Special Issue

Transgenerational Epigenetic Mechanisms, Unconscious Creativity, and Sensory Deprivation: Semi-Free Will in the Extended Dual-aspect Monism Framework

Rām Lakhan Pāndey Vimal*, István Bókkon†, Noémi Császár‡, József Pal Vas#, Henrik Szőke$

Abstract

In our prior work, we reported: (i) the effects of transgenerational epigenetic information on unconscious cognitive abilities, behavioral and emotional patterns, as well as (ii) the essential role of unconscious mechanisms in human decision processes; (iii) the least problematic five component extended dual-aspect monism framework (eDAM) for experiential and functional aspects of consciousness; and (iv) the hypothesis of semi-Free Will. Here, we discuss Free Will in the eDAM framework, by reviewing some latest results regarding the transfer of specific information through transgenerational epigenetic mechanisms. We also briefly review sensory deprivation experiments and some new studies regarding unconscious creativity, also interpreted in the eDAM framework. These presented studies and notions necessarily challenge the traditionally conception of Free Will and supports the concept of semi-Free Will, as well as our definition of consciousness as the mental aspect of a state of brain-system or brain-process, which has two sub-aspects from the first person perspective: conscious experience and conscious function.

Key Words: transgenerational epigenetic information; sensory deprivation; unconscious creativity; Free Will; consciousness; extended dual-aspect monism; semi-Free Will

***Quantum Biosystems* 2015; 6 (1): 33-53**

1 - Introduction

We address five issues:

(i) An overview of molecular epigenetic evidence that the effects of stress are passed down to the next two or three generations in some rodent species;

(ii) An historical overview of some early literature on sensory deprivation;

(iii) The relation between unconscious thought and creativity;

(iv) The issue of Free Will; and

(v) An overview of the extended dual-aspect monism (eDAM) framework and how it can interpret (i)-(iv).

These five diverse topics are related as follows:

(a) Can the eDAM framework explain topics (i)-(iv)?

(b) Does the issues (i)-(iii) necessarily challenge the traditional conception of Free Will? and

(c) Is Free Will originated from unconsciousness?

Corresponding author: Rām Lakhan Pāndey Vimal
Address: *Vision Research Institute, Neuroscience & Consciousness Research Dept.
25 Rita Street, Lowell, MA 01854 USA. Ph: +1 978 263 5028; eFAX: +1 440 388 7907. e-mail: rlpvimal@yahoo.co.in
URL: http://sites.google.com/site/rlpvimal/Home
†Psychosomatic Outpatient Department, 14 Tulipan Street, 1022 Budapest, Hungary.
‡Scientific director of Psychology and Human Resources, Budapest, Hungary
#Supervisor Psychotherapist, Head of Psychotherapy Department, Borsod University Hospital, Miskolc, Hungary
$University of Pécs, Faculty of Health Sciences, Doctoral School of Health Sciences, Pécs, Hungary

1.1 - Epigenetic mechanisms, Free Will, non-conscious and unconscious processes, and sensory deprivation

Epigenetics deals with changes in our genome that can be transmitted through mitosis and meiosis by stable mechanisms, without altering the DNA sequence (genetic code) itself. Epigenetic mechanisms include covalent DNA methylation, histone post-translational modifications (such as methylation, acetylation, ubiquitination and phosphorylation), regulatory non-coding RNAs such as microRNA, PIWI-interacting RNA and long noncoding RNAs, and hormones (Grentzinger, 2012; Shilatifar, 2006; Zhang and Ho, 2011; Csaba, 2011; Mercer and Mattick, 2013; Peschansky and Wahlestedt, 2014). Many studies have revealed that epigenetic regulations are essential contributors in neuronal gene expression, long-term memory formation, synaptic plasticity, cognitive functions, as well as in the pathophysiology of several neurodevelopmental and neurodegenerative diseases and psychiatric disorders (Guan, 2014; Woldemichael, 2014; Landry and Kandel, 2013; Gräff, 2011; Franklin and Mansuy, 2010). Epigenetic mechanisms make it possible that the obtained information can be transferred to offsprings, in a process of transgenerational inheritance (Crews, 2012).

With the intention of investigating carefully commonly held notions of Free Will, we have previously described many experimental results suggesting that unconscious processes precede voluntary actions and decisions (Bókkon, 2014; Libet, 1983; Bode, 2011; Soon, 2013). We also discussed how inherited and obtained epigenetic information in pre-, peri-, and early postnatal states plays crucial roles in many brain functions of the mature organism (Bókkon, 2014). Thus, inherited epigenetic information, as well as other forms of information obtained during development and environmental experiences, can make a subject susceptible to diverse diseases, and can also determine the development of individual brain structures, cognitive abilities, behavioral and emotional patterns and responses.

We speculated about human explicit self-consciousness[i] or self (subjective experience of subjectivity; Bruzzo and Vimal (2007)) to be an executer that intermediates between implicit nonconsciousness / unconsciousness (Vimal, 2010a) and the external environment through feedback and feed-forward interactions (Bókkon, 2014). It was also suggested that our self-conscious thinking, and every decision made at a given moment, may be a coherent and convergent dynamic manifestation of our unconscious processes.

Here we explore the concept of Free Will by presenting and discussing recent, fascinating studies concerning specific mechanisms through which transgenerational epigenetic information may be transmitted.

We also briefly review human sensory deprivation experiments, with the intention of highlighting our hypothesis that the human conscious self is an executer that cannot function without sensory environmental stimulations. We also point out the essential role of unconscious thinking in creativity.

1.2 - Definition of consciousness

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* (Vimal, 2009). An immediate advantage of this categorization is that it makes clear what materialism can do and what it cannot do. *Materialism may explain functions but cannot explain experiences*. In other words, this categorization sets the clear-cut limit for materialism. The *optimal* definition (that has the least number of problems) of consciousness is: *consciousness is the mental aspect of a state of the brain-system or a brain-process, which has two sub-aspects: conscious experience and conscious function* (Vimal, 2010c). In other words, consciousness (a) has functional and experiential aspects and (b) includes functions and subjective experiences (SEs) (including feelings, emotion- and thought-related experiences).[ii]

1.3 - The eDAM framework

The following summary of the eDAM framework (Vimal, 2008, 2010b, 2013, 2015a,b) is adapted from Vimal (2015c).

1.3.1 - The first component of the eDAM framework: Dual-Aspect Monism

This component is detailed in Vimal (2008). Concisely, it was hypothesized that a state of an entity (from an elementary particle to the human brain to the whole universe) has two aspects: (i) Mental aspect such as SEs from the first person perspective (1pp) for living systems, or qualitative aspect for both living and non-living systems, and (ii) Objective physical aspect such as neural-network and its activities from the third person perspective (3pp). Moreover, the eDAM framework proposes that the *potentiality* of primary irreducible SEs pre-exists in Nature. The 3pp-physical aspect of an entity-state is manifested in both living and non-living systems. Our hypothesis is that the superposition of relevant *potential* experiential eigen-states is a mental-state, which is a part of the mental aspect of a state of a living system or the qualitative aspect of state of a living/non-living system.

1.3.2 - The second component of the eDAM framework: the dual mode and conjugate matching and selection mechanisms

This is elaborated in Vimal (2010b). Concisely, the *potentialities* (possibilities) of SEs are *actualized* when neural-networks are formed, and a specific SE is selected by the self via a *matching* process through the interactions of two dual-aspect modes. These two modes are: (1) The *non-tilde mode* that has the *inseparable* qualitative/mental aspect and the physical aspect of a state of feedback signals related to cognition (such as memory and attention) and the self in a neural-network (that includes self-related brain-areas such as cortical midline structures), which is the cognitive nearest past approaching towards present; and (2) The *tilde mode* that has the *inseparable* qualitative/mental aspect and the physical aspect of a state of the feed forward signals due to external environmental input and/or internal endogenous input, which is approaching towards present (or will become present) and is a entropy/time reversed representation of the non-tilde mode.

Furthermore, one could argue that there are quantum (such as dendritic-dendritic microtubule) sub-pathway and non-quantum (such as classical axonal-dendritic neural and astroglial) sub-pathway in the feed forward pathway and the feedback pathway for information processing and transfer in the brain dynamics.

We propose that: (i) The *quantum conjugate matching* (between *experiences* in the qualitative/mental aspect of a state of signal in the tilde mode and that in the non-tilde mode) is related more to the qualitative/mental aspect of a state of the quantum sub-pathway and less to that of the non-quantum sub-pathways. And (ii) The classical *matching* between *experiences* in the qualitative/mental aspect of a state in the tilde mode and that of the non-tilde mode is related to the qualitative/mental aspect of a state in the non-quantum sub-pathways.

In all cases, a specific SE is selected by the self (*not* by any homunculus) (a) When the tilde mode interacts with the non-tilde mode to *match* for a specific SE, and (b) When the *necessary* conditions of SEs (Section 1.4) are satisfied. When the conjugate match is made between the two modes, *the world-presence* (*Now*) is disclosed; its content is the SE of subject (self), the SE of objects, and the content of SEs. The self is the 1pp-mental aspect of a state of self-related neural network (such as cortical midline structures) and its activities that is a part of reentrant feedback signals during wakefulness (and to the some extent during dream). The physical aspects in the tilde mode and that in the non-tilde mode are matched to link *structure* with *function*, whereas the qualitative/mental aspect in the tilde mode and that in the non-tilde mode are matched to link *experience* with *structure* and *function*. In all cases, the *inseparability* between aspects and the 1-1-1 relationship among structure-function-experience are maintained during the experience and related function.

The concept of *functional field* was used by Cacha and Poznanski (2014). In *consciousness electromagnetic information field (Cemi field) theory*, experiences are presumably from the 1pp-mental aspect of a state of dual-aspect electromagnetic (em) field: "what Chalmers terms *experience* (Chalmers, 1995) is what complex information encoded in em fields feels like *from the inside*" (McFadden, 2002). These fields may have many potential states related to experiences in superposed form embedded in the field. In that case, it would still be non-conscious processing and then the gap remains. However, if these frameworks use the essential matching and selection mechanisms of the eDAM framework to select one specific SE after matching along with necessary conditions of consciousness to be satisfied (Section 1.4), then the gap will be closed.

