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EMERGENCE OF CONSCIOUSNESS AND QUALIA FROM A COMPLEX BRAIN

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ВОЗНИКНОВЕНИЕ СОЗНАНИЯ И КВАЛИА ИЗ КОМПЛЕКСНОГО МОЗГА

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ABSTRACT

Qualia are private conscious experiences of which the associated feelings can be reported to other people. Whether qualia are amenable to scientific exploration has often been questioned, which is challenged by the present article. The following arguments are given: 1. the configuration of the brain changes continuously and irreversibly, because of genetic and environmental influences and interhuman communication; 2. qualia and consciousness are processes, rather than states; 3. private feelings, including those associated with qualia, should be positioned in the context of a personal brain as being developed during life; 4. consciousness and qualia should be understood in the context of general system theory, thus concluding that isolated, *in vitro*, properties of neurons and other brain constituents might marginally contribute to the understanding of higher brain functions, mind or qualia; 5. current *in vivo* approaches have too little resolution power - in terms of space and time - to delineate individual and subjective brain processes.

When subtle personalized properties of the nervous system can be assessed *in vivo* or *in vitro*, qualia can scientifically be investigated. We discuss some approaches to overcome these barriers.

Key words: *consciousness, qualia, dissociative disorders, mental disorders, mind, brain, emergence*

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РЕЗЮМЕ

Qualia (квалиа) являются личными сознательными переживаниями, связанные с которыми чувства могут быть доведены до знания других людей. Насколько квалиа поддаются научному исследованию часто подвергается сомнению, которое оспаривается в настоящей статье. Следующие аргументы приведены: 1-й: конфигурация мозга меняется постоянно и необратимо, из-за генетических и экологических воздействий и междуличностных связей; 2-й: квалиа и сознание являются более процессами, а не состояниями; 3-й: личные чувства, в том числе те, которые связаны с квалиа, должны быть расположены в контексте персонального мозга, и находятся в развитии в течение жизни; 4-й: сознание и квалиа следует понимать в контексте общей теории систем, таким образом, приходя к выводу, что изолированные, *in vitro* свойства нейронов и других составляющих мозг структур могут незначительно способствовать пониманию высших функций мозга, сознания или квалиа; 5-й: современные *in vivo* подходы имеют слишком низкую резолуцию с точки зрения пространственной и резолуции во времени для того, чтобы описать индивидуальные и субъективные процессы головного мозга. Тогда как скрытые персонализированные свойства нервной системы могут быть исследованы *in vivo* и *in vitro*, квалиа могут быть исследованы научно. Мы обсудим некоторые подходы к преодолению этих барьеров.

Ключевые слова: *сознание, квалиа, диссоциативные расстройства, психические расстройства, возникновение, мозг*

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INTRODUCTION

Qualia are subjective feelings of experiences that cannot be shared with other individuals and are often reported in terms of a 3rd person observer (“I am feeling that”). Qualia are a wide variety of personal experiences, associated with smell, taste, sound, emotions, pain, hunger, thirst, art and other aesthetic expressions, empathic support and pleasure of whatever origin. Qualia are considered to be inaccessible for scientific inquiry (“the hard problem of consciousness.”¹). The present article explores how qualia might be assessed and how qualia might arise in a complex system such as the brain. Central issue is which concept of the brain has to be chosen to position qualia. The feeling and reporting of qualia might indeed be conscious, whereas many contributing causes and processes are sub- or unconscious and largely beyond direct scientific exploration. A few words will be devoted here to nonconscious aspects of qualia.

