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What a feeling - the underpinnings of physical feelings as molecular level holonomic effects

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Abstract

This paper proposes biophysical principles for why geometric holonomic effects through the geometric vector potential are sentient when harmonized by quantized magnetic vector potential in phase-space. These biophysical principles are based on molecular level electromagnetic resonances in partially holistic molecules where nonintegrated information acts as the consciousness process's conduit—using the informational structure of physical feelings as a transition into subjectivity. The transformation of internal energies from potential to kinetic as 'concealed' motion may measure the causal capacity required to bridge causality for conscious experience. Conformational transitions produce bond-breaking, resulting in *boundary conditions* and limiting the molecular wavefunction to a partially holistic molecular environment with molecular holonomic effects. The van der Waals energy increases protein conformational activity (re-arrangement of bonds), causing energy transfer and information in protein-protein interactions across the cerebral cortex through the energy transduction process. Energy transitions predetermine molecular level electromagnetic resonances in aromatic residues of amino acids. The energy sharing between various nested molecular level electromagnetic resonances interacting with the intermolecular adhesion of London forces at the nexus between phospholipids and the lipophilic proteins has a key role in constraining the release of energy resulting in a vast array of information-based action through negentropic entanglement. Such information structure, passing from the objectivity of holonomic effects stemming from molecular level electromagnetic resonances, has an inherent ambiguity since meaning cannot be related to context, which constitutes preconscious experienceability. The transition from potentiality to actuality where Coulombic force is expressed as a smear of possible experiences where carriers of evanescent meanings instantly actualize through intermittent dispersion interactions as conscious experiences and return to potentiality in preconscious experienceabilities.

Keywords: Holographic brain model; Madelung formulation; internal energy, negentropic entanglement, physical feelings, microfeels, consciousness, delocalization, resonance, molecular holism; complex entropy concept, intrinsic magnetism, molecular transduction.

1. Introduction

Freudian metapsychology [1] is less esoteric to philosophical views since the source of consciousness itself is in the preconscious mind. We consider Freudian metapsychology yet generalize the preconscious mind as part of the subconscious and unconscious mind. The terms "unconscious," "preconscious," and "conscious" can be understood in several interrelated ways. First, these terms can be understood descriptively (or epistemically), where being conscious refers to what is presently known and unconscious refers to what is presently unknown. Freudian metapsychology suggests emotions and how they might relate to early experience in the unconscious. According to Freud, somatic processes cannot be unconscious, e.g., pain, pleasure, instinct, etc., but descriptive unconscious refers to a capacity for all preconscious experiences. Preconscious experienceability is not a conscious experience but a crucial stage before the onset of self-awareness and conscious perception [2]. Freudian metapsychology embraces preconscious experienceabilities as the neuropsychodynamic principle by which capacities for experiences form within the brain and are not felt (absence of phenomenology). When Freud talks about affects and emotions, he only refers to "feeling-states", i.e., purely subjective in the emotional process [3].

We call the informational descriptors of preconscious experienceabilities—physical feelings. Physical feelings are informational structures that enable preconscious experienceabilities to arise from a smear of possible experiences dictated by Nature and influenced by the environment. Unlike "qualia," which is the *feeling of experience* (a subjective phenomenon), physical feelings are raw microfeels as the analytical lenses through which quality of understanding is

fathomed in the concrescence of the subjectification process. The hard problem of consciousness is understanding the mechanism for actualizing and binding physical feelings from unconscious raw microfeels into conscious experiences.

Physical feelings constitute the functional analysis of "qualia" [4] correlated with preconscious experienceabilities. The functional analysis of 'qualia' in terms of physical feelings must, therefore, lead to actualized physical feelings higher-up, which are composed of brain regions [5] and are the fundamental agents of preconscious experienceabilities from where experiences originate in each neuron (cf., [6], [7]). The informational descriptors of physical feelings are beyond genomics [8,9] and epigenetic-driven connectivity [10].

Physical feelings are shaped by *preconscious experienceabilities* that stem from informational descriptors, including perception, cognition, and self-awareness. Still, they are not the same as a subjectivity that only reflects internally produced "*experiences of feelings*" or "qualia" through cognitive and perceptive information processing. Thus, preconscious experienceabilities are relative to receiving external information, which defines subjectivity but not conscious experientiality. According to [11], identifying experience with subjectivity is false as many experiences do not feel like anything. The 'quale' of a mental state or event is that state or event's information patterns, i.e., introspectable 'phenomenal' character. The epistemic argument arising from a difference between informational and experiential cannot occur when the 'feeling-as-information' hypothesis [12, 13] is the source of experientiality.

Feinberg and Mallat's "neurobiological naturalism" hinges on the propositions that consciousness and subjective feelings can be ontologically subjective and neurobiologically unique yet scientifically explainable. The theory does not explain how but suggests the emergence of consciousness [14]. The notion of emergence is often dialectical in phase transitions, but there are no such events in brains. In panexperiential materialism [15], consciousness is not irreducibly subjective. Experiential flow is the transition of physical feelings into subjectivity, passing from objectivity, and therefore it does not depend on the dualism associated with the mind-body problem. It is based on process-ontologies and refers to existence in terms of energy transformation processes where objective ontologies are transformed into subjective ones and *vice versa* (see [15]**)**. To us, consciousness depends on process-ontologies, but it is not primary. For instance, consciousness affects biological processes on which it depends through an *act of observation* expressed in terms of the informational structure. The *act of observation* is not the literal meaning, but that information is intrinsic. The interaction between dual modes of two types of information forges the *act of observation*.

Hence consciousness is the actualization of physical feelings by the *act of observation.* Consciousness gets actualized when the *act of observation* occurs. This expression of consciousness we call 'conscious experience'. Conscious experiences lead to a variety of emotions that are perceived. The disintegration of conscious experience through disintegrated information within the unity of consciousness happens in Charles Bonnet syndrome, disjunctive agnosia and schizophrenia [16]. Making sense of things is not what consciousness does. Consciousness, only when expressed, becomes felt or experienced. Consciousness affects cognition without being an effect of cognition. As known under psychiatric conditions like schizophrenia, the disunity of content is cognitive. This means there is "disunity of content" (cognition) within the *unity of consciousness*.

What do we define to be the nature of the consciousness process? The consciousness process carries a materialistic ontology with epistemic informational relationalism where evanescent meanings of intrinsic entities depend crucially on their interrelations, which involve *sui generis* causal powers irreducible to their components, i.e., holism The mechanisms of emergence are not entailed in the conceptual understanding of holistic epigenesis of consciousness. The relational closure achieved in the entailment organization of holarchical systems makes the holarchical system conscious through meaning, and semantics are produced intrinsically by the holarchy. In a holarchical system, the whole grants meaning to the parts composing the whole. The process by which this is done is called holism. Holism is not the ontological claim that new properties can "emerge" from the components of a system. Holism can lead to causality to the whole if there is sufficient intrinsic information, and this is when the unconscious mind becomes conscious. There is no need for emergence. Intrinsic information in a holarchy replaces

the magic of emergence through holism, and it is a measure of causal capacity. Therefore, it is a measure of feelings in preconscious experienceability that is neither matter nor energy.

The nonintegrated or differentiated information is actively transformed via signal-transducing processes. So, we can say the nature of consciousness is unitary yet differentiated [17]. The unity of consciousness comes not from the midbrain reticulum via the ascending reticular activating system as claimed by [18], which is more or less linked to loss of consciousness due to abnormalities in arousal that function as the regulator of consciousness. The unification of consciousness is not arousal-dependent. The unification of consciousness is closer to the various cortical connections (e.g., associative, commissural, and projection fibers), including the striatum, thalamus, and hippocampus associated with higher cognitive functions (e.g., language, thinking, planning, reasoning, problem-solving, and free will) are all influenced by well-integrated transcription factors for gene expression of protein-protein interactions [19].

According to philosophers' qualitative aspects, mental phenomena are without a physical counterpart. To circumvent this dilemma, [20-22] introduced the concept of '*potential qualitative*' aspects in fundamental physics. They introduced *potentiality* for a qualitative aspect in terms of elementary waveforms, such as Herbert Fröhlich's 'brainwave' [23] and David Bohm's '*pilot wave*' [24]. These are physically unobservable classically and, therefore, give rise to Maccone's argument [25], in which subjectivity and physical unobservability are identical concepts [26]. The unobservable most likely are hidden in brains' tiniest and fastest processes. One example has been "Psychons" [27] suggested being the unitary experience of consciousness, like "qualia". They are said to exert a local interaction with microstructure to penetrate within a bundle of dendrites in the cerebral cortex [28]. However, after more than 30 years, the true identity of 'psychons' has not been identified, nor has there been subsequent development of this hypothesis. Various other ideas have been presented for atomic building bricks of conscious experiences, for example, monads (Leibniz), buds, or drops of perception (William James), atoms of computation [29], atomic 'microfeels' [30], a *scintilla of subjectivity* [31] or elemental subjectivity being the intrinsic quality of experience [32].

Raw feelings are the basic form of consciousness, but [18] assumes that feelings must be felt; in other words, requiring association of feelings with the phenomenology of feelings that we say are "physiological feelings" and not "raw feelings". In our view, raw feelings are physical that give evanescent meanings in preconscious experienceability. Experienceability is the capacity for an experience that occurs preconsciously and serves as an affective function that explains experience as a testament of consciousness. We base our model on the meaning of the *feeling-as-information* hypothesis [12,13], suggesting that evanescent meaning arises from patterns of intrinsic information-carrying physical feelings. In other words, evanescent meaning as information gives form to feelings, meaning sentience as the capacity of feeling. Since the information is intrinsic, physical or raw feelings are hidden from phenomenal introspection. In this manner, we suggest that raw microfeels are always off and potential.

Preconscious experienceability is realized physical feelings with vast numbers of atomic microfeels formed as physical feelings (holons) in informational holarchies. Holons carry information in discrete epochs of the unitary experience of consciousness. ´Atomic´ here means not dividable, extremely small, and short-lived. But feelings must be repeatable so each feel can stay actualized for somewhat longer times and, in concrescences (holarchies), build dynamic conscious experiences in the form of complex actions, feelings and thoughts. All raw microfeels may be actualized since they are built upon physically defined inherent meaning. This preconscious experienceability carries an evanescent meaning realized in cognition with a distinctive phenomenology and a distinctive feel.

How does the brain attribute the preconscious experienceability associated with physical feelings? Preconscious experienceabilities have no phenomenology; therefore, we seek to understand preconscious experienceabilities through biological principles instead of phenomenology. We made the distinction because phenomenology, real as it is, is not that which is represented. To avoid a phenomenological model, we need to consider the capacity for experiences similar to how the brain constructs its spontaneous activity. Both are keys for making the capacity to feel possible, namely sentience [33]. Preconscious experienceabilities occur internally, generated as discrete molecular-embedded raw microfeels independently from thought processes or self-awareness. Only organized delocalization pathways of preconscious

experience' [34] are actualized as physical feelings. Within the continuous nonlocal holon [35], discrete epochs of preconscious experienceabilities ultimately result from constrained energy transformation in holarchies. The informational descriptor of preconscious experienceabilities as physical feelings is omnipresent in various degrees and modalities in all animals [36,37].

According to Searle [38], information exists only relative to consciousness, which means that information-based theories of consciousness are circular, i.e., they seek to explain consciousness with a concept—'information'—that presupposes conscious – ness. Searle [38] suggests that our experiences do not seem to be formed from 'pixels' but in language, i.e., cognition. This insight may be valid from the top-down perspective, where an assemble of wave packets integrates information in cortical networks of cerebral hemispheres (cf. [39]). From the bottom-up perspective, information is based on the organization of energy in the brain [40]. Information is not something separate from energy processing. Still, changeable boundary conditions in a many-body system like the brain result in the modifiable constrained release of energy [41]. Describing brain processes as having informational content is simply a different way to present the brain's energetic mechanisms from a physical perspective. Still, the information in the sense of semantics is excluded from processing meaning [42].

The relationship between the brain and mind was originally discussed in connection with Gödel's incompleteness theorem [43]. A more explicit mathematical formulation of mind has recently been developed as an immaterial nonlocal metric quantity, which cannot, although conjugate to the matter, be localized within anything in particular, not the material brain [16], [44-45]. How does the brain beget the mind from molecular holism processes [46], and how can internal energies influence cognition's ionic world? If consciousness is discrete [47], [48], [6], the perception of continuity is needed for cognitive performance. This indicates that binding together a disparate collection of thoughts is not how consciousness works. Instead, consciousness content is disintegrated within a unity of consciousness [16]. For example, feelings are a source of qualitative information since the quality of understanding is feeling. The *feeling-as-information* hypothesis can be further developed to the meaning of experience as closely related to the goal-directed activity's property, i.e., teleology [15,42].

Pribram [49] was the first to describe consciousness as a "*quanta of information."* The formalism of the process was quantum-like based on nonlocal holonomy in the brain, but his holographic brain theory was incomplete and relied on Gabor's hologram as an analogy [49]. Pribram's neural holography compares interference patterns observed in electron microscopy as a holograph of experiences in the brain. In particular, posit how nonlocal functional interactions in cortical processing can explain nonlocal holonomy differently from the microscopic 'spooky-action-at-a-distance'. Holonomic brain theory examines the scale beneath neurons where information is processed with quantum degrees of freedom, e.g., spin, charge, allowing brain functioning to be holonomic. This was the idea of Pribram [49] in claiming that his holonomic brain theory was not analogous to quantum theory, but rather its formalism obeys the same rules as that of quantum mechanics. Holonomic brain theory is formally equivalent to computations in quantum mechanics and thus constitutes quantum neurodynamics. However, the processes at the neural level, such as the distribution of ionic charge that can be identified with those described in the quantum domain, do not imply neural processes are quantum mechanical involving subatomic particles like electrons. This is a caveat in Pribram's approach as he could not justify a quantum-like substrate in his theory. We have considered delocalized electrons in partially holistic molecules as a substrate for quantum-like processes.

The *feeling-as-information* hypothesis can be applied to nonpolar hydrophobic regions, which are non-electrolytic regions of fatty acids and intersect with lipophilic membrane proteins' domains of mainly partially holistic amino acid units. Here holistic is defined as the molecular wave function expressed over many delocalized electrons where parts of molecules are partially holistic with a specific internal energy that keeps it together by canceling the classical potential energy [46] and, as shown in [50], long-range order in a thermalized milieu must partially keep π-electrons phase differences in the self-organized molecular orbital only in the absence of classical potential energy.

Bohm and Hiley [51] proposed that the mind is part of a hierarchy of information levels that link with neural processes. The linkage was not given explicitly and

remains unexplainable in Bohm's ideas about mind-matter relations (cf., [52]). If we take the electron as the primary constituency of matter, it is in this context not just an elementary particle but a dressed entity interacting and correlated with its environment [44]. This is precisely what Bohm [52] and Hiley [53, 54] suggest does happen. The information in the waves' patterns (form, shape, or phase) and not the energy or force leads to changes in an electron's motion (although energy is supplied locally for the intermediary processes). This entails information-based action at the atomic scale. The information-based action is not integrated across scale since, according to [53], it would lead to "interference,"

Bohm [52] did suggest that 'active' information links the mind and the brain but never explicitly. He also suggested that mind-like behavior exists through the "dance of electrons" and its nonconscious 'quantum force' causing actual physical feelings, nonintegrated information-carrying *inherent meaning* and relations between them. The Bohmian 'dance of electrons' bears active information that physically reflects back on the internal energy directly associated with the quantum potential energy [55]. According to [54], active information contributes to the redistribution of the internal energy shared between the kinetic and potential parts. These internal energies distinguish the extended character of quantum systems from the point-like integrity of individual classical systems from which they are absent. Such internal energies are absent in classical systems because they are points in space-time having no inner structure [56].