1.3.3 - The third component of the eDAM framework: the concept of the varying degrees of the manifestation of aspects depending on the levels of entities and contexts

This concept is discussed in Vimal (2013). Concisely, the third component is the *varying degrees of the manifestation of physical aspect and qualitative/mental aspect depending on the levels of entities and contexts*. In inert (*nonliving*) entities at classical level, such as a molecule, the physical aspect of its state is from the objective 3pp and the degree of its manifestation is high. The qualitative/mental aspect includes (a) Forms, patterns of distribution of matter/energy in space and time, and/or patterns of vibrations for both living and non-living systems as qualitative aspects (Pereira, 2015), and (b) Superposed *potential* eigen-states related to SEs for living-system. The mental aspect of a state of a living-system is from the 1pp and the physical aspect is from the objective 3pp. This implies that (a) The qualitative aspect, such as forms and patterns, can be perceived or implicitly inferred from 3pp, but (b) The mental aspect of a state of a non-living system is 'latent' to us from the 3pp. This does not mean that nonliving systems have consciousness like us that is hidden; rather, the *qualitative/mental* aspect of a state of a nonliving entity carries *potential* proto-experiences (PEs) in superposed form as a Nature's mechanism for the pre-existence of potential SEs. We perceive the form, pattern of distribution of matter/energy in space and time, and/or pattern of vibration (Pereira, 2015) related to an inert entity, which indicates the existence of its qualitative aspect; so, it is better to use the term 'qualitative aspect' (Pereira, 2015) in place of 'mental aspect' for non-living systems to avoid confusion; for the same reason, we use '1pp-mental aspect' for conscious states and 'mental aspect' for non-conscious states.

Both physical and qualitative/mental aspects of the states of nonliving systems (such as strings, elementary particles, atoms, molecules etc.) need to co-evolve to attain our brain-mind system. Biological organisms can be conscious if the organism's evolutionary development is sufficiently developed or complex and necessary conditions of consciousness are satisfied (Section 1.4). In *living* systems, at the human level, when we are awake and conscious, both aspects are present with high degree of manifestation. In other words, inert *nonliving* matter, proteins, neurotransmitters and neuromodulators including all those levels which do not satisfy the *necessary* conditions of consciousness will not be conscious. This does not mean that the eDAM is not sympathetic to quantum consciousness. In quantum dendritic-dendritic mechanism, quantum Orch OR is hypothesized to occur in microtubule-network (Hameroff and Penrose, 2014), where a specific SE say *redness* is selected from *potential* SEs embedded in brain's spacetime geometry by objective reduction (collapse) of *potential* SEs superposed in the qualitative/mental aspect of a state of neural-network. It is only at the neural-network (NN) level (in **living** systems), a specific SE will be *realized* (experienced) in a specific NN (such as *redness* will be *actualized* in the red-green V8/V4/VO-neural-network) when (a) the *necessary* conditions of consciousness (including biological laws, see Section 1.4) are satisfied and (b) a specific SE (such as *redness*) is selected by the self via the matching process.

Even the retina is not privileged to have SEs because it does not satisfy the essential conditions of consciousness, although retina is essential for vision. The retinal opponent and non-opponent neural-networks (such as red-green and yellow-blue opponent cells and luminance non-opponent cells and related visual channels), however, will have higher specificity for *potential* experiences (mental aspect) than cones and rods, which in turn will have higher specificity than molecules, atoms, and electrons.

Let us start examining aspects from humans to classical inert entities to quantum entities to sub-quantum strings. If we assume that a state of 'entity-in-itself' has *inseparable* dual (qualitative/mental and physical) aspects, then a state of 'human-in-herself' has physical aspect (such as body-brain system and its activities) and mental aspect (such as SEs, intentions, self, attention, functions, and other cognitions). The states of animals and birds have physical aspects (such as body-brain system and its activities) with high degree of manifestation, but their mental aspects seem to be of different degree (đ) of manifestation compared to humans. The states of plants have physical aspects such as their roots to branches and activities, and their qualitative/mental aspects in term of functions; it is unclear if they have experiences, self, attention, and other human-like cognitions; they may have plant-type PEs, but they are latent to us. The states of dead bodies (of human, animals, birds, and plants), inert entities, and other classical macro, micro (such as elementary particles), and ultra-micro (strings) entities have the physical aspects with high degree of manifestation; they have certain forms, patterns of distribution of matter/energy in space and time, and/or patterns of vibrations (qualitative aspect) (Pereira, 2015); but, their mental aspects are latent. By the term 'latent', we mean that the aspect is hidden, unexpressed, 'invisible', recessive (in analogy to recessive gene), or unmanifested.

For quantum and sub-quantum entities, the manifestation of aspects needs further clarification: we are puzzled on the 3pp as we are unable to visualize and we depend on our models and indirect effects. The qualitative aspect of a state of a quantum or a sub-quantum (such as string) entity is presumably its form and/or patterns of vibration (Pereira, 2015). Therefore, we propose that a state of a quantum entity has physical aspect with high degree of manifestation; and qualitative/mental aspect similar to classical inert objects. However, quantum latent mental aspect is not like human mind; rather, Stapp (2001, 2007, 2009b) has proposed that quantum entities are mindlike. We propose that the quantum or sub-quantum mindlike qualitative aspect (form and/or patterns; see Pereira (2015)) has to co-evolve with its *inseparable* physical aspect over billions of years, and the end product is human mind (mental aspect) and *inseparable* human brain (physical aspect), respectively. The above clearly elaborates the difference between living and nonliving systems.

1.3.4 - The fourth component of the eDAM framework: necessary conditions of consciousness

The necessary conditions of consciousness are developed in Vimal (2015b). Consciousness can be either *phenomenal* (non-reportable) or *access* (reportable) consciousness (Block, 2005; Lamme, 2003). For *access* (reportable) consciousness, the interactions are between feed forward stimulus dependent signals and fronto-parietal feedback attentional signals.

Attention and the ability to report are not necessary for *phenomenal* consciousness.

The *necessary* conditions for *access* consciousness are (i) Formation of neural-networks, (ii) Wakefulness, (iii) reentrant interactions among neural populations, (iv) Fronto-parietal and thalamic-reticular-nucleus attentional signals that modulate consciousness, (v) Information integration in 'complex' of neural-network, such as thalamocortical complexes with critical spatiotemporal 'grain-size' (Tononi, 2004, 2008, 2012) as summarized in (Vimal, 2015a), (vi) Working memory that retains information for consciousness, (vii) Stimulus contrast at or above threshold level, and (viii) Neural-network PEs that are superposed *potential* SEs embedded in a neural-network as pre-cursors of SEs. Certain neural-network or brain complex, such as the thalamocortical 'complex', comparatively has very high integrated information (☐), so it is a privileged area for consciousness. The criterion for the selection of *necessary* conditions is that if any of them is missing, we will not have consciousness.

1.3.5 - The fifth component of the eDAM framework: segregation and integration of dual-aspect information

This is elaborated in Vimal (2015a) in detail. Concisely, there are two stages: (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, sub-mode, and mode), which results unified consciousness. 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 integrated information theory (IIT) of consciousness (Balduzzi and Tononi, 2009; Tononi, 2004, 2008, 2012) is based on the materialistic identity theory (consciousness is integrated information). However, materialism metaphysics has serious problems (Vimal, 2010c, 2013). Therefore, IIT needs to be interpreted in terms of better metaphysics, such as the eDAM framework;

this has the least number of problems; here, information is a dual-aspect entity.

In the eDAM framework, consciousness (both experiential aspect such as SEs including feelings, emotion- and thought-related experiences and functional aspect such as related functions) is the 1pp-mental aspect of a state of related neural network (neural-network: such as thalamocortical main complex) that has high amount of integrated mental-information $\square_{mental}$. The 3pp-physical aspect of this state is this neural-network and its activity as its neural substrate that has high amount of integrated physical-information $\square_{physical}$, which is close to the term 'integrated information' $\square$ used in (Tononi, 2004, 2008, 2012) and (Balduzzi and Tononi, 2009). Since 1pp-mental and 3pp-physical aspects are *inseparable*, 'mental' and 'physical' information related to the same brain-mind state are also *inseparable*.

Furthermore, the *quality* of consciousness is determined by the set of all the informational relationships generated by the matching and selection mechanisms of the eDAM framework. The *quantity* of unified consciousness as a whole (a) is above and beyond its parts and (b) is related to the amount of information integrated through the matching mechanism (Section 1.2) (that involve interaction between feed forward and feedback signals) in a complex of elements.

In the eDAM framework (Sections 1.3.1-1.3.5), (i) The process of observing involves the matching and selection mechanisms, (ii) The observer (the self or SE of subject (Bruzzo and Vimal, 2007)) is the 1pp-mental aspect of the state of self-related integrated information, and (iii) The observed (SE of object) is the 1pp-mental aspect of the state of object-related integrated information.

Furthermore, the 'hard' problem of consciousness is clearly addressed in (Vimal, 2015a) using all five components of eDAM framework. The criticisms of the eDAM framework are addressed in Vimal (2015d).

Our hypothesis is that human consciousness: (i) Is the mental aspect of a state of the brain-system or a brain-process, which has two sub-aspects: conscious experience and conscious function (Vimal, 2010c) in the eDAM framework, and (ii) Is a self-referential and language-dependent executer that intermediates between unconsciousness and the external environment.

2 - Transgenerational information transmission

2.1 - Specific fears can be inherited

Very recently in a *Nature Neuroscience* publication, Dias and Ressler (2014) reported fascinating experimental results indicating specific fears can be inherited. By pairing the experience of a scent with an electric shock to the foot, mice were conditioned to fear the smell of acetophenone (a fruity odor). The researchers used acetophenone because it is well known that the Olfr151 gene controls the M71 olfactory receptor expression. After ten days of fear training, first generation conditioned animals (F0) were allowed to mate. The offspring (F1 generation) presented an increased startle response to the fruity smell, even though they had never encountered the smell before. The fear reaction of F1 mice was specific to acetophenone, as the mice did not startle in response to the control odors of propanol, which acts on a different Olfr6 receptor.

Moreover, the F2 generation displayed the same increased sensitivity to acetophenone.

In addition to behavioral differences, physiological changes were found in the F1 and F2 offspring. F1 and F2 generation animal's noses showed significantly more M71 neurons, which contain a receptor that detects acetophenone, than control animals. In addition, F1 and F2 mice brains showed larger M71 glomeruli, a region of the olfactory bulb that responds to the scent of acetophenone. Therefore, the conditioning of the F0 generation to fear the smell of acetophenone leads to acetophenone-specific physiological changes in the subsequent two generations. Researchers also studied the epigenome of the M71 olfactory receptor gene, and found CpG hypomethylation in the Olfr151 gene in the sperm of mice conditioned to acetophenone (F0), as well as in the sperm of their offspring (F1). This DNA hypomethylation could produce increased expression of M71 in olfactory sensory neurons (OSNs) that induced an expansion of the circuitry destined for the detection of acetophenone.