We consider the brain as a complexity (in the sense of general systems theory²) that enables the emergence of new properties. Emergence is a prevailing concept about the relationship of the material (including energetic) world and mental processes or mind. Just like the mind, life may also be viewed as an emerging complexity and is the subject of general system theories as well. Emergence claims, for instance, that life, mind and consciousness are possible because of the physical complexity of cells and of cellular aggregates such as the brain. In line with this stance, Searle³ (p 90) states that “*Consciousness, in short, is a biological feature of human and certain animal brains. It is caused by neurobiological processes and is as much a part of the natural biological order as any other biological features such as photosynthesis, digestion, or mitosis*”. Emergence in a complexity is considered conditional in the realization of higher functions of living organisms that are not simply and exclusively deduced or explained by the properties of the constituting elements; rather it is the result of their interactions. Once realized, complexities determine - at least partially - the behaviour of the constituting elements: such a top-down causal relationship must be distinguished from the bottom-up realization of complexities from its constituting elements. The present article focuses on the mind-brain relationship, i.e. how a neuronal complexity such as the brain might lead to the emergence of the mind and consciousness and, subsequently, how this might

enable the creation of qualia.

A detailed view on consciousness and the integration of neural processes is provided by Edelman and Tononi.⁴ They propose that consciousness is the product of activities of neuronal groups, in their terms Theory of Neuronal Group Selection (TNGS). Central in their concept is the dynamic core model, which is a conglomerate of neurons of a varying composition that forms the core of conscious feelings, including qualia. They position qualia in an N-dimensional reference space, so that sensory experiences are neuronally connected to many other faculties, including body awareness. They refer to William James as there is no pure atomic (of an isolated element) sensation “*No one ever had a simple sensation by itself. Consciousness, from our natal day, is of a teeming multiplicity of objects and relations, and what we call simple sensations are the results of discriminative attention, pushed often to a very high degree*”.⁴ (p 16). But what is emerged here? Basically their theory is focussed on classical neurophysiology and perception with an emphasis on organization and distribution of neuronally-bound information over the brain. In their summing-up of the theory they refer to the development of the individual and evolution during life as a key process.⁴ (p 211). “*The most momentous achievement is the transcendent leap from simple nervous systems, in which signals are exchanged in a relatively insulated manner within separate neural subsystems, to complex nervous systems based on re-entrant dynamics, in which an enormous number of signals are rapidly integrated within a single neuronal process containing the dynamic core – it is the remembered present*”. The text that follows is well in agreement with most of their conclusions, except that memory plays a modest role. Here I explore the role of memory in the development of consciousness and in the creation of qualia.

This article is as organized as follows. First, some concepts on emergence (e.g. [3,5]) are discussed and I compare some of these claims with those of systems theory² and (substance) dualism (summarized in 4 of References). We argue that in a pragmatic and practical sense these theories lead to rather similar explanations of the brain-consciousness relationship and of qualia. Second, we assess some metaphors used to enhance understanding of the idea of emergence of the mind (and qualia) in the context of contemporary neurobiological research and conclude that metaphors may often be misleading rather than clarifying. Finally we suggest some

strategies to approach the concept of qualia with contemporary neurobiological concepts

EMERGENCE, DUALISM AND SYSTEMS

At least 2 different options of dualism have been described. One is the assumption that the mind is made of an entirely different substance than the brain or any other material of the universe (substance dualism). Usually we refer to Descartes, and he acknowledged the problem how an undivided mind may affect a material brain. His solution was the epiphysis (pineapple gland) localized in the middle of the brain. Panpsychism states that the mind is attached or linked to all material: proponents of such views are Leibniz (monad theory), Spinoza (nature as an expression of God), but also modern neuroscientists (arguments in [4, 6,7]). The basic assumption is that consciousness (the mind) is present in a rudimentary form in every material entity and that a complete mind and consciousness are thought to emerge from matter and energy clusters (or systems). Anyhow, some kind of emergence is explicitly or implicitly assumed in either option.

Emergence is a universal phenomenon in the world around us, including the cosmos and nature. Examples are atoms formed from quarks, molecules as assemblies of protons, neutrons and electrons, proteins as assemblies of amino acids or the living cell as an assembly of biomolecules. Any emergent entity is a complexity or system, which affects the behaviour of the constituting elements. For instance, the protein as a whole determines part of - but not - the entire behaviour of the amino acids. The central idea of a complexity or system is that its behaviour cannot easily or in principle be predicted (or calculated) from the (isolated) properties of its constituents. Some has refuted this idea as for instance Von Bertalanffy²: *"The characteristics of the complex, therefore, compared to those of the elements, appear as "new" or "emergent."* (but are not really JK, as his claims were also): *"If we know the total parts contained in a system and the relations between them, the behaviour of the system may be derived from the behaviour of the parts."* This stance implies that either the mind or qualia are of a different quality irreducible to the physical universe (in fact assuming substance dualism), or that the physical universe allows the realization of complex emerging but irreducible systems. This article adheres to the latter position.

