Brief Report

The 'hidden' structure of uncertainties unfolding through poststructural dynamics of the entropic brain

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Abstract

A new approach attempts to express the poststructural dynamics of the entropic brain in terms of the 'hidden' structure of uncertainties. By incorporating poststructural dynamics into our understanding of the physical, we can more clearly grasp how consciousness operates within a functional system approach that appropriately considers changeable boundary conditions through functional interactions. The causality is sought in boundary conditions when uncertainty reduction becomes an act of understanding as a course of action that navigates the multiscale landscape of potentialities. Motion through the multiscale landscape continuously changes uncertainties into intentionalities via 'multiscale redundancy.' In the multiscale version of the entropic brain, the 'hidden' structure of uncertainties unfolding through the poststructural dynamics occurring at different locations, levels, and times that instantly actualize through intermittent interactions as precognitive experienceabilities and combine into a global resonance before returning to spontaneous potentiality. The entropic brain is the 'hidden' structure of uncertainties unfolding through poststructural dynamics in the transition from potentialities to intentionalities, giving form to action via quantum potential energy and then motion via quantum kinetic energy through new information pathways. These self-referential pathways enable one to predict the minimal uncertainty as the 'quantum of information' functionality. It also suggests that reducing uncertainty is an act of understanding that could, in principle, mimic the conscious experience in artificial intelligence by transcending neural computability and, therefore, highlighting the importance of self-referentiality as the mechanism of 'affective drive' in broadcasting multiscale redundancy in the landscape of action.

***Keywords**:* Entropic brain, 'affective drive', multiscale redundancy, functional interactions, intentionality, poststructural dynamics, minimum uncertainty, negentropic gain, self-referentiality.

1. Introduction

Deep learning (LeCun et al., 2015) describes the brain's functioning as an optimization process where the brain tries to make the best possible prediction by minimizing uncertainty (Lillicrap et al., 2020). However, such an approach lacks the intentionality characteristic of conscious decision-making. Therefore, reducing uncertainty does not entail eliminating uncertainty as consciousness is not a learnable problem (Parida et al., 2024). Similarly, neural network models contributed to the development of DeepMind. They focused on self-recurrent neural networks that process input. Output can reference its internal states or parameters during operation at a single layer, yet more than this is required for conscious artificial intelligence (AI). Therefore, conscious AI is a difficult engineering problem (Sanz & Aguado, 2020; De Quincey, 2023). Intelligent computing needs to be conscious (Wu et al., 2024), making it possible for machines to have artificial experiences, which is central to the development of conscious AI.

Another area of concern is the recent support for the electromagnetic theory of consciousness. In a recent paper by MacIver (2022) he refers to inward EM field interactions associated with ephaptic coupling as the brain's (quantum) energy processing mechanism. He suggests that ephaptic coupling between local electric fields (associated with ionic charge) connects the brain's internal energy and cognition, including memory. He also supports that the brain's electromagnetic field acts upon neurons as a feedback loop because ephaptic coupling promotes synchronous firing, even though consciousness is spontaneous. However, if some philosophers are right that it depends on intrinsic intentionality (Searle, 2000; Fitch, 2008) then ephaptic interaction and bioelectricity have no intentionality, and their reference in any exclusive electromagnetic theory of consciousness must be inconclusive and taken with a grain of salt.

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The "*Hard Problem of Consciousness*" (Chalmers, 1995) describes phenomenological existentialism of experience as a philosophical purview. Explaining structural and functional aspects is an easy problem for consciousness. Consciousness is hard because it is not clear why the performance of these functions accompanies experience (Chalmers,1995). Phenomenal consciousness is the subjective experience accompanying thoughts and feelings and is only real from the perspective of the individual experiencing it. Experience, as used here, implies phenomenal consciousness. The defining characteristic of phenomenal consciousness is 'feelings,' according to Damasio & Damasio (2023). If phenomenal consciousness is a felt mental state of matter, then it is necessary to define what a mental state is and what a mind is. Another way is to point out that phenomenality does not exist because neither mental activity nor the mind exists. The illusionists view is that phenomenal consciousness is merely an activity of neurons (Graziano, 2024; Dennett, 2016) suggests that the essence of phenomenality consists of "judgments" about how things appear to the experiencer. Chalmer's hard problem is a phenomenological pretext as a claim on consciousness. It does not go deep into its protracted mechanisms.

