

Tracing the Basis of Self-Consciousness Back to the Essential

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The perspectives on the genuine basis of self and self-consciousness are diverse. Against the background of two exemplary theories, a concept is presented which modifies otherwise contrasting models and merges essential features of consciousness into a modified concept. This includes the brain's comparative representation of sensations originating in the subject's body versus those originating in the environment. It will be substantiated why, in contrast to alternative proposals, specifically the comparison of these two sources of information is considered both, essential and sufficient, for self-consciousness to emerge. The modified model further includes a gradual and overlapping progression of sensory and cognitive abilities in phylogeny and ontogeny, contrasting with categorization of distinct and discrete stages of consciousness, as proposed in the literature.

Keywords

Self-awareness, Self-consciousness, Embodiment, Source monitoring.

SETTING THE ISSUE: IS AN EMBODIED SELF INDISPENSABLE FOR SELF-CONSCIOUSNESS TO EMERGE?

Consciousness, self-consciousness and self-awareness have been defined differently in the literature [1,2]. They are used in this article interchangeably in the sense of being aware of one's existence. They require a subject's personal identity or self of which the subject may become aware or conscious. What does constitute this self and, consequently, self-consciousness?

A few citations may serve as a starting point. Prinz [3] noted "Recent work on self consciousness has focused on awareness of the acting body, and (...) a complete theory of consciousness will be an embodied theory". Newen [4] distinguished between implicit self-awareness and explicit self-consciousness, and noted "We need to presuppose an embodied self as the basis" of all such cases. And further to this point, Kraus and Maier [5] evaluated the feasibility of "conscious machines" and the preconditions of consciousness in general and came to the conclusion: "In all theories that we touched (...) the emergence of consciousness crucially requires embodiment".

In agreement with the above citations as well as previous publications [6,7], embodiment will be a major issue also in the

present contribution. Aru and Bachmann [8] rightly pointed out in their editorial "Still wanted – the mechanisms of consciousness" that a "very basic attribute of consciousness" is its "panmodality", but what is missing is a word about the neuronal interface in the brain's comparative, multisensory representation of the individual's body versus its environment. This comparator function refers to embodiment (which will be addressed later on) and covers all the aspects of panmodality anyway. Might that enable an organism to experience itself as the subject who has all the daily, sensory impressions? Actually, once embodiment has been accepted as an essential prerequisite for self, the consequent question will be how the embodied self transforms into self-consciousness. May there be any mysterious, missing link, or might be an unspectacular answer conceivable? There are many theories trying to explain self-consciousness, but let us compare just two exemplary concepts in order to specify the crucial issues and merge the different views into a modified model.

THREE DISTINCT STAGES OF INCREASING NEURONAL COMPLEXITY: THE CONSCIOUSNESS MODEL BY DAMASIO AND MEYER

The model of consciousness by Damasio and Meyer [9] postulates three levels of increasing neuronal complexity, regarding both, the self and consciousness. The lowest stage, the so called "proto-self", has been defined by Damasio [10] as "a coherent collection of neural patterns which map (...) the state of the physical structure of the organism in its many dimensions". According to Damasio, this is a non-conscious map of the sensory input from the body to

the brain. At this point we are nearly about to touch the concept of embodiment, however without consciousness. Damasio and Meyer then postulate an advanced stage, the "core-self", which corresponds to the "core-consciousness". Accordingly, core-consciousness "provides the organism with a sense of self about one moment, now, and about one place, here" [9]. This may be considered something like a conscious snapshot. The next and final advancement, according to Damasio and Meyer [9], will be the "autobiographical self" as the basis of "extended consciousness". The genetic preconditions for this advancement are created by evolution during phylogeny, and are then realized during ontogeny, with the result of "extended functions" including memory, thinking and, finally, language.

Figure 1 illustrates the concept by Damasio and Meyer [9]. In this model, the subject's body is addressed by the non-conscious "proto-self". Damasio and Meyer noted that, during further progression to the "extended consciousness", the individual's model of self is put in relation to the individual's model of the world. The open question is: What does this mean as to the cerebral function which transforms this relationship into self-consciousness? For example, is it the "sense of agency" [11], i.e. the "feeling that we are the agents" who act in situations when we perform goal-directed actions? Is it any mysterious energy? Or is it, at bottom, simply a comparative, neuronal representation of multisensory input originating from inside versus outside one's own body, resting or acting? This will be discussed later on.

