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# An Overview of Knowledge Integration and the Self-Organization of Life

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## Abstract

This article aims to discuss the integration of knowledge through cognitive functions that allow human organisms to generate meaning for their self-organization when interacting with the environment. The challenge for organisms entails the essential requirement of seeking energy for their ongoing equilibrium, using their sensory-perceptive apparatus to construct a way of life that encompasses both the experienced and, continually, the imagined and fantasized worlds. Within this integration of organism and environment, the body assumes a central role, adopting an extension and overall orientation aligned with enactivism-based models of cognition. The thematic model represented here integrates diverse theoretical-empirical results under the same ontological principles.

## Keywords

Cognition, Integration, Self-Organization, Perceptual Systems, Energy, Complex Adaptive System, Enactivism, Production of Meaning, Corporeal

## 1. Introduction

Through this article, we aim to couple elements of the nature of life with broader aspects of the environment, as a challenge for the integration of knowledge (Edelman & Tononi, 2000):

Our knowledge of the real world comes as a result of the physical, psychological, and social interactions of our minds and bodies with that world. (…) Epistemology should be grounded in biology, notably neuroscience and a theory of consciousness, which, of course, includes psychology.

As one of its key assumptions, this combination involves cognitive functions that enable human organisms to interact with the environment to build their self-organization and the optimization of their equilibrium within the world. This combination presents a pathway that includes the necessary conditions for the self-organization of life, encompassing intricate self-adaptive processes that impact its trajectory within the environment. It is within this particular environment that the organism establishes its *Umwelt* by utilizing the niches that become accessible through *affordances*.

The objective of this article is to provide a comprehensive overview of the integration of discrete forms of knowledge, to analyze life as a complex adaptive system. Considering this dual perspective, the self-organization of life is inherently both evolutive and adaptive. This is due to its continuous interaction with the organism's functional structure and the dynamic relationship with the environment—the *affordances*. The environment is always another—until it becomes integrated into the organism—which needs to be unveiled in the circumstances in which one makes sense of things, the available facts. Anything that exists within different niches and makes a substantial contribution to our self-organization project becomes a matter of continuous scrutiny for the organism. It incessantly categorizes and re-categorizes to maintain its equilibrium.

An additional point of emphasis is the inherent complexity of the self-organizing system found in living beings, particularly humans. From this perspective, to be complex is to be "…both orderly and disorderly, regular and irregular, variant and invariant, constant and changing, stable and unstable…" (Edelman & Tononi, 2000), for such is the nature of the world of things, and it is through these correlations that an organism creates meaning to continually regain its equilibrium. These are the characteristics that are closely associated with the forces that converge toward the centripetal process used to attain self-organization, specifically an organism that is perpetually in a state of disequilibrium. Our relentless pursuit of generating meaning is an ongoing quest for the balance of life, constantly menaced by centrifugal forces of imbalance. This evaluation encompasses a wide range of pathways and requires a comprehensive integration of knowledge that traverses various intricate instances of meaning production, all of which remain perpetually open to an organic process in the pursuit of self-organization.

An essential discussion underlying this integration of the organism into the environment pertains to the external elements and facts surrounding the organism during its integration to the environment. This issue, the relationship between organism and environment does not appear to be definitively resolved, as mentioned by Hoffmeyer (1998) in one of the text passages.

"For while it feels rather obvious to say that the organism has a point of view, even though the visual metaphor is misleading, it doesn't feel natural to ascribe a point of view to the environment. The environment is there for the organism, not vice versa. Is this asymmetry justified?"

Hence, the environment is an entity that is not the same as the organism, but it is for the organism—it is available to the organism—because it is from the environment that all the elements necessary for the self-organization of life stem. We are aware, in principle, of the constituents integrated within our organism; by default, that which is not integrated into our organism, we do not know. Hoffmeyer states that: "The environment is there for the organism, not vice versa.", but he himself casts doubts on a rationale for such a statement. We know that this integration is embodied because it is the human sensors that provide it by engaging with elements that are available in specific niches of the environment. It is the organism, therefore, that experiences by seeing, hearing, touching, smelling aromas and tasting flavors. This appropriation arises from the collective interactions of these sensory systems, which would comprise the naturalization of what belongs to the realm of the niche into what belongs to the realm of the *Umwelt* that each organism constructs.

