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Perspective

The act of understanding uncertainty is consciousness

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Abstract

We define precognitive affect, composed of information holding dispositional states, as noncontextual, rudimentary building blocks of subjective intentionality. We take on a psychodynamic approach to intentional agency. Intentions unfold into actions in animate thermodynamics reducing subjective uncertainty by negentropic action. They are intentions in action carrying meaning in species having complex protein interactions with various regulated gene sets. In particular, the unfolding of intentionality in terms of biological purpose introduced by subjective functioning allows for a satisfactory account of subjective intentionality. The underlying experience of acting paves the way for understanding meaning of precognitive affect from subjective functioning. Therefore, the brain's subjective intentionality as the underlying experience of acting is embedded in a negentropic "*consciousness code*" of "hidden" thermodynamic energy. It is the negentropically-derived quantum potential energy in the unified functioning of brain consciousness at the macroscopic scale. While at the mesoscopic scale, Schrödinger processes create boundary conditions for negentropic action to inform the intentional agency.

Keywords: Brain consciousness, meaning, psychodynamics, intentionality, negentropic action, subjective uncertainty, understanding, functional entropy, precognitive affect, animate thermodynamics, subjective functioning, hidden thermodynamic energy, Schrödinger processes.

1. Introduction

On closer inspection, the quintessential definition of brain-based consciousness remains a hyperbole. It is a vague umbrella term loosely referring to an unspecified number and selection of scientific factors related to perception, sensation, thought, feeling, etc. (Vimal, 2009). As we assume that consciousness has a perceived subjective ontology, the result is that we experience and articulate it at the cognitive level. This naturally leads to a *phenomenological* description instead of a foundational understanding. Phenomenological tradition is a '*dressed-up form of folk psychology*' foreshadowing '*phenomenological reification.*' (Metzinger, 2006).

Phenomenology in philosophy aims to understand the subjective nature of the mind. It assumes systematic reflection to determine the essential properties and structures of conscious experience. There are two problems with a phenomenological approach: (i) the first problem is that such reflections are misguided attempts, as experimental studies have shown that conscious experience runs through different channels to perception, as indicated in blindsight studies (Humphry, 2006) and cognition as indicated in work with savants (Snyder, 2009). In particular, experimental findings from acknowledged work on savants indicate that the disintegration of spatiotemporal patterns of neuronal activity can bring about lower-level recall of vast raw less-processed information at the expense of cognitive functions, such as conceptual thinking. Savants with a severing or lesioning of the corpus callosum show extraordinary talents, like memory recall and arithmetic (Snyder, 2009). Although Schiffer (2021) has presented two consciousness', it appears that cognitive function rehabilitates a single consciousness at the expense of cognitive attributes; (ii) the second problem is that consciousness is unobservable through reflection or introspection if we extend the definition of consciousness to include unconscious and subconscious intentions (Libet, 1994, 1999).

Benjamin Libet was an American neuroscientist who pioneered the field of human consciousness. Libet et al. (1983) found that conscious volition is intention-formation events and depends on unconscious determinants of uncertainty in free will (see also Libet, 1999; Soon et al., 2008) possibility through some other mode to that of neural signaling delivered via nerve conduction. In particular, Libet (1994) suggested that a unified conscious experience other than a physical field, such as an electromagnetic (EM) field, is extrapolated by some mode other than neural messages delivered via nerve conduction. Libet (1994) was adamant that cognitive functions are not proposed as functions to be organized or mediated by the postulated conscious mental field or, as Schiffer (2019) put it "*subjective field*." Libet (1994) proposed a detailed experimental setup of how to verify the propositions, namely, (i) consciousness is precognitive; (ii) consciousness is a contiguous process but not a continuous field composed of dynamically forming discrete patterns that may create meaningful conscious experiences, a '*conscious mental field*' (Libet, 1994; Searle, 2017) whose nature has to be clarified. For example, in the absence of sensory images from the retina, as in Charles Bonnet syndrome, there is no "juggling of images" but a compensatory conscious experience based on disintegrated information (Globus & O'Carroll, 2010).

Sperry's split-brain experiments indicate that split-brain patients can act, i.e., understand, but not be self-aware of it in the other hemisphere (Sperry, 1968). This is similar to blindsight (Humphry,2006). The conclusion in split-brain and blindsight patients is that consciousness is not self-awareness but the ability to act upon a thought or visual input. The crux of the matter is that philosophers and psychologists have defined consciousness as a state of self-awareness. However, this needs to be changed to an act of understanding subjective uncertainty.