New emergent, properties can only be realized during formation of systems, i.e. the composition or configuration of an assembly of identical or dif-

ferent entities. After having rejected the principle of substance dualism, the question arises what is the difference between functional emergence and dualism: both concepts assume an overruling power of the newly realized configuration on its constituting parts. Notwithstanding their different philosophical background, in practice they are identical. One may gradually differentiate systems according to the strength of the interaction of their components: a system may contain strongly or rather weakly interacting components. If weak then the properties of the elements may dominate the emergent property of the system, and hence the emergent new property might be deducible from the properties of the elements to some extent, whereas strongly interacting elements result into a unitary acting system. In brain, for instance, the relative strength of the interneuronal interactions or the allosteric interactions of proteins determines at least in part the responsiveness to and amplification of external signals.

If consciousness is an emergent process, rather than a state it is clear that consciousness cannot be defined only in terms of anatomy, but also as nervous activity. Edelman and Tononi⁴ (p 14) use the term morphology, to be understood as the combination of anatomical and neurophysiologic aspects, does fairly well cover our present concept. Consciousness and also qualia should be understood as processes, rather than as a time-detached state or a product of that. Previously we^{8,9} and others¹⁰ have emphasized that the brain (like other living cellular configurations) is a structure far from equilibrium, which can be maintained by a large energy consumption, relative to most other organs. The energy is needed to maintain high cerebral neural activity, in addition to the continuous adaptation or modification of its anatomical structure, i.e. to maintain its (dynamic) morphology. Following a transient state of cerebral iso-electricity or following anaesthesia, coma or other states of unawareness, the mind and mental processes might re-emerge (after awakening) except in case of irreversible brain damage (details in [11]). Apparently the original morphology (combined anatomy and neurophysiology) can still be created, presumably because essential elements of the structure of the brain have remained intact. This does not necessarily point to the existence of particular cells with memory functions, but rather that many cells have some trace of history. Through mutual interactions - as evidenced by electrical activity - they realize consciousness, linked with memories and bodily

awareness (“feelings”). Compatible with this proposal is the fact that far most brain neurons are not replaced by new cells during life: it seems rather non-functional to replace old, “life-time experienced” cells by new - and “naive” - cells, unless the latter are “programmed” *in vivo*. Emergence in the context of brain implies irreversibility, not only because of gene-directed developmental or aging processes, but also via the experience-driven adaptation of the brain’s morphology. The concept of irreversibility contrasts homeostasis, the idea that the body and the brain return to previous states.

In the scientific practice key properties of cerebral nerve and other cells, i.e. action potentials or neurotransmitter release, are often characterized *in vitro*. Here I want to stress the possible difference between *in vitro* and *in vivo* ascertained physiological properties. In slabs or slices, many *in vivo* connections are lost and possible interactions are destroyed. It is as yet uncertain whether, and if so how much, the nerve cells retain age- and experience-related morphological and functional-biochemical adaptations *in vitro*. I am not suggesting that *in vitro* all *in vivo* properties are destroyed: for instance isolated rat hippocampus cells remain affected *in vitro* by ante-mortem stress.¹² Hence properties specifically emergent *in vivo* might escape *in vitro* detection and exploration, in particular when related to relatively subtle experiences.