The upcoming discussion is set against the backdrop of the presentation above, where we summarized crucial aspects of the integration between organisms and the environment. In this introduction, we endeavored to adopt an approach that appeared better aligned with the project we have been undertaking on the self-organization of life, within the context of a complex adaptive system, as we will elaborate on later. While considering the importance of many other specific categories that emerge in the context of a current theoretical approach that breaks away from the partitioning of traditional disciplines in the academic world, we are committed to a more integrated epistemological vision of what we are in the world of life.

Our presentation will be centered on the diagram below, entitled "**Figure 1**: Self-organization of life: the integration of cognitive functions". Its purpose is to shed light on a set of categories that we deem significant in justifying our perception of a continuous and cumulative projection—potentially from the analogical viewpoint emphasized by Biosemiotics—for the self-organization of life. Our conversation will be built upon the foundational core that we believe is necessary to approach life. It is worth emphasizing that, although the set of activities is grouped into distinct regions for methodological reasons, they are integrated into a totality that makes us who we are. In brief, we manifest as this state of wholeness and operate in an interconnected and global manner. Let us now move on to each of these circles and gradually integrate them with the others.

## 2. Self-Organization of Life in the Environment

Life is often depicted in numerous theories through extensive and varied models. These models incorporate organic properties that are connected to various parts of the body, such as the heart and brain, as well as fundamental principles of organization and the chemical basis of cell growth and metabolism, for example. None of this is strange or unfamiliar to the vital activity of the human organism. Specifically, they are all models that can be applied to potential life qualifications. The initiation of our project does not involve the examination of one of these models, which we deem to be specific to biology, but rather concentrates

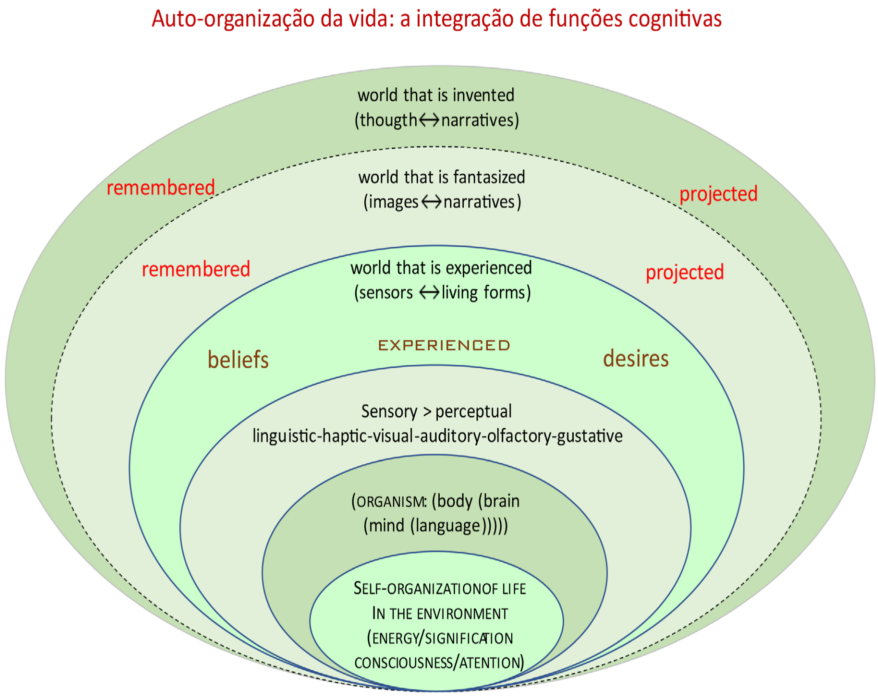


**Figure 1.** Self-organization of life: the integration of cognitive functions.

on other categories that have been formulated within the realm of human cognition. These categories, which hold multiple interfaces and are also applicable to life, are considered equally valid. Within this section, we shall emphasize the significance of the perceptive system, specifically its sensory components, as they interact with the surrounding environment.

With the self-organization of life as the primary focal point of our analysis, we have disregarded none of these biological models; instead, we have placed special emphasis on others of equal importance. When examining the relationship between the organism and its environment, our primary focus is on the search for energy, an indispensable element for any living being. The restoration of stability and equilibrium in an organism persistently experiencing disequilibrium requires the utilization of sensory-perceptive organic resources for the creation of meaning. The process of self-organization hinges upon the organism's action upon the environment, as it constructs meaningful interpretations that align with its self-organization.

