting or bottom-up activation was increased.

[…] Although spatial attention and conscious perception have been historically considered as interdependent processes, some recent studies have challenged this widely accepted view, demonstrating the existence of reliable dissociations between some forms of selective attention and conscious perception.1 [Here we will refer to attention as a mechanism for the selection of certain aspects of our physical environment. … Furthermore, we refer to conscious perception as a mechanism allowing the reportability of near-threshold stimuli.] Interesting examples of dissociations between the two processes have been observed both in blindsight patients (Kentridge, Heywood, & Weiskrantz, 1999a; Kentridge, Heywood, &Weiskrantz, 2004) suffering from severe conscious perceptual impairments, as well as in healthy individuals (Kentridge, Nijboer, & Heywood, 2008; Koch & Tsuchiya, 2007; Wyart & Tallon-Baudry, 2008). Nonetheless, it should be noted that most of the dissociations reported in the literature concern endogenous or top-down mechanisms of attentional selection. This is particularly important if we take into account that it has been widely shown that endogenous and exogenous attention constitute two independent attentional mechanisms. […]

In the case of endogenous attention, a symbolic cue (e.g., an arrow or a number) is presented at fixation indicating the likely target location among the possible target locations. In the case of exogenous attention, the cue is presented directly near or at one of the possible target locations, and is absolutely unpredictive about the target location. […]

Exogenous attention is assumed to represent the automatic capture of attention; it is relatively unaffected by cognitive load and cannot be suppressed (Jonides, 1981). Moreover, the temporal course of exogenous attention is characterized by a fast and transient response characterized by a quick rise at 150 ms and then by a fall to a lower asymptotic level, showing a typical inhibitory aftereffect, known as inhibition of return (IOR). Endogenous attention corresponds to the top-down, voluntarily deployment of spatial attention, is resource-limited, and easy to suppress. Furthermore its response is characterized by a monotonic rise to an asymptote at around 300 ms and can last for several seconds (Posner, 1980). Finally exogenous and endogenous attention are implemented by partially segregated neural substrates (Chica, Bartolomeo, & Valero-Cabré, 2011; Corbetta, Patel, & Shulman, 2008; Corbetta & Shulman, 2002). Therefore, it is possible that whereas endogenous attention does not modulate conscious perception, exogenous attention might in fact do

so. […]

This line of research convincingly demonstrates that endogenous attention can be dissociated from conscious perception, while exogenous attention strongly modulates it. However, exogenous attentional capture is not sufficient for conscious access, as there are many instances in which there is evidence of attentional capture with no subsequent conscious perception (Lambert, Naikar, McLahan, & Aitken, 1999; McCormick, 1997). For instance, it has been observed that, during visual search tasks, distractor stimuli can capture attention, affecting participants' performance and ocular movements, while participants are totally unaware of the presentation of these distractors (Theeuwes, Kramer, Hahn, & Irwin, 1998). Apart from spatial orienting, other processes might be necessary for conscious processing. For example, phasic alerting,3 manipulated by presenting alerting tones at predictable or unpredictable intervals before target appearance, increases conscious perception by modulating both perceptual sensitivity and response criterion (see Kusnir, Chica, Mitsumasu, & Bartolomeo, 2011). Therefore, although important empirical evidence has been collected, the necessary and sufficient conditions for conscious perception still remain to be determined. The Global Neural Workspace, a very well-received theory of consciousness proposed by Dehaene et al. (2006; see also Dehaene & Changeux, 2011), states the existence of three important conditions for access to conscious report: (1) a sufficient level of vigilance, (2) a sufficient level of bottom-up activation of early sensory regions, and (3) the reverberation of brain activation to higher association cortices interconnected by long-distance fiber tracts. On the basis of this theoretical model, it may be possible to understand why exogenous attention is an important modulator of our conscious experience while top-down or endogenous attention seems not to be. Chica, Lasaponara, et al. (2011) hypothesized that the effect of exogenous attention on conscious perception might plausibly be explained as the result of a synergistic action of phasic alerting and attentional capture, both produced by the cue-related bottom-up activation. In other words, the presentation of a salient, abrupt-onset cue near the location of the subsequent near-threshold target, would produce, on the one hand, a bottom-up activation of early visual areas and, on the other hand, an increase of phasic alerting, which would synergistically produce an increase of conscious perception. […]