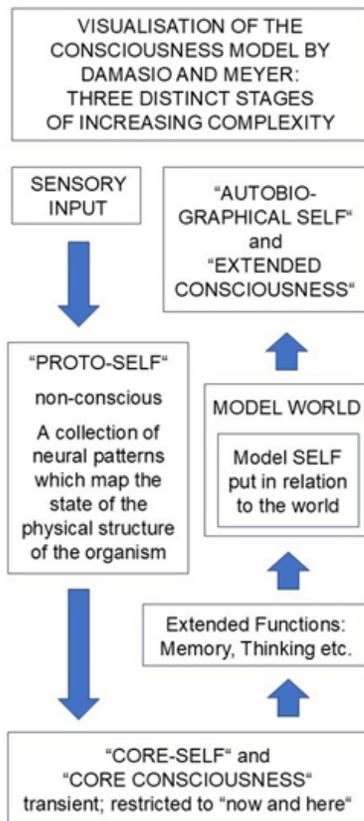


Figure 1: Visualisation of the model by Damasio and Meyer. It shows the three distinct stages of increasing complexity, which characterize

this model. The "proto-self" is said to be a non-conscious collection of neural patterns which map the state of the physical structure of the organism. By evolution and ontogenetic development, this primitive stage of self is followed by the so called "core-self" which corresponds to the "core-consciousness". It represents a limited level of consciousness which "provides the organism with a sense of self about one moment, now, and about one place, here" [9]. Progressive development of higher neuronal functions during phylogeny and ontogeny results in the so called "extended consciousness" which the authors described as "a relatively stable collection of the unique facts that characterize a person, the 'autobiographical self'".

SOURCE MONITORING BETWEEN BRAIN AND ENVIRONMENT:

THE CONSCIOUSNESS MODEL BY KUNZENDORF

The "Source Monitoring Theory" by Kunzendorf [12] tries to answer, from a completely different point of view, the question how subjective experience of one's self is generated. Figure 2 tries to briefly illustrate the principle of Kunzendorf's concept. He says "while physically monitoring either the peripheral or central source of sensations, the brain's monitoring mechanism is subjectively paralleled by the generic knowledge that all monitored sensations should be treated as 'belonging to oneself' and by the resulting illusion of a 'self as subject' having these sensations". Kunzendorf's "source monitoring mechanism" identifies the brain ("central") versus the environment ("peripheral") as the two allegedly relevant sources of sensations, namely sensations based on, for example, "visually imagined" contents versus sensations "externally generated or perceived". And Kunzendorf further notes: "The meta-awareness that one is perceiving sensations or that one is imaging sensations gives rise to the (...) illusionary experience of a 'self as subject'".

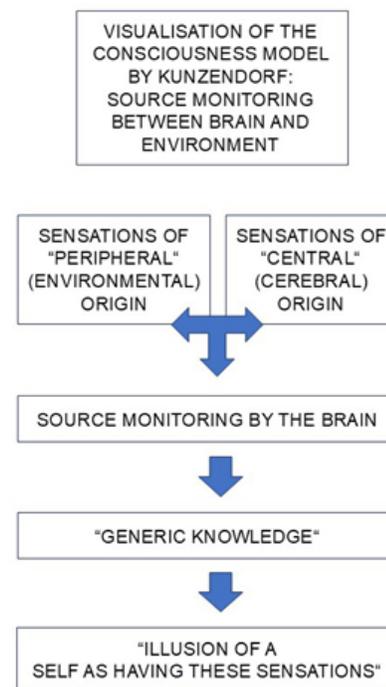


Figure 2: Visualisation of the model by Kunzendorf. Sensations originating

in the environment are indicated versus those originating in the subject's brain. The source monitoring system of the brain will then distinguish between the two sources of information. According to Kunzendorf, this process "is subjectively paralleled by the generic knowledge that all monitored sensations should be treated as 'belonging to oneself' – and by the resulting illusion of a 'self as subject' having those sensations". This "Theory of Source Monitoring" is based on an axiomatic construct termed "generic knowledge".

Thus, Kunzendorf answers the critical question of how the subjective experience of self is brought about by an axiomatic construct termed "generic knowledge" which results in the "illusion" of self. As it is the problem with any axiom, this theoretical construct escapes any empirical proof. Moreover, Kunzendorf introduces a comparator function which is based on the comparison of sensations originating in the brain ("visually imagined") versus those originating in the periphery ("externally generated or perceived"). It is irrelevant in this context, as will be further addressed in the comparative discussion of the models, whether "periphery" means exclusively the environment or whether it does also include the subject's body as opposed to the brain. Although Johnson, et al. [13] rightly noted that "source monitoring is a critical everyday memory function", it is highly significant in the present context to conclusively define the sources required for comparison in order to generate self-consciousness. This will also be discussed in the following section.