In the course of this discussion, it will be demonstrated that the generation of meaning involves a series of structured, deliberate actions in response to an environment that presents itself as disorganized and random. The environment's range of selective possibilities is quite extensive. Our deliberate actions upon the world involve extracting order from the emergent aspects of our experiences with a world that is in a state of disarray. Our experience of the environment is shaped by intentional and rational strategies that optimize our search for energy, enabling our presence and existence in the world.

The energy we strive for in self-organization is scattered and fragmented throughout the environment. Thus, our organic perceptive apparatus must selectively interact with it, leading to the utilization of our entire body as we holistically and comprehensively experience the world of things. In many social contexts, our corporeal actions prompt the utilization of the brain, mind, and language, resulting in the complete functioning of these faculties during our interactions with others and within the world. The experiential activity we are referring to is not solely derived from one corporeal factor. Conversely, it is the outcome of their interplay: in interactions, our organism shares a corporeal experience that emerges when we group them without acknowledging moments of individuality for any of them (unless in extraordinary cases).

As a result, no natural manner of looking at objects can disregard the involvement of head movements, eye movements, and even hand movements. This implies the direct participation of the prefrontal motor cortex (Gallese & Lakoff, 2005) and diverse regions of the visual cortex, alongside other brain areas involved in this experience. When we see an object[1], we can employ language to mentally manipulate it, for example, by pulling, pushing, or grasping it to facilitate additional actions. When observing an object, one cannot ignore a mental (and intentional) orientation to single it out within the visual scene to bring out some of its details or attribute a certain functionality to it. No action we undertake or project, whether physical, mental, intellectual, fictional, or real, is exempt from the influence of these factors. Gallese and Lakoff (2005) endorse these formulations, providing support from a cortical perspective, stating:

"When one imagines seeing something, some of the same part of the brain is used as when one actually sees. When we imagine moving, some of the same part of the brain is used as when we actually move. Note that these facts undermine the traditional rationale given above. We can imagine grasping an object without actually grasping it. From this, it does not follow that actual grasping and imaginary grasping do not use a common neural substrate. One can reason about grasping without grasping, yet one may still use the same neural substrate in the sensory-motor system."

A true displacement from A to B, which primarily relies on haptic and visual sensory activity, encompasses various bodily aspects such as the motor cortex, and visual cortex, as well as intentional mental factors—notably the desire to reach point B. Regardless of the perspective of the agent, whether she or he is physically moving from home to the workplace perceiving someone else's movement, or objects moving in a scene, or even imagining their movement—the cortical activity will remain the same for these situations, according to the authors. The authors' research conclusion substantiates actions involving the verb "grasp", but we can extend this validation to numerous contrasting scenarios, including x performing y, x witnessing someone performing y, x imagining performing y, etc. Hence, the fundamental principle of integration is, primarily,

[1]"To see an object" is a simplified way of referring to an act of perception. We cannot only see the *car*, the *tree,* and the *person*. We see each of these shapes in an environment, where there are other objects and other contours that surround them.

of a cortical nature, operating either through the confluence of brain processes or the mirroring of actions between different subjects.

To exemplify the potential for integration in brain activity, we will present an example put forth by Edelman and Tononi (Edelman & Tononi, 2000). This example illustrates the cortical simulation of a process that entails integrating cortical activities of various patterns in the perception of three moving images. Subsequently, we will present the diagram supplied by the authors, along with a few additional explanatory remarks, to enhance comprehension.

Figure 2 illustrates the processes implicated in eye movements during the perception of the *visual image* displayed on the right, specifically in the input/output recursive condition. The visual image consists of three distinct shapes: a rectangle with wide shaded edges, a shaded cross, and a non-shaded cross. These shapes have the potential to move or suggest an eye movement, as indicated by the frame surrounding them. Shape, color, size, placement, and movement are depicted in this image, which serves as a stimulus (and as a result) for visual processing throughout the visual cortex—the lower curvilinear arrow referring to the rectangles in the first and second columns of the figure.

The first column encompasses the V1 and V2 regions of the visual cortex. Within this column, individual rectangles denote specific types of processing performed by specialized neuronal networks, namely shape (OR), color (CL), and movement (MO). V1 and V2 serve as the primary processing centers responsible for object orientation in the visual field. Additionally, they feature specialized neurons for each visual perception attribute, denoted by the circular arrow inside each rectangle.