Precognitive affects are dispositional states and, thus, brain states since we need an objective way to understand subjectivity (Sperry, 1970). The consciousness mechanism is intrinsic to precognitive affect, not to cognition. This proposition stems from what Sperry (1987) considered the causality of mentalism. By introducing affect, one should not consider it a form of dualism (Sperry, 1980). Moreover, the feeling of experiencing thoughts is non-existent. However, the act of understanding subjective uncertainty through its reduction, where 'act' refers to the experience of acting, is consciousness, as it carries subjective intentionality. In contrast, cognition, such as language, is an instrument used subjectively for intentions but carries no subjective intentionality. Therefore, we can sidestep cognition and perception, but we cannot sidestep intentionality (non-cognitive) as an experience of acting to reduce subjective uncertainty that leads to understanding.

What is the source of consciousness? This is a question that requires an answer through a definition of consciousness. Any definition of consciousness must be epistemologically sound (Searle, 2000). Those that favor feelings say that experience is all about something that it is like to *be* that organism—something it is like *for* the organism (Nagel, 1974). The claim is if it has a qualitative feel, an associated quality of experience or qualia (Bennett & Hacker, 2022). Although Nagel claims we cannot imagine what it is like to be that organism, it is not the same if we understand it to be that organism. This difference between imagining (guessing) and understanding (knowing) brings us closer to the answer. The feeling of understanding is knowing, but the understanding of feeling is experience, without the know-how of how it feels to have that experience or the qualitative character of experience. In short, how it feels to have experience is a phenomenological concept and not solely the only concept satisfying Nagel's "*what it is to be that organism*" In contrast, the understanding of feeling is an alternative to Nagel's "*what it is to be that organism*".

The second point is the description of precognitive consciousness concerning feelings. Feelings are an ambiguous term enmeshed with emotions that compensate for our lack of understanding of subjective intentionality. As suggested in *Sentiomics*, an unconscious dynamic pattern in the brain defines the capacity for feeling (Pereira & de Agiar, 2022). However, capacity is not the feeling but can be the experience of the act as intentions in action. The feelings are not "lived" experiences but sensed intentions. Moreover, as indicated in split-brain patients, the unconscious can imply consciousness through precognitive subjective intentionality.

Feelings are intentions that are sensed (Bohm, 1989). Feelings are always felt and consciously experienced, suggesting they are cognitive and entangled with emotions. The notion of Whiteheads' atomic feels remains a speculation that, at present, is a working hypothesis (Poznanski et al., 2002a) similar to the theory of microconsciousnesses (Zeki, 2003) that posits the processing of information until that activity is strong enough to exceed a certain threshold.

On the other hand, precognitive affect is not consciously experienced yet carries intrinsic manifestations of understanding meaning referred to as subjective intentionality. Just like the intention is sensed as feeling (Bohm, 1989) and therefore intentions in action, i.e., the experience of having a thought or subjective intentionality is more fundamental than feeling. Intentionality refers to the underlying experience of acting (Searle, 1980). In understanding subjective uncertainty, the notion of intentionality as the experience of acting suggests that subjective intentionality is the source of consciousness. Although feelings only occur in organisms that can be conscious, they are not the defining aspects of consciousness, as Damasio & Damasio (2023) proposed.

The precognitive affect that arises from the information holding dispositional states created due to a variety of control boundary conditions (Paksi, 2014), and without any contextual meaning, and which are non-integrated, ensuring the presence of uncertainty. Reducing this subjective uncertainty through an intentional agent (anti-entropic process) leads to understanding meaning of precognitive affect. Psychodynamically this can be viewed as the basis for experience of acting or subjective intentionality and remains part of the conscious reality even though it originates from the subconscious.

This perspective addresses the connection between understanding meaning of precognitive affect through intentionality relying on functional interactions as an 'etiological evolutionary' account of biological purpose as an alternative organizational approach to biological teleology (De Prado & Salas, 2018). Subjective intentionality is the defining characteristic of consciousness before self-awareness, thus satisfying Nagel's "*what it is to be that organism.*" The purpose is to show how the experience of acting is the *modus operandi* of understanding via the reduction of subjective uncertainty.

2. Reduction of uncertainty during intentionality leads to understanding meaning

Subjective uncertainty is the *conscious awareness* of ignorance (Han et al., 2011). Subjective uncertainty exists at different levels of conscious awareness or self-awareness, e.g., complete unconsciousness as ignorance, partial consciousness, i.e., unaware that they are aware, e.g., in blindsight, and complete consciousness (conscious awareness) of ignorance as subjective uncertainty. These levels distinguish between unconscious experiences (e.g., preconscious experienceabilities), dynamically present in the brain, and conscious experiences when awake, by different uncertainties. Our focus remains at the level of *non-integrated information* holding dispositional states where uncertainty is present in partial (non-integrated) information and reflects a compensatory mechanism for consciousness to bring about memory formation. In other words, conscious recall arises instead of memory in the presence of subjective uncertainty when memory is reconsolidated (Solms, 2014, 2017).

