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# Consciousness from a classical physical-science perspective based on a new paradigm

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**Key words**
Anaesthesia, animal consciousness, Ansatz approach, autonomic system, bioelectric signals, bioelectric language, Cambridge Declaration on Consciousness, cellular metabolism, cochlear implant, conscious free will, default-mode activity, default-mode video-in-the-brain, conscious dream, free will, fundamental state of life, general consciousness, Hemineglect syndrome, Least Effort Principle, local tissue damage, local wake state, movie-in-the-brain, multiple local wake-state messaging, nocisensor, non-autonomic system, nonconsciousness, nonconscious free will, nonconscious mental processing, nonconscious self-awareness, nonconscious memory, orthodox paradigm, pain generation, parietal lobe, person-to-person communication, physiology, quantum consciousness, reticular formation, self-consciousness, sensory neuron, somatosensory cortex, tissue damage, tissue-damage sensor, tissue fluid, unorthodox paradigm, video-in-the-brain, vital function, wake state, wake-state sensor.

## Summary

Quantum physics has a long history of interest in consciousness, stemming from the conviction, seeded by famous names, that consciousness is "fundamental to nature" and is, thus, somehow contributory also to quantum events. One of the more recent ideas (by Stuart Hameroff and Roger Penrose) is that the brain is a quantum computer and that a particular component of neurons acts as a quantum object responsible for the emergence of consciousness. In the 2017 *New Scientist* monograph *Your Conscious Mind* the present scientific vision is summarised as "We still don't know whether it [consciousness] is real or an illusion". And it is speculated "that physicists will [one day perhaps] identify consciousness as a distinct kind of matter". This odd suggestion calls for

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physicists to bring systematic classical thinking back to the subject of consciousness. In the past, such thinking, based on the well-tested Ansatz approach, has failed miserably for consciousness, because of a self-reassuring mainstream orthodox paradigm about the function of consciousness, viz. that consciousness, assisted by the "unconscious" state, is in charge of Man's reasoning and behaviour. The new approach pursued here is the opposite thereof, viz. it is based on the new unorthodox paradigm that the nonconscious (not unconscious) state of mind is in charge of human reasoning and behaviour, and that what a person's mind becomes conscious of has previously been entirely worked out and put into action in the nonconscious state. On this basis, the author has derived a purely classical self-compatible description of the nature and function of consciousness. The key proposition is that general consciousness derives from self-consciousness, which in turn is posited to be a mental sensation of organism-wide wake state feedback from local cellular metabolism. The details have been written up here in a first short form. In a postscript it is also shown how the age-old problem of 'free will' is solved in terms of the new vision of consciousness.

- **That Man has been engineered is believed by both creationists and evolutionists (author).**
- **All consciousness is consciousness of something (philosopher Franz Brentano).**

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## 1. Introduction

A branch of physical science - quantum physics - has a long history of interest in consciousness, stemming from the conviction, seeded by famous names, that consciousness is "fundamental to nature" and is, thus, somehow contributory also to quantum events. Physicist Max Planck, father of the quantum idea, is reported to have entertained exactly this conviction. Likewise, physicist Erwin Schrödinger, originator of the famous wave equation of quantum physics, is quoted with a similar conviction [2], viz. "Consciousness cannot be accounted for in physical terms. For consciousness is absolutely fundamental. It cannot be accounted for in terms of anything else". These and similar convictions are still very popular in physical science after so many years after Planck and Schrödinger [3]. Among these convictions are those alleging that consciousness is a quantum phenomenon. One of these is that the brain is a quantum computer and that a particular component of the neuron, the microtubule, acts as a quantum object responsible for the emergence of consciousness (according to

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[2] In the New Scientist publication *Your Conscious Mind*, New Scientist, 2017.
[3] Over the ages, religions have been instrumental in spreading the belief that humans possess an immortal soul, becoming manifest also in consciousness. Small wonder that consciousness has acquired and maintains a unique standing in the mainstream vision of nature. Whence the recent finding that also many animal species possess consciousness is not readily accepted.


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anaesthesiologist Stuart Hameroff and mathematician/cosmologist Roger Penrose [4]).

The fact that quantum physics is invoked in an attempt to explain consciousness, is evidence of the failure of the many previous classical attempts to unravel the age-old mystery of consciousness, although there are numerous promises to this effect in the literature. Typical of such promises is the one found in the 2017 *New Scientist* monograph titled *Your Conscious Mind*. The promise on the back cover is that the book "takes you on a journey through the mind to discover what consciousness really is", whereas, after the reader has undertaken the "journey", the conclusion informs him/her that, "We still don't know whether it [consciousness] is real or an illusion". And, the authors do not exclude the possibility "that physicists will [one day perhaps] identify consciousness as a distinct kind of matter". If this is not meant to be pure sarcasm (in view of what some theoretical physicists ask the scientific community to believe about parallel realities), then this last remark, more than anything else, calls for physicists to bring systematic classical thinking back to the subject of consciousness. I.e., Schrödinger's conviction must be rejected, and the stand must be adopted that mind ***can*** be "accounted for in (classical) physical terms", and, hence, also the mind's states of conscious and nonconscious [5].

Before proceeding any further, it must be clarified what 'conscious', respectively 'consciousness', stands for. Viz. for a person's sensation of being awake and of participating in environmental happenings. More specifically, it stands for the sensation generated in the brain that the organism as a whole is a single, self-determined entity distinct from all other objects which the brain perceives by way of the mental processing of environmental sensory information. In other words, consciousness is essentially a sensation of self, which excludes all other perceived objects from such sensation. As such, this sensation must arise within the organism as a whole.

This argument gives rise to the author's vision that the brain is linked to strategic points of the body which convey messages to the brain about their local state of either alertness or deep sedation. All parts of the body which convey such messages of alertness, subsequently referred to as "multiple local wake-state messaging", contribute towards a joint sensation of self, nonconsciously in a first step (in which the phenomenon is evident in bioelectric language), and consciously in a second step (in which the phenomenon becomes a conscious

[4] Stuart Hameroff and Roger Penrose, *Consciousness in the Universe*, Physics of Life Reviews 11 (2014), 39 - 78.

[5] This author prefers the term *nonconscious* over the established term *unconscious* for reason that the latter has - since Sigmund Freud - acquired the unjustified meaning of an inferior (even sinister) state of mind.

 

sensation). The conscious sensation of self is generally known as self-consciousness. The preceding nonconscious version can, obviously, neither be called self-consciousness, nor a sensation. It is referred to as nonconscious self-awareness in the following.

