Research Essay

Pragmatic Information, Intentionality & Consciousness

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Abstract

It has been sixteen (16) years since Freeman and Nunez wrote their paper, "Restoring to Cognition the Forgotten Primacy of Action, Intention and Emotion" (Freeman & Nunez, 1999) where they rightfully warned us[1] about the limitations and dangers of cognitivism, neo-cognitivism, representationalism and the damage that a reductionist technocratic based science did, and would continue to do if it is left unchecked, to a more systemic approach geared to the understanding of mind, soul, intentionality and values based decision making with the potential for a better and more sound scientific paradigm of consciousness that includes the objective-subjective complementary pair grounded in biology, and particularly the neurobiology of a rich inner spiritual life conducive to inner peace, constructive creativity and intelligence, and social harmony. In this work we briefly explore some of the most innovative paradigms for the study of consciousness that in our view have been developed since 1999 with special emphasis in how the brain creates knowledge and meaning, something critical in human life for deciding courses of action which are spiritually, intellectually and emotionally important and meaningful to each of us. More importantly, this paper explores pragmatic information indices that serve the purpose, as hypothesized in works by Freeman (Freeman, 2008) and other authors (Davis & Kozma, 2013) (Davis, Gillett, & Kozma, 2015), in finding a plausible way to measure and quantify the creation of structure and order as observed in brain signals which are amplitude modulated, showing that the creation of knowledge and meaning requires energy consumption as a consequence of the interaction between the environment (the double, as Vitiello has called it) (Vitiello, 2001) and the brain which is regarded as an open thermodynamical system capable of breaking symmetry and creating coherent structures (Freeman & Vitiello, 2006).

Keywords: Pragmatic information, intentionality, consciousness, paradigm.

1. Systems Neuroscience, Brain Field Dynamics and the Biophysics of Consciousness

The Freeman-Vitiello duo have presented us with a challenging yet promising paradigm to study consciousness based on a quantum field theory that regards the brain as an open thermodynamical system that is capable of interacting with the environment, the double, in order to engage in a way described similarly by (Merleau-Ponty, 1962) and others (Freeman, 2008) (Davis, Gillett, & Kozma, 2015) (Brentano, 1973) (Brentano, 1981) as an 'intentional arc'.

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[1] Even though I am the only author of this paper, I am writing in plural since I feel this paper comes as a collaborative effort of several people to whom I am very grateful and whom have been acknowledged properly in the acknowledgement section.

During the lifetime of a human being he or she is presented with innumerable repetitions of different kinds of intentions and moments of enacting such intentional arc and therefore, the brain is constantly and continuously actualizing the fabric of knowledge and meanings relevant for value based decisions and actions, and for that it relies on past memories and somehow memories that pertain to possible futures in order to optimize a utility function (Werbos, 2003) in online decision making. This constitutes, according to Vitiello (Vitiello, 2001) the truth of the individual, which is dynamic and ever expanding as life and experience goes on.

Another duo, which is perhaps the precursor of the Freeman-Vitiello duo, is the Pribham-Bohm duo, which was instrumental in showing us a kind of universe that is conscious and intentional and manifests such traits through different agents in the universe and particularly through human beings on planet earth. Pribram (Pribram & Carlton, 1986) gave us his holographic view of the brain, something that Bohm and Hiley (Bohm & Hiley, 1995) complemented and enriched through their understanding and study of the implicate and explicate order. It is important to mention that Pribram mentored Freeman (Nuallain, 2016), particularly in developing and enlarging the view that consciousness is modulated by electromagnetic fields, which in turn modulate chemical transactions in an undeniable circularity. More importantly, in one of his most recent works, "The Form Within" (Pribram, 2013), Pribram stated that the time to seriously scientifically study spirituality and cognition has come since we now have paradigms that are systemic and integrating disciplines, like systems neuroscience, quantum field theory, quantum mechanics, non-linear systems dynamics, and systems biology and neurobiology.

A last duo that is worth mentioning is the Penrose-Hameroff (Hameroff & Penrose, 2014) duo, which has proposed a quite challenging theory and their Orch model of consciousness, which borrowed on some of the neuroscience of Pribram with quantum mechanical implications at the level of the microtubules in the dendritic networks.