The origins of subjective uncertainty are incomplete or unknown and reflect a statistical thermodynamic approach based on quantum potential energy (Poznanski et al., 2022b; Alemdar et al., 2023) or free energy based on a higher-order probabilistic representation (Friston, 2010; Solms, 2019). The latter is variational free energy, an information-theoretic functional of higher-order probabilities borrowing its terminology from thermodynamics. Yufik (2021) points to higher-order probability theory computation of the free energy, which is connected to subcellular networks and adjustments in metabolic pathways. However, the uncertainty is fundamentally deeper, i.e., at the submolecular scale, not in terms of a thermodynamic free entropy such as, e.g., entropic thermodynamic potential analogues to the free energy but rather as a "hidden*" thermodynamic* energy[1]. The de Broglie's 'hidden' thermodynamics (De Broglie, 1970, 1987) plays an unprecedented role in transferring information dependent on the de Broglie wavelength and intrinsic in the sense that it remains 'hidden' from the operational explanation of covalent chemistry.

We claim that dispositional states do not intrinsically require continuous energy input for information holding. The resultant precognitive affect has an inherent subjective uncertainty due to the lability of the information-holding dispositional states. Its meaning cannot be related to context, only correlations that may carry significance or meaning (Kolchinsky & Wolpert, 2018). It is non-contextual and carries meaning from intentions in action in the presence of subjective uncertainty. Therefore, semantic or *contextual information* removes subjective uncertainty by consolidating memory from other subsystems.

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[1]The first definition of 'information' came after WW2 when Wolfgang Köhler's idea, claimed as a mistake (opposed by Nobel laureate Sperry among others), replaced *'hidden' thermodynamic energy* with 'information'. (See Freeman, 2014).

Stonier (1997) suggests that understanding meaning arises when the activity of the information has intentionality, and this happens with an innate quality to "functionally act" as the experience of acting (cf., Juarrero, 1999). Meaning is not just about understanding the significance of something, i.e., contextual. At the molecular scale, it also includes the underlying experience of acting and paving the way for understanding the meaning of precognitive affect from a reduction of subjective uncertainty. No homunculus assigns meaning to molecular-level activity of information, but partially holistic molecules are configured by EM mediated energy throughout the neocortex. i.e., matter bound EM energy (Szent-Györgyi, 1960; Poznanski & Brändas, 2020).

Meaning unfolds into intention and intention into action (Bohm, 1989). As such, the "*feeling of meaning-as-information*" hypothesis (Schwarz, 2012; Hentzelman & King, 2014; Poznanski et al., 2022a) is replaced with understanding meaning of precognitive affect through subjective intentionality. Precognitive affect is the *experience of acting (out a thought*). The understanding meaning of precognitive affect can be seen as a *reduction of uncertainty* which is a non-felt process because we "feel the information" as understanding meaning.

The *understanding meaning* of precognitive affect is attributed to functional activity that brings causation measured through functional information (Fresco et al., 2018). When functional interactions occur through different channels of perception and cognition, as evidenced in split-brain patients and blindsight, there is a natural segregation of functionality to what David Chalmers calls easy problems and hard problems. The hard problem of consciousness depends on subjective functioning. These differences in the informational channels stem from volition as a complex interplay between conscious and unconscious processes, while subjective intentionality is solely an unconscious process.

Functional interactions result from specific laws of evolution with important properties like non-symmetry and biological nonlocality (Chauvet,1996). Re-organization/restricting redundancies (not used in functional interactions) through information-based action has further significance and creates new meaning, i.e., non-contextual. Information-based action is both volitional or intentional; we consider intentionality and volitionality to mean the same action. So, understanding meaning is not just a static concept but a dynamic process of precognitive affect attributed to subjective functioning. The gist comes from what psychologists' call "affect" (Barrett, 2022). Precognitive affect comprises information-holding dispositional states arising from the hidden thermodynamic energy that constitutes the physical basis of subjective intentionality and conscious experience before self-awareness, as per Libet's findings. See **Figure 1.**