## 2. The Ansatz approach

Systematic classical thinking in physical science makes use of the Ansatz approach, defined as the "establishment of starting assumptions and/or propositions into an educated guess about a problem and its solution that is verified later by its results". Why has this proven approach in the case of consciousness failed so miserably in establishing an educated guess which is verified by its results? Because, as this author posits, the underlying paradigm about the function of consciousness is a bad guess. This is the self-assuring mainstream paradigm that Man's conscious state of mind is in charge of Man's reasoning and behaviour, in which the "unconscious" state of mind is involved only as a useful assistant. This author posits the opposite to be the better guess, viz. the unorthodox paradigm that the nonconscious (not unconscious) state of mind is in charge of human reasoning and behaviour, and that what a person's mind becomes conscious of has previously been entirely worked out (in response to sensory information and/or memorised information-cum-knowledge) and put into action in the nonconscious state of mind.

This new, unorthodox paradigm is the first of a number of propositions of the new approach. This proposition is derived from the obvious fact that everything which a person becomes conscious of has first entered the brain by way of the sensory organs and by nonconscious bioelectric signal conveyance. Since that which becomes conscious is, obviously, ready processed and definitive, it follows that the conscious state of mind is the final stage of processing in the brain.

The second proposition is that the origin of consciousness is consciousness of the self, because only consciousness of the self can give rise to cognition of non-self objects. And consciousness of the self arises from nonconscious awareness of the self, which, in turn, arises from multiple local wake-state messaging (as explained above, and in more detail farther-on). A third proposition is that the Ansatz must be guided by the Least Effort Principle [6] of evolution.

[6] The term "least effort principle" stems from linguistics and information science. Generalised in Zipf's law, it posits that "people and animals will naturally choose the path of least effort" (Wikipedia). In this essay, the term Least Effort Principle stands for an "evolutionary predisposition for minimising the consumption of physical resources (materials and energy) for given life processes, inclusive of essential learning". More about the Least


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Further propositions are put forward in the following, with extensive reference to a block diagram shown in fig. 1:

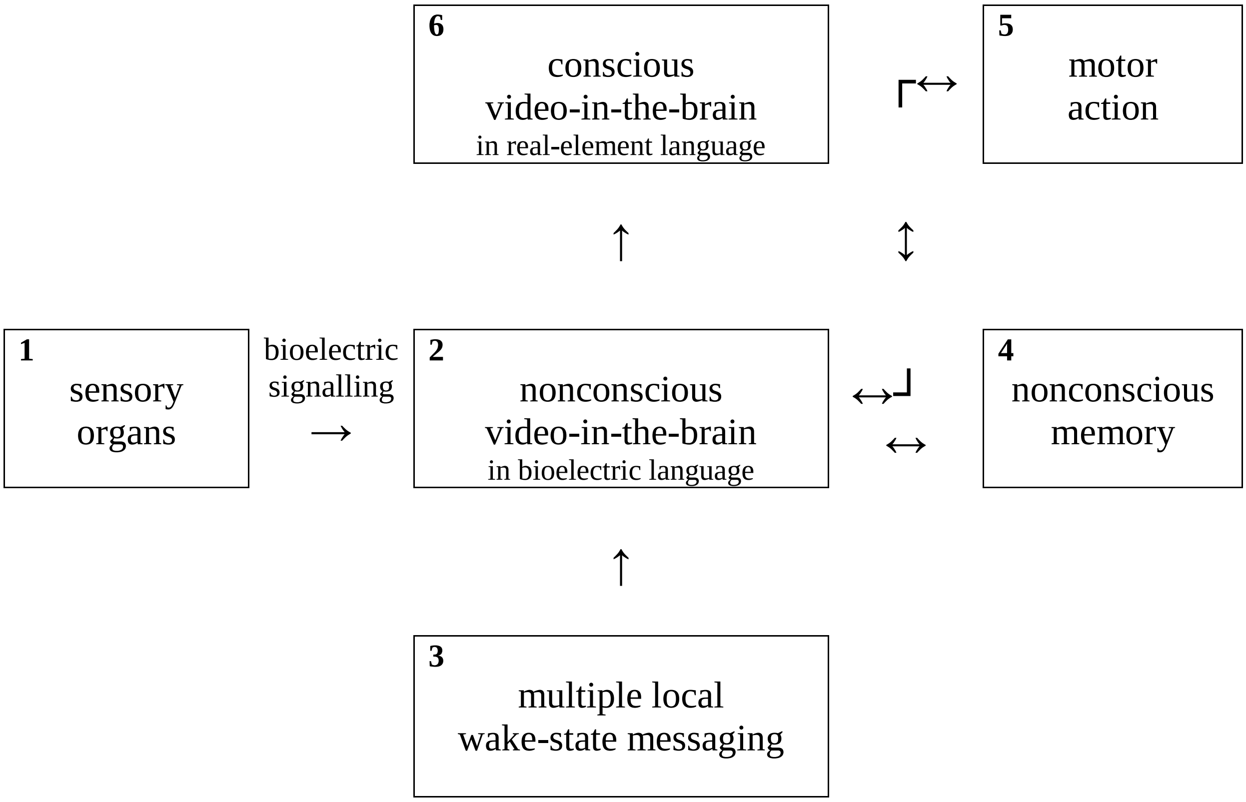


**Fig. 1**: Block-diagram presentation of the Ansatz for the author's classical vision of how the environmental reality is reproduced from sensory-signal pick-up, and subsequently rendered conscious, based on the author's unorthodox paradigm. The term 'real-element language' stands not only for the standard definition of language, viz. "words and the methods of combining them for the expression of thought" (Oxford Dictionary), but for an extended definition embracing all types of elements suitable for communication (such as meaningful sounds, gestures, sign language elements, and visual elements occurring in writing, printing, graphics, drawing, painting, photography, and videoing) [7]. The term 'bioelectric language' stands for the bioelectric equivalent of the afore-defined real-element language. It can be defined as a body-internal language for communication via nerve fibres, through neurons and across synapses both within the brain and by the brain with all non-autonomic body components requiring such communication.

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Effort Principle can be found in Essay 4 of this author (*How the Least Effort Principle governs human reasoning and behaviour*: https//hdl.handle.net/2263/58203).

[7] This extended definition of language can be formulated as "All conceivable elements of communication and the methods of combining them for describing appearances".


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The figure consists of six numbered blocks, each representing an information-receiving and/or information-outputting entity, linked by arrows which indicate the direction of information flow.