Without room for large and deeper discussion about the vast work of these three (3) duos, since it is out of the scope of this paper, we would like to finish this section by introducing an even more challenging, however, required paradigm to the understanding of the cognitive neuroscience of spirituality and its possible implications for the neurobiology of peace and social harmony. This is the connective paradigm of Melchizedek as described in (Davis, 2009) (Gillett & Davis, 2015) where an emphasis is made in the distinction between spiritual or universal values in contrast with behavioral values. The first set of values is presented as essences and presences acting through fields of different kinds with the power to override behavioral or survival values, which are the consequence of reward and fear conditioning and learning.

The relevance of this paradigm is the self-evident experiential fact and also the hypothesis that values, like love, unity, truth, humor and grace or compassion, can only exist for human beings, in human consciousness, in a chain of meanings which is based on the knowledge that such values are preverbal and extremely relevant in terms of intentions, identity and courses of actions for a peaceful and harmonious life in relationship to others. Therefore we are now presented with the possibility of putting effort and resources to a serious study of a science of inner peace and social harmony (Zhuang, Reso, & Davis, 2016) (Schübeler, Gillett, & Davis, 2016), something crucial as a plausible, necessary and more positive scientific narrative to counter balance, compensate and ideally overcome the extinction scenario of the human species, as thoroughly

described by Werbos (Werbos, 2017) (Werbos, 2017a) (Werbos, 2008) (Werbos, n.d.). This I conjecture, could lead us consciously into our next stage of evolution from homo sapiens to homo pacem.

Perhaps the question with the highest priority to answer is, how will a human brain create, in interaction with others, local and shared meaning about the knowledge that inner peace is a survival priority, and then, become coherently creative, co-operative and altruistic, so as to transmute the perception that selfish and competitive survival based behavior, can be the only guarantee for "the supremacy of the strongest." Perhaps it will be important to redefine "the strongest" as the most peaceful, kind, wise and creative.

In any case this puts us directly with the challenge already discussed by authors in collaboration with Freeman and others about how the brain creates knowledge and meaning and its philosophical implications towards a more peaceful humanity (Davis, Gillett, & Kozma, 2015) (Freeman, 2008) (Freeman, 2000).

2. The Cycle of the Creation of Knowledge and Meaning (CKM) in a Nutshell

In order to grasp the profound implication that the creation of knowledge and meaning has for conscious and wise decision-making, based on intentional acts, we have to also understand information as an active principle capable of putting in motion different systems, both mechanical and biological. Human beings act after processing written information since the brain sends the corresponding motor movement signals, which are associated to work or potential energy that is converted into kinetic.

Imagine the act of catching a wave with a surf board: the surfer looks at the horizon for a while and when the wave is presented as coming towards him, he or she processes this environmental signal and after several brain transactions, the brain derives information that is then involved in the creation of knowledge and meaning about the wave and the utility of riding the wave. Note that the surfer is usually waiting for a wave in a form of rest, a kind of meditative state, perhaps dominated by frequencies in the alpha band and, at a point in time, when the wave is near, the surfer realizes that it is: 1) a powerful wave and 2) a perfect one, clean and potentially a long ride (prediction) and then 3) he or she acts on it by paddling hard (action, motor movement) to catch the wave. After the long ride the surfer returns with a smile on his or her face (a reward or utility) ready to repeat the cycle. Also note that every wave, no matter how similar, will always be unique and will always actualize the knowledge and meanings about the many skillful and artful movements involved in surfing, eventually leading, after many repetitions of this cycle, to a certain degree of mastery.

When looking at the many energetic transactions involved in learning this art and sport, we are particularly interested in what happens in the brain when the surfer is waiting for the wave (background activity, perhaps dominated by frequencies in the alpha band as mentioned above), then the wave (stimuli) is presented to the surfer and it triggers a process in which meaning and knowledge are derived from the stimuli in a set of non-linear events with their corresponding changes in power, in different frequency bands, like the beta and gamma bands for example

(Davis & Kozma, 2013). The meaning and knowledge created about this particular wave would be associated, let's say, to size and power of the wave, quality of the wave, a quick forecast about the utility of riding the wave and finally the act of paddling and riding the wave efficiently until the reward is obtained.