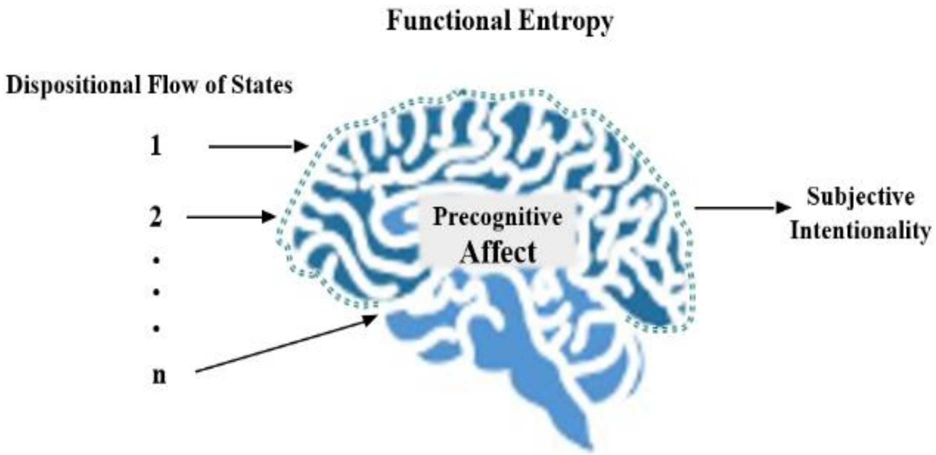

Figure 1 *A schematic illustration of the depositional flow of states contributing to the precognitive affect. Precognitive affect comprises information-holding dispositional states arising from the hidden thermodynamic energy that constitutes the physical basis of subjective intentionality. Functional entropy quantifies the affectiveness of this information, holding dispositional states enriched by hidden thermodynamic energy. The dispositional flow of states is defined by the chain of states appearing in the transition density matrix as boundary conditions for negentropic action with an intentional agency.*

Furthermore, information-holding dispositional states are building blocks of subjective intentionality that are considered non-integrated, ensuring subjective uncertainty. Uncertainties reside in biological cells (Miller, 2023). Since subjective uncertainty, their meaning cannot be related to context, constituting preconscious experienceability instead of conscious experience. The act of understanding uncertainty can be interpreted to mean understanding meaning of precognitive affect as a reduction of subjective uncertainty. It is a defining aspect of the consciousness mechanism and ceases to exist upon the complete removal of uncertainty, in which case memory begins (Solms, 2014). A thermodynamic mechanism has been proposed by Mandal & Jarzynski (2012).

The formative causation hypothesis proposes that all self-referential systems must have intentionality and are regulated not only by known energy and material factors but also by *information-based action* (Poznanski et al., 2018). *Information-based action* is the activity of information that is not directly a causal process in systems that lack functional interactions or do not construct their own (form of the) boundary conditions. The "form" of boundary conditions is ontological (but not Aristotelian) and defined through functional interactions to mean evolving boundary conditions. In systems that construct their own (form of the) boundary conditions, they exhibit causally effective information or *information-based action* (Roederer, 2003).

The *information-based action* is not a field of force (pushing and pulling) but is informing (cf., Bohm, 1990; Bohm & Hiley, 1993), which is, in essence, an experience of acting or intentionality. Thus, the characteristic organization of neural systems depends on influences that lead to the "form" that captures the self-referential character of experience by higher-level processes. When the "form" constitutes evolving boundary conditions controlled by negentropic action, it is informing as a "*consciousness code*" of intermittency spikes through patterns of spontaneous potentiality (Alemdar et al., 2023)

Functional interactions occur at different scales and represent changeable boundary conditions that carry and encode information (Kauffman, 2010). The re-organization of functional interactions is a measure of functional entropy. When functional entropy decreases, the re-organization of redundancies (not used in functional interactions), such as bond-dissociation energy and ionization energy, bring no further change, resulting in the selection of the functional interaction to be the mechanism that solidifies intentions in action into intentions. In addition, the affectiveness, or the experience of acting, is expressed in terms of functional information as the reduction of subjectivity uncertainty (Durston & Chiu, 2005; Craig Herndon, 2022).

3. Thermodynamics of intentionality

The thermodynamics of intentionality arises at the crossroads between the thermodynamics of information (Parrondo et al., 2015) and the thermodynamics of brain functioning (see Deli et al., 2021). We will label it "*animate thermodynamics*" to designate biological systems with an appearing aspect of anti-entropic behavior (Hoke et al., 2021). In brain thermodynamics, the main focus is the role of thermoregulation through the hypothalamus and metabolic activity to maintain homeostasis, while in animate thermodynamics, the role of the material is in focus, especially the animate or non-inert matter, for instance, governing the molecules' motional energy or microstate.

The holonomic brain theory (see Pribram, 1991) interprets complexity as something that can be measured by hierarchical redundancy structure as it exists in the cortex. It can be added to the thermodynamic system to maximize efficiency. Therefore, in the sense of Pribram (2013), *negentropic action* is defined as structuring the redundancies where the negentropic formation of flux in achieving deviations from equilibrium the minimum possible entropies defined as an ensemble of minima of least entropy or *"quantum of information"* (minimum *subjective uncertainty*).