Any model of reality specifically designed to focus on the synchronous activity in the brain, for example, ionic current flow in dendrites (Aru et al. 2023) cannot solve the hard problem; only a broader model of reality that includes uncertainty in energy as a fundamental aspect of physical reality opens a new perspective on the 'hidden' structure of uncertainties. As stated by Loorits (2014), "*it is the non-structured nature of qualia that makes it extremely difficult to explain*" (Forti, 2024). Qualia, which is also known as phenomenal consciousness, is not the structure but *of* the structure, i.e., poststructural, which is a new approach that attempts to understand the poststructural dynamics as the multiscale dynamic of the brain instead of the multiscale dynamics in the brain. In poststructural approaches, ascribing 'meaning' to an object does not pertain to its content but to what is not within the larger whole of the diachronic organization. For example, not only does protein folding give structure to perform the function, but the self-referentiality of protein folding is outside the structure-function relationship.

Consciousness is underived intentionality (Bourget,2010), a precognitive process directed at something to comprehend uncertainty, which is considered fundamentally psychodynamic. The difference between the poststructuralist and psychodynamic approaches is that the latter rejects the idea of free will. In classical psychodynamics, consciousness emerges from unconscious nature, shaped by biological drives and early experiences, but in the former, free will is an indispensable aspect of spontaneity. Moreover, free will is the capacity of any action to become a motion of choice, and actions have intentionality in the Searlean view (Searle, 1980,1991). Intentionalities are not mere causal processes like intentional states within the brain but intrinsic facets of consciousness (Searle, 1991).

Furthermore, the action does not imply that it carries context, as potentialities are noncontextual. Consciousness is noncontextual and allows the organism to assign 'meaning' through the reduction of uncertainty (Poznanski et al., 2023). Uncertainty reduction allows the organism to feel 'meaning' through motion. In other words, the feeling of 'meaning' is not exclusively a phenomenal experience but an experience that suggests some uncertainty reduction. Importantly it is not a total elimination of uncertainty. Emphasis is that in phenomenality, feeling is the experience. In contrast, understanding feeling is an act of understanding (Poznanski et al., 2023), and the latter can serve as an 'artificial' experience in conscious AI.

2. Negentropic gain as a precursor to motion in the landscape of action

In 1962, Warren McCulloch discussed concepts related to the potential for machines to feel. He used the analogy of anastomosing streams as interconnected information streams, illustrating how input from various sources can combine and interact so that the system is self-referential. It is all about how the entropic brain relates to the intrinsic self-referential informational pathway, so information is defined through a new direction of 'quantum biological information' (cf., Asano et al., 2015). This requires more than just a basic unit of quantum information; it requires the functionality of 'information quanta' as the minimum uncertainty (Parida et al., 2024). Qubits store data in a superposition of two quantum states, but in brains, such states are not observed, and researchers are testing this hypothesis (Nevan et al., 2024).

According to neuroscience, decoding information in the brain depends on neural representations that contain content and meaning (Mathis et al., 2024). However, the encoded intrinsic information focuses on

energy transduction[1] at the 'finer' scale (Li et al., 2019). Consequently, the free energy principle that minimizes uncertainty in theories of consciousness (Solms & Friston, 2018; Solms, 2019) is inapplicable. It relies on variational free energy, optimizing both the thermodynamic free energy and the entropy, yet uncertainty is fundamentally deeper, not in terms of thermodynamic free entropy, but rather as a 'hidden' thermodynamic energy. The de Broglie's 'hidden' thermodynamics (De Broglie, 1970, 1987) plays an unprecedented role in transferring information dependent on the de Broglie wavelength. It is poststructural dynamics in the sense it remains 'hidden' from the operational explanation of covalent chemistry. In terms of de Broglie's thermodynamic framework, spontaneous potentiality is the 'hidden' thermodynamics, free energy is defined as

$$\text{Free energy} = \text{internal energy } (\tfrac{Q_p + Q_k}{2}) - \text{quantum entropy } (S_Q) \times \text{temperature (T)}$$

When free energy is positive, the process will proceed spontaneously in the reverse direction to amplify potentiality through internal energy due to negative quantum kinetic energy Q_k due to negentropic gain (cf., hydrophobic effect). Also, long-range order in the 'action' function S arises spontaneously in the reverse direction through potentiality where temperature is the mean energy of motion. This can be extrapolated to mean consciousness is spontaneously emerging from its potentiality. This is a precursor to motion and mechanism of action due to the negentropically-derived quantum potential Q_p.