In previous work the author in collaboration with others, conjectured the existence of such a cycle of creation of knowledge and meaning (Davis & Kozma, 2013) (Davis, Gillett, & Kozma, 2015) and found with experimental data collected via ECoG signals, measured on the cortex of rabbits, that such a cycle was very plausible with a duration of approximately one (1) second and comprised of basically five (5) steps that have been thoroughly described and explained. This story relates how synchronization-de-synchronization effects with sudden transitions in spatio-temporal neurodynamics could be relevant to cognition and awareness, where the moments of very high synchronization after stimuli (3.25-3.5 seconds) relate to intense attention followed by a learning and integration period with very high de-synchronization (3.5-4 seconds). In previous studies where data was obtained from an intracranial array of 8x8 electrodes implanted over the visual cortex of rabbits (Kozma, Davis, & Freeman, 2012), ECoG data was analyzed to identify the above mentioned brain dynamics. The data was processed using the Hilbert transform methodology to produce the analytic signals as described in other studies (Davis & Kozma, 2012). It was found amongst other things that for example, a very high synchronization was associated with low amplitudes and a very dramatic de-synchronization was coupled with a dramatic drop in amplitude. It was conjectured that the spatially distributed Analytic Amplitude (AA) and Signal Amplitude (SA) patterns might carry some information concerning the meaning that the animal may associate to the stimuli and its relevance in decision-making.

In order to better illustrate brain dynamics together with these findings, a diverse set of movies showing the spatio-temporal patterns of the Signal Amplitude (SA), the Analytic Amplitude (AA), the Analytic Phase (AP) and the Instantaneous Frequency (IF) were produced. Brain dynamics movies were also created to show the different spatio-temporal patterns involved. After watching these movies many times, some evidence was derived concerning the hypothesized cycle and the emergence of awareness experience in the neocortex (Davis, Kozma, & Freeman, 2015) (The Science of Peace, 2017). A complementary analysis was also produced with the aid of pragmatic information indices based on information theory and semiotics, which will be explained in the next section.

As mentioned above, the Cycle of Creation of Knowledge and Meaning is comprised of five (5) steps that occur in a window of time of around one (1) second, just after the presentation of a stimulus. Simply put, the experiment is divided into two (2) periods of three (3) seconds each: pre-stimuli period and post-stimuli period. The pre-stimuli period is characterized by background activity while the post-stimuli period shows the one (1) second window, where knowledge and meaning are presumably created, with a return to background activity for the last two (2) seconds of the post-stimuli period. This experiment was repeated a significant number of times for two (2) different conditions CS+ and CS- where the five (5) steps of the Cycle of Creation of Knowledge and Meaning were identified, as follows:

- Step 1 (3 - 3.1 s): Initial impression, which may be termed the *"Awe"* (or noticing) moment.
- Step 2 (3.1 - 3.3 s): Chaotic Exploration of memory traces with highly distributed and desynchronized patterns, *"Search for meaning"* (a wider analysis and connection).
- Step 3 (3.3 - 3.45 s): Recognition/identification of the searched clue/decision which can be termed the *"Aha"* moment.
- Step 4 (3.45 - 3.6 s): Integration of the new knowledge in a chaotic dynamic process (*That's where it fits*).
- Step 5 (3.6 - 3.9 s): Dramatic drop in the indices toward the end of the post-stimulus brain activity, showing a return to the usual, background/default level.

Generally speaking, outside of the post stimuli window of one (1) second the system shows synchronization between channels with associated low amplitudes. This is accompanied with periods of mild desynchronization showing relatively higher amplitudes.

Overall, it can be stated that there are clear visual differences in the different movies between the CS+ and CS- collective responses. To formalize this statement and give it statistical conclusive support, robust quantitative methods of classification like discriminant or cluster analysis, for example, would have to be applied, it is suggested, with the aid of pragmatic information indices.