2. Nonadiabatic Madelung formulation of delocalized energy states

To find a connection between the general density matrix dynamics exhibited by the Liouville-Bloch equations, we will analyze quantum hydrodynamics (quantum fluid) Bohmian-type models' general structure based on Madelung's formalism [57]. The Madelung transformation allows the Schrödinger equation to be recast in hydrodynamic form. Schrödinger's equation is redefined as a dissipative Schrödinger-like equation applicable to quantum dissipation systems is used to derive delocalized energy states. The dissipative Schrödinger-like equation [57]:

$$i\gamma\frac{\partial\psi}{\partial t} = -\frac{\gamma^2}{2m}(\nabla + \nabla\beta)^2\psi + U\psi + i\gamma\frac{\partial\beta}{\partial t}\psi \qquad (1)$$

where ψ is the dimensionless molecular wavefunction, m is the mass of the molecular orbital electron ensembles in units of [mass], $\beta = \beta_r + i\beta_i$ is the dissipation parameter (dimensionless), and a modified Planck's constant, see [15] for some validation, which is an 'action' parameter ($\gamma \gg \hbar$) where $\hbar$ is the Planck's constant carries a dimension of [energy][time], U is the static classical potential energy in units of [energy], t is the time in units of [time], x is the length scale in units of [length] and ∇^2 is the Laplacian. The action parameter γ carries dimensions of [energy] [time]. Note that $\gamma \to 0$ is semiclassical, assuming $\gamma \neq 0$ as the semiquantum regime. Eqn. (1) will be generalized to include electromagnetic (EM) resonances in aromatic residues of amino acids.

The *molecular wave function* (ψ) guides the delocalized electron ensembles with respect to their phase differences. Delocalized electrons are constrained within an orbital, extending over several adjacent atoms (see **Fig**. 1). The molecular wave function, which applies to several dipole-bound electron density clouds and how they interact, requires at least a many-electron problem solution at the level of the Kohn-Sham equation [58]. The latter determines the orbitals and the ground quantum state as a functional of the electron charge density. We simplify the many-body problem by assuming a density distribution of quasi-free electrons bound to a molecular dipole core, i.e., a mean-field approximation where the effect of all the other individuals on any given individual is approximated by a single averaged effect or effective interaction. These approaches are necessary for discussing simplifications such as those of quantum potential chemistry [59] and implicitly indicate the existence of EM resonances generating EM oscillations in aromatic residues of amino acids.

Still, we do ignore interactions between dipole-bound electrons in density clouds and between multiple electron density clouds. This semiquantum approx-imation is analogous to semiclassical approaches, considering the quantum-classical boundary from the non-classical side (cf. [60]). On a more general level, one needs to understand and develop a generalization of Bohmian mechanics to comprise the Liouville-Bloch equations. The problem is that one must not only go from the charge density to the density matrix, the latter with a probabilistic interpretation as given by von Neumann dealing with an ensemble of physical systems, to the transition matrix. The new element here is the transition matrix see [15], with a different normalization specified by the boundary conditions mentioned

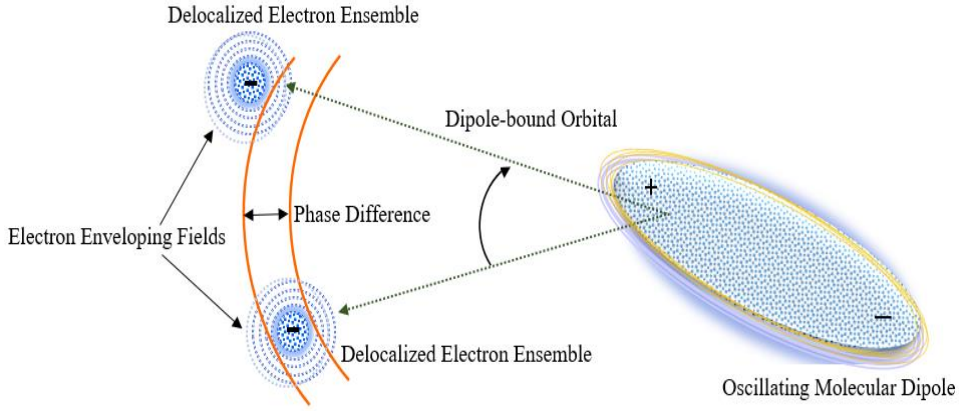

Fig. 1 *A schematic illustration of a delocalized energy state in which two dipole-bound delocalized electron* ensembles *depend on the molecular dipole's electric dipole moment. The oscillating molecular dipole located in electrolytic regions has a nonzero orbital angular momentum, enabling the delocalized electron* ensembles *to follow the positive pole's motion pseudo-nucleus for the delocalized electrons. The phase differences between the delocalized electron* ensembles *associated with the molecular orbital are located on partially holistic molecules (dipole-bound orbital), generating intrinsic magnetism that carries energy flow and intrinsic information [Adapted from [61]).*

above, i.e., tuned to temperature and time scales, thereby prohibiting decoherence.

In the brain, delocalized electrons are formed due to the mixing (overlapping) of molecular orbitals of different atoms, forming molecular orbitals, where electrons move under the influence of several nuclei. The weakest of such nonpolar covalent bonds is the delocalized π bond. These nonpolar covalent bonds are twice as strong as London dispersion forces based on dissociation energy. In **Fig**. 1, there is a schematics illustration of delocalized π bonds where delocalized electrons are nuclei shared in a nonpolar covalent bond. Electrons are fermions that prefer to pair into nonmagnetic singlets. The pairing of delocalized electrons does not necessitate the macroscopic effects of spin projections because spin projections are averaged out in molecules, thus irrelevant to their function at the molecular level. Consequently, the molecular dipole-bound electrons in their internal and orbital motion in terms of phase differences are shown schematically in **Fig**. 1. The oscillating molecular dipole is stationary under the influence of Coulomb forces. The enveloping fields of delocalized electron ensembles arise due to the 'guidance waves.'

In the ontological interpretation of quantum mechanics, the quantum potential energy [51] represents an enveloping field through which the electron interacts quantum mechanically. Although Bohm [24] did not suggest any particular importance in the macroscopic realm, a new interpretation of Bohmian mechanics has been developed under the context of quantum potential chemistry [59] and the holistic molecule [46]. This is a new guidance wave theory entailing the molecular level, where, e.g., delocalized electrons of an *amphiphilic* biomolecule can be associated with several atoms and which are often expressed as a combination of molecular orbitals, their number matching the combination to form an *amphiphilic* biomolecule. The spatial and energetic properties of the dressed electrons are determined via the molecular orbitals surrounding two or more atoms in an actual *amphiphilic* biomolecule. Bohmian mechanics extends its interpretation to the molecular level based on quantum potential chemistry [59]. It is simply classical mechanics with an additional force term that counterbalances Columbic forces leading to limited quantum effects in classical systems. Note, however, that the present approximation violates the viral theorem, as it makes plausible the stability of matter in terms of stationary states to zero kinetic energy. This must be considered when the dynamics are reassessed in future work.

The dissipative Schrödinger-like equation can be solved by substituting the Madelung transformation: $\psi = \sqrt{\rho(x,t)}\ e^{iS/\gamma}$, separating the imaginary and real parts where ρ(x, t) is the space-temporal distribution of the molecular orbital electron ensembles (dimensionless). The real part describes how the 'shape' of the molecular orbitals is represented by the phase differences in terms of the guiding wave (Hamilton-Jacobi) equation [57]:

$$\frac{\partial(S+\gamma\beta_i)}{\partial t}+\frac{1}{2m}(\nabla S+\gamma\nabla\beta_i)^2+U+Q=0 \qquad (2)$$

where $S=\frac{i}{2}\gamma\ln\frac{\psi^*}{\psi}$ is the 'spread' function of molecular orbital electron ensembles in units of [energy][time], ψ^* is the complex conjugate of the molecular wave

function, Q is the dissipative quantum potential energy in units of [energy], U is, as before, the classical potential in units of [energy] and ∇ is the gradient. The action parameter expressed in terms of the reduced Planck's constant, circumstantially given by $\gamma = n\hbar$ carrying dimensions of [energy] [time] where $\hbar = h/2\pi$ is the reduced Planck's constant in units of [energy][time], and n is the dimension of the open system, i.e., neural design, a cell-cycle time-synchronized to the thermal oscillation or the total number of microfeels corresponding to the size of the dissipative organization. For a more detailed discussion of the 'quality number n, see [15, 44]. A typical quantity in life processes such as the phosphorylation reaction would be $n \sim 10^{11}$ [15,44,45]. The gradient of the 'spread' function (∇S) in units of [energy][time]/[length]:

$$\nabla S = i\ \gamma\ \left(\frac{1}{\sqrt{\psi^*}}\frac{\partial\sqrt{\psi^*}}{\partial x} - \frac{1}{\sqrt{\psi}}\frac{\partial\sqrt{\psi}}{\partial x}\right). \qquad (3)$$

Note: $(\nabla S)^2$ has unit of ([energy][time]/[length])^2 =[mass][energy]. Moreover, given that $(\nabla E)/(\nabla S) = T$ (*Tsekov, personal communication*), where $E = -\frac{\partial S}{\partial t}$ is the total energy, it is possible to find the semiquantum potential energy as a function of T, and since the Boltzmann-Gibbs thermal entropy is dimensionless, the connection is established by multiplication by the Boltzmann constant k_B. The temperature in the brain is likely to lead to decoherence below the neural level. This is, however, of no concern because the quantum-like coherence associated with the quantum effects is predicted from the environment through the diffusive quantum potential energies through their temperature dependence, or more exactly, through the Liouville-Bloch quantum-thermal transitions, spatiotemporal tuned to the actual temperature [15,44,45]. Therefore, the elementary waveforms of sentience are not wavefunction patterns that decohere in the wet and hot milieu in the human brain.

3. The 'quantum force' underlying information-based action

Although entrenched in a generalized Liouville formulation and an original, realistic quantum interpretation, our approach is neither deterministic nor probabilistic. Nevertheless, for the moment, we will consider some simplifications, i.e., a dynamic version of Quantum Theory of Atoms in Molecules (QTAIM) without the bond pathways. QTAIM, see [62, 63], describes stationary molecular systems by modeling atoms and their bonds in relation to the hypothesis that the electron density reflects the probability of finding an electron in a region between the nuclei. Our simplified approach portrays quantum thermal perturbation in the electronic phase-dynamics, including the densities, and considers the electron ensemble of a molecular structure as a '*quantum fluid*''.

One way to characterize the long-range correlative behavior of the *quantum fluid* is through the thermalized Bloch equation [9,15,44]. The 'electromagnetic' brain harboring delocalized electrons is stable from a thermodynamic perspective and resides in well-defined molecular orbitals as measured in terms of phase differences between the delocalized electrons. There is no thermal agitation for the delocalized electrons in such an environment to achieve high mobility, so 'guidance waves' can guide their action. As already mentioned above, a more detailed account can be given by a density matrix approach, but we will avoid this approach here since we hope to be able to mimic the microscopic quantum domain by lifting the de Broglie-Bohm approach from the microscopic scale to the mesoscopic scale through quantum potential chemistry [59].

The temporal waveforms are dissipative quantum potential energy (Q) patterns. The standard configuration is independent of the amplitude, the time scale, and the phase shift. However, in the presently augmented picture, the thermal constraints expressed in the semiquantum potential energy should exhibit intrinsic information. In other words, this potential energy might gain, as one may anticipate from the density matrix approach, intrinsic information from the concealed motion [64] as a result of free energy reorganization or constrained energy release. However, the energy generated from spontaneous potentiality appears to fall short of the thermal noise and will not, therefore, be expected to affect neural brain processes. On the other hand, the biological system evolves through information-based action in terms of a force-based mechanism.

The semiquantum potential energy conveys evanescent meaning as an 'information channel' respecting a 'corrector' of the kinetic energy via a repulsive force and quantum-thermal perturbations stacked against the Coulombic attraction, all in all, as the gradient of the semiquantum potential energy (−∇Q) that constitutes the 'free energy' of de Broglie's 'hidden' thermodynamics (see [65,66]). The de Broglie's 'hidden' thermodynamics plays an unprecedented role in transferring information being dependent on the de Broglie wavelength and intrinsic in the sense that it remains 'hidden' from the operational explanation of

covalent chemistry. The nonclassical nature of hidden variables is located in each electron's configuration space and enveloping field [51,52].

The kinetic energy is $\frac{1}{2m}(\nabla S)^2$ and from the *neural Hamilton-Jacobi equation*, the total energy is $-\frac{\partial s}{\partial t}$. A semiquantum approximation to classical dynamics does not represent a quantum system's wave function properties but instead uses electron distribution (ρ). The dissipative quantum potential in units of [energy] can also be represented in terms of ρ [57]:

$$Q(x,t) = -\frac{\gamma^2}{2m}\frac{(\nabla+\nabla\beta_r)^2\sqrt{\rho(x,t)}}{\sqrt{\rho(x,t)}} \quad (4)$$

where ρ(x, t)>0, x is the spatial distance and ∇^2 is the Laplacian (in one-dimension $\equiv \frac{\partial^2}{\partial x^2}$). We assume that the dissipation parameter is independent of space position in the brain. i.e., $\nabla\beta = 0$; therefore, the dissipative quantum potential becomes the semiquantum potential energy:

$$Q(x,t) = -\frac{1}{4m}\gamma^2\left[\frac{\nabla^2\rho}{\rho} - \frac{1}{2}\frac{(\nabla\rho)^2}{\rho^2}\right] \quad (5)$$

and together with $\frac{\nabla\rho}{\rho} = \nabla(\ln\rho)$ reduces to:

$$Q(x,t) = -\frac{\gamma^2}{8m}[\nabla(\ln\rho)^2] - \frac{\gamma^2}{4m}[\nabla^2(\ln\rho)] \quad (6)$$

where ∇ is the gradient ($\equiv \frac{\partial}{\partial x}$) and ∇^2 is the Laplacian ($\equiv \frac{\partial^2}{\partial x^2}$).

The internal energy as a concealed motion leads to *energy exchanges* that result in a 'quantum force', which is an information-based action (self-force):

$$f_Q = -\nabla Q \quad (7)$$

where Q is the semiquantum potential energy that guides the actualization of the appearing phase differences, unlike Bohmian mechanics' internal energy where 'pilot waves' guide the electron in a way, so it also acts as an 'information channel' through a context-dependent energy redistribution [54,55,67]. The 'quantum force' is not a mechanical action [68] but a 'guiding-wave' force associated with local variations of ρ(x,t). The 'quantum force' guides dipole-bound electron oscillations as intrinsic influences implicit in confluences. Information-based action 'quantum force' f_Q is a driver of quantum interactions to yield a force balance responsible for establishing a steady state of molecules. The 'quantum force' in terms of ρ is:

$$f_Q = \frac{\gamma^2}{4m\rho^2}\left[\rho\nabla^3\rho - \frac{1}{2}\nabla(\nabla\rho.\nabla\rho) - \nabla\rho\left(\nabla^2\rho - \frac{\nabla\rho.\nabla\rho}{\rho}\right)\right] \quad (8)$$

The spontaneous potentiality of dipolar-bound delocalized energy states is not probabilistic but acts nonlocally through the imaginary component of the wave function. If anything changes in the system, e.g., a boundary condition at a considerable distance from the electron distribution, then the wavefunction amplitude $\rho(x,t) = |\psi|^2$ (Bohr's rule) changes simultaneously, and therefore the 'quantum force' $(-\nabla Q)$ on the electron distribution changes simultaneously. This is the paradigmatic description of nonlocality in quantum physics. In particular, the charge is incorporated with the classical potential and $-e|\psi|^2$ is the charge density where **e** is the charge of the electron. The nonclassical nature of 'hidden variables' is located in each electron's configuration space, so the Bohr rule's universality is based on the system at quantum equilibrium, where signal-locality is a peculiarity of quantum equilibrium.

Valentini [69] has shown that the nonlocal effects average to zero for a configuration space like Hilbert space in an electron ensemble. Nonlocality might decohere in quantum equilibrium ensembles unless prohibited by steady-state transitions [9]. In other words, the statistics in an equilibrium ensemble become localized according to pilot-wave theory, as suggested by [69]. This explains why nonlocal signaling in brains cannot occur unless the ensemble is far from equilibrium. However, since there appear to be nonlocal functional interactions in brains, they also need to be dissipatively adapted to structural discontinuities (non-symmetry) and the temperature and the associated time scale [9,15,44].

This does not apply to fractal space-time geometry as in a hologram where the whole is similar to its parts [70]. In a metric fractal, physical and nonlocal functional interactions must be represented by quantum chemical molecular systems configured by atoms with electrostatic interactions (London dispersion forces). Hence physical interactions depend on forces that can only operate when the medium is homogenous (local), and they concern only the structural organization without affecting its functional organization. The "absoluteness" of spacetime is not considered with the Leibnizian approach to space, which is relational in contrast to Newton's substantivalism, and space is an entity in its own right existing independently of things.