General discussion[:] The main findings of the present study can be summarized as follows: (1) consistent with previous studies, endogenous spatial attention, oriented with central symbolic cues, did not increase conscious perceptual sensitivity for near-threshold targets (Experiment 1); (2) phasic alerting increased the effect of endogenous attention on target perceptual sensitivity (Experiment 2); (3) bottom-up activation of target saliency was also effective in increasing the effect of endogenous attention on target perceptual sensitivity (Experiment 3). Overall, these results seem to directly support the hypothesis that both alerting and the level of stimuli salience are

critical factors for conscious perception. [...] Experiment 3 showed that phasic alerting is not the only way to enable an endogenous attentional modulation of conscious perception. Indeed, endogenous attention can also modulate conscious perceptual sensitivity when bottom-up target activation is increased through the presentation of an irrelevant sound, simultaneously with and in the same spatial location than the near-threshold target. [...] Nevertheless, it is worth noting that our results, rather than indicating that alerting and bottom-up potentiation inevitably lead to conscious perception, suggest that these factors are necessary but not sufficient for conscious access. As a matter of fact, other previous studies in normal observers (Naccache, Blandin, & Dehaene, 2002) and blindsight patients (Kentridge, Heywood, &Weiskrantz, 1999b) have demonstrated that alerting can increase unconscious processing but without making it available for conscious access. Thus, although alerting cues modulate perceptual sensitivity to stimuli, they do not necessarily bring those stimuli into consciousness. It could be speculated that the effects of alerting, spatial attention, bottom-up potentiation, and their reciprocal interactions on perceptual consciousness, are all a matter of degree. In other words there might be a threshold amount of attention, alerting, perceptual saliency, and their combination that must be exceeded before a stimulus reaches consciousness. [...]

Conclusions[:] The present study demonstrates that the manipulation of alerting signals and bottom-up target activation enhances the conscious perception modulation produced by endogenous attention. The attention dependent increase of conscious perception produced by alerting signals might be due to brain interactions between bilateral fronto-parietal regions activated by the endogenous cue and the ascending thalamic–mesencephalic projections associated with phasic alerting. Alternatively, the attention dependent increase of conscious perception produced by bottom-up target activation may be implemented throughout feed-forward projections from early visual areas to associative fronto-parietal networks and, conversely, by back-projections from fronto-parietal regions towards early visual areas in response to the endogenous cue."

[13] As per (Vimal, 2010b), "*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. […]
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"

[14] It will be nice to settle the inseparability vs. separability issue through empirical findings. The dual-source theory is Barnard Baars' (email correspondence in November 2015): 1pp and 3pp sorces of information. If the two sources/aspects are really 100% separable (seems highly unlikely in my view!) then we need to address its possible consequences such as ghost, zombie, soul, and God because then both sub-aspects (experiential and functional) of consciousness (Vimal, 2009, 2010b) may not need brain under *certain conditions.* Descartes, *Vedantists*, and all religious people will be very happy indeed! If the sources/aspects are inseparable, then the eDAM cannot be rejected. We may need to design better experiments with higher technology to reject it.