It is important to note that all the rabbit data was collected by Freeman and Barrie (Freeman & Barrie, 2000) in Walter Freeman's lab at UC Berkeley.

3. The Pragmatic Information Indices as a powerful measure in the detection of the Creation of Knowledge and Meaning in Spatial-Temporal Brain Dynamics

We have learnt through semiotics that pragmatic information is closely related to intention, decision-making and action (Atmanspacher & Scheingraber, 1990). This can be easily observed in a tennis match where one (1) player derives information from the movements of the other in order to anticipate his or her actions. Semantic information is different because it is derived only from grammar and linguistic ingredients, together with the articulation of sounds.

Pragmatic Information can be derived from events such as: 1) utterances that lead to meaningful action, 2) non verbal body movements (body language) and 3) biophysical markers like amplitude modulated patterns derived from brain dynamics, heart rate variability signals and levels of stress hormones to name a few.

It could be easily conjectured and rightfully so, that Pragmatic Information emerges hand in hand with the creation of meaning together with intention, before an action is even initiated, such as shouting at or knocking on a neighbor's door to invite him for dinner.

Over the last years scientists from different fields have used pragmatic information, particularly in the field of physics, to show that this concept is relevant in describing self-organizing systems based on different approaches, like synergistic and non-equilibrium thermodynamics. The relevance of pragmatic information in relation to meaning and complexity has also been pointed out.

In their paper titled "Pragmatic information and dynamical instabilities in a multimode continuous-wave dye laser," Atmanspacher and Scheingraber (Atmanspacher & Scheingraber, 1990) gave a thorough explanation following in the steps of semiotic tradition, where information has been considered from three (3) different perspectives as follows: syntactics, semantics and pragmatics. Like them, I consider very relevant the use of pragmatic information since it can be associated to intentional action and be identified via motor movement or brain dynamics that precede such movement. The reader must note that I can reveal my intentions to surf via pragmatic information when I start waxing my surfboard instead of revealing them by stating them (my intentions) verbally. We can conjecture then, that brain oscillations associated to pre motor movements, like waxing my surfboard, would be a source of pragmatic information provided that they can be measured and identified.

The need to use pragmatic information indices arises somehow from the limitations associated with the Shannon index which says nothing about the content of a message and its meaning and only gives us a probabilistic measure of semantic integrity (Shannon & Weaver, 1949). Both Freeman and collaborating authors somehow inspired by the work of Atmanspacher and Scheingraber, concur that the use of pragmatic information indices and measures are fit for the task to measure the level of order or structure in windows of brain dynamics associated with different stimuli in contrast with background activity (The Science of Peace, 2017a).

In relatively recent years, in close collaboration with Walter Freeman, myself and others upheld many conversations and work sessions that led us to the conclusion that we had to develop, together with a methodology for brain dynamics movies, another methodology with robust quantitative indices to measure the kind of distinctions that we saw in qualitative cinematic brain patterns. This methodology had to be inclusive of Pragmatic Information Indices, since we foresaw that they would be able to powerfully capture non-linear changes in brain dynamics that would be associated with the creation of knowledge and meaning based on experimental designs that Freeman carried out in his own lab in UC Berkeley, as already noted above.

We studied deeply the concept of pragmatic information and the need to translate that in terms of brain dynamics, into a mathematical form or structure, in our case a ratio, that may serve as a pointer to meaningful action, based on acquired knowledge, via learning that is somehow manifested in the neuro-energetics of the brain.

We used data collected on rabbit's cortex via ECoG from Freeman's Lab and later on we conducted experiments on human beings, both in laboratory conditions as well as in nature, to gather information in multiple frequency bands about the activity of the brain generated by different stimuli presented to the rabbits, as well as in different experimental modalities with human participants. The signals were obtained via electrodes and, particularly in human participants, we tested a diversity of technologies where we cover both small and large areas of

the brain, sometimes with a very small spacing between electrodes (Davis, Kozma, Lin, & Freeman, 2016) and we also carried out similar experiments with a largely spaced set of electrodes (Davis, Lin, Gillett, & Kozma, 2017). It is important to note that both spatial and temporal resolution can be determining factors in properly analyzing brain dynamics in order to discriminate between different and relevant brain states.