SOURCE MONITORING BETWEEN BODY AND ENVIRONMENT COMBINED WITH GRADUAL PROGRESS IN HIGHER COGNITIVE FUNCTIONS INSTEAD OF DISTINCT STAGES: MODIFICATIONS AND MERGER OF THE TWO MODELS

A comparator model previously offered by Kromer [6,7] is illustrated in Fig. 3 and postulates, as the fundamental nature of self-consciousness, a comparative processing and representation of sensory input originating in the subject's body versus sensory input originating in the subject's environment. The basic argument is that self-consciousness requires an individual to whom something can become conscious. To be an individual, the organism must be able to discriminate between its body and its environment. This comparative sensing, processing and cerebral representation is depicted on the ordinate in Figure 3. Although Riva [14] correctly noted that "our experience of the body is not direct", as it is of course the perception of the environment, this does not invalidate the basic assumption of the above concept. Even if "recalibrated" [14] by internal information, the overall process will still be a comparative mapping of the bodily versus the environmental input.

As far as phylogenetic evolution and ontogenetic development allow for a more complex integration and interconnection of neuronal input to the brain, a primitive self-consciousness, characterized by Humhrey [15] as feeling rather than thinking, will further progress to a higher-level self-consciousness. In the end, memory, thinking and language will be implicit functions. This is depicted on the abscissa in Figure 3. As it essentially happens on a continuum, both in phylogeny [16-18] and in ontogeny [19], Damasio's distinction between a non-conscious "proto-self", a low-

order "core-self" and a higher-order "autobiographical self" seems to unnecessarily categorize and complicate a basically more simple issue. Munévar [20] already questioned this aspect of Damasio's concept and noted that "evolutionary considerations demand that even a primitive self (e.g., a proto-self) exhibit features of an 'autobiographical self'." The modified model shown in Figure 3 does not imply any feature similar to the proto-self of Damasio or any other, distinct stages of consciousness but simply refers to the gradual, phylogenetic evolution (or ontogenetic development, resp.) of the nervous system's ability to comparatively represent bodily versus environmental stimuli. Actually, in the modified model, the progression of sensory and comparative abilities on the one hand, and the progressive development of higher cognitive functions on the other hand, happen essentially on a continuum and overlap on a timescale.

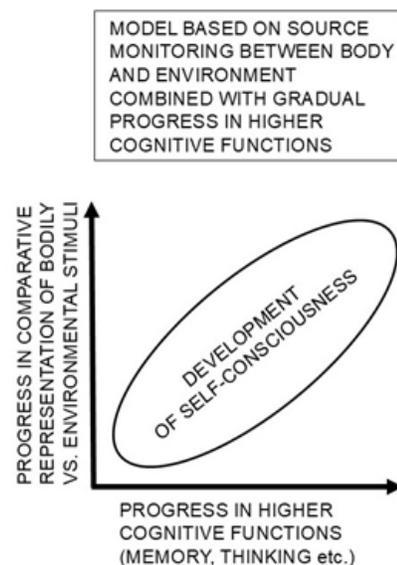


Figure 3: Visualisation of a model that modifies and unifies the features put forward by Damasio (see Figure 1) and Kunzendorf (see Figure 2). The ordinate stands for the progression of the organism's sensorial and processing ability to discriminate between sources of information and comparatively represent them. This relates to both, phylogeny and ontogeny. The source monitoring function differs from that proposed by Kunzendorf (see Figure 2) in that it refers to bodily sensations versus environmental sensations, instead of cerebral versus environmental ones. Thus, the ordinate essentially depicts the genuine basis of the transient experience of self in a daily, current situation. The abscissa stands for further phylogenetic evolution or ontogenetic development of higher cognitive functions such as memory, thinking and language, which contribute to self-consciousness in a broader sense. The crucial difference to Damasio's model is the assumption of a gradual progression of self and self-consciousness instead of distinct and discrete stages. Note: The graph is only meant to symbolize the principle of gradual progression on the two coordinates and their overlap. It is beyond the scope of this article to suggest any specific shape of the resulting curve or its scatter.