ON METAPHORS

In this section I discuss some metaphors used often to clarify the concept of emergence. The present concept of emergence is based on the ideas of complex systems. How small or how big should an assembly be to become a system? Perhaps the smallest systems are composed of entangled paired physical particles such as electrons or photons. Entanglement implies that some properties of a paired particle become only apparent (detectable), when the state of one of the particles is defined (details in [7]). For instance, the “direction” of the spin of an electron or of the polarity of a photon is instantaneously established once that of the paired particles is expressed, which is, for instance, achieved by a dedicated detector. This process might be considered as a typical property of a system, because a newly defined state is induced in either of the paired particles. One might also argue that both (paired) properties were already present during entanglement, thus before the detection. Either way, these various properties are emergent later. Some cognitive-brain models are metaphorically based on

the idea of entanglement: hence not because these elementary physical properties explain mind (as does panpsychism), but to describe the emergence of apparently preconconscious processes into conscious behaviour (e.g. decision making^{7,13}).

Searle considers consciousness as an a-causally emergent feature of the central nervous system in the same way that solidity and liquidity are emergent features of systems of molecules³ (p 112). Indeed, water molecules must interact to result in fluidity (*bottom-up emergence*) and moreover fluidity determines to a large extent the behaviour of individual molecules (*top-down functionality*). Fluidity (or solidity¹⁴, p 17-18; ³, p 122-123) is an emergent property of an ensemble of water molecules in layers of a few nanometres. “Where appearance is concerned we cannot make the appearance-reality distinction because the appearance is the reality. Searle continues: “Unlike solidity, consciousness cannot be redefined in terms of an underlying microstructure, and the surface features then treated as mere effects of real consciousness, without losing the point of having the concept of consciousness in the first place”. The contrast between the reducibility of conscious states does not reflect any distinction in the structure of reality, but a distinction in our definitional practice. The apparent contrast between the irreducibility of consciousness and the reducibility of colour etc. was *only* apparent. Just like pain, consciousness and qualia must be seen in a functioning brain: as an experience, rather than as a collection of neural activities. Searle¹⁵ (p 49-55) applies fluidity as a general principle and formulated emergence as “*bottom-up micro macro no time gap, and cause and effect are simultaneously realized as a macro feature of the system made out of that microstructure (micro) that in turn explains the existence and causal powers of higher-level of system features*”.¹⁵ (p 54). Indeed this seems plausible when considering water, but does it work in other systems, including the brain and mind? Important here is the assumption that emergence is instantaneously realized, without a time-gap³ (p 87-89). This time-gap may indeed be extremely short (femtoseconds or less), when rather non-complex entities, such as entangled particles, water-molecules or amino acids interact. In these examples emergence is a quality or state that can be observed or detected immediately. Such quality or state has no causal power on its constituting elements. Application to the problem of mind, such presumed emerged qualities are supervening in the sense of Jaegwon Kim¹⁶ without causal

properties; causation can only be provided by the physical brain (discussed in [17]). Together, these considerations show that such metaphors may be misleading, rather than illuminating. As concluded earlier in this article, mind is a process, rather than a quality and its understanding must be searched in constituting temporal neural processes rather than in an a-temporal appearance or quality.

TIME TO EMERGE

Mind is unique of each individual, and is formed during development, influenced with biological and environmental roots and through inter-human communication. Our life starts with the socialization of newborn babies by facial expression, sounds, reward and later by verbal communication, which does a baby understand before mastering speech itself. Also toilet training and regularly sleeping and eating are socializing activities. Language is socializing par excellence.⁵ Through spoken and later written language the human individual learns to express his/her feelings, desires and intentions. Moreover inter-human communication (e.g. by education, schooling) helps to master biologically determined needs, in addition to understand (internalize) concepts and rules (institutions [5]) of a family or of a society. If we want to understand the mind as a biological phenomenon the individual development should be taken into account: indeed Cleeremans¹⁸ argues that the *“brain learns to be conscious”*. And further: *“the brain continuously and unconsciously learns to re-describe its own activity itself, so developing systems of meta-representations that characterize and qualify the target first-order representations. Consciousness thus not only requires ability to learn about the geography of one’s own representations, but also requires that the resulting knowledge reflects the dispositions and preferences of the agent”*.