Block 1 receives information from the environment (of which also the recipient is part !) into five sensory organs. Blocks 2, 4 and 6 are located in the brain. Blocks 3 and 5 are located in the body.

The conveyance and processing of information in and between blocks 1 to 5 proceed entirely by bioelectric signalling or in bioelectric language, whence they remain entirely nonconscious at all times.

Block 2 is supposed to represent all facilities for processing of information, inclusive of all features essential for making optimal use of the processing outcomes towards survival and advancement of the brain-cum-body entity. One of these outcomes is the mental representation of the environment, constructed from the bioelectric signals generated by a person's eyes from optical sensory information in block 1. And this in combination with memorised information-cum-knowledge from block 4. This mental construction is referred to as a nonconscious video-in-the-brain [8].

In order for a nonconscious video-in-the-brain to be realised, the bioelectric signals received from block 1 must be recognised by block 2 as representing particular elements of the environment which gave rise to the optical sensory information entering block 1. This recognising ability is not inherited, but must be learned by the virgin brain, and, hence, involves the development of neuronal networks able to generate a video-in-the-brain from inputs of optical-information-representative bioelectric signals.

An elaboration of the learning process underlying the generation of a video-in-the-brain is not intended, but can be understood from a description of the simpler learning process underlying the generation of a mental representation of speech, elaborated below in essay section 3.

The nonconscious video-in-the-brain is incomplete and largely useless if the self cannot be identified in the video (either as an observer or as a participant). The nonconscious self-awareness (as it has been called above) is a prerequisite for

[8] The term video-in-the-brain has been inspired by the term "movie in the brain", created by neuroscientist Antonio Damasio. Damasio's term is equivalent to this author's conscious video-in-the-brain, not to the nonconscious version. It is for this reason that this author avoids using Damasio's term.

the identification of self in the video-in-the-brain, and for the subsequent identification of a challenge to oneself. The identification of self is posited to be enabled by the simultaneous conveyance of wake-state signals from all parts of the body to block 2, referred to as multiple local wake-state messaging in block 3. This is a key proposition of the Ansatz, and is briefly focussed on in the following Insert:

**Insert: Multiple local wake-state messaging as origin of self-consciousness**

A key proposition of the Ansatz of this essay is that the sensation of self-consciousness can be retraced to an organism's local biological wake state. The argument underlying this proposition consists of three parts, viz. firstly of the obvious fact that self-consciousness exists only during the wake state and discontinues during (dreamless) sleep, coma and deep anaesthetics. While this argument explains *when* the sensation of self-consciousness arises (viz. with the emergence of the wake state), it does not explain *how* this sensation arises. This question is answered by the second part of the argument, viz. that the sensation arises as a result of multiple messaging to the brain of the local wake states of all parts of the organism. In other words, every part of the organism has to report its local wake state to the brain in order for an integral sensation of self-consciousness to arise. And the third part of the argument consists of a description of the physiology underlying the multiple messaging of local wake states.

Since this author has been unable to locate a physiological description of messaging of local wake states to the brain, neither in newer handbooks on physiology nor on the Internet, he is resorting to the well-studied physiology of a similar phenomenon on which self-consciousness can be modelled; that is the physiology of pain generation.

This modelling is elaborated at length in essay section 8. Prior thereto, the reader is informed of research findings and/or reasoning of relevance to the key arguments underlying this essay, viz. findings about consciousness in wild animals, findings and reasoning on sleep and continuous brain activity, reasoning about conscious dreaming, findings and reasoning about the hemispatial neglect syndrome, and reasoning about the nonconscious fundamental state of life.

Like the signals from block 1, also bioelectric signals from block 3 have to be converted into bioelectric language prior to participation in processing, viz. into nonconscious self-awareness. This mechanism is unknown at present. The nonconscious self-awareness is posited to turn into self-consciousness at the instant of the conversion of the *nonconscious* video-in-the-brain in block 2 into a *conscious* video-in-the-brain in block 6. This conversion is associated with the conversion from bioelectric language into real-element language.

The nonconscious video-in-the-brain in block 2 is contributed to by memorised information from block 4. Once completed (i.e. rendered compatible with information from blocks 3 and 4), a copy of the nonconscious video-in-the-brain is transmitted to block 4 to be added to memory.

The memorised information in block 4 embraces all experiences of a person since birth, together with all information-cum-knowledge acquired by learning and self-reasoning. Without it, the video-in-the-brain, once rendered conscious, is unlikely to have the required close similarity to the environmental reality.

Another copy of the completed nonconscious video-in-the-brain in block 2 is rendered conscious by conversion from bioelectric language into a real-element language as specified in the legend of fig. 1. The conscious video-in-the-brain, shown in block 6, is what Man perceives as environmental reality.

It is to be noted that the information-flow arrow between blocks 2 and 6 is unidirectional, indicating that block 6 is not retro-active on block 2. This is contrary to mainstream belief, which regards consciousness to be in charge of human reasoning and behaviour. The author's counter-arguments are that such retro-action would, firstly, be too late for corrective interference with processing in block 2, and would, secondly, have no back-up by superior information/knowledge which would not have been available also in prior processing. In other words, there is no chance whatsoever of any consciousness-induced retro-interference with nonconscious mental processing [9].

While a copy of the completed nonconscious video-in-the-brain is rendered conscious, the original in block 2 is taken to a second stage of processing, viz. to an analysis of the optical and auditory representation of reality for any challenges to oneself. Again, memorised information-cum-knowledge from block 4 is called up for assistance. If a challenge is detected, memory in block 4 is yet again consulted for experience with past responses. A most-promising response is decided on in block 2, and the non-autonomic muscles in the body required for realising this response, in block 5, are activated by initiation and control from block 2. The double-headed arrows indicate that success, or otherwise, is reported back to block 2. Intermediate stages of this second stage of processing are committed to memory in block 4.

[9] These counter-arguments are "overlooked" in mainstream vision so as to safeguard the belief in free will.

In this context, it must be remembered that among the block-2-activated muscles are also those which operate the vocal chords and tongue in speech.

The processing of speech - somewhat simpler than that of the optical surveillance of the environment - is elaborated in the following essay section 3.