[15] As per (Atlas, 1964), "Maimon formulated his conception of matter and form as symbolic cognitions with reference to the Kantian conception of matter and form, i.e., matter is the manifold of perceptions, and form is the concept of unity by which the manifold is synthesized. But the conception of matter and form as symbolic cognitions can be applied equally to Aristotelian doctrine of matter and form. According to Aristotle, any object of experience is always formed matter. Matter in itself and form in itself are beyond the limits of

human experience. They are derived by the process of abstraction, and we ascribe to them metaphysical reality. In experience, however, matter and form do not exist in isolation from each other. Yet matter and form must be assumed as being separately real, otherwise it would be impossible to account for the reality of formed matter. Hence the idea of matter it itself and form in itself can be defined as symbolic, in accordance with Maimon's conception of the essence of symbolic cognition."

[16] That an eternal object can be described only in terms of its potentiality for 'ingression' [act of going in and out] into the becoming of actual entities; and that its analysis only discloses other eternal objects. It is a pure potential. The term 'ingression' refers to the particular mode in which the potentiality of an eternal object is realized in a particular actual entity, contributing to the definiteness of that actual entity.

[17] "The information carrier along a neuron is the em [electromagnetic] field fluctuation that propagates along the neuron: the action potential." His Cemi field framework hypothesizes that information is a dual-aspect entity as (Chalmers, 1995) proposed. The "complex information encoded in em fields feels like *from the inside*." The experience of redness is therefore "*what it is like* (Nagel, 1974) to be on the inside of electromagnetic field-encoded information that corresponds to the statement," 'the long wavelength light detected has a wavelength in the range of around 650 nm'. "In this sense, information and awareness are considered to be two aspects of the same phenomenon (we could call it information/awareness) viewed from alternative frames of reference". "It is possible to distinguish at least three levels of awareness, depending on the dynamics of the physical system encoding information/awareness. At the first level [**discrete awareness**] is information/awareness located with the particles of matter. A single electron, proton, atom or molecule may (from its reference frame) possess informational awareness but only of the very limited static information encoded within that particle (essentially, its quantum wave function). […] The next level of awareness is that associated with fields [**field awareness**], which, in contrast to particles, have unlimited capacity to encode complex information within a single unified physical system. Complex informational objects, like faces and shapes, and abstract objects like numbers or words, may be completely encoded (with all their inherent meaning) within a single unified field. […] The final level of awareness is **consciousness**, what Block terms *access consciousness* (Block, 1995). This has the same physical structure as field awareness discussed above—it is encoded within fields—but its additional defining characteristic is that it can communicate. This level of awareness is associated with that component of the brain's em field—the cemi field—that is able to communicate via its impact (directly or indirectly) on motor neurons and thereby generate reportable consciousness. […] The cemi field theory proposes that consciousness is the inner experience of information/awareness encoded in the brain's em field." Quotes are from (McFadden, 2002a); bold mine. This framework is consistent

with the eDAM framework. However, in Cemi framework, it is not clear (i) where SEs such as *redness* in the mental aspect of redness-related neural-net come from, (ii) how a set of discrete awareness(es) entails field awareness which in turn leads to consciousness (combination problem), (iii) what is so special about brain processes or brain em field to have SEs and not other processes or em fields (i.e., the essential ingredients of SEs, such as wakefulness, working memory, re-entry, attention, and so on, are missing), (iv) how to address the 'brute fact' of the assumption that information has dual-aspect. These queries are addressed in the dual-aspect-dual-mode PE-SE framework.

JM (Johnjoe McFadden): In partial answer to the question you raised in your email - why double aspect? It seems to me that this is inevitable since all entities can potentially have a subjective aspect (viewed from the inside) and an objective aspect (viewed from the outside). Such a change in viewing position is equivalent to a change of frame of reference in physics which can, for instance, change an electrical phenomenon into a magnetic one - the same phenomenon viewed from different frames. Similarly em information is the experience of em information viewed from the outside. Awareness is the experience of em information from the inside.

RLPV: Thanks for your rationale for selecting the dual-aspect view in your framework. However, I am sorry, this rationale is not satisfactory to me because it comes under the 'brute fact' (that is way it is!) justification. Each metaphysical or physical view has its own 'brute fact'. However, physical 'brute fact' has concrete evidence (for example, video information in em field can be observed in TV), but a metaphysical view does not have such concrete evidence that everybody can be convinced. Therefore, we need more incontrovertible justification.