If we consider emergence as crucial, the question is whether there is a next-lower level of complexity that explains the emergent process and if so what level should be considered? The question relevant in particular here is what is the adjacent lower level of complexity to explain mental processes. Searle³ (p161) states: *“There is nothing going on in my brain but neurophysiologic processes, some conscious, some unconscious. Of the unconscious neurophysiologic processes, some are mental and some are not. The difference between them is not in consciousness, because, by hypothesis, neither is conscious; the difference is that the mental processes are candidates for consciousness, because they are capable of causing conscious states. But*

that’s all”. We have already reached the conclusion that consciousness is the emergent product of a process, rather than a state. So one has to investigate which neuronal processes are responsible for consciousness: the model of Edelman and Tononi⁴ is certainly a candidate.

At first glance this would imply that consciousness cannot be expressed faster than the fastest neuronal processes, such as a neuronal action potential or neuro-receptor activation, which are in the millisecond range. But the physiology of the latter processes is not time-limiting, as for instance neuronal bundles may react already in less than 1 millisecond. The speed to localize a sound source in the space around us might well illustrate this capacity. Healthy humans localize sound within 0.2 milliseconds (references in [8,9]). So it might be argued that consciousness can nearly instantaneously be realized in (or by) the central nervous system. Psycho-physiological experiments point towards a slower realization. For instance, the classical experiments of Libet (references patients [7,9]) show that in about 250 milliseconds an experience becomes conscious (*“conscious free will”*), whereas the conscious interruption of an ongoing act requires a mere 40 milliseconds (*“free won’t”*). These observations imply that the realization of consciousness is nearly instantaneous (40 milliseconds, or so), whereas its conscious expression might last longer (a few 100 milliseconds). Similarly we interpret movements at a rate of 25 frames per seconds as smooth and realistic (higher rates may improve the perception¹⁹), suggesting that the brain constructs images well within 40 milliseconds by (unconsciously) comparing current with at least one previous image.

In this context the functioning of mirror neurons might also be considered. Monkey mirror neurons are responsive to the observation and execution of hand and mouth actions. The hand actions include grasping, placing, manipulating with the fingers, and holding.²⁰ Mirror neurons are - among others - found in the ventral premotor cortex, the inferior frontal cortex (monkey, electrophysiological monitoring) and superior parietal lobe (human, fMRI studies).²¹ The beginning of the activation of the mirror neurons is already observed within 40 milliseconds after exposure to the stimulus (grasping) and is the consequence of pre-conscious neural processes. Apparently during this short delay the brain coordinate its activity and focus it towards mirror neurons (and other brain regions). This activation might become part of a conscious

experience after about 250 milliseconds. The neural processes leading to initial activation of the mirror neurons are too fast to be delineated and detected, but their later consequences can well be detected (visualized) with fMRI. One issue is whether these fast processes are the result of initial learning²⁰ and thus pre-conscious, whereas in a naive organism activation of mirror neurons happens in a conscious state. Qualia are in the domain of consciousness; hence both in a learning phase and possibly during persisting activity of the mirror neurons might reflect a time path towards conscious focusing. The process of focusing in a complex system, such as the brain is largely unknown, because tools for the detection of the required temporal or spatial sensitivity are lacking.

Qualia are personal experiences realized in a person-unique brain. This idea might be illustrated with patients suffering from the so called dissociative identity syndrome (DIS). Individuals who were exposed in their youth to severe stress, such as sexual misuse or violence, might develop DIS. In daily life they may suppress the memories of the stressful experiences, to which they become emotionally responsive when switching to the “identity” that has access to their stressful memories. In an experimental setting switches between identities might be evoked within 15 minutes or less, which allow monitoring of various physiological parameters successively in the same subject. When hearing scripts referring to the psycho-traumata the personalities react differently: only the identity with a conscious memory of the psycho trauma has an emotional response such as increased heart rate, less heart rate variability or higher blood pressure.²²⁻²⁴ Moreover fMRI analysis show that several brain regions are specifically activated or suppressed in trauma-associated identity (details in [23,24]). These provocation studies do not only show that mental states might switch relatively fast (in minutes), but also, and that is in particular relevant for the present report, that the impact of an experience, i.e. qualia, is dependent on the historical background of a personality (identity in the present example).