## 3. Speech within the new-paradigm Ansatz approach

<u>Introductory remark:</u> One has to note that not only the *conscious* video-in-the-brain, in which speech is embedded, but *conscious* speech itself is perceived as a continuously ongoing, uninterrupted happening, although the Ansatz assumes, of necessity, that the *nonconscious* processing can take place only piecemeal on a succession of quasi-stationary self-consistent intervals of the continually incoming sensory information (not dissimilar to the succession of stationary frames of a movie film). Intervals are chosen by the brain so as to enable the brain to make sense of the contents of each such interval. For visual observations the sampling interval is reported to be about 1/60 of a second. This must also be the typical sampling interval for piecemeal speech processing for videos-in-the-brain to create a visual and auditory illusion of uninterrupted continuity.

The new, unorthodox paradigm underlying the Ansatz, visualised by the block diagram of fig. 1, must allow as many as possible performances of Man to be explained. Of particular importance of these is speech, to be elaborated in the following.

The bioelectric nature of communication within biological organisms necessitates that all sensory information picked-up from the environment is converted into bioelectric signals in block 1 before being conveyed to the brain. There, in block 2, these bioelectric signals are converted into mental representations of the real sources from which the sensory information emanated. These mental representations include a mental video of objects and happenings in the environment, a mental representation of the sounds and odours emanating from these objects, and, sometimes, also a mental representation of the speech emanating from an interlocutor.

The signals conveyed from eyes, ears and nose in block 1 to block 2 are conversions of optical, auditory, and olfactory information into bioelectric signals which cannot otherwise be brought to the brain. Once arrived at the brain these signals undergo further conversion into the afore-mentioned mental representations. The bioelectric signals from block 1 are inputs into the brain, just as the optical, auditory, and olfactory information were inputs into eyes, ears, and nose. These signals still contain the original optical, auditory, and olfactory information, but in a concealed form from which the original information has to be reconstituted in a first step, and, in a second step, turned into the afore-mentioned mental representations.

The procedure underlying this processing is complicated and largely unknown, particularly where the conversion of optical information into a video-in-the-brain is concerned. The processing of speech is easier to explain, at least superficially, it helps the understanding of mental processing in general, and is sketched in the following:

The key argument is that the processing involves the generation of neuronal networks, which perform tasks aimed at realising the afore-mentioned mental representations. In the case of speech, the brain must learn how to reconstitute speech information from the bioelectric signals entering block 2. This reconstituted speech information is, of course, in form of bioelectric language as long as it undergoes further processing. In a last step of processing the bioelectric-language-encoded speech information is rendered conscious by conversion into a mental representation of real speech.

To be more specific, processing of speech-representing bioelectric signals arriving in block 2 consists, in a first task, of distinguishing between bioelectric signals representing speech and other sounds, in a second task, of identifying speech-representing bioelectric signals as constituents of a known or unknown language of speech, and, in a third task, of identifying the words of the language of speech concerned. To perform these tasks, block 2 must have analysing neuronal networks able to convert the incoming bioelectric signals into elements of a bioelectric language, which allow the three-task sequence to be executed. Additionally, the memory in block 4 must be called upon to assist (e.g. for translation between bioelectric languages representing different languages of speech). Subsequent to execution of the third task, the words in bioelectric language are rendered conscious in a real language of speech, viz. in the mental representation of the speech emanating from an interlocutor.

How can the brain be taught to understand speech? Let's start with mother-tongue speech: Success of learning derives from persistent coaching by the mother as well as from exercising by the learner. Both coaching and exercising lead to the development of auditory neuronal networks in block 2 which convert bioelectric signals from the ear into elements of a bioelectric language representative of mother-tongue words. These language elements, when rendered conscious, generate a sensation of speech (in block 6), known as hearing.

The success of exercising of the learner can be explained as being due to a linking of the auditory neuronal networks to neuronal networks which govern the motor action of muscles involved in the vocalisation of speech. These neuronal networks (in block 2) generate messages - conveyed from block 2 to block 5 - which cause the muscles acting on vocal chords and tongue to issue verbal utterances. These verbal utterances by the learner are heard by the mother, who corrects the utterances. Both the learner's utterances and the mother's corrections enter block 1 of the learner and give rise to different bioelectric signals. These cause block 2 to adjust the learner's auditory neuronal networks to a more correct output, evidenced by decreasing signal differences in subsequent trials.

The foregoing argument regarding hearing and learning-to-hear of speech finds support by the experience with a hearing device known as cochlear implant, recommended for remedial treatment when the bioelectric signals generated by the cochlea in the ear (block 1) deteriorate to weak or non-existent. Such an implant bypasses the damaged parts of the cochlea by feeding electric signals, generated by a speech converter, to electrodes implanted into the cochlea, and further into the auditory nerve to the brain.

The electric signals generated by the speech converter can, for a given speech sequence, obviously, not be identical to the bioelectric signals originally generated by the undamaged cochlea, whence the originally developed and fine-tuned auditory neuronal networks fail to function as with an undamaged cochlea.

It is not surprising therefore that rehabilitation of speech hearing by cochlear implant succeeds only to a limited extent, reported to never becoming normal again. Intensive exercising over months, assisted by logopaedists, may eventually enable patients to associate words with the sound sensation in block 6. Within these limitations, cochlear implants are reported to "work particularly well for adults and children who have lost their hearing after acquiring spoken language and for young children who were born deaf" [10]. The same source reports also that "Research suggests that [deaf] children given a cochlear implant in their first year of age can develop language skills at a comparable rate to normal-hearing children".

The last finding shows that the function of an undamaged cochlea is the same as that of a speech converter in a cochlear implant, viz. to convert speech into bioelectric signals, nothing more. In other words, the learning-to-hear-speech technique applied to young learners leads to the same mother-tongue proficiency

[10] https://patient.info/doctor/cochlear-implants


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regardless of whether the bioelectric signals are generated by an undamaged cochlea or, in different form, by a speech converter in a cochlear implant.

It is most likely that the foregoing findings on learning-to-hear-speech technique can be extrapolated to a learning-to-see-a-video-in-the-brain technique. In fact, it has been suggested that the tactile sense of young children plays a key role in the early stages of the learning-to-see process. Later, though, also person-to-person communication contributes substantially to the learning-to-see process. This can explain why mental representations of a given environmental reality in different brains belonging to the same cultural group appear to be identical, although a similarity would be more likely. Clarity on this question can be expected if it becomes possible, far into the future, to compare videos-in-the-brain of humans to videos-in-the-brain of animals observing the same environment.

## 4. Consciousness in early and in contemporary wild animals

Man's knowledge of early animals is somewhat uncertain because remains consist either of bones or of offspring in the $xyz^{th}$ generation. Because 99% of land animals were extinguished in a catastrophic encounter of earth with an errant cosmic body 65 million years ago, offspring of earlier animals are found mainly in the oceans. Consequently, consciousness in really early animals can be inferred primarily from currently existing fishes and other sea creatures, whereas consciousness in early land creatures must be inferred from currently existing offspring of creatures who lived less than 65 million years ago.