We structured the methodology in a way that would allow us to deeply study any frequency band and also a comparison between them. First we decided which bands we wanted to study, whether it is narrow or broad, and second we Band Pass Filtered the signal to obtain another signal in that particular band. Then this new signal was Hilbert transformed to obtain a set of new signals as follows: Analytic Amplitude (AA), Analytic Phase (AP) and Instantaneous Frequency (IF) based on certain computations. With these signals (AA, AP and IF) we computed a set of indices based on the range of the Signal Amplitude and the Analytic Amplitude (RSA, RAA, SAA) for certain sub-windows of time. These indices were in turn used in the computations of the pragmatic information indices.

With the Pragmatic Information Indices we were in the position to capture relevant nonlinear events presumably associated with the creation of knowledge and meaning and to derive both qualitative and quantitative information via brain dynamics movies and statistical analysis respectively. As mentioned before, the Pragmatic Information Indices HRSA, HRAA and HSAA are derived from another set of indices based on the range of the signal amplitude (RSA), the range of the analytic amplitude (RAA) and the value of the analytic amplitude squared (SAA), also represented as AA^2, where every one of them is divided by a type of Euclidean Distance (ED) between channels, sometimes based on the analytic phase (ED_AP) and others based on the analytic amplitude squared (ED_AA^2) (Davis & Kozma, 2012).

4. Some final considerations and philosophical, theological and spiritual implications

After the methodology and the Pragmatic Information Indices were tested, we went deeper in our research and found further support for the hypothesized cycle of knowledge and meaning creation in Brentano's three (3) step cognitive operation comprising human consciousness (Davis, Gillett, & Kozma, 2015) (Brentano, 1973) (Brentano, 1981), where more likely, each band was telling a story about particular aspects of the cycle. With more analysis on different rabbits and cortices, we were able to confirm Brentano's insights concerning the steps involved in conscious intentional behavior and we contrasted that with our cycle steps, as well as what we had learned from Aquinas and Freeman (Freeman, 2008).

At one stage, another striking similarity between the cycle of creation of knowledge and meaning appeared in the ideas and writings of Raimon Panikkar, PhD in Philosophy, PhD in Science, PhD in Theology and a Doctor Honoris Causa. These similarities are to be found both in Panikkar's work (Panikkar, 2006) and Sergio Bergman's reference to Panikkar (Bergman, 2009). In Table I we can identify the correspondence between the Knowledge and Meaning Creation Cycle, Brentano's Types and Panikkar's four (4) moments in spiritual experience.

Table I. Similarities between the Knowledge and Meaning Creation Cycle, Brentano's Types and Panikkar's four (4) moments in spiritual experience.

		Post Stimuli Period	*Characteristic Behaviour*	*Brentano's types*	*Panikar's Types*
Knowledge Creation Cycle Steps	**Awe** Step 1	3 - 3.1 s	Hyper Synchronization and low AA2	Type 1 (targeting, noticing)	First moment, pure experience
	Chaotic Exploration Step 2	3.1 - 3.3 s	Desynchronization with dramatic drops ("null spikes") Followed by a strong raise for AA2	Type 2 (binding its stimulus characteristics)	Retrieval of that moment available for later referral
	Aha Step 3	3.3 - 3.45 s	Tendency towards synchronization and drops of AA^2	Type 3a (categorizing it, attaching a semantic marker to it)	Interpretation we make about the experience with the aid of language
	Chaotic Integration Step 4	3.45 - 3.6 s	Strong desynchronization with abundant "null spikes" and a strong raise in AA^2	Type 3b (categorizing it, attaching a semantic marker to it)	Linguistic Integration with cultural context
	Background Activity Step 5	3.6 - 3.9 s	Synchronization with low AA^2 & occasional desynchronization periods showing high AA^2	Type 3c (categorizing it, attaching a semantic marker to it)	Delivery and reception of wisdom and understanding of the knowledge of the transcendental