To rule out social influences, the researchers performed in vitro fertilization (IVF) experiments. Male mice were trained to fear acetophenone, and ten days later the animals' sperm was harvested. The sperm was carried to another lab where it was used to artificially inseminate female mice.

While the authors could not perform behavioral tests on these mice because of laboratory regulations about animal quarantine, the brains of the offspring presented larger M71 glomeruli, just as before. Researchers suggested that the acetophenone used in the F0 fear conditioning experiments could enter the circulatory stream to activate olfactory receptors expressed on sperm.

While unanswered questions remain, for example, Dias and Ressler did not perform control experiments where the F0 animals were exposed to the acetophenone odor without the shock, nevertheless, these experiments are the first steps toward support for the existence of specific transgenerational epigenetic information transmission.

As per eDAM framework (Section 1.3), these effects are in the physical and *inseparable* mental aspects of mind-brain-body states. Dias and Ressler's (2014) reports indicating specific fears can be inherited in the mental aspect and the acetophenone induced Olfr151 gene that controls the M71 olfactory receptor expression is related to the inseparable physical aspect.

2.2 - Drastic changes in food availability may induce specific transgenerational responses

Bygren (2014) investigated the hypothesis that a large fluctuation in food availability during grandparents' early development influences their grandchildren's cardiovascular mortality rates. Subjects consisted of 317 randomly selected people born in 1890, 1905, and 1920 in Sweden.

According to Bygren's analysis, if "*the paternal grandmother up to puberty lived through a sharp change in food supply from one year to next, her sons' daughters had an excess risk for cardiovascular mortality*".

Bygren could demonstrate only a connection between the paternal grandmother and her son's daughter. They discuss that neither selection pressure, learning, nor could imitation explain the results of their analysis. X-chromosome linked epigenetic inheritance through spermatozoa is a reasonable process, which is limited to transmission via the father (due to sex differences under meiosis). It was concluded that drastic changes in food availability could give specific trans-generational responses. Bygren proposed epigenetic inheritance (including micro-RNAs) through the gametes as a plausible mechanism for the transgenerational responses in mammals.

As per eDAM framework (Section 1.3), these transgenerational effects on cardiovascular mortality rates are in the physical aspects of mind-brain-body states; it would be interesting to investigate if there are some changes in their mental aspects as well.

2.3 - Transgenerational information transmission produced by maternal separation

Fascinating experimental results pertaining to transgenerational information transmission produced by unpredictable maternal separation combined with unpredictable maternal stress (MSUS method see Weiss, 2011) were reported by Gapp (2014) in Nature Neuroscience. Mice pups were separated from their mothers for 3 hours daily from postnatal days 1 to 14.

During separation periods, the mothers were also stressed, for instance, by being confined to a narrow tube. Traumatic isolation experiences produced marked behavioral, metabolic and molecular effects in mice. Explicitly, Gapp found up regulation of numerous miRNAs in F1 animal MSUS sperm, and that miRNAs were also altered in serum as well as in the hippocampus and hypothalamus of adult F1 MSUS mice. In addition, miRNAs were affected in the serum and hippocampus of adult F2 MSUS mice, but not in F2 sperm. The effect of stress appears to diminish by the third generation, as miRNAs were normal in F3 mice; however, F3 MSUS mice presented behavioral symptoms similar to those exhibited by F1 and F2 animals. The authors speculated that it was possible that miRNA changes first appearing in sperm were transferred to other non-genomic or epigenetic marks, such as DNA methylation or histone post-translational modifications, which explain the observed behavioral symptoms. Researchers also investigated a possible link between sperm RNAs and the effects of MSUS. They isolated RNA from sperm of MSUS mice, injected it into wild-type fertilized mouse oocytes, and re-implanted the oocytes into females. When the resulting offspring (MSUS-RNAinj mice) became adults, they presented very similar metabolic and behavioral traits as the MSUS mice. Authors also performed serum insulin and blood glucose analyses and found various anomalies in MSUS mice and MSUS-RNAinj mice. In brief, these experiments demonstrate transgenerational behavioral, metabolic, and molecular effects of early trauma in mice by direct exposure to MSUS in early postnatal life, and by injection of sperm RNAs from MSUS males.

Furthermore, Leimar and McNamara's model (2015) shows that "*the passing of maternal cues and the transgenerational integration of sources of information readily evolve*". Moreover, Gorelick and Bertram's phenotypic model (2003) of sex-limited temporally fluctuating selection demonstrates that "*substantial heritable variation can be maintained and thereby provides impetus to develop population epigenetic models*". In addition, Magdon-Maksymowicz and Maksymowicz (2015) claim that "*proposed epigenetic contribution may be seen as a candidate for possible explanation of observed deviation from the Gompertz law, also among senior members of society*". Stamps and Krishnan's hypothesis (2014) that "*information from ancestors and information from personal experiences are combined via nonadditive, Bayesian-like processes*".

As per eDAM framework (Section 1.3), these transgenerational behavioral, metabolic, and molecular effects produced by maternal separation are in both mental and physical aspects of mind-brain-body states.

2.4 - Stress during pregnancy can be passed down through several generations

Preterm birth is one of the most important causes that can produce health problems in later period of life**.** In the latest experiments (Yao, 2014) timed-pregnant rats were stressed daily by restraint and forced swimming. Rats F0 were placed in a customized transparent Plexiglas container for 20 minutes every day during days 12 to 18 of gestation. The inner diameter of the container was planned to the size of the animals to restrain turning and maintain the animals in a standing position of the body.

Forced swimming happened in a round water tank. The next two F1 and F2 generations were then divided into two groups that were either stressed or not stressed.

The daughters of stressed animals had shorter pregnancies compared to daughters of those who had not been. In addition, the grand-daughters of stressed animals had shorter pregnancies, even if their mothers had not been stressed. A surprising outcome was that during pregnancy, mild to moderate trauma had a compounding consequence across generations. Namely, stress effects grew larger through each generation. In other words, the most dramatic impact of prenatal stress on developmental line has been found in the F3 generation.

Yao and his colleagues (2014) have shown that maternal stress or the cumulative effects of recurrent stress influence risk of preterm birth and reduced health outcomes across three generations. They have revealed that maternal stress could generate miRNA modifications that affect on epigenetic regulation of gene expression that finally effects across several generations. It seems that recurrent prenatal stress across many generations amplifies hypothalamic-pituitary-adrenal axis responses to exacerbate variations in gestational lengths and produce adverse maternal and offspring behaviours.

As per eDAM framework (Section 1.3), these transgenerational effects produced by stress during pregnancy that can be passed down through several generations are shown in the physical aspects (such as shorter pregnancies) of mind-brain-body states. It would be interesting to investigate the effects on their mental aspects (such as behavioral effects) as well.

2.5 - Circulating miRNAs in epigenetic inheritance in mammals

A recent bioinformatics analysis has provided evidence for the role of circulating miRNAs in epigenetic inheritance in mammals (Sharma, 2014). In addition, Barry (2013) has proposed that vesicles released by tissues into the bloodstream (van der Pol, 2012) may transmit RNA-mediated somatic cell-derived regulatory information to the germline. Vesicles mainly contain sncRNAs (Lasser, 2012) and miRNAs (Guduric-Fuchs, 2012).

As per eDAM framework (Section 1.3), the transgenerational effects produced by circulating miRNAs need to be investigated for both physical and mental aspects.

3 - Detrimental effects of sensory deprivation: human mind is dependent on adequate sensory contact with the external world

A number of studies have demonstrated sensory input to be essential for proper brain development and function. Sensory deprivation can induce profound changes in central processes and multisensory functions in early infancy (Mowery, 2014; Putzar, 2010; Qi, 2010; Collignon, 2009; Putzar, 2007; Carvell and Simons, 1996).

In contrast, sensory isolation/deprivation can also be applied as an alternative treatment. In modern parlance, sensory isolation/deprivation is now called a restricted environmental stimulation technique (REST). Sensory deprivation (or perceptual deprivation) is a reduction or removal of stimuli from one or more of the senses (Rasmussen, 1973). The REST method is used for the treatment of stress-related pain such as chronic headaches, premenstrual pain, fibromyalgia, etc. There are two basic methods of REST known as chamber and flotation REST (Suedfeld and Bow, 1999; Bood, 2006, 2009).

During chamber REST treatment, subjects lie on a bed in a totally dark and sound reducing room. During flotation REST, subjects are placed in a water tank with an extremely high saline concentration (mainly magnesium sulphate, which does not irritate the skin), which allows patients to float supine on the water. The flotation tank can exclude sound and light and retain heat, and the water temperature is kept about at 34.7°C. It has been suspected that the positive affect of REST can be attributed to the deep relaxation inducing reduction of stress hormones and the release of endogenous endorphins.

In spite of the restorative effects of temporary REST, prolonged sensory isolation experiments conducted over the last century report detrimental effects on subjects. These prolonged sensory deprivation experiments were not intended as therapy, but conversely for torture and manipulations such as brainwashing, mind control, and interrogation of military prisoners. We should make clear the distinction between sensory deprivation (SD) and perceptual deprivation (PD) studies. During SD, subjects are subjected to minimized total sensory stimulation, which is reduced to levels as low as possible. Subjects are placed in a dark and soundproofed chamber wearing gauntlet-like gloves and are instructed to lie quietly on a mattress. Earplugs or earmuffs also can be used to reduce the level of sound stimulation.

The social stimulation (social isolation) communication between subject and experimenter is also kept to a minimum level. In contrast, the objective of PD studies (perceptual deprivation, also known as McGill type experiments or partial isolation) was not to cut subjects off from all sensory stimulation, but to remove patterned or perceptual stimulation, so far as it could be arranged (Heron, 1957). For instance, McGill subjects were confined in a lighted cubicle wearing translucent goggles that allowed for only perception of diffuse light.

The first prolonged human sensory and perceptual deprivation experiments were supported by the U.S. government and related to the Cold War in the 1950s. Several renowned psychologists (mostly unknowingly) obtained research funds from the U.S. government and various agencies that were directly or indirectly sponsored by the CIA (Weinstein, 1990; Brown, 2007; McCoy 2006). In 1951, the first human perceptual deprivation experimental results by Donald Hebb (who was a professor of psychology at Montreal's McGill University) and his team had to be kept secret. Hebb paid his male voluntary graduate students $20 a day, which was an excellent salary for the time. Students were placed in small chambers containing little more than a bed where they lay for up to several days, wearing cardboard cuffs and gloves to reduce tactile sensations, while they were exposed to constant diffuse white light and noise to eliminate patterned vision and hearing. Hebb wanted to observe his students for six weeks (prolonged isolation); however, the majority lasted no more than a few days in isolation (Heron, 1957).