Therefore, the brain is not essentially a Riemannian space-time manifold [71] but rather a system of epistemic relations between intrinsic information harnessing an informational structure reflecting a grossly nonmetrical fractal neural geometry that is dynamic holarchy [72].

4. The 'negentropic force' underlying holonomic effects

We consider an entropic version of Madelung's formalism, and the 'hidden variables' are linked in a medium like a brain to nonlocal holonomy. Madelung formalism, usually considered a precursor of the entropic version of Bohmian quantum mechanics, has recently been given a stochastic Brownian quantum theoretic interpretation [73]. Noting that atomic and molecular motion is perturbed by thermo-quantum fluctuations in, e.g., the brain, the formulation provides a fundamental platform for nonequilibrium irreversible processes [74,75] and will direct the focus towards nonequilibrium quantum mechanical systems [57]. The standard quantum chemical picture of electrons residing in well-defined molecular orbitals is thermally activated. The quantum-thermal agitation in such an environment achieves high mobility/correlations, guided by ambient perturbation.

The negentropic force is the mesoscopic image of the microscopic quantum force f_{Q}. Hence, in a mean-field approach, one can replace f_{Q} (Eqn. 8) by $-\nabla \mathrm{Q}_{\mathrm{sq}}$, where the negentropically derived semiquantum potential energy is:

$$Q_{sq} = -\frac{\gamma^2}{2\mathrm{m}}[\nabla \mathrm{S_Q}]^2 + \frac{\gamma^2}{2\mathrm{m}}\nabla^2 \mathrm{S_Q} \tag{9}$$

where [67]:

$$\mathrm{S_Q} = -\frac{1}{2}\ln(\rho) \tag{10}$$

to be called *quantum entropy* (dimensionless). This is an analog of Boltzmann-Gibbs classical entropy to the realm of quantum hydrodynamics, but a perfect analogy does not exist. This is not the von Neumann entropy in units of Boltzmann constant. Still, it is a density of the complex entropy concept based on Fisher (real) and Shannon (imaginary components) [76]. It characterizes the space-temporal distribution of the electron ensemble is assumed to generate a degree of order and chaos in the background space associated with the molecular wavefunction. This is characterized by $\mathrm{S_Q}$ which is positive and negative, describing the balance of the information flows, in which negative $\mathrm{S_Q}$ denotes information [77], that is, information (theoretic) entropy (a measure of measure of the uncertainty of data in an 'information channel') via *Brillouin's negentropy principle of information* [78,79], essentially equivalent to thermal entropy [50,68]. Note: Dimensionality in the transduction process is not conserved.

Equation (9) describes the spatial-temporal distribution of the ensemble assumed to generate a modification and, thus, a degree of 'order' of the spontaneous information-entropy characterized by Eqn (10). The first term on the RHS of Eqn. (9) is viewed as the 'corrector' of the kinetic energy term, and the second term on the RHS influences the classical potential energy term U. The kinetic energy becomes $\frac{1}{2\mathrm{m}}(\nabla \mathrm{S})^2 - \frac{\gamma^2}{2\mathrm{m}}[\nabla \mathrm{S_Q}]^2$ and the classical potential energy becomes $\mathrm{U} + \frac{\gamma^2}{2\mathrm{m}}\nabla^2 \mathrm{S_Q}$. This implies that the kinetic energy of the ensemble of electron distributions via phase differences contains a negentropic term $\frac{\gamma^2}{2\mathrm{m}}[\nabla \mathrm{S_Q}]^2$ that is related to gain in intrinsic information. Internal energies reflect nonlocal correlations of phase differences, resulting in energy exchange from potential to kinetic energy.

Environmental perturbations might obfuscate the standard virial relations of pioneering quantum chemistry between the kinetic and the potential energy. This energy transition defines the information-based action due to the 'gain' of intrinsic information, a neuropsychodynamic mechanism related to a partially holistic molecule [46]. The information of partially holistic molecules refers to the action of giving form to partially holistic molecules. Intrinsic Information is defined through the semiquantum potential energy that gives form to partially holistic molecules. The notion of form in quantum potential chemistry [59] can be intrinsic information through *molecular holism* [46]. The intrinsic information is transduced through *Brillouin's negentropic principle of information* [78,79] as negentropic action. The latter is the flow of $\mathrm{Q_{sq}}$ through a repulsive force due to the negentropically derived semiquantum potential, guiding the molecular orbitals of delocalized π-electrons. The passage of intrinsic information, which is the $\mathrm{Q_{sq}}$ that gives form to partially holistic molecules, is through "*negentropic force*" $(-\nabla \mathrm{Q_{sq}})$.

Intrinsic information is Fisher's information that relies on uncertainty and, at the fundamental level, comprises negentropic influences that carry microfeels of meanings that comprise semantic information at a large scale. This latter process involves the capacity of negentropically interconnected partially holistic molecules to mutually affect, i.e., in-form, each other. This is the basis of negentropic entanglement. Negentropic entanglement gives form by realizing long-

range phase coherency associated with phase differences of dipole-bound electron oscillations. This different quantum entanglement process exists spontaneously in the brain's environment between evanescent meanings—a labile process of formation occurs when negentropic gain balances entropy production and produces Fisher's information (dimensionless) from constrained energy release, dependent on thermo-quantum internal energy representing the mesoscopic aggregated effect of the microscopic random thermal fluctuations:

$$\text{Fisher's Information (FI)} = \langle Q_{sq} \rangle - S_Q \qquad (11)$$

where $\langle Q_{sq} \rangle$ is the expectation value (dimensionless) of the semiquantum potential $\propto$ FI (Fisher information [80]) with $S_Q > 0$ (since $0 < \rho < 1$) is the dimensionless quantum entropy, and $-S_Q$ in Eqn (11) means long range phase coherence will spontaneously increase quantum potentiality and functions as an "integrator" of non-integrated intrinsic information through a 'negentropic force': $f_{S_Q} = -\nabla Q_{sq}$ underlying nonlocal holonomy in partially holistic molecules. Note: energy is transferred in discrete jumps or 'quanta.' In a more exact formulation, these jumps are resonance structures breaking away from the continuum.

Partially holistic molecules are sectors of molecules that are influenced by nonlocal holonomy that carry 'meaning' through negentropic action. $f_{S_Q} = -\nabla Q_{sq} = 0$ implies phase incoherency of the oscillating molecular dipole-bound electrons. The molecular orbital of delocalized electrons is neither particles nor waves but particle waves following de Broglie's wave theory [81]. The free energy of de Broglie's hidden thermodynamics provides constraints for negentropic gains in the steady-state situation, leading to *inherent meaning.* The negentropic gain is $\langle Q_{sq} \rangle - S_Q > 0$ has a secondary role in conveying so-called evanescent meaning. The latter can never be definite, for the meaning must be continuously qualified.

The reference to 'meaning' alludes to semantics as conveyors of evanescent meaning, and the word 'informs' alludes to concealed motion on account of the negentropic term $\frac{\gamma^2}{2m}\nabla^2 S_Q$ canceling the classical potential energy $U = -\frac{\gamma^2}{2m}\nabla^2 S_Q$. The negentropically derived semiquantum potential energy (Q_{sq}) represents the mesoscopic aggregate of the micros-microscopic random thermo-quantum fluctuations. The negentropically derived 'quantum force': ($-\nabla Q_{sq}$) guides thermo-quantal fluctuations of an ensemble of dipole-bound electron distributions through their phase differences.

$$f_{S_Q} \rightarrow \textit{ concealed motion acts on KE + gives form 'meaning' through PE} \qquad (12)$$

Here the kinetic energy (KE) of the dipole-bound delocalized band of electron states is acted upon nonlocally due to the concealed internal energy motion resulting in a gain of intrinsic information where the semiquantum potential energy (PE) is the carrier of *inherent meaning.*

Expressing free energy in terms of $\langle Q_{sq} \rangle$ as a random variable indicated by Eqn (11), it should be mentioned this randomness originates from quantum thermal fusion. The quantum thermal fusion that imparts thermo-qubits for communication is not a dual aspect – it is an irreducible correlation process beginning at the fundamental microscopic level and does not separate (classical and non-classical) information in the real- and imaginary parts of the Nalewajski [76] complex entropy. This leads to the idea that non-classical entropy and Fisher information originate from the dissipative quantum potential in space-time [82]. In other words, Fisher's information represents the smear of possible experiences in the brain as an approximation to the Shannon formalism in [9,15].

It is essential to regard the semiquantum potential energy as internal energy because it has no external source [54]. However, we define the semiquantum potential energy to be thermo-quantum internal energy, representing the mesoscopic aggregated effect of the microscopic random thermo-quantum fluctuations. The origin of thermo-quantum fluctuations can be thought of as the movement of semiquantum potential energy rather than kinetic energy due to the large fluctuations that emerge from the constant jiggling of neighboring atoms in a warm environment of the brain. The real component for Q_{sq} is temporally positive and negative in amplitude. This signifies how the internal energy is redistributed between the kinetic energy (negative values) and potential energy (positive values). Thermo-quantum internal energy is a somewhat strange concept. However, we note that under the de Broglie guiding equation, the microscopic thermal motion or fluctuation is represented by the imaginary part of the thermo-quantum internal energy.

In other words, the given change from the average phase differences is relatively insignificant because the imaginary part is quite small. The minuscule size of the imaginary part indicates a unique pattern that is not periodic but chaotic that reflects the movement of the phase differences from their average values. The chaotic waveform resembles a characteristic pattern ("consciousness code") that may have an informational content reflected in the movement of the phase coherence. Phase differences are not constant, implying no long-range coherence necessary for stability for the unitary binding of physical feelings in the consciousness code [50]. This observation, however, hides a deeper nexus as the biological environment is characterized by thermal timescales many orders of magnitude faster than the neuronal timescales typically on the microsecond level. As a result, energetic processes associated with the latter are much, often an order of magnitude, smaller than the thermal noise. For more details regarding the decoherence problem, see [15, 44].

The dipolar-bound orbitals' delocalization enhances electron-electron's mobility where incoherency is necessary (i.e., phase coherency) for the information-based (negentropic) action, resulting in a 'negentropic force': [16]. Importantly, mesoscopic 'long-range order' in brains exists only in the absence of classical potential energy [50]. Therefore, the semiquantum potential energy cannot emerge classically as phase coherence has been demonstrated without the classical potential energy. In other words, the semiquantum potential energy balances the 'long-range' coherency associated with the phase differences of dipole-bound electron oscillations. The absence of classical potential energy triggers coherence correlated phase differences manifested by an ensemble of the pilot-wave force (f_{Q}) [83].

Our theory posits that nonlocal holonomy results from negentropic entanglement of nonintegrated information through the 'negentropic force'. Therefore, there can be no "spooky action," and nonlocal holonomy in brains is through negentropic entanglement. The nonintegrated information juxtaposes several mechanisms on the quantum / classical regime boundary. Nonlocal holonomy invokes an interplay between thermal ordering and structural discontinuities induced through information-based (negentropic) action. This essentially leaves the possibility for nonlocal holonomy and negentropic action to be associated with the metamorphosis of consciousness process arising from the delocalization of electronic signaling in hydrophobic regions of neuronal membranes, proteinaceous structures of the microstructure and its continuation through protein-protein interactions across the cortical regions, including subcortical regions like hippocampus and thalamus.

Intrinsic information is active and has an associative action. It can be assumed to be spontaneous potentiality. Patterns forming spontaneously reduce entropy and create 'information flow'. Intrinsic information is a carrier of uncertainty where "quanta of information" is minimum uncertainty and a measure of causal capacity. It is a bridge to causality (conscious experience). The semantic aspects of information are ignored in Turing computation. Hence the *act of observation* can be measured by entropy deficiency or information distance' between Fisher and Shannon. This provides a measure of an information resemblance between two types of patterns: Fisher and Shannon information flow. Fisher information is an information measure that reflects the overall 'order' or 'sharpness' of the pattern as carrying information. Shannon information reflects a measure of uncertainty or 'disorder', while Fisher information provides a measure of its narrowness or 'order'. Shannon information probes an average measure, cf. the concept of entropy, over a large domain.

In contrast, Fisher's information provides a local measure of the distribution or sharpness of inhomogeneity, cf. the deviation from a given distribution. Distributed processes like Shannon information are non-structural; localized processes like Fisher information are structured and comprise information structure in the brain. The information structure is in the spectral domain as a sinusoid, which enables rapidly finding correlations by harmonizing one pattern with another. In the brain, interference patterns may result in scales of matching patterns. This is known as physical feelings, and consciousness is the actualization of physical feelings by the *act of observation*. This happens at the moment when consciousness begins that includes Fisher's information as a smear of possible experiences related to negentropic gain becoming related to Shannon's information in a steady-state situation. This is accomplished in the brain by reducing uncertainty through memory formation as nonlocal [84].

Intrinsic information performs under steady-state conditions, i.e., it does not generate any changes in the total entropy. Negentropy is produced at the expense of producing entropy elsewhere when intrinsic information is not transferred if intrinsic information is

nonintegrated. We have associated negentropy with the Fisher information as the difference between equilibrium and a given nonequilibrium organization. In comparison, Shannon's information-theoretic concept, Eqn. (11) formulates a balance between entropy production and negentropic gain, the latter attaining self-organization. For instance, in [26], 'qualia' are associated with informational descriptors made up of entropy gains matching the exported entropy production. The information accrued corresponds to a lower thermodynamic entropy, which becomes negentropy /order. Consequently, since entropy usually is associated with noise, i.e., implies random thermal motion of atomic and molecular constituents, its decrease will create a holistic molecular organization [46], i.e., 'order'. Indeed, meaningful information is semantic [42], so it will be necessary to understand better the content of consciousness by identifying the informational structure.

5. Concrescence of holons as informational structures in phase-space

We intend to create an 'internal model' of intrinsic information that entails qualitative experience via energy transformations and internal energy processing involving long-range correlations, ODLCI, as materialized by in-phase perturbations of the delocalized electrons forming instantaneous dipoles sensitive to quantum thermal fluctuations in unsaturated fatty acids (e.g., docosahexaenoic acid, arachidonic acid etc.). It is further suggested that such partial holistic coherency results in protophenomenal properties in *amphiphilic* biomolecules, exhibiting both polar/hydrophilic and nonpolar/hydrophobic regions, such as lipid membranes, proteins, and nucleic acids. At the most fundamental level, the preconscious experienceabilities transcend spontaneous potentiality as evanescent meaning and hence only at the "boundaries" [41].

This epitome exemplifies how boundary conditions constrain energy release, resulting in delayed entropy. Change to boundary conditions carries intrinsic information invoking energy transformations, suggesting that physical feelings should be related to the *long-range order* of the actualized phase coherency. The (semi)quantum potential energy carried in molecules (cf. [59]) is the kinetic energy of concealed motion associated with molecules. Kinetic energy is the energy of motion or the capacity to cause the movement of molecules. Concealed motion changes the boundary conditions. Parts of the molecules are partially holistic with a specific semiquantum potential that keeps them together by balancing the classical energy (Coulombic force).

What is the physicalistic understanding of feelings in the brain? Qualitative physical processes are information-based actions without force-based interaction. Hameroff [85] has shown that anesthesia prevents conformational dynamics suggesting an indirect causal link between delocalized π bonds in functional molecules and their interaction through London dispersion forces [86]. In other words, anesthesia increases uncertainty in the brain to a stage where intrinsic information is completely removed. The phase differences of delocalized electrons act as an integrator of intrinsic information equivalent to 'uncertainty in the brain' but at a higher level. This suggests that the process of subjectification is disrupted at the boundary between the classical system where conscious cognition is found and the quantum subsystem where intrinsic information is found. This can be interpreted as the brain's overwhelming uncertainty or ambiguity (see **Fig**. 2).