Recent work points to consciousness as a multiscalar phenomenon (Aru et al., 2023; Storm et al., 2024). A multiscale brain carries patterns of redundancies across self-referential anastomotic pathways. Since energy transduction occurs across scales, creating multiscale redundancy, there is a direct connection between self-referential pathways and multiscale redundancy. Self-referential systems introduce unique challenges that can disrupt the decoupling of multiscale redundancy. In such systems, the interactions across scales are deeply intertwined, so effective models that summarize microscopic details into macroscopic laws are impossible.

[1]Energy transduction is preferred over energy transformation because the multiscale brain includes metabolic energy from ATP, which belongs to internal energy.

Decoding information decoded from multiscale redundancy in self-referential anastomotic pathways at each scale in a self-referential system entails the process of transition from potentialities to intentionalities. Information encoding occurs when the negentropic gain facilitates information-based action to give form (suggesting movement in the landscape of action). Therefore, information decoding is through action, and information encoding is through motion. How does the decoding of information take place? When functions describe actions at the molecular scale, they can be understood as decoded information as part of multiscale brain functioning.

This suggests that functions are descriptions of actions that can be experiential through decoded information and that *experiences* are part of brain functioning. Therefore, a quale as a 'quantum of information' functionality becomes the smallest unit as a measure of uncertainty (Parida et al., 2024). If the system is not self-referential, minimum uncertainty cannot be decoded from multiscale redundancy, and '*experience*' is not realized. Thus, 'zooming' out and averaging into a condensed form of information would result in a loss of information-based action.

The 'act of understanding' can be conceived as a course of action that navigates the landscape of potentialities. Movement through the landscape continuously changes uncertainties into intentionalities via 'multiscale redundancy'. The 'hidden' structure of uncertainties unfolding through poststructural dynamics occurring at different locations, levels, and different times that interact and combine into a 'global resonance' attributed to self-referentiality.

The low precision in the brain's ability to predict the minimum uncertainty in the 'hidden' structure of uncertainties relies on *constraint closure,* a process across scale that defines each evolving holon as a source (microscale) reservoir of potentialities describing the action of one scale onto another across boundary conditions and unidirectionally to a 'sink' (macroscale). Self-referentiality introduces the novel concept of re-organization of information patterns, which provides a way to reduce multiscale redundancies, including the same amount of information, defined as 'repetitions' through a selection of functional interactions. The selection of functional interactions is through self-referentiality in the multiscale space (see **Fig. 1**). This can be viewed as a quantum-level description of the attentional processes in the theatre of consciousness, as proposed

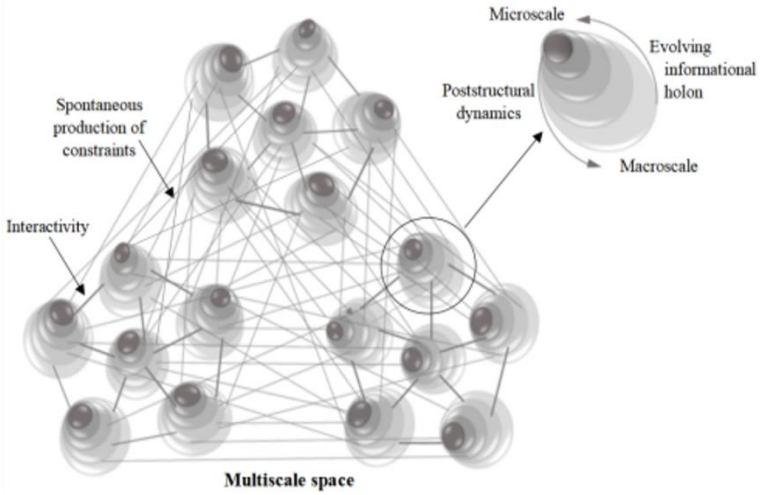

Figure 1. *Schematic illustration shows the multiscale space of evolving informational holons that underlie the self-referentiality of poststructural dynamics. The interactivity between evolving informational holons is realization relations (not causation). The functional systems patterns comprise many functional interactions, but interaction is insufficient for consciousness. When the functional interactions form a holarchical modularity by restructuring multiscale redundancies, the spontaneous ordering can give rise to action and path selection for subtly weak unity of consciousness. Each evolving informational holon has as a "source" (microscale) reservoir of potentialities describing the action of one scale onto another, across boundary conditions and unidirectionally (non-symmetrically) to a "sink" (macroscale) representing the constraint closure (Montevil & Mateo, 2015). Adapted from Poznanski (2024a).*

in Newman & Baars (1993). In symplectic quantum mechanics, phase space is a nonlocal holon in which self-assertive conditions reflect the modular nature of the self-referential system. In a multiscale version of the entropic brain, it is a holarchy modulated through interactivity (see **Fig.1**).