Autobiography is not THE fundamental basis of self-consciousness

"Extended consciousness" in Damasio's model relies on the subject's autobiography, which is naturally composed of quite variable contents sampled during lifetime. The latter do not provide

any convincingly reliable substitute for the body as a genuine basis of self-consciousness, although they contribute to it. Actually, self-consciousness even occurs in a patient suffering from a severe identity loss, i.e., in a patient not remembering his autobiography [21,22]. Such a patient would still experience himself as an individual based on perception of the own body in comparison to perception of the environment. The body's paramount importance as the fundamental basis of self-consciousness (embodiment) is further discussed below in connection with Kunzendorf's model. The above example of an identity loss is to some extent reminiscent of Damasio's core consciousness [9], and it exemplifies what provides the individual in the current situation ("now and here") [9] with the vivid feeling of self, basically independent of remembering the own autobiography.

Source monitoring: The very special features of bodily sensations

Kunzendorf's "Theory of Source Monitoring" [12] introduces a comparator function, just as the modified model (Figure 3) does, but in contrast to the latter it relies on a comparison between stimuli of central (cerebral) origin to stimuli of peripheral origin. No matter whether the peripheral stimuli originate in the environment or in the subject's body, their comparison to sensations originating in the brain (imagination) will not constitute any reliable and steady experience of self. Kunzendorf already acknowledged that his source monitoring mechanism may only work "so long as such source monitoring is not diminished by sleep, hypnosis, dissociation, psychosis, or subliminal innervation". But even without such interferences, sensations genuinely originating in the brain (imagination) are unsteady, not sufficiently reliable and therefore a poor basis of self.

By contrast, bodily sensations will be perceived by any individual as own because any part of the body is experienced in the context of the rest of the body. Any change over time or during illness, even mental illness, will take place still embedded in this continuity of the complex scenario of bodily sensations, both current and stored sensations. This enables the organism to distinguish bodily sensations from other sources. Bodily sensations can be considered the most reliable basis of self (embodiment). As it is evident from introspection, perception of the environment is always paralleled by perception of one's own body.

Nonetheless and without contradiction to the above, a cerebral comparison between sensations originating in the body versus those originating in the brain would still fail to generate a sense of self. In this scenario, the crucial reference to the outside world is missing. Based solely on this comparison, the organism would not be able to experience itself as an individual as opposed to the environment.

The same objection applies to Newen [4] when he referred to the concept of an embodied self. He mentioned "non-cognitive low-level homeostatic or bodily processes which produce an existential feeling as a result of being sensitive to one's blood-flow, heart-beat (...) one's visceral processes etc." This reminds of the concept of the non-conscious "proto-self" introduced by Damasio and

Meyer [9]. It should once again be noted that bodily sensations as such, without their comparative, cerebral representation to environmental stimuli, will not result in the experience of one's self as opposed to the outside world.

In an excellent overview on the neurology of consciousness, Tononi et al. [23] seem to be arguing to the contrary (refer to it for further references). They write, "we are conscious of our thoughts, which do not seem to correspond to anything out there", and further, "consciousness here and now seems to depend on what certain parts of the brain are doing, without requiring any obligatory interaction with the environment or the body". However, stored and remembered environmental sensations will still provide the stock for a comparative, neuronal representation to ever-present bodily sensations. Hence, this specific source monitoring process, crucial to self-consciousness, will still work while "we are conscious of our thoughts".

Tononi et al. [23] also address out-of-body experiences possibly suggesting "that it may be possible to lose one's bodily self without losing consciousness". But they further note "the subject feels that he – his experiencing self – is located or centered somewhere else with respect to his body, typically hovering over it at some distance. Moreover, he may be able to contemplate his own body from this new perspective". Obviously, in this state of disturbed consciousness, the patient still experiences his own body as a reference, however from a pathologically distracted perspective. Once more, this does not conflict with the concept of source monitoring between body and environment, crucial to self-awareness.

Thus, a source monitoring mechanism that distinguishes conservative and steady sensations originating in the subject's body from erratic and fluctuating sensations originating in the environment is best suited for generating a sense of self. The comparative representation of bodily versus environmental stimuli will function both in the acting and in the resting state of the individual, and therefore the resulting experience of self does not depend on the "sense of agency" [11].

Is there any mystery behind self-consciousness?