Together this section illustrates that the basis of consciousness and qualia are already laid nearly instantaneously (within 40 milliseconds or so), whereas the time to realize a conscious experience is in fact 10-fold higher (likely more than 200 milliseconds). In neuronal networks the respective number of transitions differ in orders of magnitude (10 to 100x). Apparently, the required organization of the underlying neuronal morphol-

ogy constrains the timing of realization of qualia. Such fast neuronal events escape detection with the most advanced scanner techniques including functional MRI.

NEUROBIOLOGICAL AFTERTHOUGHTS

The brain is a structure partly detached from the outer world. All living cells are maintained in nearly steady state far from equilibrium and without the continuous influx of energy (oxygen, nutrients) such a state cannot be maintained. The brain has its own intracerebral dynamics, and moreover its steady state is only apparent. In fact a core characteristic of the brain, like any other organ or living cell, is irreversibility: its state changes continuously, it never returns to a previous state. Irreversibility is the additive result of aging - of course not unique for the brain - and the continuous formation of new memories. In a previous article⁸ I proposed the brain as a personal universe: like the cosmic universe it is continuously expanding, in particular in the perspective of the formation of memories, but in addition it has individually unique characteristics. Consciousness and personal feelings, qualia, should be seen in this context.

A neurobiological theory on qualia should incorporate irreversibility of the brain and in particular continuous accumulation of memories. A conscious experience does not only depend on awareness, but on acquired and precipitated personal memories as well. Hence the presumed N-dimensional space⁴ should include a domain for memory, which is likely not a separate group of cells^{9,11} rather a multitude of neurons have some trace of their history. These presumably historical traces can become manifest in personal memories, that in some way are not (completely) destroyed during life. That is not to say that the involved molecules survive, rather that memories and associated morphology are continuously reproduced during life. This is why brain neurons are by and large not completely replaced by new cells. It seems biologically risky if not impossible to replace continuously a large proportion of old “life-time experienced” cells by new, hence naive, cells. In short, cerebral emergent processes imply irreversibility not only by gene-directed developmental processes, but also via the continuous adaptation or modification of the neurophysiological properties of brain neurones during life time. The subjectivity of qualia is that they are formed in a personal brain and experienced as such, just like many other feelings. In this way qualia are the basis of personhood.^{25,26}

STRATEGIES FOR QUALIA

The concept of qualia must be seen in the context of consciousness. Qualia become a part of consciousness, although pre-conscious processes contribute and these processes are irreversible. This article emphasizes that consciousness, and hence qualia, are a process, rather than a state (an immobile frame), and moreover that the composition of the brain is never constant: and if so consciousness and qualia does not arise from an immobile configuration, instead it is (re)created continuously, both during normal functioning, and after states of unconsciousness. Consciousness and qualia must be seen in the context of irreversibility, and not as serving homeostasis. Irreversibility implies that the brain is continuously reshaped not only through genetic processes, but above all by experiences and memories of them, forming together our personal universe.^{8,9} We discuss the concept of consciousness and qualia in the context of general system theory. Hence we conclude that isolated and *in vitro* properties of neurons and other constituents does not lead to a full understanding of the brain, of the mind and of qualia.

The above considerations and suggestions do not explain qualia; rather they delineate biological conditions to be fulfilled to evoke qualia. The subjectivity of qualia ought to be sought in the already proposed personal brain or personal universe. The question is what kind of scientific theory might describe such personal constellation or is it so that such description is beyond (neuro) science? First some general considerations. Any bioscientific theory is derived from and applies to phenomena or properties that can be abstracted from prototypical objects, such as living organisms or functioning brains. Try, for instance, to describe scientifically the behaviour of a single falling leaf. Such a description does not really apply to a particular leaf, but rather to a "population of leaves"; ideally the construed model shows that the particular leaf belongs to the population in question, and is not an outlier or even impossible. The present issue of the qualia is whether the delineated conditions are enough to explain the occurrence of qualia. Some of the suggestions might be scientifically explored and either falsified or verified. Based on these results further research strategies might be developed. Current realizable strategies might include challenge studies, of which we have described a few (dissociation studies and mirror neurons), that are highly dependent on empathic mechanisms based on previous personal experiences. One option is

to design research protocols for longitudinal observation on subject with standardized experiences between the observations.