The quantum mechanics of spontaneous creation of consciousness is from the brains' spontaneous potentiality. The process of consciousness is no longer capable of continuing as spontaneous potentiality. As a formative cause of the consciousness process, spontaneous potentiality is the semiquantum potential energy that realizes *inherent meaning* through the 'negentropic force'. The resultant information-based (negentropic) action actualizes intrinsic informational patterns as physical feelings. The 'negentropic force'-driven molecular embedded raw microfeels of nonintegrated intrinsic information become actualized as evanescent meaning leading to preconscious experienceabilities. The mind's evanescent meaning is fostered in the brain's spontaneous potentiality as concrescences of physical feelings. In the preconscious pathway leading to cognitive consciousness, we see transcription factors for gene expression of protein-protein interactions [19] playing a role in global consciousness through transduction of energy in extramembraneous proteins as the scanning mechanism is an integral part of the consciousness process. Therefore, they are constituents of nonintegrated information and must be stored in memory. Consequently, making it possible for conscious experience to form by processes of evolved 'Shannon' information in conscious cognition.

However, there is no conscious cognition without recognition, so conscious recall arises instead of memory, and only in the presence of 'uncertainty' is memory reconsolidated [87]. Thus, memory must be a way of compensating for partial information. This

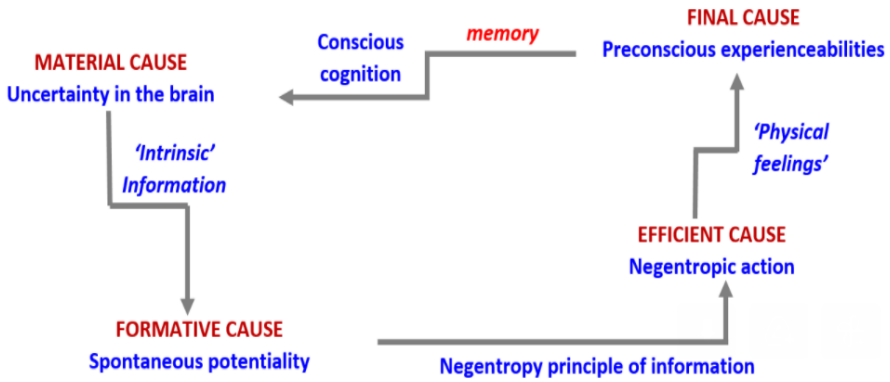

Fig. 2. *Aristotelian fundamental causes of the subjectification process as a relational holon. The causes are integrated, so no infinite regress is associated with the first and final cause. Spontaneous potentiality via the negentropy principle establishes the potential existence as a formal cause in nonlocal contextual potentials (semiquantum potential energy). Intrinsic information transcends both the contextual (potential) and the realized (actual) aspects of consciousness's causal explanation. Note that the holon's closure requires conscious cognition, and therefore, 'uncertainty' must be in the brain in liaison with higher-order cognitive functions, including memory. The closure of the holon at the nexus between the subjectification process and its expression via conscious cognition is bidirectional since uncertainty in the brain supervenes on the lower-level intrinsic information.* One can also think of 'uncertainty' arising from intrinsic/internal information response.

compensatory mechanism is broadly defined as "uncertainty" [87]. In other words, consciousness and memory formation must be intimately linked [88, 89]. Memory after consciousness requires the end of consciousness and the beginning of memory, suggesting an illusion [90]. However, the sequence of pre-consciousness to post-consciousness is not an illusion when building the neurobiology of semantics that links to syntactical rules. The content of consciousness is a meaningful aspect of the whole, arising in cognition as neural correlates of consciousness. The analytical approach we have taken brings to the fore the mechanism of consciousness as an elaborate composition of inter-related meanings we have defined as physical feelings. Consciousness has no content or form that can be represented with syntactical representations because consciousness is relational. When examined by direct introspection, it appears changeless and unfindable. However, through semantics, the consciousness process comes to fruition with the *feeling-as-information hypothesis* that symbolizes the content of consciousness.

Classical information theory measures the decrease in uncertainty, for example, when consciousness ends, and memory begins. This Shannon information is not intrinsic but environmentally influenced. The spontaneous potentialities involve the information-based (negentropic) action of negentropic entanglement predetermined by the transformation of internal energy as a concealed motion of the classical system, which is, by definition, an "affective drive" [1]. The '*affective drive*' is a disturbance in the internal system resulting in interference effects enhancing the underlying mean-field approximation and extend its range of applicability by enabling to capture electronic decoherence [91]. We say that the consciousness mechanism is not cognitive, i.e., (1) brain-based consciousness uses integrated information theory. Instead, we claim that the consciousness mechanism is (2) cell-based consciousness that uses a variety of energy-transduction processes. The difference is that in (2), the process underlying consciousness, the so-called "affective drive," is across scale, is based on energy-transductive processes, while in (1), the "affective drive" is across the brain regions (or brain states), issuing a higher-level theory of consciousness.

Computational functionalists eliminate the mind and treat the brain as an extensive neural network where experience emerges from the paths of neuronal connections. The "affective drive" is across the metacognition brain regions (or brain states). This meta-cognitivist approach is an oversimplification because it suggests that spiking is the signal that enables consciousness from the upper brain stem (reticular nuclei) to the cortex. If correct, consciousness flowing in neural networks must be correlates of consciousness visible through brain imaging. Hence consciousness is not intrinsic to the cortex and is actualized from subcortical structures. This fits in well with the Freudian conceptualization of consciousness as different from the medical definition of self-awareness and more inclined to be subconscious and unconscious. However, any lesions here obliterate consciousness, not because cons-

ciousness originates here but because consciousness cannot be enabled without proteinaceous structures that rely on chemical reactions or biochemical energy (ATP).

The Freudian concept can still work at a deep level and not necessarily subcortically. The meta-cognitivist approach that claims consciousness to be dependent on different neural networks simplifies the brain's biophysical picture by ignoring various transduction processes across a scale that leads to the nonintegrated intrinsic information—for example, energy transduction in membrane proteins and many others. At a molecular level, enzymatic cascades break off covalent bonds, increasing classical potential energy that contributes to preconscious pathways and the semiquantum potential energy. We suggest that this is through the transduction of potential energy as concealed motion, where the resultant kinetic energy carries evanescent meanings due to the transformation of energy from potential to kinetic energy. This transformation of energy is due to the 'gain' of intrinsic information. Transduction processes enzymatic cascades result in partially holistic molecules induced by the instantaneous dipoles in amino acids of lipophilic proteins

We claim that the subjectification process has information-based (negentropic) action of negentropic entanglement occurring through partial holistic coherency of molecules. This process occurs in discrete epochs generating intrinsic information in informational holons that become actualized in an informational holarchy. Intrinsic information is wholly entailed by potentialities arising from the energy transformation. Informational holons we call raw microfeels, are objective at the fundamental level. They are needed to carry an evanescent meaning of actualized physical feelings upon concrescence in phase-space (frequency space or in the resonant vibration space).

How is the intrinsic information communicated as evanescent meaning, and how would it have actualized physical feelings? The brain is an open many-body system with changeable boundary conditions. This implies that constrained energy release carries information-based action. The constrained energy release is nonlocal in the quantum potential chemistry framework [59]. It refers to the intrinsic information energy anticipated by cognitive, physical systems, i.e., there is a semiquantum regime in the classical system (cognitive) that is coupled nonadiabatically to a quantum communicated as *evanescent meaning* through the internal energy's concealed motion [64, 92]. The evanescent meaning a subjective observer extracts from the pattern or sequence corresponds to physical feelings ready to convey an intimate connection to cognition and, through memory, to become a conscious experience. Still, physical feelings are intrinsically informational, occurring without any cognitive influence based on information-based action [93] in an informational holarchy [35].

Here energy transformation arises at the boundaries of holons/holarchies (boundary conditions). Boundary conditions constrain the release of energy in nonequilibrium processes such that thermodynamic work is done—the constrained release of energy delays entropy production. When more work is done in a more constrained release of energy in nonequilibrium processes, entropy production is delayed, allowing the entropic disorder to be rapidly transferred to the environment [41]. This transfer decreases entropy, and changeable boundary conditions carry information resulting in a gain in intrinsic information as negentropy. Open dissipative structures that do not construct their boundary conditions do not exhibit negentropy. The animate matter in organisms constructs their boundary conditions in terms of qualitative aspects through self-organization [94]. Animate matter, e.g., regarding brains, is called "*panexperiential matter*" [15]. It differs from all other matter in constructing and reconstructing boundary conditions that lead to gain in intrinsic information. The physicochemical substrates are enzymatic proteins in membrane proteins (see next section).

According to [5], physical feelings at the microscopic level are barely known and must be thoroughly elucidated if consciousness is fully understood. However, physical feelings are not an isolated waveform pattern but a sum of many waveforms, perturbed by quantum-thermal fluctuations and entrained through information-based action in an informational loop of interconnected nonintegrated information. Although the thermal fluctuations might 'swallow' quantum entanglement in spin systems, i.e., it would be eliminated because of its small magnitude, the internal thermo-quantum energy does invoke negentropic entanglement spontaneously.

The unilateral action without the lower holon's interaction affects the higher holon within the holarchy (see **Fig**. 3). Not only is the evanescent meaning of the whole determined by the inherent meaning of the parts, but the nature of the parts is determined by the whole defining a holarchy. Our use of 'holarchy' refers to sys-

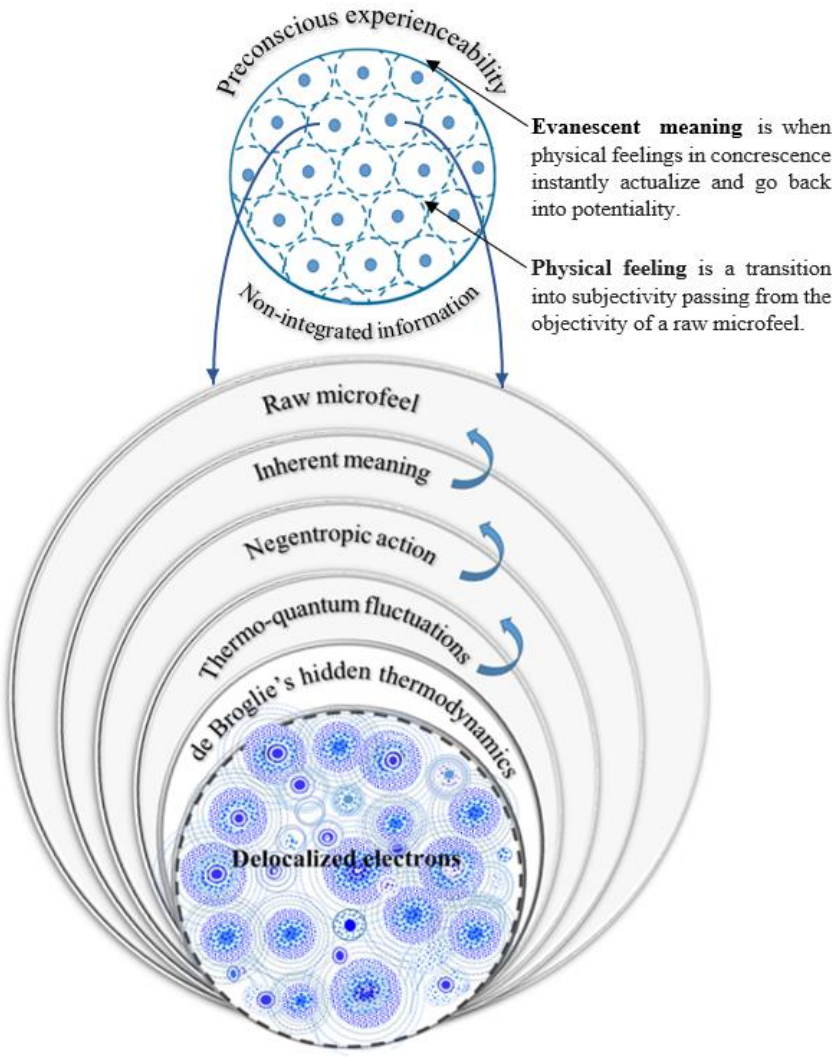

Fig. 3 *A descriptive illustration of 'information structure' in the spectral domain as a holarchy that stems from delocalization in partially holistic molecules. The holarchical structure connotes changeable boundary conditions atypical in aromatic residues in amino acids. Self-referential internal energy processing leads to the instantiation of objective raw atomic microfeel in a holon as a quantum of information (bottom). The constrained release of energy results in delayed entropy and its eventual elimination of the environment. It defines preconscious experienceability as a decrease in entropy or 'gain' of intrinsic information (negentropy), occurring in interconnected informational loops originating from the delocalized electron ensembles, leading to physical feelings actualization as an ensemble of such quanta (top). Intrinsic information is the phase differences between delocalized electron ensembles that are nonintegrated and incoherent. The informational holarchy of physical feelings functions as an integrated whole of each individual or quasi-autonomous holons. The incoherency is necessary for the information-based (negentropic) action that results in a 'negentropic force.' The ongoing' negentropic force' acts as an agent of negentropic entanglement. The information-based (negentropic) action originates from delocalized electron ensembles (the primary constituency of panexperiential matter) as Fisher's information (blue arrows). In holism, the holarchy is a relational ordering of holons comprising quanta of information which is a phase-space consisting of de Broglie's 'hidden' thermodynamics, thermo-quantum fluctuations, and inherent meaning resulting from information-based (negentropic) action. It is also worth pointing out that Fisher's information is not Shannon information but intrinsic information-carrying evanescent meaning. Fisher's information is the 'internal' or intrinsic information, and Shannon's information is the 'external' sensory information. These two types of information do not combine and are nonintegrated but interact when consciousness ends and memory begins.*

tems where its parts govern the 'whole'. The term 'holarchy' was originally defined by Koestler [95] as a particular type of hierarchical organization made of individual holons. Holons are parts of a more extensive system and simultaneously individual 'wholes'. Observed from 'lower' levels - a holon will look like a whole, while observed from 'higher' levels - it will look like a part. Unlike hierarchies, holarchies are created by 'bottom-up' processes. Here, informational relationalism between holons at a 'low' level defines the higher level. The manifestation of new properties in a holarchy is not found in lower-level holons.

Physical feelings that are not felt are not an oxymoron because the informational structure cannot be felt until actualized in conscious experiences. The 'information structure' is in the spectral domain as a sinusoid that enables correlations to be identified as a *quantum of information* in which waveforms are constrained by the Dirac delta function in time or space to represent the minimum uncertainty of not being "felt." An ensemble of such quanta is a phase-space or Hilbert Space, and "quanta of information" are the Whiteheadian "microfeels" that we propose to be molecular-embedded microfeels as physical feelings (see **Fig**.3).

Preconscious experienceability entails a process of actualization that is information-based action. More importantly, intrinsic information transfers across the nested holarchies of discrete raw microfeels as epochs originating from the molecular orbital of delocalized (nonlocalized) π-electrons. Intrinsic information embodies the information-driven interaction where energy is provided from within. Its evanescent meaning arises from changes in the boundary conditions of a many-body system like the brain [41]. The holarchic organization of information is the basic unit of the capacity for experience in the preconscious, embedded in larger wholes (see **Fig**. 3). They are influenced by and, at the same time, influence these larger wholes. Nonintegrated informational loops of preconscious experienceabilities are crucial before self-awareness and perception [2]. What is not in the focus of consciousness is not consciously experienced. Still, many preconscious experienceabilities are present beyond 'focus.' Preconscious experienceabilities are a portal through which raw microfeels in concrescence become conscious. If physical feelings are outside of preconscious experienceabilities, they are not within awareness and are not conscious [2].

What are the necessary conditions for information-based action instantiating preconscious experienceability? Preconscious experienceabilities are mostly objective "off" ('potential state') in brains, only subjective and "on" in partial conscious experiences (actualized). The Subconscious is the level just below the conscious level, where dynamical informational structures are in a "potential state." What are epochs' "potential state" conditions governing the "off" stage in instantiating preconscious experienceabilities? This needs to be understood as a two-stage process. First, the semiquantum potential energy from the energy transformation through intrinsic information gain creates incoherency or entropy production, which is necessary for balancing the negentropic action that results in a 'negentropic force' [15]. The second stage is macroscopic 'long-range order' that exists only in the absence of classical potential energy, a form of coherence in phase differences [50]. This negentropic entanglement allows for the consciousness process to be attained [83] and the communication activity to proceed [9,15,44].