According to the preceding discussion, the comparative, neuronal representation of bodily versus environmental stimuli may be regarded as an essential prerequisite for the constitution of any individual and for self-consciousness to emerge. However, there is still one open question which is related to the "hard part of the problem" of consciousness [24]: Is cerebral "integration" [25] of sensory stimuli, going along with the comparison mentioned above, sufficient for or even equivalent to self-consciousness and subjective experience? I.e., is self-consciousness simply the direct result of comparative, neuronal representation of somato-visceral or vestibular and, for example, visual, acoustic, tactile or olfactory stimuli originating in the organism's body versus those originating in its environment? Or is there any mysterious energy behind? No convincing answer has been presented since Chalmers' publication [24].

The former option offered by the modified model as illustrated in Figure 3 renders the view on consciousness much less complex than generally believed. A concept as simple and uncompounded as possible is always the best option in case no empirical proof of more complex explanations is available. Actually, neuronal networks can process and integrate stimuli, facilitate or weaken impulse transmission thereby performing filter functions, or encode information for memory. Moreover, what is of particular importance in the present context, neuronal networks can pay attention, at least to some extent, simultaneously to information from different sources, for example from inside and outside the own body ("divided attention") [26,27]. Thereby sensory input from the two sources is comparatively represented. But there is not any hint to be found in neurosciences that neuronal networks can accomplish anything principally beyond those functions.

Two metaphors may describe the essential feature of the modified concept more vividly: Without the comparator function mentioned above, reception of stimuli from outside the body would generate excitations in the responsive neurones with the result of 'images' that would remind of those produced by an automatic camera, while nobody is there to look at it [6]. Actually, for a conscious perception, the individual must look at those images, so to speak, through his body's window. Only the body can reliably constitute the individual's entity as an essential prerequisite for conscious perception. This fundamental nature of self-consciousness is to distinguish from the accumulation of episodic and other memorable contents of consciousness which build up the subject's autobiography during lifetime.

Thus, however challenging, comparative neuronal representation of bodily versus environmental stimuli may not only be sufficient to generate, but actually equivalent to, a subject's basic experience of self. The whole issue may be simply one of comparative, neuronal mapping of the perceived multimodal 'images', without any transformation onto another subjective level. We should break through our mental barriers: There is at least no reason discernible to assume any mystery behind.

A brief outlook beyond the specific scope of this article

Comparator functions appear to be widespread functions in the central nervous system [11,28-30]. A comparator function may not only explain the emergence of self-consciousness as outlined in this article, but it may also explain the emotional feature of percepts. Sensations that are either in line or in conflict with the individual's needs, his planned or ongoing actions and their results will be experienced by the individual as either pleasant or unpleasant. As with the generation of self-consciousness, the emotional feature of percepts may also be directly equated with a comparative, neuronal representation, in this case between expectation and outcome. What we here might label as "qualia" (i.e., the way a specific conscious experience feels for the subject) may just be the mix of physiological reactions [31] to the comparative representation of compatible or incompatible sensations. A more detailed discussion is beyond the scope of this article.

Self-awareness in dreaming [32-34] is likewise beyond the scope of this article, but may also briefly be addressed. Irrespective of different modes ("primary" or "reflective") [35], a dreamer's eventual experience of self is based on the memory, imagination or even limited sensation of the own body and sometimes also on personal identity features dominating the dream, versus what is imagined, remembered or even fabricated as the outside world. Thus, any limited self-consciousness during a dream seems to be once more a matter of source monitoring. Source monitoring as a fundamental, cerebral function has been reviewed by Johnson, et al. [13]. For an overview and for literature on lucid dreams, see [34] and Wikipedia.

CONCLUDING REMARKS

There are a number of authors (only a few of them cited in this contribution) who rightly emphasise embodiment as a crucial requirement for consciousness, but they seem to leave the end open by still chasing a phantom. Although it may be perceived as a challenge, the most simple and uncompounded solution might be to equate the basic nature of self-consciousness, in the current daily situation, with the comparative, neuronal representation of sensations originating in the subject's body versus those originating in the environment. However, it should be emphasized that this hypothesis does by no means question the experimental work regarding the neuronal mechanisms underlying this comparative process [11,26,36-42]. This empirical work is of paramount importance.

Neuroimaging paralleled by neurobehavioral assessment [43] may be one option among others to address the neuronal interface between bodily and environmental input to the brain, for example in subjects with versus without cerebral lesions and disturbed consciousness. The comparative, neuronal representation of multisensory input from different sources is no doubt extremely complex and quite difficult to unravel, but this methodological problem does not conflict with reducing the concept of the basic nature of self-consciousness to the essential, as outlined in this contribution.

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