The brain is often considered an organ designed to integrate and transmit or transfer information, a belief popularized by those who see the brain as a computer and information processor (Keller et al., 2024). Any notion of integrated information is prime to failure since "zooming out" or looking at it from a broader perspective eliminates the underlying poststructural dynamics that the self-referential system conveys. It debunks the century-old premise that consciousness is a flowing stream (James, 1890). This is because no information is continually transformed, as is when information flows. Bateson's definition of "*a difference which makes a difference*" does not apply since information does not carry 'meaning' but is an action that is intentional. Moreover, unlike the metacognitive approach (Volzhenin, 2022), the multiscale approach, the brain is self-referential and not self-observing, which does not require a homunculus.

3. Self-referentiality in broadcasting multiscale redundancy

The self-referential nature of life originated in the cellular membrane of unicellular organisms (Torday & Rehan, 2012; Torday, 2015). Self-referentiality refers to the interactivity between the whole and the parts. In addition, multiscale redundancy is a way information is handled without information flow or information transfer, rejecting the brain as a Turing machine or information processor.

Self-reference is associated with such poststructural dynamics involving functional complexity rather than just complexity in the brain (Hempel et al., 2011), so a change in functionality explains dynamic organicity. Defining complexity as a measure of change in functionality requires functional interactions. Functional interactions control boundary conditions, so information is causally effective. Functional interactions as a conduit for evolving boundary conditions. Paksi (2014) proposed that evolving boundary conditions, not natural evolution, are pivotal in how the brain evolves in the environment during its life span.

Nonlocal physical interactions that result in function are called functional interactions. Only in biology do we have an information-based action that is functional (it can be acausal), i.e., nonlocal functionality. Information-based action is one such aspect of nonlocal functional interactions that allows the organism to be self-aware, etc. Functional interactions have three specific properties (Chauvet, 2004): (i) non-symmetry, (ii) non-locality and (iii) non-instantaneity. All three properties give functional systems their unique characteristics. These three properties are exhibited only in the brain by patterns in action. Moreover, functional interactions exhibit dynamical pathways unique in brains and, hence, not phenomenally equivalent in other functional systems, questioning the usefulness of functionalism (see Cohen & Dennett,2011).

A mathematical formalism of the model is based on what is referred to as a functional system (Chauvet,1996). Functional systems theory involves re-examining the concept of function as being outside of the function-structure relationship. It is a poststructural approach born from a desire to include diachronic organizational relations rather than synchronic organization relations that underlie observable phenomena. Macroscale sinks amplify microscale sources into progressive ordering through diachronic causality. Each source-to-sink pathway is a functional interaction (see **Fig. 1**).

The poststructural dynamics suggest that traditional philosophical dichotomies between objective and subjective experiences and brain and mind are unnecessary. This is because in the multiscale brain, redundancies are re-organized/restructured across scales, and patterns of constrained energy are created, connecting a vast array of information-guided actions that give 'form' through new information pathways. The mindlessness of poststructural dynamics discards the 'mind' as a vessel separated from the physical workings, as Dennett (1998) suggested in his concept of the myth of double transduction, where transduction refers to a second vessel from the physical brain, like a mind.

How can an informational interpretation of physical reality change the boundary conditions so nonlocal action entails a property of functional interactions? Functional interactions occur at different scales and represent boundary conditions in which hierarchical information in multiscale redundancy comes about (Pribram, 1991), which is how the diachronic (nonlocal) action becomes anastomosing. If boundary conditions are changeable, then a functional aspect is introduced. That is, changeable boundary conditions refer to the constraints that affect the validity of a theory or model (Kauffman, 2020). Changeable boundary conditions are a feature of dynamic organicity (i.e., the dynamic state of being organic) as proposed in the dynamic organicity theory of consciousness (DOT) (Poznanski et al., 2024a, b). Moreover, consciousness would be impossible in non-organic artificial systems unless a functional system approach appropriately considers changeable boundary conditions through functional interactions.