What is causing experiences, if not subjective intentionality? Conscious experience is the experience of acting that forges understanding meaning of precognitive affect by reducing subjective uncertainty. The dynamics behind how the intentions unfold into actions as *composed of "quanta of information" or thermodynamic "bits"* (Street, 2020). In our thermodynamic approach (Beshkar, 2018), we have associated intrinsic information with *hidden thermodynamic energy* if it is demonstrable that the creation of intrinsic information in the brain is modulated by *hidden thermodynamic energy* in order to suggest that the brain has information obtained from about the environment at the submolecular scale that is hidden, i.e., endogenously produced yet active across scale, and that is why we claim that the mechanism of subjective intentionality is mostly unconscious (Lumer, 2019).

According to Brillioun (1953) "*negentropic information principle*", Shannon's information (theoretic) theory, based on the concept of entropy, should correspond to the decrease of entropy commensurate with an amount of negative entropy or negentropic gain (Brillioun,1951), also compare Wiener's definition Wiener (1948) of information related to negentropy (or negative entropy). This may sound unclear, given that information theory and thermodynamics are on the opposite side of the same page, but realizing this ambiguity, the entropies exhibit essentially the same function (Tribus & McIrvine, 1971; Wicken, 1987).

We must not forget to consider the functional information of the brain and functional entropy to account for the thermodynamics of intentionality. In addition, the negentropic action is an information-based action where the functional entropy is reduced (cf. Chauvet, 2004), and the *negentropic entanglement* is a cumulative effect of negentropic action. Further advancing Wiener's view, we are saying that subjective intentionality is the mechanism of understanding which can correlate to "information" in the above context (reduction of subjective uncertainty). For example, Loued-Khenissi & Preeuschoff (2020) state that the brain uses energy for *negentropic gain* to minimize uncertainty without learning.

Suspended action is more than potentiality (Bohm, 1989). This process is the negentropic action from suspended action to information-based action, which entails a 'negentropic force'; if contiguous, it points to negentropic entanglement. Negentropic entanglement (negentropic=relating to information gain; entanglement=binding) should not be confused with quantum entanglement. The difference is that the former is fundamentally intrinsic, based on an extension of quantum thermodynamics, while the latter is conceptually rooted in orthodox quantum mechanics for isolated systems, i.e., in the quantum connection between the particles. Negentropic entanglement is hence a matching-up mechanism empowering a unitary consciousness to exist via contiguous negentropic action, i.e., at any action, a single, unified consciousness, a subjective awareness of the total conscious experience - a qualitative, unified subjectivity (Poznanski et al., 2019).

Brillioun (1951) posited that Shannon's entropy decreases with knowledge about the system's different structure. However, subjective uncertainty is a statistical thermodynamic measure operating in informational-related processes (e.g., intrinsic information) which are non-sensory and non-perceptual and fluctuate through a set of "*intermittency spikes*" (Alemdar et al., 2023). This is a new way for an organism to attain information that is not sensed or perceived in some way (even if in a non-reportable way) and is multiscalar due to the re-organization/ restructuring of the redundancies (not used in subjective functioning) across scale. The greater the functional entropy, the larger the subjective uncertainty. The less subjective uncertainty, the more meaningful it is.

This *classical potential* is an analog[2] of the Bohmian *quantum potential* and depends on quantum-thermal fluctuations and temperature. It is derived from the classical Brownian motion (Nelson, 1966; Uzun, 2022). We have defined the classical *potential* (Q) based on the hydrodynamic model of quantum mechanics (Poznanski et al., 2022b, Alemdar et al., 2023):

$$\mathrm{Q} = -\frac{\gamma^2}{8\mathrm{m}T^2k_B^2}(\nabla f)^2 - \frac{\gamma^2}{4\mathrm{mT}k_B}\nabla^2 f \qquad (1)$$

where T is the temperature in Kelvin, k_B is Boltzmann's constant in units of [energy]/Kelvin, f is the fluctuations in units of [energy], γ is a spread function parameter in units of [energy][time], t is time [time], m is the effective mass of protons in units of [mass], ∇ is the gradient in units of $[\text{length}]^{-1}$, and ∇^2 is the Laplacian in units of $[\text{length}]^{-2}$.