6. Capacity of feeling through molecular holism

This section defines the functional loci at the fundamental level in the brain where preconscious experienceabilities arise across lipophilic and hydrophilic domains of membrane proteins through *molecular holism* [46]. The process starts with quantum potential chemistry, where the neuronal cell membrane's quantum integrity defines the lipophilic domains, which are hydrophobic and nonpolar. These subtle electronic potential energies are amplified within the millisecond range in the hydrophilic domain due to covalent modifications of membrane proteins. These modifications via lipophilic proteins (not enzymes) transfer electrons due to enzymatic reactions in hydrophilic proteins [96, 97]. Such covalent modifications might also be another possible explanation for physical action in the brain via self-references.

According to [98], unsaturated fatty acids containing double carbon bonds exhibit coherence through conjugated bonds that form delocalized orbitals, enhancing the mobility of electrons in hydrophobic membrane regions. Conjugated bonds are the locations of delocalized electrons across phospholipids. Thermally activated electron transfer is a two-step process involving negentropic entanglement in the lipophilic domains and enzyme-catalyzed reactions in the membrane proteins' hydrophilic domains.

Intramembrane proteases are enzymes that have the property of breaking up transmembrane domains of integral membrane proteins. Intramembrane proteases have catalytic sites located within the transmembrane helices and form an aqueous environment within the hydrophobic lipid bilayer, with both polar and nonpolar amino acids. However, enzymatic reactions occur with catalytic sites in the hydrophilic part of the integral membrane.

We hypothesize that the actualization process occurs in membrane proteins at the lipophilic domain within hydrophobic regions but not in the ligand-gated ion channels. A unique mechanism for actualization must be presupposed, in all likelihood probably substantially similar for all physical feelings. Even though it evolved through nature, each epoch has an inherent meaning or intrinsic informational content. We suggest molecular dipoles possessing Coulombic attraction force interacting with delocalized electrons 'quantum force' by information-based guidance wave forces and quantum-thermal fluctuations, such as 'negentropic force', yield a force balance responsible for establishing a steady-state of molecules and providing the actualization of physical feelings in nonpolar regions. Their interaction is still possible with a structural rearrangement of charges and currents without energy absorption and entropy modification. Thus, no average value changes. Therefore, if the actualization process is to be identified, it can only be in nonpolar molecules as the charge could dramatically affect the sentient nature of the interaction as well as invaliding Eqn (1).

The evanescent meanings are labile and spontaneous. They are an altered representation of the coherent phase differences via amino acids in lipophilic proteins. Overall, London forces are the only intermolecular bonds in nonpolar molecules. This leads to lipophilic membrane proteins' domains comprising mainly partially holistic molecules. Here holistic is defined as *the e*ncoding of phase relations between delocalized electrons where parts of molecules are partially holistic with a specific semiquantum potential energy that keeps it together by balancing the classical potential energy [46]. The holonomic effects stem from the intrinsic evolution of the quantum states, i.e., thermo-quantum fluctuations [99].

The evanescent meanings enter cognition by chemical reactions. The metabolic chemical reactions require oxidation involving enzymatic cascades, which results in partially holistic molecules. The requirement for a steady-state in connection with the equilibrium of molecular open systems ensures nonintegrated information and minimizes entropy production. This requires a finer grain of energy processing and, in addition, London forces where quantum force interacts with Coulombic attraction force to yield force balance responsible for establishing the brain's spontaneous potentiality as the base of the unconscious mind.

The unconscious mind is whe**r**e physical feelings comprise the brain's spontaneous potentiality outside of conscious awareness. Here physical feelings are borne from the brain's spontaneous potentiality involving internal energy processing. The conscious mind expresses physical feelings in cognition through evanescent meanings. One might ask how preconscious experienceabilities are possible given the enormous numbers of discrete physical feelings without an integration process? Here experienceability refers to our capacity for conscious experiences proceeding from objectivity to subjectivity in all spectra of physical feelings. For example, a self-similar fractal-like informational structure is the foundation of energy dissipation in vortices, in which the constrained energy processing forms an informational fractal that is turbulent, therefore possessing infinite degrees of freedom. This informational structure might explain the process from objectivity to subjectivity. However, while [100] suggests that it is through synchronous oscillations found in the microtubules of neurons, we propose a more detailed process, in agreement with Mandell [101] intermittent turbulent magnetic fields, i.e., intermittent vortices may constitute the physical constituency of a process from, objectivity to subjectivity.

EM vortex fields are not EM waves but intrinsic brain magnetic fields emanating from the vortex core within the membrane phospholipids of neurons that guide molecular 'energy' transduction both inside and outside of neurons via microstructure and protein-protein interactions, respectively. Brain magnetic fields' global and local nature depends on space and length scales. The core of the magnetic vortex originates in membrane phospholipids of neurons locally. The global dynamic is when the core 'opens up' and becomes a magnetic field that is gauge invariant. Hence, the 'mixing' of magnetic field lines is possible and can also lead to harmonization. Intrinsic EM fields set up aromatic residues in amino acids at the ligand-receptor junction, protein-protein interactions in the extracellular domain and microstructure of subnetworks of large assemblies of neurons harmo-

nize endogenous EM fields, resulting in nonuniform EM field, therefore, allowing for energy to be guided in nonhomogeneous EM fields. In particular, cellular signaling intercellular extra-membranous protein-protein interactions allow for continuous communication conveying information by changing boundary conditions, ambiently compatible, associated with intermittent compatible dispersion interactions between extramembrane proteins and water-soluble proteins [102].

Now proteins bind to each other through a combination of hydrophobic bonding, van der Waals forces, and salt bridges at specific binding domains on each protein. These domains can be small binding clefts or large surfaces and can be just a few peptides long or span hundreds of amino acids. The size of the binding domain influences the strength of the binding. This involves a nonbonding electron, i.e., a valence electron in an atom that does not bond with other atoms. The term refers to a nonbonding orbital where the π-electron is delocalized throughout a molecule (see **Fig.** 4). Phase differences of delocalized energy states are assumed to be found in the hydrophobic regions of lipid membranes in chains of membrane phospholipids within unsaturated fatty acids containing double carbon bonds in the hydrophobic areas. Hydrophobic domains of membrane phospholipids need to be isolated from ionic activity to prevent hydration. For example, the polar head of phospholipids is immersed in water resulting in regions where molecular ions participate in conformational energy maps (cf., [103]). Note that hydrophobic lipids self-assemble in an aqueous environment.

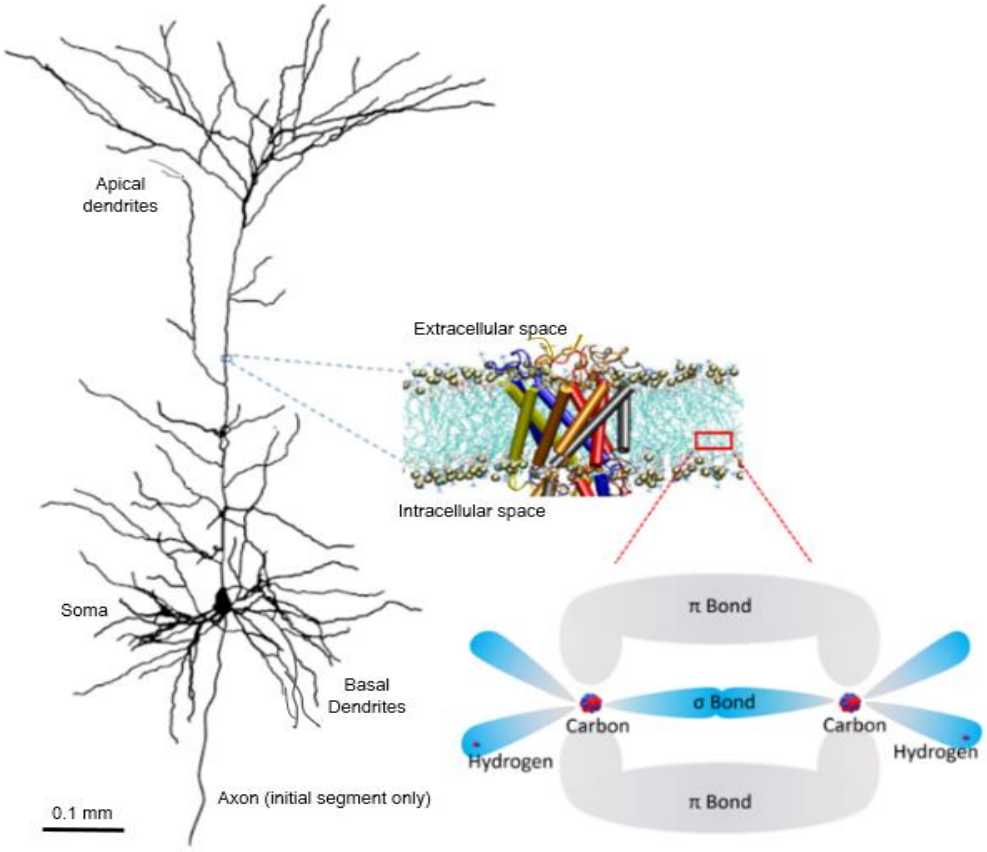

Fig. 4 *A schematic illustration of pyramidal neurons showing an enlargement of the interior of a membrane. The effect of conjugated bonds forms delocalized orbitals enhancing the mobility of electrons in chains of membrane phospholipids in unsaturated fatty acids containing double carbon bonds within the hydrophobic areas of many molecular dipoles within the hydrophobic regions of membrane phospholipids, comprising many homologs phase-differences each an information-based action under the influence of 'quantum force' interacting with Coulombic attractions force to yield a force balance responsible for establishing steady-state of molecules. The lipophilic proteins are embedded/integrated into membrane lipids via London forces to the phospholipid's hydrophobic sections. The membrane comprises lipid structures such as arachidonic acids 2nm in length interposed with ionic channel pores of 1-2 nm across the lipid bilayer 4nm in length. The arachidonic acid biomolecular structure is further enlarged, showing its subsection. The inset shows the double carbon-carbon bond's molecular orbital configuration (R-CH=CH-R), where R = extension of this biomolecule. The double carbon bond consists of one π bond and one σ bond: Grey = π bond formed from p orbitals of each carbon (carbon typically has 3 sp2 orbitals and 1 p orbital perpendicular to the plane). The σ bond (blue) is due to the overlap between two sp2 orbitals. Hydrogen is bonded to carbon via σ bonds (sp2 hybridization).* (Source: Adapted from [104]).

Many studies point to systems-level anesthetic effects like dendritic spiking in the anesthetic suppression of consciousness (see, e.g., [105,106]) but claim anesthetic disruption of corticocortical top-down connectivity is not a direct mechanism. To elucidate the associated physical mechanism, one must determine the most miniature scale of consciousness loss under natural circumstances. In other words, one should not claim that the mechanism constitutes the common final pathway via which each and every anesthetic agent induces unconsciousness. Further steps such as enhancing electron mobility for increasing protein conformation energy and entropy may be needed since enhancing electron mobility is a conscious cognition [85].

Hameroff [85] has reduced the analysis to protein conformation examinations via confluences of London forces, but this valuable exploration needs a deeper final stage to be sought. This hypothesis supports consciousness loss during anesthetic drugs, evidently affecting the London forces. Is protein-protein interaction a bridge from delocalization to the unity of consciousness? Some quantum consciousness theories make this misguided argument for the unity of consciousness based on quantum holism [107], which refers to a unified whole where a singular wave function governs all the particles affected instantaneously. We avoid this trap and refer to partially holistic molecules in *molecular holism* [46].

We claim, however, that the guidance waves do so *in situ*. In nonpolar regions, enzymatic reactions are not taking place. Anesthetic gases break up the dispersion forces so that preconscious experienceabilities do not reach conscious awareness, but London dispersion forces *per se* are not information-based. So, the mechanism of preconscious experienceabilities is not associated with an anesthetic agent but through the transduction of the energy in membrane proteins [108] and the transcription factors for gene expression of protein-protein interactions [19].

The receptor-ligand complex results in molecular energy transduction through the EM field generated by mostly aromatic residues in all biochemical receptor-ligand systems [109]. These residues acquire a synchronized effect due to an interconnection produced by the EM field between amino acids in the protein. Molecular transduction in the receptor-ligand complex includes pathways through protein-protein interactions in the extracellular domain associated with the magnetic field. In certain regions, an electric charge couples with an opposite charge via (dispersion London forces). This action is immediately replicated across the entire subnetwork generating an EM field within the protein. This is replicated immediately in the intracellular microstructure domain that occurred in the extracellular domain as the ligand was coupled.

Does preconscious experienceability have a gateway to conscious experience? We argue based on the same reasoning that preconscious experienceabilities take shape based on spontaneous potentialities that shape preconscious experienceabilities as conscious experiences by evanescent meanings. How does evanescent meaning influence cognitive function as carried for the unification of consciousness? The concealed motion conveys 'meaning' where preconscious experienceabilities are instantiated as specific patterns of actualized physical feelings. However, what is intended by the concept of preconscious experienceability must always be thought of as being entirely preconscious where physical feelings in concrescences can instantly be actualized due to the 'gain' of intrinsic information and back into potentiality.

7. Molecular-level EM resonances and London forces constrain energy

The CEMI field theory [110] claims that the brain's endogenous EM field integrates information from spiking neurons. The claim is that the EM field generated by moving charges influences the motion of moving charges. Therefore, electrical field interactions between neurons, known as ephaptic interactions, play a functional role in integrating information. But how that integration happens remains unsolved. The brain integrates inputs of many kinds - electromagnetic, mechanical vibration, ionic charge, water, photons, phosphorylation states, and gravitational effects over many scales all contribute to a brain state at any one moment. That state then determines an output. EM field does not integrate information in the brain. The integration is unnecessary as the "glue" needed for combining the information is negentropic entanglement [83].

The CEMI field theory's problem is no evidence that energy flow and information are conscious. For instance, EEG does not reveal physical feelings since the electric field does not carry semantic meaning in space-time. According to semiotics, consciousness is an information-based 'temporal structure' (Pereira Jr, *personal communication*). It is unknown how the CEMI field theory can bind the feeling of meaning-as-information required for consciousness. Here informa-

tion is understood to be patterns of constrained energy. The question is whether constrained energy is EM? The information does not depend on the EM field since the EM field exists without any information produced. Therefore, information is not stored within the EM field, nor is information conveyed by the EM field.

Neuroscience over the last century has mainly been concerned with electrostatic fields in neurons and ignoring *intrinsic magnetism*. This flaw in thinking was changed by the two-brains hypothesis [111]. Here there are two inseparable functional domains: the EM brain and the Electro-ionic brain. An electric field exists only in the absence of delocalization, so there is no EM energy flow. When delocalized electrons (not free carriers) are considered part of the circuit, the intrinsic magnetic field and the electric field coincide, resulting in EM energy flow. The endogenous EM field is due to the movement of ions at the neuronal level. Yet, the intrinsic magnetization that defines the seat of consciousness occurs in the absence of ionic current flow at the molecular level due to molecular-level EM resonances. Neuronally generated EM fields are mostly electrical fields, including ephaptic interactions, while sub-neuronally generated EM fields are nested magnetic fields [112]. A nested hierarchy of EM fields is distributed throughout the cortex [112]. This system of EM fields would harmonize, resulting in a nonhomogeneous EM field that guides molecules while constraining EM energy flow.

Amino acids with resonant side-chain structure (conjugate bonds) include phenylalanine (an amino acid with an aromatic ring), Arginine, tryptophan, tyrosine, serotonin [113] etc., are the molecular basis by which delocalized electrons function in molecules. Energy sharing between various nested EM resonances. This yields EM energy transfer between EM resonances. EM resonances between clouds of delocalized charges where there is collective delocalization of electrons between benzene rings and aromatic residues of amino acids are key to understanding how the brain works at the molecular level [109]. The motion of delocalized electrons in benzene rings and in aromatic residues of amino acids where the velocity is nonconstant due to the nonlinear pathways of delocalization.

A general resonance theory of consciousness is based on resonating frequency (energies) at different physical scales, with resonance as a critical requirement for combining micro-conscious entities with large macro consciousness. The concept of "resonance" here refers to electrons moving throughout the whole molecules (requiring delocalization) with shared vibrations by which rudimentary consciousness is unified [114]. This panpsychist viewpoint leads to a hierarchy of conscious entities failing to explain how all matter is associated with some capacity for consciousness. In contrast to the resonance theory of consciousness [114], delocalized states in molecules are in sectors where enzymes reflect the boundary conditions limiting the molecular wavefunction and creating a partially holistic molecular environment with molecular holonomic effects [115].