This author's vision about consciousness in currently existing wild animals derives from the observation that a large fraction of species are either hunters or prey of other species, or both. All are in fierce competition for food, and all cope so well that they must have so excellent an awareness of self, of a foe, of a potential prey, and of all food- and survival-related details of the environment, that this awareness appears to be comparable to that of Man. And if this awareness is called self-consciousness and consciousness in Man, then the same awareness in animals must also be called self-consciousness and consciousness.

This author's vision about early development of consciousness is that such development became essential as soon as the rate of reproduction dropped in new species, and these species had to rely on the reliable and fast identification of threats and of moving food. Self-consciousness had, of course, to develop first before general consciousness could develop, and before a sensation of pain became possible.

 

The view of (some) neuroscientists has been expressed in the Cambridge Declaration on Consciousness formulated in 2012 (Wikipedia), stating, *inter alia*, that "Convergent evidence indicates that non-human animals have the neuro-anatomical, neuro-chemical, and neuro-physiological substrates of conscious states along with the capacity to exhibit intentional behaviours. Consequently, the weight of evidence indicates that humans are not unique in possessing the neurological substrates that generate consciousness. Non-human animals, including all mammals and birds, and many other creatures, including octopuses, also possess these neurological substrates".

A complementary finding, not derived from the study of neurological substrates, but from behavioral studies comes from ichthyologist Jonathan Balcombe, a researcher of animal sentience, who concludes [11] that octopuses in particular and fishes in general possess consciousness and more. In Balcombe's words (p. 177), ". . . fishes are individuals with minds and memories, able to plan, capable of recognizing others, equipped with instincts and able to learn from experience. . . . fishes also show virtue through cooperative relationships both within and between species". And what is more, fishes can communicate by sound or by other physical means.

And from a consortium of neuroscientists studying the brains of birds one learns [12] that "so-called 'primitive' regions of avian brain are [in fact] sophisticated processing regions homologous to those in mammals". Whence these researchers propose a renaming of the structures of the bird brains to better reflect the "homologies between avian and mammalian brains". Moreover, they emphasise that "We have to get rid of the idea that mammals - and humans in particular - are the pinnacle of evolution. We also have to understand that evolution is not linear, but an intricate branching process".

The foregoing tells us about the brain power and consciousness of mammals, fishes, and birds at the present stage of evolution, and not about that of their early ancestors. But some inference can be made from a neurological substrate known as the 'reticular formation' (also referred to as reticular system).

In Man the reticular formation is found in the brain stem, reported to be "the most ancient part of the brain and the one part that is absolutely necessary to the life of the organism" (Encyclopedia of Neuroscience, 2009). According to Wikipedia, "The reticular formation consists of more than 100 small neural networks, with varied functions including the following:
1. Somatic motor control, 2. Cardiovascular control, 3. Pain modulation,

[11] Jonathan Balcombe, *What a Fish knows*, Oneworld Publications, 2017.
[12] E. D. Jarvis and 27 co-authors, Nature Reviews Neuroscience 6 (2005), 151-159.

 

4. Sleep and consciousness, 5. Habituation". Regarding point 4, the reticular formation is said to "play a central role in states of consciousness", and that "injury to the reticular formation can result in irreversible coma".

An Internet search reveals that not only mammals, but also fishes and birds have reticular formations (though not necessarily confined to the brain stem). This widespread occurrence of reticular formations can be interpreted to mean that the reticular formation originates from a common ancestor of fishes, mammals, and birds. In other words, the reticular formation has been a very early neurological substrate of the brain, indicating that first manifestations of consciousness may have existed as early.

The so-called "functions" of the reticular formation as listed above must not be interpreted as meaning that the reticular formation in Man is also the centre of processing of e.g. pain (pt. 3) and of consciousness (pt. 4), but rather that the human reticular formation is a gating system for body messages to younger processing centres in the brain (e.g. tissue-damage messages and multiple local wake-state messages on way to the parietal lobe, as elaborated in essay section 6).

## 5. Sleep, continuous brain activity, and conscious dreaming

In an article about the physiology of sleep, the MD's Michael Schupp and Christopher D. Hanning [13] report the following: "Sleep is a state of reversible unconsciousness in which the brain is less responsive to external stimuli. We are functionally blind during sleep with no response to visual stimuli and a decreased threshold of response to auditory stimuli." And, "sleep (or, at least, an activity-inactivity cycle) is present in all species throughout evolution, and sleep deprivation leads to drastic deterioration in cognitive function". Also, "sleep might conserve energy by lowering metabolic rate by 10% compared with quiet wakefulness". Furthermore, "there is no evidence that sleep is important for tissue repair". But, "Sleep has been implicated as an important factor in storage of long-term memory. Facts learned during the day are usually better remembered the next morning".

The last-named, very common, observation can be explained by research findings reported by neurologist Marcus E. Raichle [14]. The explanation is that in the resting mode of the organism, the brain engages in activities over and above those for maintaining the vital functions (known as metabolic autonomic activities), which Raichle calls "default-mode activities". It is argued (by the

[13] British Journal of Anaesthesia, vol. 3, nr. 3, 69-74, 2003.
[14] Marcus E. Raichle, *The brain's dark energy*, Scientific American, Febr. 17, 2010.

 

author of this essay) that these activities should be responsible for the phenomenon of conscious dreaming.

The argument runs as follows: Since Man is "functionally blind during sleep, with no response to visual stimuli" (Schupp and Hanning), the default-mode activity must be entirely focussed on brain-internal sources, i.e. on the nonconscious memory in block 4. And, since the wake-state cognition-focussed activity of the brain is concentrated primarily on the generation of videos-in-the-brain, it is virtually unavoidable that also the 'default-mode activity' generates videos-in-the-brain. The latter, which, for distinction, is here proposed to be called 'default-mode videos-in-the-brain', are expected to be default-mode inventions composed of memory fragments from block 4. These default-mode videos-in-the-brain are bioelectric-language-encoded, and are, hence, nonconscious (as are bioelectric-language-encoded wake-state videos-in-the-brain). Some of the default-mode videos-in-the-brain are rendered conscious, thereby becoming conscious dreams. Some of these dreams are quasi-realistic (for instance, in form of a rational conversation with an acquaintance), while others are irrational illusions.