Hebb and his colleagues presented their dramatic preliminary results concerning human perceptual isolation studies at the Canadian Defense Research Board symposium in 1952. Hebb (1952) reported that volunteers endured hallucinations, disorientation, delusions, cognitive impairment, out of body experiences, and scored lower in solving mathematic problems in their isolation studies. In 1953-1954, it is likely that studies by Hebb and his colleagues had leaked to the popular press.

The first reports about hallucinations under perceptual isolation (Heron, 1953, 1957; Brown, 2007) enraptured scientists and started a widespread interest in other responses to isolation.

Following on from early work by Hebb and colleagues, many researchers became involved in sensory and perceptual deprivation experiments. Some, like Donald Ewen Cameron, psychiatrist at the McGill-affiliated Allen Memorial Institute, who was also president of the American and World Psychiatric Associations, often conducted many unethical and unscrupulous experiments such as brainwashing techniques, drug dis-inhibition, prolonged sleep, and psychological isolation that were combined with electro-convulsive therapy, and produced in many cases permanent and complete amnesia (Gillmor, 1987; Scheflin and Opton, 1978; Cameron, 1960; Raz, 2013). Within the two decades since its inception, research interest in sensory deprivation experiments has essentially ceased with only a few researchers still conducting sensory deprivation studies (Zubek, 1969, 1973; Raz, 2013).

The BBC televised a Horizon program entitled Total Isolation (BBC, 2008), which aimed to recreate the sensory deprivation study performed 40 years ago by Hebb. Before isolation, the volunteers were required to do various tests assessing visual memory, verbal fluency, information processing, and suggestibility. Next, the six volunteers were placed in a nuclear bunker. Three volunteers were placed alone in dark and sound-proofed rooms, while the other three wore goggles and foam cuffs, with white noise piped into their ears. Volunteers were monitored to determine the effect of 48 hours of sensory/perceptual deprivation. After 48 hours, the volunteers reported that hallucinations and inability to sense time made the experience difficult. Three volunteers experienced auditory and visual hallucinations such as snakes, oysters, tiny cars, and zebras. One volunteer was convinced their sheets were wet. However, two volunteers seemed to tolerate the isolation without issue. When the 48 hour isolation procedure was completed, the tests taken before isolation were repeated. The results revealed that all volunteers' ability to complete the previously assessed tasks became poorer. Memory capacity of one volunteer fell 36%, and all subjects had trouble thinking of words beginning with a nominated letter (in this case, the letter was "F"). All four men involved with the study (but neither of the two women) had remarkably increased suggestibility.

Recently, Mason and Brady (2009) performed short-term, near-total sensory deprivation experiments. This study wanted to reveal if perceptual disturbances could be elicited by a brief period of complete isolation from sound and vision in both highly hallucination prone and non-hallucination prone groups. 19 healthy volunteers were placed into a sensory-deprivation room that almost completely excluded light and sound for 15 minutes. Isolated people presented visual hallucinations, perceptual distortions, paranoia, and depressed mood. The volunteers who were less prone to hallucinations reported fewer perceptual distortions, but they still recounted a variety of delusions and hallucinations.

This wealth of sensory deprivation experiments well demonstrates that the stability of the human mental state is dependent on adequate sensory contact with the external world. Outcomes of sensory deprivations are essentially dependent on deprivation conditions, deprivation duration, and individual differences. Even in normal subjects without pharmacological manipulation, the prolonged stress resulting from SD can produce detrimental neurological changes in the human brain, which can manifest in maladaptive behaviors and disorders. Therefore, an organism requires not only stimulation but also continually varied external sensory information for the maintenance of normal and adaptive behavior (Heron, 1953; Scott, 1954, 1959; Goldberg, 1961). Continuous exteroceptive stimulation has an essential motivational function; behavior can be directed by increasing (or decreasing) sensory input to maintain an adequate level of varied sensory information (Schultz, 1965). This stimulus variation can function as a drive state.

Extraneous stimulation conveyed by peripheral mechanisms executes a general control over the activity of the central processes, upon which proper functioning of selectivity, and thus adaptive behavior, depends (Scott, 1954, Goldberg, 1961). Without external cues mediated by peripheral processes, there could be no behavior. Hebb's position (1954) was that a sensory event has two distinct functions. It arouses or guides a specific response, but it also has a non-specific role of maintaining the brain function that operates during the normal waking state.

As per eDAM framework (Section 1.3), these detrimental effects of sensory deprivation resulting visual hallucinations, perceptual distortions, paranoia, depressed mood, and so on are shown in the mental aspects of mind-brain-body states. It would be interesting to investigate the effects on their physical aspects as well.

4 - Unconscious thinking and creativity

> "*One evening, contrary to my custom, I drank black coffee and could not sleep. Ideas rose in crowds; I felt them collide until pairs interlocked, so to speak, making a stable combination. By the next morning I had established the existence of a class of Fuchsian functions, those which come out from the hypergeometric series; I had only to write out the results, which took but a few hours.*" Henri Poincare, 2001

Latest neuroimaging studies by Creswell (2013) have shown that a brief distraction period (two minutes) of unconscious thought (UT) produced better behavioral decisions compared with making an immediate decision (ID). Information about cars and other items were presented to 27 healthy volunteers while they underwent neuroimaging. Next, before volunteers were asked to make decisions about the items, they had to perform a difficult distractor task (memorizing sequences of numbers) to prevent them from consciously thinking about the information related to the decision.

When the subjects were initially learning information about items, the neuroimaging results revealed that the brain areas responsible for making decisions (left intermediate visual cortex and right dorsolateral prefrontal cortex) continued to be active (or reactivated) even when the conscious brain was distracted with a number memorization task. Creswell (2013) proposed that the brain may continue to unconsciously process decision-related information during the distraction period, which made it possible to perform higher quality decisions.

Recent studies support the concept that cognition is due to the dynamic interactions of distributed brain regions operating in large-scale networks.

The default mode network (DMN, also called the default network, default state network) is a network of interconnected brain regions (including the medial prefrontal cortex (MPFC), posterior cingulate cortex (PCC), and lateral and medial temporal lobes (MTL)), which are active when a subject is not focused on the outside world and the brain is at wakeful rest (Spreng, 2010; Buckner, 2008). When subjects perform stimulus-based tasks, activity increases in the executive network (EN) and decreases in DMN (Fox, 2006; Golland, 2007; Lin, 2011).

Kühn (2013) have shown how creative ideas could emerge from the brain. They searched for neural correlates of creativity with the help of structural MRI. Researchers found a positive correlation between creative performance and gray matter volume in DMN in all creativity measures. These results support the notion that the DMN is important in creativity, and provides a neurostructural support for the idea that unconscious information processing is important in creativity.

Ritter (2012) studied the role of unconscious processes in the idea generation and idea selection parts of the creative process. They revealed that subjects could not produce more creative ideas after unconscious thought than after conscious thought. Nevertheless, volunteers who thought about their ideas unconsciously took an important advantage because they were more capable of recognizing their most and least creative idea. In other words, subjects who had unconsciously thought about their ideas could select their most creative and least creative idea from many self-generated ideas. This unconscious idea selection is essential to our everyday creativity. When we successfully generate diverse ideas, we need to select the most creative idea, while excluding the incorrect ideas. Ritter suggested that further research should be performed to reveal if longer unconscious periods promote not only the idea selection, but also the idea generation part of the creative process.

The widespread view considers creativity to be the production of something novel and useful within a given social context.

According to Lavazza and Manzotti (2013)

"A creative thinker, thus, is not only capable of finding new combinations of existing concepts or symbols; he or she must be able to expand the semantic domain to totally unexpected and new concepts and ideas. Sometimes, the outcome of creativity may go against everything that had been defined so far". Creativity is not the same thing as intelligence, since usually people with high intelligence do not tend to have a high creative output. In addition, IQ tests can not measure divergent thinking, which is an essential part of creativity. It has been revealed that people with the greatest creative output (for instance, well-known writers and architects) had mean IQs in the 120 range (Andreasen, 1987; Mackinnon, 1965). High levels of creativity require convergent as well as divergent thinking. Divergent thinking is an essential cognitive process that is associated with future creative achievement (Runco and Acar, 2012). During divergent thinking, the unconscious processing can use our long-term memory capacity with parallel layout, and simultaneously can access a lot of associated items under weak top-down control (Hommel, 2012). Thus, because the unconscious brain is capable of processing information in parallel, it can guarantee sufficient resources for idea production (Fleck and Kounios, 2009). In contrast, convergent thinking requires strong top-down control and can represent very few or just one item (Colzato, 2012).

According to neuroimaging experiments, during random episodic silent thought (REST, also referred to as the default state), the primary regions of the brain to become activated are the cortical areas (such as frontal, temporal and parietal, and the retrosplenial cingulate), and the brain is spontaneously reorganizing and acting in a self-organizing manner (Andreasen, 1995, 2005). These findings suggest that whereas conscious thought may be focused and convergent, unconscious thought may be more associative and divergent (Ritter, 2012).

As per eDAM framework (Section 1.3), the creativity is a part of mental aspect of related neural-network (NN) state and its inseparable physical aspect is a NN (such as DMN that includes MPFC, PCC, and MTL) and related neural activities during mostly unconscious information processing. High levels of creativity involve convergent as well as divergent thought processing in parallel with multiple possibilities in both aspects.

5 - Discussion

5.1 - Transgenerational epigenetic mechanisms, unconscious creativity, and sensory deprivation

John Locke (1632-1704) proposed that at birth our mind can be a *tabula rasa* ("blank tablet") (Ashcraft, 1986). Later, French naturalist Jean-Baptiste Lamarck (1744-1829) was among the first to suggest that certain acquired traits can be heritable from parents to offspring (Packard, 1901; Koonin and Wolf, 2009). However, Lamarck's notion about heredity was ultimately rejected by science, until the end of the 20th century when the epigenetics movement emerged.

Dias and Ressler's (2013) study is the first to support the notion that specific conditioned information can be transferred to offspring by epigenetic mechanisms. It should also be highlighted that 90 years ago, Pavlov did some very interesting experiments that can be linked to Dias and Ressler's (2013) experimental results. Pavlov trained mice to associate food with the sound of a bell.