The mechanisms leading to consciousness entail the *act of observation*. The dual modes associated with information-based action linked to geometric holonomic effects through the geometric vector potential and the magnetic vector potential as a channel of information for linking to higher activity come together. Whatever belongs together is disclosed within a unity of consciousness. Disparate matches are not mutually exclusive but co-occurrences supporting disunity of content within the unity of consciousness, thereby supporting accounts for clinical phenomena such as Charles Bonnet syndrome, disjunctive agnosia and schizophrenia [16]. EM resonances happen due to energy transitions. Consequently, energy transduction from potential to kinetic as 'concealed' motion may be the source of energy flow guided by EM resonances. However, this is practical at short distances, but EM energy flow across the cortex, likely through protein-protein interactions, is possible over long distances.

John [116] asserts that a specific EM field 'resonates,' leading to the stream of consciousness as a property of these energy distributions. However, *resonance* is limited to conjugated π-bonds in benzene rings found within the amino acids of proteins and microtubules actin. The delocalized electrons in benzene rings form a wavefunction that oscillates back and forth between two possible positions. The three double bonds can be located between carbons 1 and 2, 3 and 4 and 5 and 6 or 2 and 3, 4 and 5 and 6 and 1. These bonds containing two electrons oscillate between these two states and have the same energy. This corresponds to EM waves of a wavelength of 3000 $cm^{-1,}$ which is about 0.35 eV and is in the infrared region of the EM spectrum (hence can be thermally excited). If the electrons are traveling in benzene rings, they oscillate in a circle so that the direction changes and accelerates as the velocity is not constant. In linear pathways, this change in velocity would not occur. As there are no other molecules apart from benzene rings that exhibit delocalization of electrons that travel in a way that mitigates a nonconstant velocity, there is a local magnetic field with the vector magnetic potentials.

Confomational transitions are aided through London forces and invoke geometric vector potential. Conformation transitions are dependent on interactions with London forces. These conformational transitions are responsible for information-based action geometric holonomic effects. Removing the London forces and the transition from objectivity to subjectivity is impossible as the dual modes are not fully bound together due to temporal coordination disrupting consciousness.

The intermolecular adhesion of London forces at the nexus between phospholipids and the lipophilic proteins has a key role in constraining the release of energy resulting in a vast number of neural processes across the cortex under the guidance of quasi-electrostatic fields. We postulate that this EM energy flow is distributed in the cerebral cortex due to microstructure and protein-protein pathways in the extracellular domains that guide the patterns of constrained energy as negentropic entanglement of the encoded consciousness code. However, negentropic entanglement explicitly appears only when there are coherence-correlations within actual phase differences [15], not just by the standard phase coherency but also via partial holistic coherency [46]. The van der Waals energy could increase protein conformational activity (re-arrangement of bonds) [85], causing energy transfer and information in protein-protein interactions across the cerebral cortex through the transduction process.

The magnetic field plays a passive role on the time scale involved in neural activity, i.e., it is driven by an electric field but exerts no controlling influence on the electric field, despite that the magnetic field is time-varying. Instantaneous diffusion of the magnetic field depends on the neuronal size and the time range over which neuronal activity is assumed to act. Conditions under which time changing magnetic field is negligible depends on the dimensionless parameter [117]:

$$\kappa = \sigma\mu_o\mu\, L^2/T \qquad (13)$$

where σ is electrical conductivity, μ_o is the free space permeability, μ is the relative permeability of the medium in resonator, L is the length scale, and T is the time range. For neurons $L=10^{-4}$ m and $T=10^{-1}$ msec, the magnetic field behaves quasistatically. In general, large-scale phenomena are denominated by the magnetic field, while in neuronal activity phenomena, the electric field dominates. This, of course, does not apply to sub-neuronal activity that occurs more rapidly and magnetic field can dominate. This is the EM brain in the two brains hypothesis, where such a hybrid mechanism suggests that 'information flow' is conveyed by energy processing. In the EM brain, the magnetic field dominates at a short time range and in the electro-ionic brain, the electric field dominates at the neuronal level in the msec time range. However, the magnetic field dominates at a large length scale for both neuronal and sub-neuronal activity, i.e., across the whole cortex or globally. Importantly, in the presence of a time-varying magnetic field, the electric field includes a magnetic vector potential **A**, i.e., $\mathbf{E} = -\nabla\varphi + \frac{\partial \mathbf{A}}{\partial t}$ where φ is the electric potential.

To understand how EM resonance arises in the brain, we need to pinpoint the delocalization of electron densities throughout the membrane protein and cytoskeletal structures within the microstructure of neurons (see **Fig**. 5). However, we ignore water molecules containing dynamically coupled electric dipoles associated with essential biomolecules within the cytoplasm (see [118]). The microstructure could resonate as intrinsic information to modulate time [72], resulting in EM effects communicating intrinsic information at the neuronal level. EM resonance should not be confused with the delocalization of aromatic electrons in DNA that would not prevent non-resonance. Therefore, aromaticity does not rule out unconsciousness if the mechanism is based on aromatic electrons in a resonating state, as suggested by Myakishev-Rempel & Savelyev [119].

Microstructure contains a dense meshwork of proteinaceous structures (see **Fig. 5**). Proteins are neutrally charged macromolecules assembled from amino acids using information encoded in genes in a polypeptide chain linked by peptide bonds. At random orientations, the arrangement of charges in some molecules is static when no electric field is present. Still, in the presence of a nonuniform electric field [120], the protein clusters become polarized and separate by orienting the dipole moments of polar molecules that produce permanent dipoles, which attract surface charge densities (so-called bound charge densities), causing a displacement of charge. These bounded charges produce *intracellular capacitive effects* that can contribute to ionic current flow in the electro-ionic brain arising from the dispersion (fluctuation) of free charge by affecting the voltage created by charged surfaces of proteins in the intracellular fluid (see [121]).

Holonomic brain theory [49] considers molecules of high dipole moments located on the dendritic membrane of neurons suggestive of membrane proteins. The enhancement mechanism of many instantaneous dipoles within the hydrophobic regions of membrane phospholipids, comprising many homologs phase-differences, each an information-based action. In the

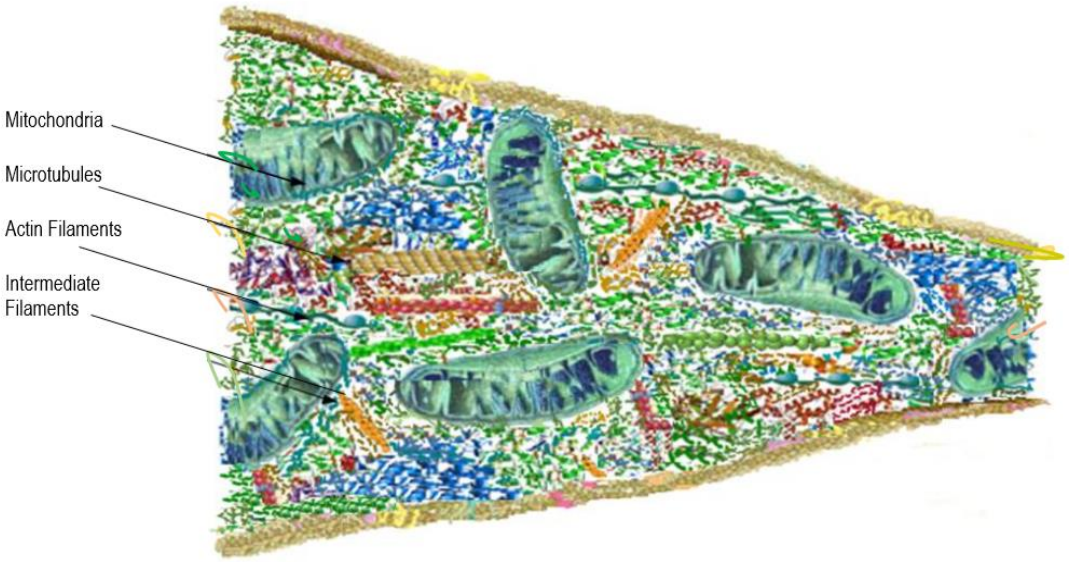

Fig. 5 *A schematic illustration of a longitudinal section of the neuronal branchlet with microstructure showing cytoskeletal proteins and closely compressed accumulated membranous organelles that extend to the distal part of branchlet – interlinking actin filaments, intermediate filaments, and microtubules. The cytoskeleton is a network of connected actin and intermediate filaments and microtubules, including mitochondria in neurons, causing a gradually tapered towards one end or tip. These proteinaceous structures constitute a fissured domain. The mitochondrial membrane is the largest organelle (~0.2 μm) within the cytoskeleton and dominates the constituency of the proteinaceous structures since the endoplasmic reticulum does not enter into branchlets below a micron. Adapted from [121].*

'electromagnetic' brain, there is an interaction between quantum and classical electromagnetic forces (e.g., Coulomb forces that operate in the 'electro-ionic' brain and quantum forces that operate in the 'electromagnetic' brain) in three-dimensional space but describable through nonclassical 'hidden' variables acting on electrons beyond these forces. Such intermittent dispersion interactions depend on a vast array of changeable boundary conditions, thus constraining the release of energy and connecting vast numbers of neural processes. How to define a changeable boundary condition? The boundary conditions are geometric phase-shifters and represent the actual degrees of freedom. Changeable boundary conditions are instigated when precise conditions correspond to correlations in phase-space or in connection with associated phase coherency. This was demonstrated without classical potential energy [50].

The electrostatic coupling between quantum and classical charges* during the energy level transition (energy quantization) and conformational transitions (re-arrangement of bonds) are precursors of the above-mentioned changeable boundary conditions. The coupling between the quantum and classical subsystems is based on the inductive electrostatic effect of the classical point charges on the quantum charges. The potential energy at the molecular level is produced by overcoming the intermolecular force of attraction (London forces), i.e., the vanishing of classical-quantum potential energy. As shown in [122], large energy input is required to break bonds for harnessing intrinsic information when there is no electrostatic environment. Electrostatic equilibrium stabilizes the molecule during delocalization, so less energy input is required to break bonds and produce information. Interactions involving enzymatic cascades result in partially holistic molecules, only fragments of complex molecular systems. The quantum cooperative mechanism of enzymatic activity as a macroscopic phenomenological description of quantum effects [123] in molecules is the biological substrate of coupling between quantum and classical domains.

Quantum mechanical description based on quantum potential chemistry where the wavefunctions of delocalized electron ensembles are partially holistic and move under a common semiquantum potential energy can be described through the Schrödinger-like equation replaces the Planck's constant ($\hbar$) with a modified Planck's constant (γ) where $\gamma \gg \hbar$ and the dynamics are altered when Eqn (1) incorporates charge carriers moving in a nested local EM field, resulting in the presence of a magnetic vector potential (**A**) [99]:

$$i\gamma\frac{\partial\psi}{\partial t} = \frac{1}{2m}(-i\gamma\nabla - (\gamma\frac{\partial\Lambda}{\partial t} + q\mathbf{A}) - i\gamma\nabla\beta)^2\psi + (q\,\phi + i\gamma\frac{\partial\beta}{\partial t})\,\psi \qquad (14)$$

*Quantum states rely on the properties of "quantum charge," often in nonpolar regions where delocalization occurs. The notion of a "classical charge" in ionic current flow is attributed to force-based action.

where q is the electric charge in units of [current][time], φ is the electric potential in units of [voltage], γ is the action parameter in units of [energy][time], and **A** is the magnetic vector potential in units of [force]/[current], and Λ is a vector potential (dimensionless).

Equation (14) has dimension of [energy]. Note: [energy]/[mass] = ([L]/[T])^2 and ([energy] [time] /[L])^2= [mass][energy]. Bohm and Hiley [51] treat the 'quantum force' $f = -\nabla Q$ on an equal footing to the classical Lorentz force $\mathbf{F} = q[\mathbf{E} + V \times \mathbf{B}]$ where $\mathbf{E} = \partial\mathbf{A}/\partial t - \nabla\varphi$ is the electric field, $\mathbf{B} = \nabla\times A$ is the magnetic field, and V is the velocity of the electron ensemble. Eqn (13) describes EM resonating structure, and the holonomy associated with **A** is associated with the property of the EM field. In contrast, the holonomy associated with Λ is intrinsically related to the evolution of ψ.

Interacting electrostatically with molecular ionic charge necessitates **A** as a phase-shifter that creates a causal effect that can produce 'action-at-a-distance'. When the classical electromagnetic Lorentz force vanishes, the magnetic vector potential still affects the 'quantum force' caused by the local variations in $\rho(x, t)$.

Suppose all the information relating to the system is included in the phase differences between delocalized electrons. In that case, this 'quantum force' sensitivity is obtained from the phase shifts induced by **A,** which is the mechanism for coherence through particular periodicities of discrete energies. **A** can drive the phase, which influences the relation to the coherent system's momentum (∇S). Consequently, the coherent system is affected by **A** by changing the phase of a coherent system without a magnetic field. Classically $f = 0$, $\mathbf{B} = \nabla\times \mathbf{A} = 0$ but $\mathbf{A} \neq 0$. The causative 'quantum force' induced dynamic effect appears as correlations associated with the phase (S) difference at specific frequency domains. A 'quantum force' induced holonomic effect attributed to **A** action as 'action-at-a-distance' acts as a causative phase shifter. This is caused by the magnetic dipole moments' sensitivity to the phase shifts acting upon the molecular dipoles. It is concluded that **A** allows the organism to be self-aware of the environment by exchanging information [124]. Szasz et al. [125] had shown that **A** behaves as an elementary waveform without damping. Surprisingly, **A** was suggested to have a functional role in molecular systems as an informational channel without using the classical EM field (see [124,125]).

The special arrangement of the π-electrons in amino acids permits control of the energy leading to the precision of the signal and creating an internal EM field. This magnetic vector potential can then harmonize with a wave identity Λ is associated with information-based "temporal structures" is due to changeable boundary conditions (Λ) to induce a *constraining release of energy* that provides the intrinsic information required to bridge causality (conscious experience) from causal capacity as a carrier of uncertainty. EM field is globally distributed and nonuniform; however, **A** represents EM momentum and the molecular Aharonov-Bohm effect [115]. The EM momentum can no longer generate magnetic fields under quasi-static conditions in the brain, so **A**=0 outside of the EM resonating structure. Therefore, solitary electrostatic waves represent global 'footprints' of the information-based action that resulted from the nested distribution of molecular EM resonances. Although Hales [126] suggests such an environment could exist within ionic channels during the propagation of action potentials, Lindsay et al. [117] suggest a quasistatic, i.e., a stationary environment dominates neuronal functioning. In particular, only at the subneuronal scale do EM fields harmonize with the endogenous EM field enabling the geometric holonomic effects to play a causal role in biological consciousness leading to the holonomic concept of memory.

8. Concluding Remarks

The most common and popular consciousness models postulate that physical activity in the brain is before consciousness [127]. This suggests that the expression of consciousness arises in cognition, supporting the idea of the dynamic unconscious. Indeed, while consciousness is based on a wide area of the brain, including the limbic system, sensorimotor cortex and association cortex, a large part of it appears to operate at the unconscious and subconscious levels. These levels within the dynamic hierarchy exhibit information-rich energy processing in the brain. What does this suggest about mechanisms of signal transduction across scales? In potential quantum chemistry [59], energy processing conveying the transition from potential to kinetic energy is 'evanescent meaning' from changeable boundary conditions.

Freudian metapsychology has two "sides": (1) Panexperiential materialism and (2) Metacognition. The difference is that in (1), the process underlying consciousness, the so-called "affective drive," is across scale, is cell-based consciousness based on energy-transduction processes, while in (2), the "affective drive" is across the brain regions (or brain states), is brain-based consciousness fueled by integrated information theory issuing a higher-level theory of consciousness. We argue that consciousness is not cognitive but dependent on

energy flow to cognition and must therefore be based on panexperiential materialism. Panexperiential materialism is all about how all experiences are activated by information and its associated action in a materialistic framework. It is also important to note that in (1), the '*intrinsicness problem*' [50] replaces the '*hard problem of consciousness*' [128].