Boundary conditions constrain the energy release into a few degrees of freedom, causing a more delayed entropy[2] production and more easily *amplified*. It has been proposed that metastability (i.e., critical instabilities as the edge of chaos (Sbitnev, 2024) manifests critical instabilities, i.e., metastability) results from negative quantum kinetic energy (Gross et al., 2021). By analogy, consider informational metastability as *an amplification* of interactivity, which occurs at discrete periods when momentum is zero, resulting in the rate of change in quantum entropy being zero (i.e., negentropic gain). This can be amplified by a negentropic gain that produces an information-based action, not a force-based action with a reaction force. When use is made of information as a verb to inform, it becomes a causal, information-based action where the mechanism of action gives form assigning 'meaning' through a reduction in uncertainty. This negentropic gain specifically results in information-based action constraining the release of energy, resulting in energy transfer and creating patterns of constrained energy connecting a vast array of information-guided actions that give 'form' through new information pathways. These conditions eliminate uncertainty since quantum kinetic energy is negative (see **Appendix**). This happens at discrete times, so uncertainty exists at other times otherwise, consciousness would not be actualized, and memory would take over (Solms, 2014).

[2]Entropy is a measure of uncertainty.

The multiscale brain is holonic because of the quantum degree of freedom expressed as information channels through functional interactions, representing diachronic interactions. When considering quantum degrees of freedom, quantum entropy determines that the quantum potential acts as an informational channel, containing spatial information as an entity representing space (Fiscaletti, 2012). The topology of space and time is a manifold that gives rise to the quantum potential defined as the balance between the intrinsic internal energies of spatial and momentum dispersion in symplectic quantum systems (Brown,1997; Henriksson,2022). Negentropically-derived quantum potential does not lend to separating the interacting molecules but gives form through new information pathways by adding a quantum degree of freedom (Curcuraci & Ramezani, 2000).

The entropic brain hypothesis proposes that the quality of any conscious state depends on the system's entropy measured through functional entropy (Carhart-Harris et al., 2024). Concepts such as poststructural dynamics suggest new ways for 'quantum biological information' to reduce uncertainty (entropy) and lead to understanding as an '*affective drive'* to cognition. While certain affective states may lack a specifically intended referent, the '*affective' drive*' establishes a connection between these affective states and intentional states through information-based action that is postulated to stem from the 'hidden' thermodynamic energy attributed to thermo-quantum fluctuations (Poznanski et al., 2024).

'Quantum biological information' (as intrinsic information) arises from energy transduction and negentropic gain. It is guided by negentropically-derived quantum potential (entropic pilot waves) that give form (suggesting movement in the landscape of action). It is a seamless whole unified via contiguous action that is surmised to arise from movement across scale. This is an outcome of the partially holistic organization where globally continuous processes in the entropic brain are thought to begin before reaching the final stages. It represents the epigenesis of the '*affective drive*' in self-referential pathways (see **Fig. 2**). The interaction points to the transition from potentiality to intentionalities expressed as a smear of