Pavlow (1923) reported that "successive generations took fewer and fewer training sessions before they would search for food on hearing a bell even when food was absent". It is probable that the science of epigenetics will have a compelling force to rethink our conventional notions, among them, the basis for our Free Will.

Regarding the briefly described sensory and perceptual deprivation experiments, these old works carried out in the 1950s and 1960s, presented a number of interesting results. One of the most important outcomes, as Scott (1954) and Hebb (1954) emphasized, is that extraneous stimulation conveyed by peripheral mechanisms plays an essential role in maintenance of normal waking state brain function. Prolonged sensory deprivation that, for instance can produce almost total deprivation of the sight, sound and touch, can produce dramatic effects on human brain and behavior such as hallucinations, disorientation, and delusions. Since continuous and adequate sensory cues from the external world are essential to maintain the stability of the normal human waking mental state (i.e. essential to maintain consciousness), these results may support our hypothesis (Bókkon, 2014) that a possible major function of human self-consciousness is as an executer (self: (Bruzzo and Vimal, 2007)), which mediates between unconsciousness and the external environment. It may also be possible that the external world acts as an "external memory", and the human language-dependent consciousness mediates between subjective unconscious memory and the "external environmental memory". This process makes possible such activities as exchanging information with other people and the prospect that self-consciousness can continuously develop in self-organized evolution.

As discussed in the above, many experiments and studies support the notion that conscious thought may be focused and convergent, while unconscious thought may be more associative, creative and divergent. The lingual abstraction itself acts as a convergent and coercive force for categorization, and as a result of abstraction, words and complex language can develop, which is the base of our human self-consciousness. It may be possible that unconscious thought uses visual/geometric processes that can be associative and divergent. Eminent Hungarian philosopher Kristóf Nyíri (2000, 2003, 2008) has long argued that people first think in pictures, and then only in words. According to Nyíri, we are able to grasp conceptually only what we can also imagine, what we can visualize as an image. The image is a more natural mediator than the word, and the visual representation is phylogenetically more ancient. In addition, during ontogeny, the visual representation precedes the abstract linguistic representation (Dillon, 2013). Vygotsky's principle maintains unconscious cognition and conscious verbalization are two separate lines during development, resulting from development of the anatomical structures of the human speech after the first year of life, at which point these two developmental lines meet and "cross" each other. In addition, during the categorization process, increases in the degree of abstraction can give the impression that a word can exist independent of the perceptual reality level (Harnad, 1996). Indeed, only concrete things exist in the material world and the universe. Lingual words such as "cat" do not exist in the material reality, but of course physical cats do exist. When parents teach their children to speak, they teach the association between the heard word "cat" (and later the written word) linked to a general (abstract) view of the cats.

Thus, the convergent lingual abstraction process produces written and spoken words that abstract from reality.

Kosslyn's (1994) depictive theory about visual imagery suggests that images are quasi-pictorial and that they resemble pictures. The reality simulation principle of (Kosslyn, 2007) states that mental imagery mimics the corresponding events in the world. However, there is increasing evidence that visual perception and imagery share common neural substrates, and that both visual perception and imagery induce activation in retinotopically organized striate and extrastriate areas (Broggin, 2012; Cichy, 2011; Lewis, 2011; Albers, 2013; Palermo, 2013). Kosslyn also suggested that adults are able to encode information using words, but children are not capable of this because they do have not fully developed their verbal skills. In addition, according to experiments in cognitive neurology and physiology, children are thinking in eidetic pictures, but they gradually lose this ability while they learn to speak, read and write (Giray, 1976; Neisser, 1967). Searleman (2007) proposed that when a person looks at a picture and verbalize it can inhibit the eidetic memory. In addition, (2013) demonstrated that dreaming and visual perception share similar neurocognitive mechanisms. Namely, authors revealed that: "*specific contents of visual experience during sleep are represented by, and can be read out from visual cortical activity patterns shared with stimulus representation*" (Horikawa, 2013). Since dream pictures are originated mainly from unconscious processes, and that dreaming and visual perception share similar mechanisms, these may support that unconscious processing also uses picture-like representation, which can be a base for the unconscious creativity.

5.2 - Free Will

Arthur Schopenhauer's 1839 prize essay "On the freedom of the will" (Schopenhauer, 1999) addressed the academic question posed by the Royal Norwegian Society of Sciences in 1839: "Is it possible to demonstrate human free will from self-consciousness?"

Briefly,[iii] as per Schopenhauer, humans have absolutely no Free Will. He began by analyzing the basic concepts of freedom and self-consciousness and asserted that there are three types of freedom, namely, physical freedom (absence of physical obstacles to actions: only he is free who acts according to one's will and nothing else), intellectual freedom (when the mind has a clear knowledge of the abstract or concrete motives to action, which occurs when the mind is not affected by, for example, extreme passion or mind-altering substances), and moral freedom (absence of any necessity in person's actions, freedom of will not influenced by anything). Self-consciousness is a person's awareness of his or her own willing, including emotions and passions. According to Schopenhauer, when a person inspects her or his self-consciousness, s/he finds the feeling "*I can do whatever I will as long as I am not hindered*." However, he argued that this is merely physical freedom. He asserted "You can do what you will, but in any given moment of your life you can *will* only one definite thing and absolutely nothing other than that one thing." Thus, the Royal Society's question has been answered "No."

The transgenerational epigenetic mechanisms, unconscious creativity, and sensory deprivation can challenge our notion of real Free Will as they indicate that our consciousness (brain and mind) cannot function without environmental sensory input. In addition, the brain requires an extremely complex informational environment, while consciousness can handle only several items of focus at a time (Baars, 1997). In reality, most environmental stimuli are subliminal or not consciously perceived, but still exert essential influences on our motivations, behavior, emotions and decisions (Ziauddeen, 2012; Aarts, 2008; Pessiglione, 2007; Custers and Aarts., 2010; Jensen, 2012; Mlodinow, 2012; Parma, 2012; Hilsenrat, 2011; Milyavsky, 2012; Muscarella, 2013).

One may argue that so called 'Free Will' might originate from unconsciousness: (i) If human language-dependent consciousness is an abstraction, (ii) If unconscious processes precede voluntary actions and decisions, and/or (iii) If creativity takes place in the unconscious dual-aspect state. However, if a question is wrong, then there is no right answer. The question of Free Will may be inappropriate, since it (our Will is free) suggests we can make decisions regardless of external and internal factors. One could argue that there could be external and internal interactions during unconscious state; therefore, our Will cannot be completely free if it originates from the unconsciousness; rather, one suspects that our Will may be semi-free (see Section 5.3 below).

As we previously suggested (Bókkon, 2014), every part of our universe involves interactions, in which each part mutually determines the other. In any given situation, our decision, as a response to a given external or internal event, depends inexorably on nonconscious, inherited, and obtained information; on learned information; and on the spatiotemporal context (environmental factors), where we make our actual decision. Since unconscious processes may be essential for our creativity (unconscious processes can promote idea selection and idea generation), this may also challenge the existence of conscious completely Free Will.

Chris Nunn commented (personal communication in January, 2011) that 'choosing' between different options in the light of one's biology and immediate environment does not have to involve consciousness - indeed Libet's findings rather suggest that 'choices' of this sort are likely to be always unconscious. Moreover, Libet's data (Libet, 1983, 1985, 2003) fits better with the variable concept of Free Will because (1) readiness potential (550 msec earlier) is due to the instruction to flex their wrist, so it is not random, and (2) the subjective urge to move (200 msec earlier) has Libet lag of 350 msec is average value (it is not fixed, it has standard deviation i.e., variability/uncertainty is injected during processing so Will is not completely deterministic. Thus, Free Will is variable and depends on unknown factors (uncertainly/variability injected during processing).

5.3 - Semi-free Will: a variable concept of Free Will

The followings are adapted from (Vimal, 2010d). Science presumes causality, either deterministic or quantum; both are opposite to Free Will (Perlovsky, 2011, 2010) in addition to the suspicion raised on the existence of completely Free Will. Free Will is neither completely free as argued on complete (or quantum) randomness basis, nor completely deterministic as argued on pure Laplacian determinism basis (Brembs, 2010; Bruzzo and Vimal, 2007). Free Will depends on vagueness (uncertainty), crispness, and the hierarchical levels of neural processing in a complex manner (Perlovsky, 2010).

We propose that Free Will is variable (semi-Free Will), which depends on the degree of specificity for multiple choice, and is based on adaptive, behavioral, endogenous variability (Brembs, 2010), co-evolution, co-development, co-tuning via sensorimotor organism-environment interaction; this proposal is consistent with the eDAM framework (Section 1.3). Variability entails variable concept of Free Will, i.e., a degree/quantity of Free Will (Brembs, 2010). Variability (Brembs, 2010) is injected (a) in the physical aspect of a system as needed depending on the context via non-specific (Vimal, 2008, 2010b) and/or vague (Perlovsky, 2009, 2010) endogenous (independent of external stimuli) signals and (b) in the mental aspect of a state of a system via non-specificity due to superposition of multiple choices (Vimal, 2008, 2010b) or vagueness in cognitive brain via dynamic logic[iv] (Perlovsky, 2009, 2010).

We conclude that Free Will is variable based on evolution's adaptive, behavioral, endogenous variability and depends on the context; it is neither completely deterministic nor completely random; rather, Will is somewhat semi-free between the deterministic and the indeterministic random extremes.

In other words, Free Will is NOT free; it may be semi-free. It is based on many factors, such as previous experiences, memory traces, reasons, uncertainty, and so on.[v]

The collapse of uncertainty or various possibilities to a specific decision is stimulus dependent. There are so many factors that are hard to keep up and hence Free Will *appears* as free, but Will is variable depending on the context.

Conclusions

In conclusion, the possible existence of specific, transgenerational, epigenetic information transmission is a challenge to the notion of Free Will. In addition, we described many experiments and concepts, pointing out the unconscious processing may play a central role in our creativity and decision making processes, and that consciousness (brain and mind) cannot function without environmental sensory input. According to Meloni (2014), "*The brain is increasingly thought of as a tool specifically designed to create social relationships, to reach out for human relationships and company, literally made sick by loneliness and social isolation*". These studies were originally made by Cacioppo and Patrick (2008) and Hawkley and Cacioppo (2010).

Overall, the presented studies and notions may fundamentally challenge the traditionally notion of Free Will. In addition, the reviewed studies may also support our idea that structural and functional evolutionary development of the brain made it possible that human language-dependent conscious-self functions as a self-referential executer that intermediates between unconsciousness and the external environment.