The question remains as to how the nonconscious-to-conscious conversion of default-mode videos-in-the-brain can occur if the conscious part of the brain is inactive. The answer is that this part of the brain is not necessarily entirely inactive, for more than one reason. One of these reasons derives from the fact that sleep occurs on a number of depth levels, ranging from an almost-sleep state to a coma state, whence a nonconscious-to-conscious conversion may occur at a shallow depth of sleep.

A nonconscious-to-conscious conversion may also be caused in an indirect way, viz. by the involuntary random stimulation by the brain of motor neurons in an extremity, which then causes the affected extremity to send wake-state messages back to the brain. If interpreted by the brain as indicative of the existence of a conscious state, the nonconscious-to-conscious conversion can proceed.

In conclusion, the occurrence of conscious dreams is not a persuasive argument against the multiple local wake-state hypothesis of self-consciousness.

## 6. Hemispatial neglect syndrome

In the foregoing, the occurrence of conscious dreams has been explained as a consequence of the gradual restitution of self-consciousness when the level of sleep moves closer to the wake state, causing a gradual restitution of the wake state also in some or all parts of the organism. In reverse, the wake-state-to-sleep transition is accompanied by a gradual weakening of the multiple local wake-state messaging to the brain. This phenomenon can be experienced also when a limb "goes to sleep" on account of being undernourished due to an artery constriction, or when a limb or another specific part of the organism turns numb when treated with a local anaesthetic.

This phenomenon becomes extreme at a medical condition known as the "hemispatial neglect syndrome" - also abbreviated as Hemineglect syndrome - caused by damage (e.g. by a stroke) to the parietal lobe [15] of the brain. If the damage is, for instance, on the right-hemisphere part of the lobe, and is severe, patients are reported, e.g. by neuropsychologist Jennie Ogden [16], to "ignore or disown their own left limbs". In other words, the patient's brain regards these limbs as foreign to the patient's body, even against visible counterevidence (thus Ogden).

How can the occurrence of the afore-described Hemineglect syndrome be interpreted in terms of the multiple local wake-state hypothesis? This author argues as follows: If the syndrome is, indeed, due to damage to the right-hemisphere part of the parietal lobe, and only to this lobe, then this lobe must be the only terminal recipient of wake-state messages from the affected limbs on the left. And, the syndrome arises if this part of the parietal lobe can no longer read both the incoming wake-state messages and any incoming local tissue-damage messages (i.e. messages giving rise to sensations of pain).

That messages of local tissue damage to limbs on the left are picked-up and processed by the right-hemisphere part of the parietal lobe is an established fact [17], and that local wake-state messages are picked-up and processed identically is posited by this author. This argument is elaborated in essay section 8, where it is argued that both types of messages make use of the same nerve fibres for conveyance to the same processing centre in the brain, i.e. the parietal lobe.

At this stage some explanation is required about the relationship between processing centres named in the literature in connection with sensations of consciousness and pain. The centres mentioned in this essay are the reticular formation, the parietal lobe, and the somatosensory cortex: The parietal lobe

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[15] The outer layer of the brain's most dominant part, the cerebrum, is known as cerebral cortex. The cortex is commonly divided into four left-right-paired areas (i.e. left-hemisphere-and-right-hemisphere-paired), called lobes. One of the four left-right-paired areas is known as the parietal lobe. This lobe is reported to receive and interpret signals of touch, cold, heat, pressure and tissue damage (Steve Parker, *The Concise Human Body Book*, Dorling Kindersley, 2009). Here this lobe is posited to also receive and interpret multiple local wake-state messages.

[16] Jenni Ogden, *The Bizarre Disorder of Hemineglect*, Internet posting, 2012.

[17] E.g. Steve Parker, *The Concise Human Body Book*, Dorling Kindersley, 2009.

belongs to the more recent developments of the brain, which did not exist in early animals, as did the reticular formation. Hence, while in humans the terminal recipient for multiple local wake-state messages and for local tissue-damage messages is the parietal lobe, in early animals this terminal recipient was the reticular formation (as earlier suggested in essay section 4). In the human brain, which possesses both a parietal lobe and a reticular formation, multiple local wake-state messages as well as local tissue-damage messages pass through the latter to reach the former [18].

Regarding the somatosensory cortex, mentioned in essay section 8 as a terminal recipient of multiple local wake-state messages and local tissue-damage messages, this part of the cerebral cortex is also part of the parietal lobe [19], whence the terms somatosensory cortex and parietal lobe are interchangeable in pertinent arguments.

In conclusion, the Hemineglect syndrome strongly supports the posited relationship between the sensation of self-consciousness and multiple local wake-state messaging from body to brain, but also the posited physiological relationship between multiple local wake-state messages and messages of local tissue damage as referred to above, and as further elaborated in essay section 8.

## 7. The nonconscious fundamental state of life

The fact that all of Man's vital functions (temperature regulation, digestion, pulmonary respiration, blood composition, pH adjustment, blood circulation, blood pressure control, cell metabolism, *involuntary* organ functions, etc.) [20] are nonconsciously regulated by the brain, day and night, throughout life, justify the nonconscious state to be regarded as the fundamental state of life.

This can definitely not be said of the conscious state, because this state is associated with the wake state of the organism, and because of the fact that the conscious state cannot make any useful contribution whatsoever to the nonconscious regulation of the vital functions [21].

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[18] As shown by pictorial information in Steve Parker's book: *The Concise Human Body Book,* Dorling Kindersley, 2009.

[19] Werner Kahle, Michael Frotscher, *Taschenatlas Anatomie vol. 3*, 11th ed., Thieme, 2013.

[20] I.e., all functions operating as part of the "autonomic" subsystem of the peripheral nervous system.

[21] As implied by the finding that the vital functions "keep the body going even when all other brain functions have ceased or are suspended" (Brain-science writer Rita Carter: *The Brain in Minutes*, Quercus, 2018).


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The nonconscious fundamental state of life finds expression in the new paradigm underlying this author's vision of self-consciousness, leading to the argument that the conscious state would not have come about without the nonconscious fundamental state of life. In other words, the nonconscious physiological mechanisms for operation of the vital functions (which operate perfectly well without ever turning conscious) serve as standards also for the physiological mechanisms underlying functions which eventually give rise to conscious sensations, such as self-consciousness and pain.

This standard is that the sensors of sensory neurons [22] are strategically placed in those parts of the organism which are to be monitored, that nerve fibres convey messages from these neurons to the brain, and that specific components of the brain read these messages and respond [23].