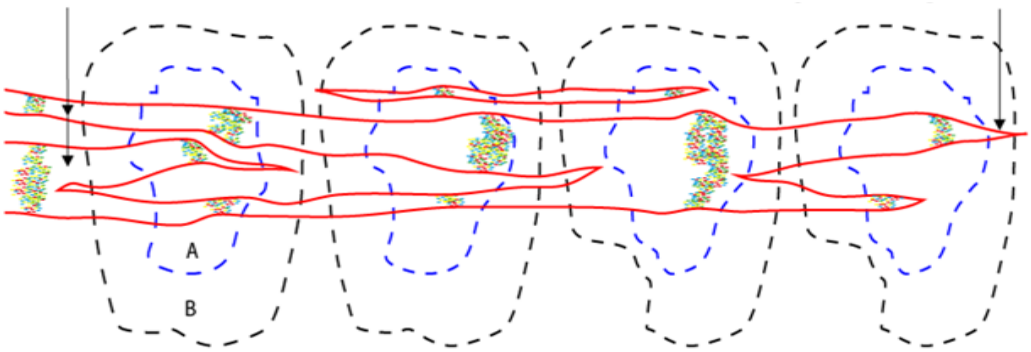

Figure 2 *Movement through the landscape of action or 'affective drive*' in self-referential pathways *of cortical areas (A & B) where area A represents precognitive experienceabilities and their actualization, and area B represents parts with no experientiality due to the absence of qualia, also known as phenomenal consciousness. Colored "dots" represent 'intentionalities' within one nonlocal holon with the "thickness in time" of the immediacy actualized precognitive experienceabilities. Each nonlocal holon, or intramolecular interference pattern, can be extended continuously by repeated actualizations. By large numbers of actualized precognitive experienceabilities, extended time frames, and rich modalities and spectra, feelings, intentions, acts, thoughts, etc, are formed (i.e., everything consciously experienced). The diagram shows continuous red areas, including all actualized precognitive experienceabilities, as 2-D areas representing 3-D volumes moving as a poststructural dynamic process. The 'intentionalities' are actualized as precognitive experienceabilities, which are extremely numerous and much more freely spread as pixels in the molecular constituency of the brain than is possible to show here. The suggested borders are changeable and permeable, allowing for energy transport and the formation of intrinsic information. The precognitive experienceabilities are labile either off or on, i.e., potential or actualized, and their causal action appears and disappears from the unconscious and originates from boundary conditions. The arrows indicate the start and the end of the consciousness experience across different cortical regions. Courtesy of Jan Holmgren.*

possible experiences instantly actualize through intermittent interactions as precognitive experientialities and return to spontaneous potentiality. In the multiscale brain, spontaneous potentiality depends on molecular size and the nature of intramolecular cohesion in a partially holistic system.

4. Conclusion

The movement in the landscape of action is known as the '*affective drive'* (Poznanski et al., 2023). Its mechanism is self-referentiality, which fosters the phenomenology of consciousness as an across-scale movement in the landscape of action. Intentions are sensed as feelings (Bohm, 1989), are top-down events linked to conscious experience, belong in the realm of both conscious perception and conscious cognition, yet are distinct from intentionality. This adds to the precognitive basis of consciousness, its lability, and its entropic nature.

Appendix

We explain the role of entropic pilot waves in negentropic gain, facilitating information-based action to give form (suggesting movement) and is not a force-based action with a reaction force. The negentropic force is a repulsive force that does not lead to the separating of the interacting molecules but involves entropic pilot waves guidance of the information-based action as an internal energy transduction from quantum potential energy to quantum kinetic energy and does not separate the interacting atoms in molecules, like the Pauli repulsion force, which is negligible. It is characterized by quantum degrees of freedom in the redundancy structure and decoded relative to scale (multiscale redundancy).

The quantum (effective) kinetic energy Q_k for a many-body system is given as

$$Q_k = -\sum_{j=1}^{n} \frac{\gamma^2}{2m_j} \frac{(\nabla_j \rho^{0.5})^2}{\rho}$$

where ρ is the electron density, ∇_j is the Del operator in the j^{th} bound state of n-dimensional abstract configuration space, m_j is the (effective) mass of the j^{th} bound state, γ is the action parameter, Q_k is the quantum kinetic energy when delocalization occurs far from the dipolar core or nuclei, where the Coulombic attraction force becomes negligible, and pilot wave forces take over. Note that the ρ is greater in the denominator, so Q_k decays with distance, known as a 'partially holistic' system.

Consider *intrinsic information* occurring through informational pathway derived from the continuity equation when the momentum is zero (∇S=0) to be the equation signifying negentropic gain:

$$\frac{\partial S_Q}{\partial t} = 0$$

where S_Q is the quantum entropy (Fiscaletti,2012). The momentum is determined by the gradient of the 'action' function (S) of the dimensionless polarization wave function (ψ_n), i.e., wave function in an electromagnetic field describing the instantaneous state of the enveloping field density of dipole-bound delocalized electrons. According to Heifetz & Cohen (2015), the fluctuations from the average values (real part) are presented by the imaginary part of the momentum (∇S). When the momentum of the polarization wave function is zero (∇S=0), it indicates that the quantum kinetic energy part in the equation of motion is negative, viz.

$$\frac{1}{2m}(\nabla S)^2 - \frac{\gamma^2}{2m}(\nabla S_Q)^2$$

The condition of negentropic gain influences negentropic action through entropic pilot wave force (negentropic force). At negative quantum kinetic energy, the rate of change of quantum entropy is zero, signifying that the negentropic action acts as an informational pathway and facilitates the movement of information-based action for information encoding. This suggests that the quantum potential energy facilitates the movement of information-based action through quantum kinetic energy. This process reflects upon the poststructural dynamics of the multiscale dynamics. The process of how the movement of information-based action for information encoding is suggested to be a manifestation of quantum kinetic energy directed at reducing uncertainties. When the negative quantum kinetic energy of the polarization wave function occurs, the information-based action increases quantum biological information sufficiently for the act of understanding to take effect, rendering consciousness.

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Conflict of interest

The authors declare no commercial or financial relationships that could create a conflict of interest.

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