In the eDAM framework (Section 1.3), (i) a variable concept of Free Will is proposed, which is based on co-evolution's adaptive, behavioral, endogenous variability; (ii) Free Will is neither completely deterministic nor completely random; (iii) rather, it is somewhat *semi*-Free Will ('between the deterministic and the indeterministic extremes') (de la Sierra, 2008) and varies depending on the context to suit the best for a specific space, time, and circumstances; (iv) therefore, morally, ethically, and legally, we are responsible for our choice of action.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content.

Acknowledgments

The authors gratefully thank for the critical comments and editing for Alexis Pietak (Queen's University, Kingston, Ontario, Canada) and Chris Nunn for his comments on Free Will in Section 5.2. RLPV was supported by VP-Research Foundation Trust and Vision Research Institute research Fund. The first author (RLPV) is also affiliated with Dristi Anusandhana Sansthana, A-60 Umed Park, Sola Road, Ahmedabad-61, Gujrat, India; Dristi Anusandhana Sansthana, c/o NiceTech Computer Education Institute, Pendra, Bilaspur, C.G. 495119, India; and Dristi Anusandhana Sansthana, Sai Niwas, East of Hanuman Mandir, Betiahata, Gorakhpur, U.P. 273001 India. His URL: http://sites.google.com/site/rlpvimal/Home and Email: rlpvimal@yahoo.co.in.

References

Aarts H, Custers R, Marien H. Preparing and motivating behavior outside of awareness. Science 2008; 319: 1639.

Albers AM, Kok P, Toni I, Dijkerman HC, de Lange FP. Shared Representations for Working Memory and Mental Imagery in Early Visual Cortex. Curr Biol 2013; 23(15): 1427–1431.

Andreasen NC, O'Leary DS, Cizadlo T, Arndt S, Rezai K, Watkins GL, Ponto LLB, Hichwa RD. Remembering the past: Two facets of episodic memory explored with positron emission tomography. Am J Psychiatry 1995; 152: 1576–1585.

Andreasen NC. Creativity and Mental Illness: Prevalence Rates in Writers and their First Degree Relatives. Am J Psychiatry 1987; 144: 1288–1292

Andreasen NC. The Creating Brain: The Neuroscience of Genius. New York and Washington DC: Dana Press, 2005.

Ashcraft R. Revolutionary Politics & Locke's Two Treatises of Government. Princeton: Princeton University Press, 1986.

Baars BJ. Fehling MR, LaPolla M, McGovern K.A. Consciousness creates access: Conscious goal images recruit unconscious action routines, but goal competition serves to "liberate" such routines, causing predictable slips. In Cohen JD, Schooler JW. (Eds.), Scientific approaches to consciousness: The Twentyfifth Annual Carnegie Symposium on Cognition. Hillsdale NJ, England Lawrence Erlbaum, 1997 pp: 423–444.

Balduzzi D, Tononi G. Qualia: the geometry of integrated information. PLoS Comput Biol 2009; 5(8): e1000462.

Barry G. Lamarckian evolution explains human brain evolution and psychiatric disorders. Front Neurosci 2013; 7: 224.

BBC Total Isolation. Horizon programme. 2008; Link: http://www.andyworthington.co.uk/2008/01/27/bbc-torture-experiment-replicates-guantanamo-and-secret-prisons-how-to-lose-your-mind-in-48-hours/

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

Bode S, He AH, Soon CS, Trampel R, Turner R, Haynes JD. Tracking the unconscious generation of free decisions using ultra-high field fMRI. PLoS One 2011; 6: e21612.

Bókkon I, Vas JP, Császár N, Lukács T. Challenges to Free Will: transgenerational epigenetic information, unconscious processes and vanishing twin syndrome. Rev Neurosci 2014; 25: 163–175.

Bood SA, Kjellgren A, Norlander T. Treating stress-related pain with the flotation restricted environmental stimulation technique: are there differences between women and men? Pain Res Manag 2009; 14: 293–298.

Bood SÅ, Sundequist U, Kjellgren A, Norlander T, Nordström L, Nordenström K, Nordström, G. Eliciting the relaxation response with the help of flotation–REST (Restricted Environmental Stimulation Technique) in patients with stress-related ailments. IJSM 2006; 13: 154–175.

Brembs B. Towards a scientific concept of free will as a biological trait: spontaneous actions and decision-making in invertebrates. Proc R Soc B 2010; 278: 930–939.

Broggin E, Savazzi S, Marzi CA. Similar effects of visual perception and imagery on simple reaction time. Quarterly Journal of Experimental Psychology. 2012; 65: 151–164.

Brown RE. Alfred McCoy, Hebb, the CIA and torture. J Hist Behav Sci 2007; 43: 205–213.

Bruzzo AA, Vimal RLP. Self: An adaptive pressure arising from self-organization, chaotic dynamics, and neural Darwinism. J Integr Neurosci 2007; 6(4): 541–566.

Buckner RL, Andrews-Hanna JR, Schacter DL. The brain’s default network: anatomy, func-tion, and relevance to disease. Ann NY Acad Sci 2008; 1124: 1–38.

Bygren LO, Tinghög P, Carstensen J, Edvinsson S, Kaati G, Pembrey ME, Sjöström M. Change in paternal grandmothers' early food supply influenced cardiovascular mortality of the female grandchildren. BMC Genet 2014; 15: 12.

Cacha LA, Poznanski RR. Genomic instantiation of consciousness in neurons through a biophoton field theory. J Integr Neurosci 2014; 13(3): 1–40.

Cacioppo JT, Patrick B. Loneliness: Human Nature and the Need for Social Connection. New York: W.W. Norton and Company, 2008.

Cameron DE. Production of differential amnesia as a factor in the treatment of schizophrenia. Comprehensive Psychiatry 1960; 1: 26-34.

Carvell GE1, Simons DJ. Abnormal tactile experience early in life disrupts active touch. J Neurosci 1996; 16: 2750–2757.

Chalmers DJ. Facing up to the problem of consciousness. J Consciousness Stud 1995; 2: 200–219.

Cichy RM, Heinzle J, Haynes JD. Imagery and perception share cortical representations of content and location. Cereb Cortex 2011; 22: 372–380.

Collignon O, Voss P, Lassonde M, Lepore F. Cross-modal plasticity for the spatial processing of sounds in visually deprived subjects. Exp Brain Res 2009; 192: 343–358.

Colzato LS, Ozturk A, Hommel B. Meditate to create: the impact of focused-attention and open-monitoring training on convergent and divergent thinking. Front Psychol 2012; 3:116.

Creswell JD, Bursley JK, Satpute AB. Neural Reactivation Links Unconscious Thought to Decision Making Performance. SCAN 2013; 8: 863–869.

Crews D, Gillette R, Scarpino SV, Manikkam M, Savenkova MI, Skinner MK. Epigenetic transgenerational inheritance of altered stress responses. PNAS USA 2012; 109: 9143–9148.

Csaba G. The biological basis and clinical significance of hormonal imprinting, an epigenetic process. Clin Epigenetics 2011; 2: 187–196.

Custers R, Aarts H. The unconscious will: how the pursuit of goals operates outside of conscious awareness. Science 2010; 329: 47–50.

de la Sierra AO. Between Random Impossibility and Illusory Certainty, The Survival of Free Will Neurophilosophy of Consciousness 2008; 1: 170–181.

Dias BG, Ressler KJ. Parental olfactory experience influences behavior and neural structure in subsequent generations. Nat Neurosci 2014; 17: 89-96.

Dillon MR, Huang Y, Spelke ES. Core foundations of abstract geometry. Proc Natl Acad Sci USA 2013; 110: 14191–14195.

Fleck JI, Kounios J. Intuition, creativity, and unconscious aspects of problem solving. In William PB.: Editor-in-Chief (Ed.), Encyclopedia of consciousness (pp.431–446). Oxford: Academic Press, 2009.

Fox MD, Corbetta M, Snyder AZ, Vincent JL, Raichle ME. Spontaneous neuronal activity distinguishes human dorsal and ventral attention systems. Proc Natl Acad Sci USA 2006; 103: 10046–10051.

Franklin TB, Mansuy IM. The prevalence of epigenetic mechanisms in the regulation of cognitive functions and behaviour. Curr Opin Neurobiol 2010; 20: 441–449.

Gapp K, Jawaid A, Sarkies P, Bohacek J, Pelczar P, Prados J, Farinelli L, Miska E, Mansuy IM. Implication of sperm RNAs in transgenerational inheritance of the effects of early trauma in mice. Nat Neurosci 2014; 17(5): 667–669.

Gillmor D.I. Swear By Apollo. Dr. Ewen Cameron and the CIA-Brainwashing Experiments. Montreal: Eden press, 1987.

Giray EF, Altkin WM, Vaught GM, Roodin PA. The incidence of eidetic imagery as a function of age. Child Dev 1976; 47: 1207–1210.

Goldberg I. The effects of sensory deprivation on intellectual efficiency as a function of personality. PhD dissertation. The University of Oklahoma, 1961. see the full text at https://shareok.org/bitstream/handle/11244/1481/6005523.PDF?sequence=1

Golland Y, Bentin S, Gelbard H, Benjamini Y, Heller R, Nir Y, Hasson U, Malach R. Extrinsic and intrinsic systems in the posterior cortex of the human brain revealed during natural sensory stimulation. Cereb Cortex 2007; 17: 766–777.

Gorelick R, Bertram SM. Maintaining heritable variation via sex-limited temporally fluctuating selection: a phenotypic model accommodating non-Mendelian epigenetic effects. Theory in Biosciences 2003; 122: 321–338.

Gräff J1, Kim D, Dobbin MM, Tsai LH. Epigenetic regulation of gene expression in physiological and pathological brain processes. Physiol Rev 2011; 91: 603–649.

Grentzinger T, Armenise C, Brun C, Mugat B, Serrano V, Pelisson A, Chambeyron S. piRNA-mediated transgenerational inheritance of an acquired trait. Genome Res 2012; 22: 1877–1888.

Guan JS, Xie H, Ding X. The role of epigenetic regulation in learning and memory. Exp Neurol 2015; 268 30–60.

Guduric-Fuchs J, O'Connor A, Camp B, O'Neill CL, Medina RJ, Simpson DA. Selective extracellular vesicle- mediated export of an overlapping set of microRNAs from multiple cell types. BMC Genomics 2012; 13: 357.

Hameroff S, Penrose R. Consciousness in the universe: a review of the 'Orch OR' theory. Phys Life Rev 2014; 11(1): 39–78.