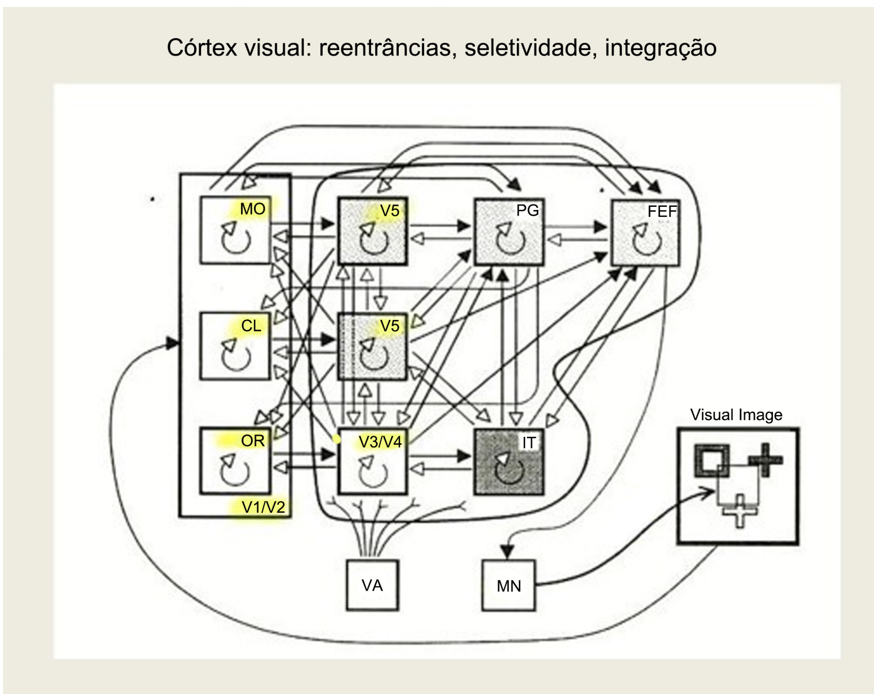


Figure 2. Visual cortex: reentrants, selectivity, integration.

Following this, the primary processing establishes connections with more specific groups of neurons in the visual cortex, leading to the generation of refined perceptions. Hence, it is possible to have 1) OR referring, in the second column, to V3/V4, cortical regions engaged in the processing of shapes delineated by chromatic protuberances; 2) CL refers to V4 for processing chromatic hues; 3) MO sends impulses to V5, which operates specialized shapes in the direction and orientation of object movement.

Furthermore, the schema depicts diverse mechanisms for integrating visual perception with neuronal groups in other brain regions: 1) IT, or inferotemporal cortex, crucial in the visual perception of object details such as straight edges, rounded corners, and interrupted lines, as well as movement details including circular, left to right, lateral, and vertical movements; 2) MN—motoneuronal cortex, a significant component in the characterization of eye movements; 3) VA—entails assigning value to the perceived objects; 4) PG—responsible for details of the object's location in the visual field; 5) FEF—premotor frontal cortex, which governs the orientation and attentional aspect of eye movements within the frontal field of vision.

The three aspects highlighted in the processing activity of the visual cortex demonstrate the absence of isolated processing in this simulation—and in the experience, as shown by Lakoff e Gallese in the article mentioned above, instead indicating a fundamental interdependence on: 1) INTEGRATION, which shows the linkage between all the areas of the visual cortex, as well as additional areas of the frontal motor cortex, the inferotemporal cortex; 2) SELECTIVITY, which implies the procedural preponderance of a particular area, which is more specific than others; 3) REENTRANCE, which characterizes the neuronal processing as drawn up by Edelman & Tononi (1994), according to a dimension we emphasize below:

"Edelman & Mountcastle (1978) proposed that reciprocal pathways form the substrate of cortical integration by allowing the dynamic, bidirectional exchange of neural signals between areas in a process called *reentry*. Reentry has several important characteristics: It occurs between neuronal populations either within the same cortical map or between separate maps. It involves ongoing and parallel exchange of signals between the reentrantly linked cell populations."

The concept of "reentrance" is not confined to a specific location, but rather permeates the dynamic processes of the brain. Due to its frequent occurrence in the authors' texts, this concept is considered fundamental, yet it remains complex due to its various correlations within a specific brain region, as demonstrated in the aforementioned figure, or even in remote areas. Nevertheless, there appears to be a consensus that their concept suggests a neural organization of the brain, relying on groups of neurons that perform coordinated and synchronized triggers as a prerequisite for consciousness.