REFERENCES

1. Chalmers D. Facing up the problem of consciousness J Consc Studies 1995;2(3):200-19.
2. Von Bertalanffy L. General System Theory. New York: Braziler; 1969: p. 55.
3. Searle JR. Rediscovery of Mind. Cambridge Mass: MIT Press; 1992.
4. Edelman GM, Tononi G. A universe of consciousness; how matter becomes imagination. New York: Basic Books; 2000: 3-207.
5. Searle JR. Making the social world: the structure of human civilization. Oxford/New York: Oxford University Press; 2010:3-202.
6. Meijer DKF, Korf J. Quantum modeling of the mental state: the concept of a cyclic mental workspace. Syntropy J 2013;1:1-41.
7. Korf J. Quantum and multidimensional explanations in a neurobiological context of mind. Neuroscientist 2014;1-11.
8. Korf J. The iso-energetic brain; the idea and some implications. Neuroscientist 2012;16:118-24.
9. Korf J. The mind as an emerging configuration of the personal brain. Dial Phil Ment Neuro Sci 2012; 5(1):21-4.
10. Prigogine I, Stengers I. Order out of chaos: man's new dialogue with nature. Toronto: Bantam Books; 1984:1-312.
11. Korf J. In quest of specific neurons of mind and mental disorder. Dial Phil Ment Neuro Sci 2013; 6(1):34-8.
12. Krugers HJ, Karst H, Joels M. Interactions between noradrenaline and corticosteroids in the brain: from electrical activity to cognitive performance. Front Cell Neurosci 2012;6:15.
13. Potos EM, Busemeyer JR. Can quantum probability provide a new direction for cognitive modeling? Behavioral and Brain Sciences 2013;36:255-327.
14. Searle JR. The mystery of consciousness. London: Granta Books; 1997.
15. Vicari G. Beyond conceptual dualism; ontology of consciousness, mental causation, and holism in John R Searles's philosophy of Mind. Amsterdam-New York: Rodopi BV; 2008.
16. Kim J. Physicalism, or something near enough. Princeton NJ: Princeton University Press; 2005: 1-186.
17. Crisp TM, Warfield TA. Kim's master argument. Nous 2001;35(2):304-16.
18. Cleeremans A. The radical plastid thesis: how the brain learns to be conscious. Front Psychology 2011;2:86(1-12).

19. Watson JB. High frame rates in human vision: a view through the window of visibility. *SMPTE mot. Imag J* 2013;122:18-32.
20. Cook R, Bird G, Catmur C, Press C Heyes C. Mirror neurons: From origin to function. *Behavioral Brain Sci* 2014;37:177-241.
21. Rizzolatti G, Craighero L. The mirror-neuron system. *Annu Rev Neurosci* 2004;27:169-92.
22. Reinders AATS, Nijenhuis ERS, Quak J, Korf J, et al. Psychobiological characteristics of dissociative identity disorder: a symptom provocation study. *Biol Psychiatry* 2006;60:730-40.
23. Reinders AATS, Willemssen ATM, Vos HPJ, den Boer JA, Nijenhuis ERS. Fact or factitious? A psychobiological study of authentic and simulated dissociative identity states. *PloS One* 7(6): e39279. doi:10.1371/journal.pone.0039279.
24. Schlumpf YR, Reinders AATS, Nijenhuis ERS, Luechinger R, et al. Dissociative part-dependent resting-state activity in dissociative identity disorder: a controlled MRI perfusion study. *PLoS One* 2014; 9(6): e98795.
25. Damasio AR. *The feeling of what happens: body emotions and the making of consciousness*. New York: Harcourt Brace; 1999:1-386.
26. Voss JL, Heather HD, Paller KA. More than a feeling: Pervasive influences of memory without awareness of retrieval (and commentaries and reply). *Cogn Neurosci* 2012;3(3-4):193-226.