## 8. The physiology of self-consciousness modelled on that of pain

The following is a key text of this essay, because it describes the probably first vision of consciousness which is successfully derived from a classical physical-science perspective. This vision is aimed at obviating earlier attempts of attributing to consciousness a fundamental physical nature, as mentioned in the Introduction. Basic to this author's vision is a classical Ansatz which explains the origin of consciousness out of the physiology for the generation of self-consciousness. This physiology, in turn, is modelled on the well-studied physiology for the generation of pain.

The reasoning is started with the argument that in evolution the physiology for the generation of pain must have been preceded by the physiology for the generation of self-consciousness, because pain cannot be felt without self-consciousness. It is also argued that once the physiology for the generation of self-consciousness was established, the physiology for the generation of pain followed soon, because of the evolutionary advantage of the latter, and because the two physiologies are posited to be very similar. This similarity will be sketched in the following subsection 8.1.

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[22] There exists a large variety of neurons. In this essay reference is made only to three major types: cranial neurons (nerve cells at the brain end of nerve fibres), sensory neurons (nerve cells at the body end of nerve fibres), and motor neurons (nerve cells at the muscle end of nerve fibres). Cranial neurons are also referred to as interneurons, because they connect one neuron to another.

[23] The response may be via a nerve fibre to a neuron, or by means of hormones, conveyed by the blood stream. The response of a cranial neuron to a message about tissue damage is the sensation of pain.


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The approach follows a pattern in which, first, the hitherto unknown physiology for the generation of self-consciousness is modelled on the known physiology for the generation of pain, to be followed by the hypothesis that, in evolution, the former has preceded the latter. To be finalised in a vision in which the two physiologies are both, mutually compatible and compatible with evolutionary principles.

## 8.1 The physiologies underlying pain and self-consciousness

The reported physiology for the generation of pain can be briefly described as follows [24]: The sensors of sensory neurons, specialising in the detection of tissue damage, are strategically placed throughout the organism wherever tissue damage is to be monitored (except for brain and liver). These sensors, known as nocisensors (from *nocere*: Latin for damage) convey bioelectric messages about local tissue damage via nerve fibres [25] to a part of the brain known as somatosensory cortex, which is part of the parietal lobe. There, any such message is converted into a sensation of pain at the location of the message-issuing nocisensor.

The proposed physiology for the generation of self-consciousness can then be similarly described as follows: The sensors of sensory neurons, specialising in the detection of the local wake state, are strategically placed throughout the organism wherever the wake state is to be monitored. These sensors, here proposed to be called wake-state sensors, convey bioelectric messages about the local wake state, via nerve fibres, to a part of the brain capable of generating a sensation of self-consciousness from the incoming messages. As argued in essay section 6, this part of the brain is the parietal lobe.

To be more specific about the conveyance of wake-state messages and the message-processing part of the brain, the argument is further developed as follows: The Least Effort Principle (explained in essay section 2) disfavours the construction of two separate extensive systems of nerve fibres for sensors serving the same locations, i.e. locations where both nocisensors and wake-state sensors perform their tasks. Therefore, it is posited that the system of nerve fibres conveying the messages of local tissue damage was not established for these messages, but was pre-existent for purposes of conveying the messages of

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[24] E.g. Rita Carter, *The Brain Book*, 2nd ed., Dorling Kindersley, 2014, and S. Silbernagl, A. Despopoulos, A. Graguhn: *Taschenatlas Physiologie*, Thieme, 2018.

[25] To be more specific, one has to know that the nerve fibre at the sensor end consists of a rather long so-called peripheral axon of the actual nocisensory neuron, whose soma (the neuron body) is situated close to the spinal cord. The message from the nocisensor passes via the soma into a second, so-called central axon, thence into the spinal cord, and further towards the somatosensory cortex, where cranial neurons interpret the signal as pain. This pain is sensed as if occurring at the site of damage.


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local wake-states. In other words, the nerve-fibre system found to serve the conveyance of messages of local tissue damage was, in fact, originally established for local wake-state messaging, and was subsequently co-used for the conveyance of messages of local tissue damage. This co-use was made possible by adding nocisensors to the monitoring end of the conveying nerve fibre, where previously only wake-state sensors were attached.

The foregoing self-consciousness-prior-to-pain-sensation argument is supported by a further argument based on the Least Effort Principle. Viz. the argument that tissue damage occurs rather infrequently, because the sensation of pain causes organisms to shy away from damaging encounters. Local wake-state messaging, on the other hand, occurs frequently during the wake state. Therefore, a nerve fibre used only for the infrequent conveyance of local tissue-damage messages would, in the long run, be doomed to decomposition according to the neuroscientists' rule "Use it, or loose it". Not so a nerve fibre used for the frequent conveyance of local wake-state messages. The Least Effort Principle would favour the infrequent co-use of this nerve fibre for another purpose, such as the conveyance of local tissue-damage messages.

The proposed common use of a given nerve fibre for both local wake-state messaging and local tissue-damage messaging is not only supported by findings about the Hemineglect syndrome (essay section 6), but also by findings about local anaesthesia. The mechanism is reported to commonly involve the blockage of nerves "between the peripheral nerve ending and the central nervous system" (Wikipedia). This means that messages from nocisensors, but also from wake-state sensors, can no longer be conveyed to the parietal lobe, causing the anaesthetised location to appear both numb and pain-free.

Last, not least, the afore-going arguments about common conveyance of messages from wake-state sensors and from nocisensors, together with the established finding that the latter are processed in the parietal lobe, make it likely that also messages from the wake-state sensors are processed in the parietal lobe. In other words, this author posits the parietal lobe to be the brain's centre of self-consciousness.

## 8.2 Wake-state sensing via cellular metabolism

A description of the physiology of the generation of self-consciousness is incomplete without an educated guess about the biophysics behind the messaging of wake-state sensors. A wake-state sensor can be unimodal or polymodal, depending on the number of stimuli available. For instance, nocisensors are polymodal, i.e. they react to a variety of stimuli, viz. to


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mechanical, chemical, and thermal stimuli deriving from tissue damage [26]. The number of stimuli behind the messaging of wake-state sensors can be guessed at only after a survey of the available choices.

This author entertains the idea that suitable stimuli can be derived from the cellular metabolism, for the simple reason that one can expect the metabolic rate to substantially increase whenever the sleep state changes into the wake state [27]. The cellular metabolic activities of interest here pertain to the consumption of glucose and oxygen by a cell, but also to the generation of waste products in the cell and the emission of carbon dioxide from the cell.