Harnad S. The Origin of Words: A Psychophysical Hypothesis. In: Durham W, Velichkovsky B. (Eds). Communicating Meaning: Evolution and Development of Language, Hillsdale, NJ: Lawrence Erlbaum Associates, 1996.

Hawkley L, Cacioppo J. Loneliness matters: a theoretical and empirical review of consequences and mechanisms. Ann Behav Med 2010; 40: 218–227.

Hebb DO, Heron W, Bexton WH. The effect of isolation upon attitude, motivation, and thought. In Fourth Symposium, Military Medicine I, in cooperation with McGill University, Ottawa: Defense Research Board, 1952.

Hebb DO. The problem of consciousness and introspection. In Delafresnaye JF. (Ed.), Brain mechanisms and consciousness. Springfield, 111 .: Thomas C.C, 1954, pp. 402–421.

Heron W, Bexton WH, Hebb DO. Cognitive effects of a decreased variation in the sensory environment. Am Psychol 1953; 8: 366.

Heron W. The pathology of boredom. Sci Am 1957; 196: 52–56.

Hilsenrat M, Reiner M. The impact of subliminal haptic perception on the preference discrimination of roughness and compliance. Brain Res Bull 2011; 85: 267–270.

Hommel B. Convergent and divergent operations in cognitive search. In Cognitive Search: Evolution, Algorithms, and the Brain. Strüngmann Forum Reports, Vol. 9, (Eds) Todd PM, Hills TT, Robbins TW. Cambridge, MA: MIT Press, 2012, pp. 215–230.

Horikawa T, Tamaki M, Miyawaki Y, Kamitani Y. Neural decoding of visual imagery during sleep. Science 2013; 340: 639-642.

Jabr F. Self-Awareness with a Simple Brain. Scientific American Mind 2012; 23(5). <http://www.scientificamerican.com/article/self-awareness-with-a-simple-brain/>

Jensen KB, Kaptchuk TJ, Kirsch I, Raicek J, Lindstrom KM, Berna C, Gollub RL, Ingvar M, Kong J. Nonconscious activation of placebo and nocebo pain responses. Proc Natl Acad Sci USA 2012; 109: 15959–15964.

Koonin EV, Wolf YI. Is evolution Darwinian or/and Lamarckian? Biol Direct 2009; 4: 42.

Kosslyn SM. Remembering Images, in Gluck MA, Anderson JR, Kosslyn SM (Eds.), Memory and Mind: A Festschrift for Gordon H. Bower, New Jersey, Lawrence Erlbaum Associates, 2007.

Kosslyn SM, Image and brain: The resolution of the imagery debate. MIT Press, 1994.

Kühn S, Ritter SM, Müller BCN, van Baaren RB, Brass M, Dijksterhuis A. The importance of unconscious processes in creativity – a structural MRI study. J Creat Behav 2014; 48 (2): 152–163.

Lamme VA. Why visual attention and awareness are different. Trends Cogn Sci 2003; 7(1), 12–18.

Landry CD, Kandel ER, Rajasethupathy P. New mechanisms in memory storage: piRNAs and epigenetics. Trends Neurosci 2013; 36: 535–542.

Lasser C, Eldh M, Lotvall J. Isolation and characterization of RNA-containing exo- somes. J Vis Exp 2012; e3037.

Lavazza A, Manzotti R. An externalist approach to creativity: discovery versus recombination Mind Soc 2013; 12: 61–72.

Leimar O, McNamara JM. The evolution of transgenerational integration of information in heterogeneous environments. Am Nat 2015; 185(3): E55–69.

Lewis KJ, Borst G, Kosslyn SM. Integrating visual mental images and visual percepts: new evidence for depictive representations. Psychol Res 2011; 75: 259–271.

Libet B, Gleason CA, Wright EW, Pearl DK. Time of conscious intention to act in relation to onset of cerebral activities (readiness-potential): the unconscious initiation of a freely voluntary act. Brain 1983; 106: 623–642.

Libet B. Unconscious cerebral initiative and the role of conscious will in voluntary action. Behav Brain Sci 1985; 8: 529–566.

Libet B. Cerebral physiology of conscious experience: Experimental Studies. In N. Osaka (Ed.), Neural Basis of Consciousness. [Advances in consciousness research series, 49]. Amsterdam & New York: John Benjamins, 2003.

Lilly JC, Gold EJ. Tanks for the Memories: Flotation Tank Talks. Gateways Books & Tapes, 2000.

Lin P, Hasson U, Jovicich J, Robinson S. A neuronal basis for task-negative responses in the human brain. Cereb Cortex 2011; 21: 821–830.

Lipka, R. P., & Brinthaupt, T. M. (Eds.). Self-perspectives Across the Life Span. Albany, NY: SUNY Press, 1992.

Mackinnon DW. Personality and the Realization of Creative Potential. Am Psychol 1965; 20: 273–281.

Magdon-Maksymowicz MS, Maksymowicz AZ. Epigenetic contribution to age distribution of mortality within the Penna model. Theory Biosci 2015; [Epub ahead of print].

Mason OJ, Brady F. The psychotomimetic effects of short-term sensory deprivation. J Nerv Ment Dis 2009; 197: 783–785.

McCoy AA. question of torture: CIA interrogation, from the Cold War to the War on Terror. New York: Metropolitan Books, 2006.

McFadden J. The Conscious Electromagnetic Information (Cemi) Field Theory: The Hard Problem Made Easy? J Consciousness Stud 2002; 9(8): 45–60.

Meloni M. The social brain meets the reactive genome: neuroscience, epigenetics and the new social biology. Front Hum Neurosci 2014; 8: 309.

Mercer TR, Mattick JS. Structure and function of long noncoding RNAs in epigenetic regulation. Nat Struct Mol Biol 2013; 20: 300–307.

Milyavsky M, Hassin RR, Schul Y. Guess what? Implicit motivation boosts the influence of subliminal information on choice. Conscious Cogn 2012; 21: 1232–1241.

Mlodinow L. Subliminal: How Your Unconscious Mind Rules Your Behavior. Vintage Books, New York, 2012.

Mowery TM, Kotak VC, Sanes DH. Transient Hearing Loss Within a Critical Period Causes Persistent Changes to Cellular Properties in Adult Auditory Cortex. Cereb Cortex 2014; Feb 18. [Epub ahead of print]

Muscarella C, Brintazzoli G, Gordts S, Soetens E, Van den Bussche E. Short- and long-term effects of conscious, minimally conscious and unconscious brand logos. PLoS One 2013; 8: e57738.

Neisser R. Cognitive Physcholigy. New York: Applenton-Century-Crofts, 1967.

Nyíri K. Képek az idegrendszerben és a filozófiában. (Pictures in the nervous system and philosophy.) In Pléh Cs, Kovács Gy, Gulyás B. (Eds). Kognitív idegtudomány. (Cognitive neuroscience) (771–781). Budapest, Osiris Publisher Ltd, 2003.

Nyíri K. The Picture Theory of Reason. Talk given at the 23rd International Wittgenstein Symposium, Kirchberg am Wechsel, August 13-19, 2000. http://www.hunfi.hu/nyiri/krb2000.htm

Nyíri K. Visualization and the Limits of Scientific Realism. Paper presented on May 13, 2008, at the conference Richard Rorty's Philosophical Legacy, University of Pécs (Hungary), 2008. Revised Dec. 2011. http://www.hunfi.hu/nyiri/Nyiri_VLSR.pdf

Packard AS. Lamarck, the founder of evolution: His life and work. New York: Longmans, Green & Co, 1901.

Palermo L, Nori R, Piccardi L, Zeri F, Babino A, Giusberti F, Guariglia C. Refractive errors affect the vividness of visual mental images. PLoS One 2013; 8(6): e65161.

Parma V, Tirindelli R, Bisazza A, Massaccesi S, Castiello U. Subliminally perceived odours modulate female intrasexual competition: an eye movement study. PLoS One 2012; 7: e30645.