Dennett [129] admits, based on meta-cognition, neither the '*intrinsicness problem*' nor the hard problem. This meta-cognitivist approach is an oversimplification because it suggests that only one transduction occurs only in one step, from the senses to the neural activity in the brain. This spiking activity is across the brain networks, and it drives consciousness through informational integration via the coalescence of different elements. If correct, consciousness flowing in neural networks [130,131] must be correlates of consciousness visible through brain imaging. Still, the idea of a central core brain network [132, 133] is not contingent on the final integration of consciousness across scales. We argued that brain-based consciousness dependent on different neural networks simplifies the brain's biophysical picture by ignoring energy transduction in membrane proteins, intrinsic potential information transduction through the negentropic principle of information and concrescences of different elements as a subjectification process of actualization.

The results suggest that experienceabilities are spread like in holonomic brain theory [49], positing that the "physical" aspects are classically defined variables. In contrast, the 'functional' aspects are phase operators to elucidate quantum interactions between van der Waals London forces [85] with the negentropically derived 'negentropic force' [15]. How electronic potential energies play a role in coupling dipoles, leading to protein conformational oscillations was elucidated based on *molecular holism* [47]— a molecular version of de Broglie's hidden thermodynamics theory. The nonlocal functional interactions observed in the interference patterns of coupled dipoles become London forces' confluences through quantum potential chemistry theory [59]. We theorized on the mechanism of instant actualization of physical feelings based on a nonintegrated information theory of consciousness that relies on delocalization between dipoles.

In our nonintegrated information theory of consciousness, instantaneous dipoles induced by a balance between Coulombic attraction force and 'quantum force' to actualize the concrescence of holons as informational structures collectively composed of physical feelings. The notion of physical feelings as a solution to the 'hard problem of consciousness' may close the epistemic aspect of the '*explanatory gap*' associated with *materialism* and the subjective form [134]. However, no current theory has completely resolved how the brain's physical processes give rise to subjective experiences. Hence, the gap created between the objective, material brain and the mind, i.e., the intimately known, private *qualia* of subjective experience, or "what it is like" to experience something, has not been bridged.

We have proposed a solution to close the explanatory gap. Classical information theory measures the decrease in uncertainty, for example, when consciousness ends, and memory begins. The spontaneous potentialities are environmentally influenced. Intrinsic information is Fisher's information that relies on uncertainty and, at the fundamental level, comprises negentropic influences that carry molecular-embedded microfeels of meanings that comprise semantic information at a large scale. This latter process involves the capacity of negentropically interconnected partially holistic molecules to mutually affect, i.e., in-form, each other. This is the basis of negentropic entanglement. Although we propose a molecular approach, there is a problem with coupled process structures, in-forming each other on all levels of a neural organization [135]. A dual-aspect theory of information [136], where one is classical and non-classical, is a wedge to close the exploratory gap between the mind and the body.

Although several theories have been promulgated concerning the etiology of consciousness as a hologram inextricably linked to memory, its mechanism remains obscure. Ab initio approaches in quantum chemistry are inadequate for understanding consciousness as a "*quanta of information,"* where sentience is a temporal wave acted upon by dual modes coming together by way of harmonization supporting disunity of content within the unity of consciousness. Therefore, we propose that the consciousness process involves a temporal waveform that is acted upon by an *act of observation*. The *act of observation* occurs in which the dual modes associated with information-based action linked to the geometric vector potential and the EM resonances producing the magnetic vector potential come together in terms of mutual information. At the cellular level, mutual informativeness within and between neuronal groups through which the activity patterns can become their own "observer" through a high level of reciprocal signaling "re-entry" within and between neuronal groups, resulting in

the emergence of conscious experience [137]. This metacognitive approach is incomplete because it assumes some complexity level that enables consciousness to emerge from neural activity. By introducing the dual aspect information concept at the molecular level, we have shown that the emergence is unpacked and can be explained through an *act of observation*.

The quantum mechanics of spontaneous creation of consciousness is from the semiquantum potential of a Warshel & Levitt [122] type brain model as an open quantum system. We call brain spontaneous potentiality [138]. The term ´consciousness can be understood as nonlocal dynamic relations of immediately actualized and disappearing physical feelings. It provides a solution to how widely distributed preconscious experienceabilities exist in the brain [139]. A *priori* for the neural correlate of feelings was postulated that unitary consciousness's binding problem arises from intermittent dispersion interactions between extramembrane proteins and water-soluble proteins whose transcription factors span the cerebral cortex, including the thalamus striatum and hippocampus but not the cerebellum. Preconscious experienceabilities stem from weak electrostatic attractions, promoted by quantum-thermal perturbations, by constraining the release of energy and connecting vast numbers of neural processes across the cortex as quasi-autonomous informational holarchies of discrete physical feelings.

Preconscious experienceabilities, then, denote informational structures within the brain ´close below´ conscious experiences, potential in relation to conscious experiences, while concrescences can denote all afferent and efferent processes that underlie preconscious experienceabilities. To understand preconscious experienceabilities, there is a need to understand how raw feelings (“microfeels”) containing intrinsic information at the mesoscopic level bind together physical feelings at the quantum-classical transition, leading to constraint energy processing, where ‘information structure’ encompasses evanescent meaning. Brillouin’s negentropic information principle directly linked spontaneous potentiality and free energy of de Broglie’s hidden thermodynamics. We have defined inherent meaning explicitly as the free energy of de Broglie's hidden thermodynamics due to gain in intrinsic information. It is a conduit for evanescent meaning due to concealed information at the boundary between quantum and classical transition and a building block of the consciousness process based on multiple transduction processes.

Finally, quantum models of consciousness are unrealistic from a biological perspective because the brain is an open quantum system [140]. As Tegmark [141] criticized the Orch OR model [142], the wave function has rapid decoherence. Our model is based on dissipative phenomena and does not suffer the same problems as other quantum models. No informational field continuously and permanently gives off the "radiance of consciousness". **What we postulated are molecular-embedded microfeels that are evanescent Therefore, by our definition, consciousness represents quanta of information (i.e., the temporal waveform in phase-space) that in each moment actualizes into conscious experience certain selections of the unconscious molecular embedded microfeels that, for long periods, resting in potentiality, constitute the preconscious experienceability.**

In addition, other problems with quantum models are based on the notion that extracellular space in the brain is nonmetric. The resulting interactions between the interconnected collections of neurons or brain matter and its extracellular fluid constitute an important additional source of information that must be included in the study of consciousness [143]. The scale of the whole brain is large compared to molecules. Still, how interconnectedness via volume transmission, intermittent London forces and protein interactions manifest from fractal neural geometry [70] that provides opportunities for information-rich dynamic activity [144], yet experimental verification is beyond the range of short-range van der Waals interactions and only long-range forces, such as electrostatic forces, can be elucidated with electrostatic force microscopy.

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Conflict of Interest

All authors declare no conflict of interest

References

[1] Solms, M. (2014) A neuropsychoanalytical approach to the hard problem of consciousness. *Journal of Integrative Neuroscience* **13**, 173-185.

[2] Schiffer, F. (2019) The physical nature of subjective experience and its interaction with the brain. *Medical Hypotheses* **125**, 57-69.

[3] Del Carril, M. (1979) Freud on unconscious emotion. *Diálogos* **33,** 109-124.

[4] Lewis, C.I. (1929) *Mind and the World Order*. New York: Charles Scribner's Sons.

[5] Damasio, A. & Carvalho, G.B. (2013) The nature of feelings: evolutionary and neurobiological origins. *Nature Reviews Neuroscience* **14**, 143-152.

[6] Edwards, J.C.W. (2005) Is consciousness only a property of individual cells? *Journal of Consciousness Studies* **12**, 60-76.

[7] Baluška, F. & Reber,A. (2019) A sentience and consciousness in single cells. How the first minds emerged in unicellular species. *BioEssays* **41**, e1800229.

[8] Baluška, F., Yokawa, K., Mancuso, S. & Baverstock, K. (2016) Understanding of anesthesia-why consciousness is essential for life and not based on genes. *Communicative & Integrative Biology* **9**, e1238118.

[9] Brändas, E.J. (2018) Molecular theory of the genetic code. *Molecular Physics* **116**, 2622-2632.

[10] Changeux, J.P. (2017). Climbing brain levels of organization from genes to consciousness. *Trends in Cognitive Science* **21**, 168-181.

[11] Carruthers, P. (1989) 'Brute experience' *Journal of Philosophy* **86**, 258-269.

[12] Schwarz, N. (2012). Feelings-as-information theory. In P. Van Lange, A. Kruglanski, & E. T. Higgins (eds.) (2012), *Handbook of theories of social psychology* (pp. 289-308). Sage.

[13] Heintzelman, S.J. & King, L.A. (2014) (The feeling of) meaning-as-information. *Personality and Social Psychology Review* **18**, 153-167.

[14] Feinberg, T.E. & Mallatt, J. (2020) Phenomenal consciousness and emergence: eliminating the explanatory gap. *Frontiers in Psychology* **11**,1041.

[15] Poznanski, R.R & Brändas, E.J. (2020). Panexperiential materialism: A physical exploration of qualitativeness in the brain. *Advances in Quantum Chemistry **82**, 301-367.*

[16] Globus, G.G. & O'Carroll, C.P. (2010) Nonlocal neurology: Beyond localization to holonomy. *Medical Hypotheses* **75**, 425-432.

[17] Edelman, G.M. (2003) Naturalizing consciousness: A theoretical framework. *Proceedings of the National Academy of Sciences* (USA) **100**, 5520-5524.

[18] Solms, M. (2021) *The Hidden Spring: A Journey to the Source of Consciousness*. Profile Books, London.

[19] Suzuki, H. (2006) Protein-protein interactions in the mammalian brain. *Journal of Physiology* (London) **575**, 373-377.

[20] Aerts, D. (2009) Quantum particles as conceptual entities: A possible explanatory framework for quantum theory. *Foundations of Science* **14**, 361-411.

[21] Aerts, D. (2010) A potentiality and conceptuality interpretation of quantum physics. *Philosophica* **83**, 15-52.

[22] Pereira Jr., A., Vimal, R.L.P. & Pregnolato, M. (2017) Can qualitative biophysics solve the hard problem? In R.R. Poznanski, J.A. Tuszynski and T.E. Feinberg (eds) *Biophysics of Consciousness: A Foundational Approach*. World Scientific, Singapore.

[23] Fröhlich, H. (1973) The connection between macro- and microphysics. *La Rivista del Nuovo Cimento* **3,** 490-534.

[24] Bohm, D. (1952) A suggested interpretation of the quantum theory in terms of hidden variable. II *Physical Review* **85**, 180-193.

[25] Maccone, L. (2009) Quantum solution to the arrow-of-time dilemma. *Physical Review Letters* **103**, 080401.

[26] Beshkar, M. (2018) A thermodynamic approach to the problem of consciousness. *Medical Hypotheses* **113**, 15-16.

[27] Eccles, J.C. (1990) A unitary hypothesis of mind-brain interaction in the cerebral cortex. *Proceedings of the Royal Society* (London) **B240**, 433-451.

[28] Beck,F. & Eccles, J.C. (1992) Quantum aspects of brain activity and the role of consciousness. *Proceedings National Academy of Science (*USA) **89**, 11357-11361.

[29] Chomsky, N. (2016) *What Kind of Creatures Are We?* Columbia University Press, New York.

[30] Holmgren, J. (2014) Natural evolution and human consciousness. *Mens Sana Monographs* **12**, 127-38.

[31] Pereira Jr., A., Nunn, C., Nixon, G. & Pregnolato, M. (2018) Consciousness and cosmos: building an ontological framework. *Journal of Consciousness Studies* **25**, 151-205.

[32] Harman, G. (1999) The intrinsic quality of experience. In, W.G. Lycan (ed) *Mind & Cognition*. Blackwell Publishers, Oxford.

[33] Pereira Jr.,A. (2021) The role of sentience in the theory of consciousness and medical practice. *Journal of Consciousness Studies* **28**, 22-50.

[34] Whitehead, A.N. (1929). *Process and Reality*. Macmillan, New York.

[35] Koestler, A. & Smythies, J.R. (1969) *Beyond Reductionism: New Perspectives in the Life Sciences*. Hutchinson, London.

[36] Pribram, K. H. (2013) *The Form Within: My Point of View*. Westport, CT: Prospecta Press.

[37] Northoff, G. (2014) Localization versus holism and intrinsic versus extrinsic views of the brain: a neurophilosophical approach. *Minerva Psichiatrica* **55**, 1-15.

[38] Searle, J.R. (2000) Consciousness. *Annual Review of Neuroscience* **23**, 557-578.

[39] Freeman, W.J. (2003) A neurobiological theory of meaning in perception. Part 1. Information and meaning in nonconvergent and nonlocal brain dynamics. *International Journal of Bifurcation & Chaos* **13**, 2493-2511.

[40] Pepperell, R. (2018) Consciousness as a physical process caused by the organization of energy in the brain. *Frontiers in Psychology* **9,** 2091.

[41] Kauffman, S. (2019) Answering Schrödinger's "What Is Life"? *Entropy* **22**, 815.

[42] Summers, R. (2022) Quantifying the meaning of information in living systems. *Academic Letters*: 4874.

[43] Hofstadter, D. (1979) *Gödel, Escher, Bach: An Eternal Golden Braid*. Penguin Books, London.

[44] Brändas, E.J. (2021) A Universe in our brain: Carnot's engine and Maxwell's demon. *Progress in Theoretical Chemistry and Physics* **33**, 305-330.

[45] Brändas E.J. (2021) The Fourier-Laplace Transform—A Conjugate Link Between the Material Brain and the Conscious Mind. *Frontiers Human Neuroscience* **15**, 736761.

[46] Boeyens, J.C.A. (2008) The holistic molecule. In, J.C.A. Boeyens and J.F. Ogilvie (eds) *Models, Mysteries and Magic of Molecules*. Springer. Dordrecht.

[47] Bodovitz, S. (2004) Consciousness is discontinuous: the perception of continuity requires conscious vectors and needs to be balanced with creativity. *Medical Hypothesis* **62**, 1003-1005.

[48] Bodovitz, S. (2008) Consciousness disintegrates without conscious vectors. *Medical Hypothesis* **70**, 8-11.

[49] Pribram, K.H. (1991) *Brain and Perception: Holonomy and Structure in Figural Processing*. Lawrence Erlbaum, New Jersey.

[50] Poznanski, R.R., Cacha, L.A., Latif, A.Z.A., Salleh, S.H., Ali, J., Yupapin, P., Tuszynski, J.A. & Tengku, M.A. (2018) Spontaneous potentiality as formative cause of thermo-quantum consciousness. *Journal of Integrative Neuroscience* **17**, 371-385.

[51] Bohm, D. & Hiley, B.J. (1993) *The Undivided Universe: An Ontological Interpretation of Quantum Theory*, Routledge, London.

[52] Bohm, D. (1990) A new theory of the relationship of mind and matter. *Philosophical Psychology* **3,** 271-286.

[53] Hiley, B.J. (1995) Nonlocality in microsystems. In J. King and K.H. Pribram (eds) *Scale in Conscious Experience: Is the Brain Too Important to be Left to the Specialists to Study*? Hillsdale: Lawrence Erlbaum.

[54] Hiley, B.J. (2002) From the Heisenberg picture to Bohm: a new perspective on active information and its relation to Shannon information. In, A. Khrennikov (ed.) *Quantum Theory: Reconsideration of Foundations*. Växjö University Press, Sweden.

[55] Dennis, G., de Gosson, M.A. & Hiley, B.J. (2015) Bohm's quantum potential as an internal energy. *Physics Letters* ***A*** **379**, 1224-1227.

[56] Brown, M.R. (2004) The symplectic and metaplectic groups in quantum mechanics and the Bohm interpretation. *Ph.D. thesis*. Theoretical Physics Research Unit, Birkbeck College, University of London.

[57] Mollai, M. and Fathi, S.M.S. (2021) An application of the Madelung formalism for dissipating and decaying systems. *Symmetry* **13**, 812.

[58] Kohn, W. & Sham, L.J. (1965) Self-consistent equation including exchanged correlations effects. *Physical Review* **140**, A1133-A1138.