## 3. Integrated Perceptual Experience

In this section, we will highlight an approach to the dimensions of human cognition, specifically centered around three stages outlined in the flowchart: the world of experience, the world of fantasy, and the world of imagination. These stages come together in the lived world, i.e. what we fantasize, what we live as we imagine, and what we also live, according to Gallese & Lakoff's (2005) simulation perspectives. In summary, we are an amalgam of these stages that lead to the self-organization of a way of life that we cultivate based on a set of beliefs—which activate our continuously remembered present—and desires—which prompt us to imagine possible worlds—beyond the present moment. Our existence is shaped and brought into reality by this assemblage of factors, which we will attempt to define in the subsequent discussion.

Human cognition, in a broad sense, must be regarded as an innate and indispensable phenomenon for the organism. Its continuity is reliant on perpetual activity, as the production of meaning serves as a vital mechanism for learning and survival. Notwithstanding this characteristic of process regularity, variations exist in the organism's conceptualization's interaction with the environment. It may be inappropriate, even when considering four approaches to cognition, to formulate theories of cognition or develop a methodology based on any of these approaches. It might be more suitable to view it as a natural philosophy that applies to organisms (particularly human beings) and is centered on experiential realism. Although there are distinctions, we will refrain from delving into the theoretical aspects of the 4-E cognition approaches in our discussion. However, it is worth noting that our conversation may touch upon enaction/enactivism without a thorough exploration of the theoretical aspects put forth by Noë or Hutto, for example. Now, let us draw attention to a brief passage from Noë's (2004) work.

"The main idea of this book is that perceiving is a way of acting. Perception is not something that happens to us or in us. It is something we do. (…) The world makes itself available to the perceiver through physical movement and interaction. In this book I argue that all perception is touch-like in this way: Perceptual experience acquires content thanks to our possession of bodily skills. What we perceive is determined by what we do (or what we know how to do); it is determined by what we are ready to do. In ways I try to make precise, we enact our perceptual experience; we act it out."

According to the enaction perspective, perception is fundamentally the organism's action on the environment. In addition to Noë's general perspective on perception as action, it is important to underscore the distinct forms of action associated with each sensory pattern. To qualify as haptic, a system must incorporate a wide range of qualified corporeal actions to handle actions involving, for example, the hand, considering elements such as muscular contraction, and orientation relative to the body and objects.

Additionally, it is important to acknowledge in the author's formulation that our actions are constrained by our sensory capabilities. Thus, it becomes necessary to underscore the elements that Noë deems fundamental for the perceiver (or experiencer), specifically, the capability to discern specific stimuli within the perceptual field. While it is true that certain stimuli can exhibit multimodal properties, for instance, a cake's visual qualities encompassing its shape, color, and texture, as well as the taste and smell sensations that evoke experiential memories. It is plausible that the occurrence of multimodality is not simultaneous, but rather gradual, taking into consideration the sensations involved and the experiencer's memory.

Hutto (2011) and other authors, in the meantime, explore enaction in the context of enactivism, emphasizing fundamental differences.

"According to the originally formulation, enactivism is committed to the idea that mentality is something that emerges from the autopoietic, self-organizing, and self-creating, activities of organisms. The activities in question are themselves thought of as essentially embedded and embodied interactions between organisms and their environments, interactions that occur and are themselves shaped in new ways over time."

The author's initial comment makes it clear that enaction is not merely a generic depiction of the organism's interactions with the environment. Instead, it surpasses this level and emerges as crucial for the self-organization of life. To put it differently, an organism's structure is determined by its interaction with the environment and the experiences it encounters within it. Moreover, the author emphasizes that enactivism is defined by the primacy given to an organism's experiences rather than sensory activities. Experiencing encompasses more than the sensory encounter of an organism with its environment. What does this factor imply in the context of overcoming primary sensory activities?

Hutto (2011) himself draws attention to the comment made by Noë (2004):

"To perceive is not merely to have sensory stimulation. It is to have sensory stimulation that one understands … Perceptual experience presents the world as being this way or that; to have experience, therefore, one must be able to appreciate *how* the experience presents things as being."