[18] 1.11 Recollection or memory (smriti) is mental modification caused by the inner reproducing of a previous impression of an object, but without adding any other characteristics from other sources. (anubhuta vishaya asampramoshah smritih) [अनुभूतविषयासंप्रमोषः स्मृतिः]

- anubhuta = experienced
- vishaya = objects of experience, impressions
- asampramoshah = not being stolen, not being lost, not having addition
- smritih = memory, remembering

Memory can take on associations: Memory is something with which we are all familiar. Some previously stored impression simply awakens, stirs in the unconscious, and then springs forth into the conscious awareness, having pierced the veil between conscious and unconscious. However, a rising memory often brings along with it many other memories that then get linked in such a way that the original memory is not seen in its pure form. In other words, the

memory is being distorted; it is commingled with the other types of thought patterns.

Mere memory is less of a block to meditation: The memory being described here is the pure memory, without having stolen, or had additions from other memories or the creative, fantasizing, hallucinating process of mind. It is quite natural for these thought impressions to rise in the mind field. By discriminating between the types of thoughts, we can see which are simply memories, and which are memories that have become distorted and effectively turned into fantasies, which are vikalpa, described in sutra 1.9. Mere memory is not so disturbing to our natural peace of mind, whereas when associated with all of the other inner process, leads to the troublesome mental process that blocks deep meditation.

[19] As per Vivekananda's interpretation, "[1.2] *yogashchittavrittinirodhah* Yoga is restraining the mind-stuff (Chitta) from taking various forms (Vrttis) [p9…] Eyes do not see. Take away the brain centre which is in the head, the eyes will still be there, the retinæ complete, and also the picture, and yet the eyes will not see. So the eyes are only a secondary instrument, not the organ of vision. The organ of vision is in the nerve centre of the brain. [p9…] The eye is the external instrument, we need also the brain centre and the agency of the mind [manas]. [p9…] First there is the instrument, then there is the organ, and third, the mind [manas] attachment to these two. The mind [manas (is different from western scientific term 'mind' that includes all mental entities), which is a subtle matter, the central processor, and is liaison between *Puruṣa* and *Prakṛti*: (Vimal, 2012))] takes the impression farther in, and presents it to the determinative faculty—*Buddhi*—which reacts. Along with this reaction flashes the idea of egoism. Then this mixture of action and reaction is presented to the *Purusa*, the real Soul, who perceives an object in this mixture. The organs (*Indriyas*), together with the mind (*Manas*), the determinative faculty (*Buddhi*) and egoism (*Ahamkara*), form the group called the *Antahkarana* (the internal instrument). They are but various processes in the mind-stuff, called *Chitta*. The waves of thought in the *Chitta* are called *Vrtti* ("the whirlpool" is the literal translation). What is thought? Thought is a force, as is gravitation or repulsion. It is absorbed from the infinite storehouse of force in nature; the instrument called *Chitta* takes hold of that force, and, when it passes out at the other end