[59] Boeyens, J.C.A. (2000) Quantum potential chemistry. *South African Journal of Chemistry* **53**,49-72.

[60] Bracken, A.J. & Wood, J.G. (2006) Semiquantum versus semiclassical mechanics for simple nonlinear systems. *Physical Review* A **73**, 012104.

[61] Piela, L. (2014) *Ideas of Quantum Chemistry*. Second edition. Elsevier, Amsterdam.

[62] Arriaga, J.D.J, Fortin, S. & Lombardi, O. (2019) A new chapter in the problem of the reduction of chemistry to physics: the quantum theory of atoms in molecules. *Foundations of Chemistry* **21**, 125-136.

[63] Matta, C.F., Lombardi,O. & Arriaga, J.J. (2020) Two-step emergence: the quantum theory of atoms in molecules as a bridge between quantum mechanics and molecular chemistry. *Foundations of Chemistry* **22,**107–129.

[64] Holland, P. (2015) Quantum potential energy as concealed motion. *Foundations of Physics* **45**, 134-141.

[65] de Broglie, L. (1970) The reinterpretation of wave mechanics. *Foundations of Physics* **1**, 5-15.

[66] de Broglie, L. (1987) Interpretation of quantum mechanics by the double solution theory. *Ann Fond. Louis Broglie* **12**, 1-23.

[67] Sbitnev, V.I. (2009) Bohmian trajectories and the path integral paradigm. Complexified Lagrangian mechanics. *International Journal of Bifurcation & Chaos* **19**, 2335-2346.

[68] Wissner-Gross, A.D. & Freer, C.E., (2013) Causal entropic forces. *Physical Review Letters* **110**, 168702.

[69] Valentini, A. (2002) Signal-locality in hidden-variables theories. *Physics Letters A*, **297**, 272-278.

[70] Pellionisz, A.J. (1989) Neural geometry: towards a fractal model of neurons. In, R. M.J. Cotterill (editor) *Models of Brain Function*. Cambridge University Press, Cambridge.

[71] Le Bihan, D. (2020) On time and space in the brain: a relativistic pseudo-diffusion framework. *Brain Multiphysics* **1,** 100016.

[72] Bandyopadhyay, A. (2020) *Nanobrain: The Making of an Artificial Brain from a Time Crystal*. CRC Press, Taylor & Francis Group, Boca Raton, FL.

[73] Tsekov, R. (2018) Dissipative Relativistic Bohmian Mechanics. *Chemistry* **27**, 771-776

[74] Kirkaldy, J.S. (1965) Thermodynamics of the human brain. *Biophysical Journal* **5**, 981-986.

[75] Collell, G. & Fauguet, J. (2015) Brain activity and cognition: a connection from thermodynamics and information theory. *Frontiers in Psychology* **6**, 818.

[76] Nalewajski, R. F. (2016) Complex entropy and resultant information measures. *Journal of Mathematical Chemistry* **54**, 1777-1782.

[77] Sbitnev, V.I. (2008) Bohmian split of the Schrodinger equation onto two equations describing evolution of real functions. *Kvantovaya Magiya* **5**, 1101-1111.

[78] Brillouin, L. (1953) The negentropy principle of information. *Journal of Applied Phys*ics **24**, 1152-1163.

[79] Brillouin, L. (1962) *Science and Information Theory*. Academic Press, New York.

[80] Heifetz, E. & Cohen, E. (2015) Toward a thermo-hydrodynamic like description of Schrödinger equation via the Madelung formulation and Fisher information. *Foundations of Physics* **45**, 1514-1525.

[81] de Broglie, L. (1964) *The thermodynamics of the isolated particle (or the hidden thermodynamics of particles)* Gauther-Villars (ed) French Academy of Sciences, Paris.

[82] Resconi, G, Licanta, I., Fiscaletti, D. (2013) Unification of quantum and gravity by non classical information entropy space. *Entropy* **15**, 3602-3619.

[83] Poznanski, R.R., Cacha, L.A., Latif, A.Z.A., Salleh, S.H., Ali, J., Yupapin, P., Tuszynski, J.A. & Tengku, M.A. (2019) Theorizing how the brain encodes consciousness based on negentropic entanglement. *Journal of Integrative Neuroscience* **18,** 1-10.

[84] Stuart, C.I.J.M., Takahashi, Y. & Umezawa, H. (1978) On the stability and non-local properties of memory. *Journal of Theoretical Biology* **71**, 605-618.

[85] Hameroff, S.R. (2006) The entwined mysteries of anesthesia and consciousness. *Anesthesiology* **105**, 400-412.

[86] Craddock, T.J.A., St. George, M., Freedman, H., Barakat, K.H., Damaraju, S., Hameroff, S. & Tuszynski, J.A.(2012) Computational predictions of volatile anesthetic interactions with the microtubule cytoskeleton: Implications for side effects of general anesthesia. *PloS One* **7**, e37251.

[87] Solms, M. (2017), Consciousness by Surprise. In, R.R.Poznanski, J.A.Tuszynski and T.E. Feinberg (eds) *Biophysics of Consciousness: A Foundational Approach*. World Scientific, Singapore.

[88] Schwartz, J., Stapp, H. & Beuregard, M. (2005) Quantum physics in neuroscience and psychology: a neurophysical model of mind-brain interaction. *Philosophical Transactions. Royal Soc*iety **B360**, 1309-1327.

[89] Stapp, H.P. (2009) *Mind, Matter, and Quantum Mechanics*. Springer, Berlin.

[90] Dennett, D.C. (2017) *From Bacteria to Bach and Back: The Evolution of Minds.* Norton, New York.

[91] Holm, D.D. Rawlinson, J.I. & Tronci, C. (20121) The bohmion method in nonadiabatic quantum hydrodynamics. *Journal of Physics: A: Mathematical and Theoretical* **54**, 495021.

[92] Holland, P. (1993) *The Quantum Theory of Motion: An Account of the de Broglie-Bohm Causal Interpretation of Quantum Mechanics*. Cambridge University Press: Cambridge, UK.

[93] Roederer, J.G. (2003) On the concept of information and its role in nature. *Entropy* **5,** 3-33.

[94] Emmeche, C. (2004) Organicism and qualitative aspects of self-organization. *Revue Internationale de Philosophie* **228**, 205-217.

[95] Koestler, A. (1967) *The Ghost in the Machine*. Hutchinson, London.

[96] Tong, T.Y. (1990) Electrical modulation of membrane proteins: enforced conformational oscillations and biological energy and signal transductions. *Annual Review of Biophysics and Biophysical Chemistry* **19**, 83-106.

[97] Moser, C.C, Anderson, J.L.R. & Dutton, P.L. (2010) Guidelines for tunnelling in enzymes. *Biochimica et Biophysica Acta* **1797**, 1573-1586.

[98] Crawford, M.A., Broadhurst, C.L., Galli, C., Ghebremeskel, K., Holmsen, H., Saugstad, L.F, Schmidt, W.F., Sinclair, A.J. & Cunnane, S.C. (2008) The role of docosahexaenoic and arachidonic acids as determinants of evolution and hominid brain development. In, K. Tsukamoto, T. Takeuchi, T.D. Beard and M.J. Kaiser, eds. *Fisheries for Global Welfare and environment*. 5th World Fisheries Congress. Yokohama, Japan.

[99] Foskett, M.S. & Tronci, C. (2020) Holonomy and vortex structures in quantum hydrodynamics. Mathematical Science Institute Publications (preprint).

[100] Craddock, T.J.A., Priel, A. & Tuszynski, J.A. (2014) Keeping time: Could quantum beating in microtubules be the basis for the neural synchrony related to consciousness? *Journal of Integrative Neuroscience **13***, 293-311.

[101] Mandell, A.J. (2013) Can a metaphor of physics contribute to MEG neuroscience research? Intermittent turbulent eddies in brain magnetic fields. *Chaos, solitons & Fractals* **55**, 95-101.

[102] Nam, H-J., Han, S.K., Bowie, J.U. & Kim, S. (2013) Rampant exchange of the structure and function of extramembrane domains between membrane and water-soluble proteins. *PloS Computational Biology* **9**, e1002997.

[103] Pullman, B. (1977) An aspect of submolecular biology: quantum-mechanical exploration of biomolecular con formations-the case of phospholipids. In, B. Kaminer (ed) *Search and Discovery: A Tribute to Albert Szent Györgyi*. Academic Press, San Diego.

[104] Georgiev, D.D. (2021) Quantum information in neural systems. *Symmetry* **13**, 773.

[105] Meyer, K. (2015) The role of dendritic signaling in the anesthetic suppression of consciousness. *Anaesthesiology* **122,** 1415-1431.

[106] Signorelli, C.M., Uhrig, L., Kringelbach, M., Jarraya, B. & Deco, G. (2021) Hierarchical disruption in the cortex of anesthetized monkeys as a new signature of consciousness loss. *NeuroImage* **227**, 117618.

[107] Esfeld, M. (1999) Quantum holism and the philosophy of mind. *Journal of Consciousness Studies* **6,** 23- 38.

[108] Calisto, F. Sousa, F.M, Sena, F.V, Refojo, P.N., & Pereira, M.M. (2021) Mechanism of energy transduction by charge translocating membrane proteins. *Chemical Reviews* **121**,1804-1844.

[109] Cortes,A, Coral,J., McLachlan,C., Corredor,J.A., & Benitez,R. (2022) Molecular transduction in receptor-ligand systems by planar electromagnetic fields. *Brazilian Journal of Biology* **82**, e232525.

[110] McFadden, J. (2020) Integrating information in the brain's EM field: The CEMI field theory of consciousness. *Neuroscience of Consciousness* **17**, niaa016.

[111] Goodman, G., Poznanski, R.R., Cacha, L.A. & Bercovich, D. (2015) The two-brains hypothesis: towards a guide for brain-brain and brain-machine interfaces. *Journal of Integrative Neuroscience* **14**, 281-293.

[112] Fingelkurts, A.A., Fingelkurts, A.A. & Neves, C.F.H (2013) Consciousness as a phenomenon in the operational architecture of brain organization: criticality and self-organization considerations. *Chaos, Solitons & Fractals* **55**, 13-31.

[113] Tonello, I., Cocchi, M, Gabrielli, F. and Tuszynski, J.A. (2015) On the possible quantum role of serotonin in consciousness. *Journal of Integrative Neuroscience* **14**, 295-308.

[114] Hunt, T. and Schooler, J.W. (2019) The Easy Part of the Hard Problem: A Resonance Theory of Consciousness. *Frontiers in Human Neuroscience* **13**, 378.

[115] Mead, C.A. (1980) The molecular Aharonov-Bohm effect in bound states. *Chemical Physics* **49**, 23-32

[116] John, E.R. (1980) Multipotentiality: a statistical theory of brain function. In, R.J. Davidson and J. M. Davidson (eds) *The Psychobiology of Consciousness.* Plenum Press, New York.

[117] Lindsay, K.A., Rosenberg, J.R. & Tucker, G. (2004) From Maxwell's equations to the cable equation and beyond. *Progress in Biophysics and Molecular Biology* **85**, 71-116.

[118] Nishiyama, A., Tanaka, & Tuszynski, J.A. (2020). Nonequilibrium quantum brain dynamics. *Advances in Quantum Chemistry **82**, 159-180*

[119] Myakishev-Rempel M. & Savelyev I.V. (2022) How Schrödinger's Mice Weave Consciousness. In: Bandyopadhyay A., Ray K. (eds) Rhythmic Advantages in Big Data and Machine Learning. *Studies in Rhythm Engineering.* Springer, Singapore.

[120] McIntyre, C.C. & Grill, W.M. (1999) Excitation of central nervous system neurons by nonuniform electric fields. *Biophysical Journal* **76**, 878-888.

[121] Poznanski, R.R., Cacha, L.A., Al-Wesabi, M.S., Ali, J, Bahadoran, M., Yupapin, P.P. & Yunus, J. (2017) Solitonic conduction of electrotonic signals in neuronal branchlets with polarized microstructure. *Scientific Reports* **7,** 2746.

[122] Warshel, A. & Levitt, M. (1976) Theoretical studies of enzymic reactions: dielectric, electrostatic and steric stabilization of the carbonium ion in the reaction of lysozyme. *Journal of Molecular Biology* **103**, 227- 249

[123] Achimowicz, J., Cadwer, A., Pannert, L & Wojcik, E. (1977) Quantum cooperative mechanism of enzymatic activity. *Physic Letters* **60A**, 383-384.

[124] Trukhan, E. M. & Anosov, V. N. (2007) Vector potential as a channel of informational effect on living objects. *Biofizika* **52**, 376–381.

[125] Szasz, A., Vincze, G., Andocs, G. & Szasz, O. (2009) Do field-free electromagnetic potentials play a role in biology? Electromagnetic *Biology and Medicine* **28**, 135-147.

[126] Hales, C.G. (2014). The origins of the brain's endogenous electromagnetic field and its relationship to provision of consciousness. *Journal of Integrative Neuroscience* **13**, 313-361.

[127] Doerig, A., Schurger, A. & Herzog, M.H. (2021) Hard criteria for empirical theories of consciousness, *Cognitive Neuroscience* **12**, 41-62.

[128] Chalmers, D.J. (1996) *The Conscious Mind*. Oxford University Press.

[129] Dennett, D.C. (1991) *Consciousness Explained*. Little, Brown and Co, New York.

[130] Demertzi, A., Soddu,A. & Laureys,S. (2013) Consciousness supporting networks. *Current Opinion in Neurobiology* **23**, 239-244.

[131] Qin, P., Wu, X., Huang, Z., Duncan, N.W., Tang, W., Wolff, A., Hu, J., Gao, I., Jin, Y., Wu, X., Zhang, J., Lu, I., Wu, C., Qu, X., Mao, Y., Weng, X, Zhang, J. & Northoff,G. (2015) How are different neural networks related to consciousness? *Annals of Neurology* **78**,594-605.

[132] Scheinin, A., Kantonen, O., Alkire, M., Langsjo, J., Kallionpaa, R.E., Kaisti, K., Radek, L., Johansson, J., Sandman, N., Nyman, M, Scheinin, M., Vahlberg, T., Revonsuo, A., Valli, K. & Scheinin, H. (2021) Foundations of human consciousness: imaging the twilight zone. *Journal of Neuroscience* **41**, 1769-1778.

[133] Edelman, G.M., Gally, J.A. & Baars, B.J. (2011) Biology of consciousness. *Frontiers in Psychology* **2**, 4.

[134] Levine, J. (1983) Materialism and qualia: The explanatory gap. *Pacific Philosophical Quarterly* **64,** 354-61.

[135] Jantsch, E. (1980) *The Self-Organizing Universe: Scientific and Human Implications of the Emerging Paradigm of Evolution*, Frankfurt, Pergamon Press.

[136] Chalmers, D.J. (1995) Facing up to the problem of consciousness. *Journal of Consciousness Studies* **2**, 200-219.

[137] Edelman, G.M. and Tononi, G. (2000) *Consciousness: How Matter Becomes Imagination*. Allen Lane, London.

[138] Northoff, G. (2018) *The Spontaneous Brain*. MIT Press, Cambridge, MA.

[139] Gazzaniga, M.S. & LeDoux, J.E. (1978). *The Integrated Mind.* Springer-Verlag, Boston, MA.

[140] Sbitnev, V.I. (2016) Quantum consciousness in warm, wet, and noisy brain. *Modern Physics Letters* **B30**, 1650329.

[141] Tegmark, M. (1999) The importance of quantum decoherence in brain processes. *Physical Review* **E61**, 4194-4206.

[142] Hameroff, S.R. & Penrose, R. (1996) Conscious events as orchestrated space-time selections. *Journal of Consciousness Studies* **3,** 36-53.

[143] Green, H.S. & Triffet, T. (1997) *Sources of Consciousness: The Biophysical and Computational Basis of Thought*. World Scientific, Singapore.

[144] Singh, P, Sahoo, P., Ghosh, S., Saxena, K, Manna, J.S, Ray, K., Krishnananda, S.D., Poznanski, R.R. & Bandyopadhyay, A. (2021) Filaments and four ordered structures inside a neuron fire a thousand times faster than the membrane.: theory and experiment. *Journal of Integrative Neuroscience* **20,** 777-790.