Equation (1) shows a gradual reorganization of the brain's internal energy with temperature, suggesting that the *classical potential* as a *non-Bohmian quantum potential* is not limited to absolute zero temperature, as Schrödinger's equation assumes. The analysis of this equation leads to a kinetic interpretation of temperature: Temperature measures the average kinetic energy of atomic and molecular motions. The thermal and quantum fluctuations exert commensurable competing effects and become '*mixed*' as both thermal and quantum fluctuations. This can be observed with the temperature dependence of the *classical potential*. We note that ∇E /∇S = *T*, where ∇S is the rate of change in entropy and ∇E is the rate of change in internal brain's energy.

[2]Analogical reasoning helps produce productive models of biological phenomena, not realism. Quantum statistical mechanics is usually developed from its classical counterpart by a melange of quantum-classical concepts, namely statistical mechanics, but a distinguishing feature of traditional quantum mechanics is that it does not have a classical counterpart. In this respect, our quantum analogues are based on deductive theoretic modern quantum statistical mechanics (e.g., Löwdin, 1992).

Why is Q also an *information potential*? Unlike the *Bohmian quantum potential*, which is a carrier of information because of nonlocality (Hiley, 1995), the *classical potential* carries information derived from negentropic action. The negentropically-derived *classical potential* bears in its definition information about chaotic fluctuations of the medium on its ground state that are zero-point fluctuations. Its organization is based on Brownian wanderings of the particles on the ground state of the quantum system (Nelson 1966;1967) and is, therefore, a "classical" *information* potential derived from *hidden thermodynamic energy* demonstrating that the creation of intrinsic information in the brain is modulated by hidden thermodynamic energy.

4. Schrödinger processes as boundary conditions for negentropic action

The brain is a non-equilibrium open system that can continuously accommodate its boundary conditions for energy-time and entropy-temperature constrained under steady-state conditions. The result is a flow of dispositional states that dump entropy into the environment while producing a '*sea of information* (cf. information-based action, not force-based action). These *local entropy decreases* help organisms evolve, maintaining the constraining boundary conditions and re-organizing the *free energy* in agreement with the expelled entropy production. The interplay between the time scales and the temperature is the mechanism for negentropic action, which takes us from the microscopic- all the way through multiscaling to the macroscopic scale. One of the consequences is the build-up of negentropic gain, matching the entropic production, i.e., the heat dumped into the environment. This is our anti-entropy principle in the brain. Although this is sometimes labeled as an anti-entropic mechanism, it does not violate the second law of thermodynamics. Anti-entropic processes connected with thermal and quantum fluctuations, especially ground state instabilities, play a role in the anti-entropic mechanism (Nelson, 1985; Conrad,1996).

The Bloch-Liouville equations (Husimi, 1940) uniquely describe an expedient-constructive fusion of quantum-thermal fluctuations organized by the transition density matrix, which is the base for the irreducible character of non-integrated information. Moreover, Schrödinger processes (Föllmer & Gantert, 1997) enable the passage for a proper wave function to become, or form, the boundary conditions that manifest the constraints in the hidden thermodynamic energy, resulting in a flow of information at the mesoscopic scale just above the microscopic scale of quantum mechanics. Here the transition density matrix (Jordan block) has the attribute of a chain of (quantum) states, each represented by a wave function where the dimension and the phases at each location in the particular area of the brain are protected from decoherence, the 'coupling' of the representative waves into the chain of transitions is the protection mechanism. It governs how a transition density matrix, forming a Jordan block, can be derived (Brändas, 2020, 2023).

The representation has the attribute of a chain of (quantum) states, each represented by a wave function, where the dimension and the phases at each location in the open system, here the particular area of the brain, are given by proper boundary conditions involving the time scales of the actual process and the actual temperature. By its very nature, the transition density matrix, by coupling the representative waves into a chain of transitions, will be protected from decoherence as the thermal fluctuations, e.g., those at the hot and wet conditions in a living brain, that threaten to wash out precise quantum effects, are responsible for maintaining the boundary conditions.

The intentional agency is never characterized by being in a particular (quantum) state. Even if each of the representing wave functions is delocalized over the various positions in a particular part of the brain (depending on the experience of acting), they would not be Schrödinger waves (i.e., solutions of the Schrödinger equation for an isolated system) as they would be subjected to decoherence. Starting with a quantum system characterized by a Hamiltonian, being in the pure quantum state, $|\psi\rangle$, $\langle\psi|\psi\rangle = 1$, given by the density matrix, $\rho = |\psi\rangle\langle\psi|$, representing a perfect quantum description of an isolated system and subject to the Schrödinger equation. We have, for simplicity, used Dirac's bra-ket notation, which defines the scalar product between two arbitrary members of the actual Hilbert space. We skip the mathematical details as they belong to the accepted wisdom of quantum mechanics. A thermodynamic system will not display complete knowledge, for instance, one might find that $\rho = \sum_{k,l=1}^{n} |\psi_k\rangle \omega_{kl} \langle\psi_l| = |\boldsymbol{\psi}\rangle \boldsymbol{\omega} \langle\boldsymbol{\psi}|$, with the density matrix represented by the matrix $\boldsymbol{\omega}$ in the orthonormal basis ψ_k, with $\langle\psi_k|\psi_l\rangle = \delta_{kl}$, which under the axioms of general quantum theory always can be diagonalized, with the eigenfunctions of ρ given by ψ_k, and the eigenvalues ω_k occurring along the diagonal of the matrix $\boldsymbol{\omega}$, simplifying the density matrix representation to be written as