Glucose and oxygen are delivered to the cell by blood passing through capillaries in close vicinity to the cell, and carbon dioxide is picked up by the same blood passing through the same capillaries. Hence, the wake state and the sleep state can be inferred from the concentration of glucose, oxygen, and carbon dioxide in the blood in these capillaries.

This is, however, not where sensors for these chemicals are located. Rather, suitable locations for sensors are in the tissue space between capillaries and cells. This is a space filled with 'tissue fluid', which serves as a transfer medium for chemicals diffusing from the capillaries into cells, and vice versa.

Of the three chemicals (glucose, oxygen, and carbon dioxide), the one offering the most direct measurement of the cellular metabolic rate is carbon dioxide, because its concentration in the tissue fluid is semi-proportional to the cell's metabolic activity. Not so the measurement of glucose and oxygen in the tissue fluid. For monitoring the consumption of these two, their rates of diffusion through the tissue fluid would have to be measured. Therefore, it is concluded that the stimulus for activation of a wake-state sensor derives from a measurement of the concentration of dissolved carbon dioxide (and of hydrogen-carbonate ions) in the tissue fluid in the vicinity of the sensor (whence the wake-state sensor is to be regarded as unimodal).

The foregoing propositions regarding wake-state sensors and cell-metabolic stimuli are key parts of a theoretical Ansatz for demystifying the phenomenon of consciousness. Both require confirmation by physiological research.

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[26] Wikipedia, and S. Silbernagl, A. Despopoulos, A. Graguhn: *Taschenatlas Physiologie*, Thieme, 2018. All of these stimuli stem from damage-generated electronic or ionic fields which are readily converted by nocisensors into bioelectric signals.

[27] This relationship is evidenced by the observation that a limb can become numb during the wake state when starved of the free circulation of blood by a closing pressure on a major artery. Then, the limb's wake-state sensors inform the brain of the inability of the limb's muscles to operate as they are supposed to do.

## 9. Conclusion

In terms of the definition of the Ansatz used, it can be said that the new paradigm and the arguments developed on basis thereof provide plausible starting and supporting propositions of a new "educated guess" about the nature and function of both self-consciousness and general consciousness. Of particular significance is that both the proposed nature and function thereof are purely classical, and therefore not only accessible to classical reasoning, but also to experimental investigation by biophysicists, physiologists, and neuroscientists.

Regarding the scientific vision about consciousness described in the 2017 *New Scientist* monograph *Your Conscious Mind*, the present essay clearly shows consciousness to be no illusion, but that it is as real as are other functions of a living organism. And, consciousness is definitely not a "distinct kind of matter".

Remark: The new paradigm underlying the new vision of consciousness may be interpreted by some as robot-like. This is neither intended and justified, nor implied in the Ansatz and arguments used in this essay.

## Postscript (with a particular focus on free will)

The above new-paradigm-based physicist's vision of consciousness is a physical-science-compatible alternative to the traditional mainstream vision which was and still is in denial of a classical nature and function of consciousness, for reason that Man is reluctant to admit that his/her reasoning and behaviour derive from purely natural biophysical interaction, and nothing else. This is unlikely to be surprising to neuroscientists and physiologists, but must be surprising to all those who have been waiting for a quantum vision of consciousness so as to safeguard the mainstream belief in a superiority of Man.

The new paradigm is expected to meet resistance from the mainstream cognitive sciences, as well as from jurists and philosophers who have become accustomed to the concept of free-willed motivation, which is misunderstood to be put in question by the new paradigm.

The belief in the existence of a free will has existed as long as Man has been around, i.e. long before so-called unconsciousness has been posited - by the physician Sigmund Freud - to not only exist, but to interfere, every now and then, with this free will. Because this interference was interpreted mainly as aberrant from normal behaviour, it is not surprising that conscious free will was never considered by the mainstream to be an illusion created by a well-hidden, essentially benevolent, nonconsciousness. The fact that this author regards *conscious* free will as an illusion does not imply that free will does not exist altogether.

In fact, the new paradigm opens the way to a new vision of free will. Viz. to a *nonconscious* free will masquerading as a conscious free will. This nonconscious free will is not free in the sense that the brain is free to decide on any conceivable behaviour of its owner, but to decide on a behaviour which is meaningful within the life-long experiences nonconsciously processed and memorised. In other words, nonconsciousness is free to choose from a number of challenge-responding options gathered over a lifetime in nonconscious memory.

The foregoing argument reveals that the nonconscious free will is as "free" as mainstream thinking believes conscious free will to be. In other words, there is no problem with personal responsibility for criminal misbehaviour, as feared by jurists if nonconsciousness should turn out to dominate Man's reasoning and behaviour, as under discussion since the early nineteen eighties, when physiologist Benjamin Libet found that the motor response to a sensory stimulus is not triggered by a conscious decision, but well in advance thereof. Thus, a nonconscious motivation derived by a nonconscious free will is just as juridically relevant as it is today under an illusionary conscious free will [28].

This essay is the sixth in a series [29] by the same author, originally intended to introduce important, critically evaluated, findings of the cognitive sciences into physical science. While progressing from essay to essay, this author has realised that many of the published findings of relevance to the author's themes did not meet the stringent requirements of physical science. Consequently, there was little alternative to approaching the theme with an Ansatz and with arguments typical of physical science. This is particularly evident in this essay.

Evident is also, that some arguments and findings in earlier essays had to be amended or even abandoned. This is true, in particular, for earlier statements about consciousness. For instance, in Essay 3.1 [30] it was misalleged that the function of consciousness is that of creating self-awareness. In view of the above new vision, which posits general consciousness to arise from self-consciousness, this earlier statement is obviously invalid. And, in view of the

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[28] The proposition of a nonconscious free will safeguards not only the juridical responsibility of Man, but also the essence of Immanuel Kant's reasoning about human "dignity".

[29] Essays on Cognitive Physical Science: University of Pretoria Repository UPSpace: Essays 1, 2, 3, 3.1, 4, and 5.

[30] http://hdl.handle.net/2263/58202, November 2016.

physiological mechanism of the generation of self-consciousness, it is also no longer helpful to regard consciousness as an emergent property.

Particularly useful has turned out to be the introduction of the Least Effort Principle in Essay 3 [31]. For particular applications of this principle, the reader is referred to Essay 4 [32].

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[31] http://hdl.handle.net/2263/50310, October 2015.
[32] http://hdl.handle.net/2263/58203, November 2016.