it is called thought. This force is supplied to us through food, and out of that food the body obtains the power of motion, etc. Others, the finer forces, it throws out in what we call thought. Naturally we see that the mind is not intelligent; yet it appears to be intelligent. Why? Because the intelligent soul is behind it. You are the only sentient being; mind is only the instrument through which you catch the external world. Take this book; as a book it does not exist outside, what exists outside is unknown and unknowable [unknown matter-in-itself]. It is the suggestion that gives a blow to the mind, and the mind gives out the reaction. If a stone is thrown into the water the water is thrown against it in the form of waves. The real universe is the occasion of the reaction of the mind. [p10] A book form, or an elephant form, or a man form, is not outside; all that we know is our mental reaction from the outer suggestion. Matter is the "permanent possibility of sensation," said John Stuart Mill. It is only the suggestion that is outside. Take an oyster for example. You know how pearls are made. A grain of sand or something gets inside and begins to irritate it, and the oyster throws a sort of enameling around the sand, and this makes the pearl. This whole universe is our own enamel, so to say, and the real universe is the grain of sand. The ordinary man will never understand it, because, when he tries to, he throws out an enamel, and sees only his own enamel. Now we understand what is meant by these *Vrttis*. The real man is behind the mind, and the mind is the instrument in his hands, and it is his intelligence that is percolating through it. It is only when you stand behind it that it becomes intelligent. When man gives it up it falls to pieces, and is nothing. So you understand what is meant by *Chitta*. It is the mind-stuff, and *Vrttis* are the waves and ripples rising in it when external causes impinge on it. These *Vrttis* are our whole universe. The bottom of the lake we cannot see, because its surface is covered with ripples. It is only possible when the rippled have subsided, and the water is calm, for us to catch a glimpse of the bottom. If the water is muddy, the bottom will not be seen; if the water is agitated all the time, the bottom will not be seen. If the water is clear, and there are no waves, we shall see the bottom. That bottom of the lake is our own true Self; the lake is the *Chitta*, and the waves are the *Vrttis*. [p11 ...] *Chitta* manifests itself in all these different forms - scattering, darkening, weakening, and concentrating. ... The *Ekagra*, the concentrated form of the *Chitta*, is what brings us to *Samadhi*.

[p13…] 1.11. *anubhootavishayasanpramoshah smritih* Memory is when the (Vrttis of) perceived subjects do not slip away (and through impressions come back to consciousness). Memory [is also *Vrttis*] can be caused by the previous three [*Vrttis*: *Viparya*/false substitution, *Vikalpa*/Verbal delusion, sleep & dream] For instance, you hear a word. That word is like a stone thrown into the lake of the *Chitta*; it causes a ripple, and that ripple rouses a series of ripples; this is memory. So in sleep. When the peculiar kind of ripple called sleep throws the *Chitta* into a ripple of memory it is called a dream. Dream is another form of the ripple which in the waking state is called memory. [p18]".

[20] 6. My working hypothesis related to co-evolution of aspects and the emergence of CM, QM, and deeper level physics

It is as follows:

Pre-BB (quantizable) dual-aspect vacuum (*Śunyatā*) field with QFs → BB (caused by QFs) → (quantizable) dual-aspect unified field (thermal unified and nonthermal stochastic/fluctuating zero-point radiation field (ZPF) continuous field: (de la Pena, Cetto & Valdes-Hernandez, 2015)) → four (quantizable) fundamental dual-aspect fields (17 elemenary particles are excited states (modes) of the field) →

If Nature is determinstic then micro-deterministic CM (classical mechanics) with causality as in the Cellular Automaton Interpretation of QM (CAIQM) ('t Hooft, 2015) related to the physical aspect and the eDAM-MIR-DIQM ***or*** if Nature is random, then dual-aspect ZPF interacts with matter and leads to quantization as in the Stochastic Interpreation of QM (SIQM) related to the physical aspect ((de la Pena, Cetto & Valdes-Hernandez, 2015).pp.84-86) and the eDAM-MIR-PIQM; its indeterministic quality sometimes appears non-causal as in Copenhagen Intepretation of QM (CIQM) →

Macro-deterministic, causal, real, and local CM, where dual-aspect ontological states are real and are the dual-aspect basis states of the eDAM's Hilbert space used in the superposition.

In the CAIQM and the eDAM-MIR-DIQM, a wavefunction is NOT an ontological state; it is rather a template state, i.e., it is the superposition of ontological states as basis states of Hilbert space and represents the probabilities of each ontological state. It is closer to Ensemble Interpretation (EI) of QM. For the eDAM, states are dual-aspect.