It is interesting to ponder on Panikkar's work about religious or spiritual experience and the almost one to one relationship with the cycle of creation of knowledge and meaning. According to him there are four (4) relevant and distinct moments in spiritual experience where *meaning, relevance and transcendence* emerge together with the articulation of the experience in language and culture. The first moment is what he calls a *pure experience* similar to the awe moment or "Step 1", the second moment is associated with the retrieval of that moment available for later referral, similar to chaotic exploration or "Step 2", which serve the purpose to outline the content of the experience in relation to stored schemata. After that, it follows another moment concerning the interpretation made about the experience with the aid of language, paralleling the Aha moment or "Step 3." Finally follows the delivery and reception of the wisdom and understanding associated with our experience into the culture that we coexist with and where we conduct our meaningful actions (this involves the comparison with the linguistic and cultural symbolic database and the experiences that they refer to, and in the spiritual case, with having achieved or realized the knowledge of the transcendental reminding us of the final stage of chaotic integration or "Step 4."

The combination of philosophy and science hand in hand with the experience of the transcendental reported by Philosophers, Prophets and Prophetesses, and Saints of old and modern days allows the expansion of our understanding of consciousness, leading us eventually to the kind of integration that shapes human identity (Hughlings, 1887). This comes with the potential towards the embodiment of spiritual values that play a part in the creation of meaningful life experiences, allowing us to apply new knowledge in order to improve our sense of well-being in relationships, as beings-in-the-world-with-others, aided by creativity and constructive intelligence in daily life.

Freeman's views on knowledge and meaning construction and intentionality are closely related with the ideas expressed in this work, *"the philosophical foundation from which the sciences*

grew is accessible through the work of one of its originators, Thomas Aquinas. The core concept of intention in Aquinas is the inviolable unity of mind, brain and body" (Freeman, 2008). Together with Freeman, who echoes Aristotle, Aquinas and Brentano, I concur that the creation of meaning and knowledge arises in cortical activity, instead of in sensory input, and so far, based on observation, it seems to be well represented by the cycle previously described. The indices of Pragmatic Information are a good initial point to quantitatively approach this challenge and when combined with Freeman's techniques of videoing brain dynamics (which we conjecture show the structure of meaning qualitatively) equips us with powerful tools to improve our understanding of brain dynamics implicit in the cycle we have described and therefore bring us closer to the core of what human consciousness really is.

5. Future Perspectives

Since the challenge that presents to us the study of consciousness and particularly the study of inner peace is immense, it seems to me that a necessary starting point is to deeply understand how the brain participates in the creation of knowledge and meaning. This will more likely require a combination of first person and third person science, where our choices for action are evaluated via utility functions that somehow are related to our energy consumption, stress and psychophysiological coherent bodily states. This may involve inferring such subjective states and values from subjective utilities and probabilities that somehow could also be related to Heart Rate Variability (HRV), Brain and Hormonal dynamics.

It seems to me and others, that we will put our focus on experimental paradigms conducive to the unraveling of the willful generation of relaxed and peaceful states of being for long periods of time, which in turn facilitate social harmony and better possible futures for the human species. It is natural that research questions may arise in order to ideally find answers to puzzling types of experiences and existential modalities associated with spiritual experiences (for many associated to a relationship with The Creator) and how that relates to health and general well being. Finally, I foresee that somehow a better understanding of these matters and more importantly, the commitment to pursue inner peace, will equip us to participate more intimately in the solution to the 21st century dilemmas within the context of a Universal Frame of Ethics that can be studied under the umbrella of new and more comprehensive scientific paradigms (Luria, 1973) (Freeman & Barrie, 2000) (Davis, 2009) (Panikkar, 2006).

Some questions to be explored are: 1) Could it be that the CKM is central to the experience of deep insights and inspirations when engaged in, for example, scientific research, philosophical inquiry, creative activities and religious, spiritual or mystical experiences?, and 2) Are these experiences reproducible at will both in life and the lab so as to create learning environments where people can learn how to function in different cultural contexts with the foundation of a universal framework of ethics that allows them to significantly overcome unhealthy habits, addictions, disease and compulsive survival needs?

I am convinced that these are questions very relevant to explore in these times of global turmoil and it seems to me that finding answers to them will be vital for our survival and in the achievement of harmonious living.

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