$$\rho = \sum_{k=1}^{n} |\psi_k\rangle \omega_k \langle \psi_k| \, ; \quad \sum_{k=1}^{n} \omega_k = 1 \tag{2}$$

In equation (2) ω_k is interpreted as the probability of finding the system in the state $|\psi_k\rangle$. In this more general situation, one finds ρ, ψ_k from the Schrödinger-Liouville equations and the associated time evolution. According to the philosophy of von Neumann, the system operator ρ defines the entropy S, in units of Boltzmann's constant, k, and base e, through the traditional relation, where the trace is defined as the (invariant) sum of the diagonal elements of the matrix

$$S = -\mathrm{Tr}\{\rho \ln \rho\} = -\sum_{k=1}^{n} \omega_k \ln \omega_k \tag{3}$$

As an example, we take the trivial case of all $\omega = 1/\Omega$, where Ω is the number of microscopic states corresponding to a given macro-state, arriving at the well-known Boltzmann formula $S = \ln \Omega$, displaying maximum entropy at the equilibrium probability distribution. Note that the condition stationary condition, $dS = 0$, incorporates both the maximum/minimum of the entropy and the steady state scenario.

One needs to generalize quantum mechanics to open systems, i.e., to consider the environment (environmental interactions) already on the fundamental Schrödinger-Liouville level. Fortunately, celebrated mathematical theorems guarantee this extension - including the case of the fundamental Coulomb interaction. The theorem authorizes a rigorous receipt for determining these general eigenvalues and eigenfunctions via analytic continuation into the lower complex energy plane. We will not get into the technical details, as they have been well examined and analyzed, except pointing out that the traditional Hermitian symmetric representation must be replaced by complex symmetric representations during the procedure of analytic continuation and that the eigenvalue might be complex, i.e., $\varepsilon = E - i\Gamma/2$, where the complex part of the eigenvalue is related to the lifetime of the resonance, i.e., $\tau = \hbar/\Gamma$. Another striking consequence of this extension is that there will appear degenerate situations where it will not be possible to diagonalize the corresponding matrix $\boldsymbol{\omega}$.

We will not go into the details of how these new objects appear, except pointing out that the dimension, n, of the higher order degeneracy is determined by the appropriate boundary conditions involving the temperature and the time scales. This gives rise to a simple, complex symmetric form for $\boldsymbol{\omega}$ of the type given below (Note: that analytic continuation imposes the constraint of complex symmetric forms).

$$Q_{kl} = \left(\delta_{kl} - \frac{1}{n}\right) e^{\frac{i\pi}{n}(k+l-2)} \tag{4}$$

The fundamental realization is that $\boldsymbol{Q}$ is nothing but a complex symmetric representation of a Jordan block, i.e., a unitary transformation can transform it; see below

$$\boldsymbol{Q} \to \boldsymbol{J};\ \boldsymbol{J} = \begin{pmatrix} 0 & 1 & \cdots & 0 & 0 \\ 0 & 0 & & 0 & 0 \\ \vdots & & \ddots & & \vdots \\ 0 & 0 & \cdots & 0 & 1 \\ 0 & 0 & & 0 & 0 \end{pmatrix} \tag{5}$$

Such a Jordan block representation of the system operator (density matrix), ρ, incorporates the addition of a transition matrix component, ρ_{tr} to the system operator in the pocket of the degeneracy of dimension n,

$$\rho_{\mathrm{tr}} = \sum_{k=1}^{n-1} |\psi_k\rangle\langle\psi_{k+1}| \tag{6}$$

i.e., a transition matrix ρ_{tr} that will be added to the system matrix $\boldsymbol{\omega}$ becoming (where α is arbitrary here, but in general depends on the nature of the problem)

$$\rho \to \rho' = \rho + \alpha\rho_{\mathrm{tr}};\ \boldsymbol{\omega} \to \boldsymbol{\omega}' = \boldsymbol{\omega} + \alpha Q \tag{7}$$