Pavlow IP. New researches on conditioned reflexes. Science 1923; 58: 359–361.
Pereira JrA, Vimal RLP, Pregnolato M. Can Qualitative Biophysics Solve the Hard Problem? In Poznanski RR. Tuszynski JA, Feinberg TE. (Eds.), Biophysics of Consciousness: A Foundational Approach. Singapore: World Scientific Publishing Co Pte Ltd (in preparation), 2015.
Perlovsky LI. Consciousness and Free Will, a Scientific Possibility Due to Advances in Cognitive Science. WebmedCentral Psychol 2011; 2(2): MC001539.
Perlovsky LI. Free Will and Advances in Cognitive Science. 2010. http://arxiv.org/ftp/arxiv/papers/1012/1012.3957.pdf
Perlovsky LI. "Vague-to-crisp" neural mechanism of perception. IEEE Trans Neural Netw 2009; 20(8), 1363-1367.
Peschansky VJ, Wahlestedt C. Non-coding RNAs as direct and indirect modulators of epigenetic regulation. Epigenetics 2014; 9: 3–12.
Pessiglione M, Schmidt L, Draganski B, Kalisch R, Lau H, Dolan RJ, How the brain translates money into force: a neuroimaging study of subliminal motivation. Science 2007; 316: 904–906.
Poincare H. The Value of Science. Essential Writings of Henri Poincare. New York: Random House, 2001.
Putzar L, Goerendt I, Lange K, Rösler F, Röder B. Early visual deprivation impairs multisensory interactions in humans. Nat Neurosci 2007; 10: 1243–1245.
Putzar L, Hötting K, Röder B. Early visual deprivation affects the development of face recognition and of audio-visual speech perception. Restor Neurol Neurosci 2010; 28: 251–257.
Qi HX, Jain N, Collins CE, Lyon DC, Kaas JH. Functional organization of motor cortex of adult macaque monkeys is altered by sensory loss in infancy. Proc Natl Acad Sci USA 2010; 107: 3192–3197.
Rasmussen J. Man in Isolation & Confinement. Chicago: Transaction Publishers, 1973.
Raz M. Alone again: John Zubek and the troubled history of sensory deprivation research. J Hist Behav Sci 2013; 49: 379–395.
Ritter SM, van Baaren RB, DijksterhuisA. Creativity: the role of unconscious processes in idea generation and idea selection. Think. Skills Creat 2012; 7: 21–27.
Runco MA, Acar S. Divergent thinking as an indicator of creative potential. Creativ Res J 2012; 24: 1–10.
Runco MA, Marz W. Scoring divergent thinking tests using total ideational output and a creativity index. EPM 1992;52:213–221.
Scheflin AW, Opton EM. The Mind manipulators. New York: Paddington Press, 1978.
Schopenhauer A. On the Freedom of the Will. Oxford: Basil Blackwell, (1999).
Schultz DP. Sensory restriction: Effects on behavior. New York and London: Academic Press, 1965.
Scott TH, Bexton WH, Heron W, Doane BK. Cognitive effects of perceptual isolation. Can J Psychol 1959; 13: 200–209.
Scott TH. Intellectual effects of perceptual Isolation. Unpublished doctoral dissertation, McGill University, 1954.
Searleman A. Is there such a thing as photographic memory? And if so can it be learned? Mind Brain 2007; 2: 27–28.
Sharma A. Novel transcriptome data analysis implicates circulating microRNAs in epigenetic inheritance in mammals. Gene 2014; 538: 366–372.
Shilatifard A. Chromatin modifications by methylation and ubiquitination: implications in the regulation of gene expression. Annu Rev Biochem 2006; 75: 243–269.
Soon CS, He AH, Bode S, Haynes JD. Predicting free choices for abstract intentions. Proc Natl Acad Sci USA 2013; 110: 6217–6222.
Spreng RN, Schacter DL. Default network modulation and large-scale network interactivity in healthy young and old adults. Cereb Cortex 2012; 22: 2610–2621.
Stamps JA, Krishnan VV. Combining information from ancestors and personal experiences to predict individual differences in developmental trajectories. Am Nat 2014; 184(5): 647–657.
Stapp HP. Quantum Theory and the Role of Mind in Nature. Foundations of Physics 2001; 31: 1465–1499.
Stapp HP. Mindful Universe: Quantum Mechanics and the Participating Observer. Berlin, Heidelberg, New York, US.: Springer, 2007.
Stapp HP. Philosophy of Mind and the Problem of Free Will in the Light of Quantum Mechanics. In von Mueller, A. (Ed.), On Thinking. Berlin, Heidelberg, New York: Springer, 2009a. See also http://arxiv.org/abs/0805.0116.
Stapp HP. Quantum reality and mind. J Cosmology 2009b; 3: 570–579.
Suedfeld P, Bow RA. Health and therapeutic applications of chamber and flotation restricted environmental stimulation therapy (REST). Psychol Health 1999; 14: 545–566.
Tononi G. An information integration theory of consciousness. BMC Neurosci 2004; 5(1): 42.
Tononi G. Consciousness as integrated information: a provisional manifesto. Biol Bull 2008; 215(3): 216-242.
Tononi G. Integrated information theory of consciousness: an updated account. Arch Ital Biol 2012; 150(4): 293–329.
van der Pol E, Boing AN, Harrison P, Sturk A, Nieuwland R. Classification, functions, and clinical relevance of extracellular vesicles. Pharmacol Rev 2012; 64: 676–705.
Vimal RLP. Proto-experiences and Subjective Experiences: Classical and Quantum Concepts. J Integr Neurosci 2008; 7(1): 49–73.

Vimal RLP. Meanings attributed to the term 'consciousness': an overview. J Consciousness Stud 2009; 16(5): 9-27.

Vimal RLP. Consciousness, Non-conscious Experiences and Functions, Proto-experiences and Proto-functions, and Subjective Experiences. J Consciousness Exploration & Res 2010a; 1(3): 383–389.

Vimal RLP. Matching and selection of a specific subjective experience: conjugate matching and subjective experience. J Integr Neurosci 2010b; 9(2): 193–251.

Vimal RLP. On the Quest of Defining Consciousness. Mind Matter 2010c; 8(1): 93-121.

Vimal RLP. Variable Concept of Free Will: Semi-Free Will in Dual-aspect Dual-mode Framework. Vision Research Institute: Living Vision and Consciousness Research. 2010d; 3(10): 1–50. [Available: <http://sites.google.com/site/rlpvimal/Home/2010-Vimal-FreeWill-LVCR-3-10.pdf>]

Vimal RLP. Emergence in Dual-Aspect Monism. In A. Pereira Jr. & D. Lehmann (Eds.), The Unity of Mind, Brain and World: Current Perspectives on a Science of Consciousness (pp. 149-181). Cambridge, UK: Cambridge University Press, 2013.

Vimal RLP. A dual-aspect framework for consciousness: segregation and integration of information. Vision Research Institute: Living Vision and Consciousness Research. 2015a; 7(2): 1–33. [Available: <http://sites.google.com/site/rlpvimal/Home/2015-Vimal-IIT-in-eDAM-LVCR-4-1.pdf >]

Vimal RLP. Necessary conditions of consciousness: Extended Dual-Aspect Monism framework. Vision Research Institute: Living Vision and Consciousness Research. 2015b; 7(1): 1–28. [Available: <http://sites.google.com/site/rlpvimal/Home/2015-Necessary-Conditions-Conciousness-1.pdf >]

Vimal RLP. Biological Naturalism in Extended Dual-Aspect Monism and Conscious Robots. Vision Research Institute: Living Vision and Consciousness Research. 2015c; 7(3): 1–23. [Available: <http://sites.google.com/site/rlpvimal/Home/2015-Vimal-eDAM-BN-LVCR-7-3.pdf >]

Vimal RLP. Extended Dual-Aspect Monism framework: Criticisms addressed. Vision Research Institute: Living Vision and Consciousness Research. 2015d; 7(4): 1–30. [Available: <http://sites.google.com/site/rlpvimal/Home/2015-Vimal-eDAM-Criticisms-Addressed-1.pdf >]

Weinstein H. Psychiatry and the CIA: Victims of Mind Control. Washington, DC: American Psychiatric Press, 1990.

Weiss IC, Franklin TB, Vizi S, Mansuy IM. Inheritable effect of unpredictable maternal separation on behavioral responses in mice. Front Behav Neurosci 2011; 5: 3.

Woldemichael BT, Bohacek J, Gapp K, Mansuy IM. Epigenetics of memory and plasticity. Prog Mol Biol Transl Sci 2014; 122: 305–340.

Yao Y, Robinson AM, Zucchi FC, Robbins JC, Babenko O, Kovalchuk O, Kovalchuk I, Olson DM, Metz GA. Ancestral exposure to stress epigenetically programs preterm birth risk and adverse maternal and newborn outcomes. BMC Medicine 2014; 12(1) :121.

Zhang X, Ho SM. Epigenetics meets endocrinology. J Mol Endocrinol 2011; 46: R11–R32.

Ziauddeen H, Subramaniam N, Gaillard R, Burke LK, Farooqi IS, Fletcher PC. Food images engage subliminal motivation to seek food. Int J Obes (Lond) 2012; 36: 1245–1247.

Zubek J, Bross M. Changes in critical flicker frequency during and after fourteen days of monocular deprivation. Nature 1973; 241: 288–290.

Zubek J. (Ed). Sensory deprivation: Fifteen years of research. New York: Appleton Century Crofts, 1969.

Endnote

[i] It is necessary to define the terms to avoid confusion: (i) **Consciousness** is defined as the mental aspect of a state of brain-system or brain-process, which has two sub-aspects: *conscious experience* and *conscious function* from the first person perspective (Vimal, 2010c). (ii) **Self-consciousness** is an acute (rapid onset and/or a short course) sense of self-awareness. It is a preoccupation with oneself, as opposed to the philosophical state of self-awareness, which is the awareness that one exists as an individual being; although some writers use both terms interchangeably or synonymously. (Lipka and Brinthaupt, 1992).(p. 228). Self-consciousness refer to very different phenomena and is a specialized subdomain of consciousness in creatures that possess self-consciousness, and even in them it appears only intermittently on a background of sustained consciousness. (iii) **Self-awareness** is the capacity for introspection and the ability to recognize oneself as an individual separate from the environment and other individuals. It is not to be confused with consciousness. While consciousness is being aware of one's environment and body and lifestyle, self-awareness is the recognition of that consciousness (Jabr, 2012).

[ii] A conscious function or experience is a sub-aspect of consciousness, which is the subjective 1pp-mental aspect of a state of a brain-system. The objective 3pp-physical aspect is the related neural-network (NN) of the brain-system and its activities. 1pp is acronym for first person perspective and the 3pp is for third person perspective. The brain-system is the mind-brain system that has many states. Each state has two aspects: 1pp-mental aspect that includes our consciousness (both sub-aspects: functional and experiential), and 3pp-physical aspect that includes NNs and their activities.

[iii] This paragraph is adapted from http://en.wikipedia.org/wiki/On_the_Freedom_of_the_Will.

[iv] As per (Perlovsky, 2010b), "Dynamic logic is a process-logic, a process 'from vague to crisp,' from vague statements, conditions, models to crisp ones […] A basic property of dynamic logic is that it describes perception and cognition as processes in which vague (fuzzy) mental representations evolve into crisp representations. More generally, dynamic logic describes interaction between bottom-up and top-down signals (to simplify, signals from sensor organs, and signals from memory). Mental representations in memory, sources of top-down signals, are vague; during perception and cognition processes they interact with bottom-up signals, and evolve into crisp mental representations; crispness of the final states correspond to crispness of the bottom-up representations, e.g., retinal images of objects in front of our eyes. Initial vague representations and the dynamic logic process from vague to crisp are unconscious; only the final states, in which top-down representations match patterns in bottom-up signals, are available to consciousness and mentally perceived as approximately logical states." This is consistent with the eDAM framework (Section 1.3).

[v] As per (Stapp, 2009a), "We are interested here in brain dynamics. Everyone admits that at the most basic dynamical level the brain must be treated as a quantum system: the classical laws fail at the atomic level. This dynamics rests upon myriads of microscopic processes, including flows of ions into nerve terminals. These atomic-scale processes must in principle be treated quantum mechanically. But the effect of accepting the quantum description at the microscopic level is to inject quantum uncertainties/indeterminacies at this level. Yet introducing even small uncertainties/indeterminacies at microscopic levels into these nonlinear systems possessing lots of releasable stored chemical energy has a strong tendency---the butterfly effect---to produce very large macroscopic effects later on. Massive parallel processing at various stages may have a tendency to reduce these indeterminacies, but it is pure wishful thinking to believe that these indeterminacies can be completely eliminated in all cases, thereby producing brains that are completely deterministic at the macroscopic level. *Some* of the microscopic quantum indeterminacy *must* at least occasionally make its way up to the macroscopic level. […] In particular, environmental decoherence effects certainly do not, by themselves, resolve this problem of reconciling the quantum indeterminacy, which irrepressibly bubbles up from the microscopic levels of brain dynamics, with the essentially classical character of our descriptions of our experiences of 'what we have done and what we have learned'."