Sensory stimulation serves as a fundamental datum of perception, yet the act of experiencing confers upon objects in the world a level of appreciation that surpasses the mere sensory activity of the organism. Consequently, it is not solely a question of primary experience, but rather its evaluative significance that surpasses the sensory aspect. Hutto (2011) mentions, for example, that an organism's experience of a *tomato* exceeds the sensory domain of the fruit's shape and color. Our experience with such fruit may encompass various aspects beyond the sensory primitives, such as flavors, varieties, consumption patterns, and more. Ultimately, the influence of sensory activity only constitutes a fraction of what is appropriately structured by brain activity following our perceptual activity.

The act of experiencing the world presents a substantial challenge for all organisms, as well as for the numerous theories that have endeavored to explain it. This challenge demands a heightened state of alertness for our sensory extensions. The only way self-organization can be guaranteed is through this activation of sensory-perceptual processes. The unquestioned principle that experiencing the world is fundamental to cognition requires an exploration of how this process can be rationally conceptualized. As previously indicated, drawing from Hoffmeyer's perspective, the environment plays a role in shaping the organism, yet the reciprocal relationship does not hold: our perceptual systems must actively pursue what is beneficial for the organism, while also steering clear of potential hazards. As per Noë's (2004) expression: "*Perception is not something that happens to us, or in us. It is something we do.*" and cognition results in that which it accomplishes for the sake of its self-organization.

The initial manner of actively perceiving the environment can be understood, in part, as being influenced by Gibson's concept of direct perception, a theoretical approach that, given its inherent differences, we can align with the original purposes of enaction. Gibson (1972) emphasizes the concept of direct perception as follows:

"What is "direct" visual perception? I argue that the seeing of an environment by an observer existing in that environment is direct in that it is not mediated by visual sensations or sense data. The phenomenal visual world of surfaces, objects, and the ground under one's feet is quite different from the phenomenal visual field of color-patches. I assert that the latter experience, the array of visual sensations, is not entailed in the former. Direct perception is not based on the having of sensations. The suggestion will be that it is based on the pickup of information."

There exists a distinct operational and theoretical disparity between Gibson's concept of visual perception and radical enactivism, primarily due to the latter's lack of emphasis on the visual system. Nonetheless, there is likely a certain level of proximity to enactment. In the first case, both approaches eliminate any form of intermediation between the organism and the environment: Gibson rejects the involvement of sensory input and maintains that visual experience is immediate; radical enactivism asserts the non-involvement of representation and conceptualism as intermediaries, as experiencing is considered a natural and spontaneous learning process of the organism, shaped solely by its own experiences. While the proposal of radical enactivism is of greater relevance to our discussion, it is unnecessary to delve into the intricate conceptual foundations of rejecting conceptualism and representation[2].

About the three stages depicted in the diagram, it is evident that the organism, in addition to its direct and organic interaction with the environment for its vital

[2]There are ongoing disagreements regarding radical enactivism's rejection of representational and conceptual intermediaries for our experiences. Comprehending this stance may require a more sophisticated understanding of the boundaries we should establish for our experiences in the world. Indeed, our understanding of *red* does not originate from a conceptualization of the color red, despite its potential accuracy—the perception of chromatic waves within the approximate range of 580 to 700 nanometers. The same applies to our perception of the *tartness* of a lemon, or the *harmonious sound* of a flute, among other similar experiences, which are not contingent on our conceptual knowledge of these phenomena. However, the understanding of a perfect number can solely be attained through the use of abstraction.

sustenance appropriates a whole symbolic dimension when it uses the remembered present and the projected desire for the generation of possible worlds that possess the same cortical realism as the lived world, as Gallese & Lakoff (2005) put it. Apart from the empirical world experienced, organisms also partake in the sharing of objects that are both invented and imagined, but which, nevertheless, form an essential part of their way of existing in the world.

Aside from particular approaches, it is evident that no theoretical movement or human functioning can be devoid of the ramifications of the brain, a point we have emphasized since the outset of this proposition. While the brain serves as the central processor for our responses to the surrounding environment, acknowledging this fundamental fact does not automatically address fundamental inquiries regarding the cognitive functions of the organism itself. Neuronal activity is indispensable, but it does not provide a complete explanation for our behavior in the environment or our existence within it. Consider this: is there any human activity, irrespective of its simplicity or sophistication that does not rely on cortical activity? We believe that the theoretical-methodological framework proposed in this study enables future specifications and developments within the scope of the physical, psychological, and social interactions of our minds and bodies in the "world of life" (*Umwelt*).

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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