Therefore, the ensuing consequences for biological applications are the constraining boundary conditions involving the temperature and the related time scales of the dissipative system dynamics. Biological systems, in contact with their environments, necessitate a collective integration of quantum-thermal correlations, characterized by the thermal time scale, at temperature T, given by, in combination with long-range correlative behavior distinguished by the relaxation time τ_{rel}

$$n \propto \frac{kT}{\hbar}\tau_{\mathrm{rel}} = \frac{\tau_{\mathrm{rel}}}{\tau_{\mathrm{corr}}} \tag{8}$$

The dimension, n, or number of actual degrees of freedom, displays a basic relation between the temperature and the time scales, τ_s, in multiples of τ_{corr} at the same time providing a constraining relation or boundary condition for the dissipative system evolving at non-equilibrium steady state conditions, $dS = 0$. Noting that the function $-x \log x$ has a maximum at 1/e, one finds that the entropy for a thermal system, with n degrees of freedom, at equilibrium, defined by $S = k \log \Omega$, with Ω proportional to e^n, obtains as $S \propto nk$. A biological system evolving at $dS = 0$ with the entropy change can be divided into two parts, i.e.,

$$dS = dS_{\mathrm{e}} + dS_{\mathrm{i}} \tag{9}$$

where dS_{e} is the entropy flux due to exchanges of energy-matter with the environment, dS_{i} the entropy production due to the irreversible processes inside the system. The second law admits $dS, dS_{\mathrm{i}} \geq 0$. Under the steady state condition, $dS = 0$, one might find a negative entropy flux, $dS_{\mathrm{e}} = -dS_{\mathrm{i}}$, i.e., a perfect matching between negentropic gain and entropy production.

5. Conclusions

As the thermal fluctuations, e.g., those at the hot and wet conditions in a living brain, threatens to wash out precise quantum effects, the latter necessary for maintaining an indispensable long-range organization, it is adamant about finding a strategy that frustrates the interferences, i.e., forbids the abstruse decoherence problem and supports the boundary conditions for negentropic action. Unfortunately, the free energy principle in theories of consciousness (Solms & Friston, 2018; Solms, 2019) rely on variational free energy, optimizing both the thermodynamic free energy and the entropy, so they cannot address this problem. Any realistic approach to understanding consciousness as a biological phenomenon depends on the temperature at the submolecular scale.

We explained contiguity from the submolecular scale just above the atomic scale to the macroscale of intrinsic information based on negentropic action. Negentropic entanglement is a matching-up mechanism empowering a unitary consciousness via contiguous negentropic action. For example, information that arises from metabolic activity is endogenously produced but not intrinsic, as it arises at the cellular level only. Therefore, the resultant intrinsic information and energy are inextricably interwoven in two ways: (i) EM energy upon which information-*based action* assigns meaning to the precognitive affect; and (ii) "*hidden" thermodynamic energy*, which is negentropically-derived quantum potential energy by which subjective intentionality is embedded in a negentropic *consciousness code* at short time and space intervals. The "action" is a form of energy that permeates the material composition of the brain's internal energy. It is an operational process of intentionality, which is the defining act of an intentional agency.

The reduction of subjective uncertainty brings about intentions unfolding into actions by an intentional agency comprising the depositional flow of states which is contiguous, labile, and temperature-dependent. The temperature dependence suggests that hidden thermodynamic energy drives the mind's subjective intentionality. The epoch of unified functioning of consciousness commences from the brain's subjective intentionality and, through the reduction of subjective uncertainty by negentropic action, leads to understanding meaning of precognitive affect. The notion of understanding needs to be clarified as the experience of acting. Therefore, the precognitive affect forms an '*act of understanding*' or subjective intentionality that relies on intentions sensed as feelings. This is supported by our definition of consciousness—the act of understanding uncertainty. Here "uncertainty" is psychodynamically fundamental; one cannot know the microstate of a physicochemical system precisely because it fluctuates through Q. Furthermore, to define subjective uncertainty as psychodynamically fundamental, one needs to define matter as active or non-inert. We have done this in the *panexperiential materialism* framework (Poznanski & Brändas, 2020). Hence, the non-inert matter is fundamental *quid pro quo* subjective uncertainty.

Finally, the "act" here connotes the underlying experience of acting. For example, the experience of the act of thinking a thought is non-felt. What is the subjective experience of a thought? There are no feelings attached to the experience of the act of thinking a thought implying that subjective intentionality is more fundamental than feelings. Our definition of consciousness gives groundwork for developing a model that paves the way for understanding meaning from imagined and real experiences. We hope to implement the anti-entropic mechanism of consciousness that requires matching across scale and hence explain Freud's model of the mind as being multiscalar and not metacognitive, as generations of psychologists have assumed in the past.

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