The Fundamental Problem of the Science of Information

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Abstract

The concept of information has been extensively studied and written about, yet no consensus on a unified definition of information has to date been reached. This paper seeks to establish the basis for a unified definition of information. We claim a biosemiotics perspective, based on Gregory Bateson's definition of information, provides a footing on which to build because the frame this provides has applicability to both the sciences and humanities.

A key issue in reaching a unified definition of information is the fundamental problem of identifying how a human organism, in a self-referential process, develops from a state in which its knowledge of the human-organism-in-its-environment is almost non-existent to a state in which the human organism not only recognizes the existence of the environment but also sees itself as part of the human-organism-in-its-environment system. This allows a human organism not only to self-referentially engage with the environment and navigate through it, but also to transform it in its own image and likeness. In other words, the Fundamental Problem of the Science of Information concerns the phylogenetic development process, as well as the ontogenetic development process of *Homo sapiens sapiens* from a single cell to our current multicellular selves, all in a changing long-term and short-term environment, respectively.

Keywords

Science of Information; Human-Organism-in-its-Environment; Gregory Bateson; Distributed Cognition; Ecology; Communication; Shannon Information; Distilled Information; Bateson Information

1. Introduction.

Biosemiotics claims organisms are not only sign-acting, sign-manipulating and sign-creating systems, but also products of sign-action. In general, Biosemiotics is founded on three key thinkers: The Estonian proto-semiotic biologist Jakob von Uexküll (1864–1944), the bio-cybernetic thinking of Gregory Bateson (1904–1980) and the semiotic logic of Charles Sanders Peirce (1839–1914). This triad forms the backbone of biosemiotics. Uexküll's understanding of the organism-in-its-environment is, perhaps, the keystone to the inside-outside problematic. Peirce's sign model and semiotic theory emphasises how cognising, and the inside-outside synthesis, is a condition of sign interpretation, and the principle of a difference, underpinning Bateson's ecological standpoint, brings these two positions together to distinguish what has become the biosemiotic project. The melding of these three key thinkers is perhaps best summed up by Jesper Hoffmeyer, who states that "[b]iosemiotics is the name of an interdisciplinary scientific project that is based on the recognition that life is fundamentally grounded in semiotic processes" (Hoffmeyer 2008a: 3) and that it is "an approach to the study of living systems that takes the production, exchange, and interpretation of signs to be constitutive for life" (Hoffmeyer 2010: 368). So, in summary, biosemiotics is the study of "the sign-character of the processes that takes place inside or between living systems (from the single cell to full organisms and further to populational or ecological systems)" (Hoffmeyer 2008b: 4).

Hoffmeyer's statements succinctly express the nature of biosemiotics, and emphasize its interdisciplinarity, its dependence on Peircean semiotics, its concern for biological (or intrinsic) information, and its positing that life and semiosis are coextensive. Though it has to be acknowledged that there are many voices that are discordant with this view, as biosemiotics is a new *interdisciplinary scientific project* (Emmeche 1999; Pattee 2013; Barbieri 2012 & 2013). Some even reject the notion of biological (or intrinsic) information (Rubin 2017). Further, biosemiotics acknowledges information to be an implicitly semiotic term, which puts it at odds with the more recognized concept of Shannon Information. However, it remains unclear how semiosis is related to information (Kull et al. 2009: 169). Many scholars have emphasized the lack of meaning in information when contrasted with semiosis (Brier 1999; Battail 2009; Sharov 2010; Markoš & Cvrčková 2013; Battail 2013). While others have hinted at the close relationship between information and semiosis (Kull et al. 2009; Brier & Joslyn 2013; Cannizzaro 2013; Matsuno 2013; Vitti-Rodrigues & Emmeche 2017). Additionally, there are scholars that mention that a unification of information and semiotics is possible (Emmeche 1999; Battail 2009; Pattee 2013; Barbieri 2013; Battail 2013; Cannizzaro 2013; Rohr 2014; Auletta 2016; Vitti-Rodrigues & Emmeche 2017; Heras-Escribano & de Jesus 2018). This paper does not attempt to clarify the relationship between information and semiotics. It is a brief review of the disparate ideas of what information is, so as to draw correlations between these to establish a footing on which a unified definition of information may be built. We claim a biosemiotic perspective is necessary for this, because how a living system interacts with its environment (from a cell to a human organism) is constitutive of sign relations and information exchange.

Organisms are interpreters of and responders to information, which they may perceive as signs (i.e., of food, danger, orientation, copulation), or as James Gibson (1966) would have it, organisms are perceptual systems that perceive stimulus, which are distinct from their source. So, when we refer to a stimulus as being a sign, what we mean by "sign" is simply a relation whereby one part of the world is being used to stand for something else other than itself. As Favareau (2007) states: "The key to this understanding is that 'sign relations' are primarily not something psychological, linguistic or even human-specific – but rather, simply those internal-to-external relations that all living organisms must establish in order to successfully negotiate the never 'fully knowable' world upon which all aspects of their lives depend". Pheromones used by ants to communicate are chemical compounds used, for example, to indicate the presence of food. Throughout the animal kingdom pheromones are used to signify danger, food source, territory or disposition to mate. At some point in evolution the volatilised chemical compounds (we refer to as pheromones) came to have particular significance because some experience led to a relation between physiology and extraneous matter. Organisms have evolved manipulating their environments which they structure to enhance communication (i.e., to mark territory or direction of food) and improve performance. Offloading tasks onto the environment organisms simplify cognitive and physical activity (see Kirsh, 1995), and social organisms, having developed the capacity to manipulate their environments, build structures in which they embed information enabling them to shape and manage the collective's activities.

Biosemiotics is also generous in its recognition of many types of information, including,

Syntactic or Shannon information – is that type of information that underlies the Mathematical Theory of Communication proposed by Shannon (Shannon 1948). It involves the sharing of a message between two parties, i.e., having the ability to recognize the originally sent message out of all possible messages that might have been sent. The semantic content is found to be irrelevant to the engineering problem requiring the efficient transmission of the syntactic elements in the message. The fact that Shannon information does not involve meaning has made it difficult to integrate it into biosemiotic use in the context of Peircean signs. And it has been claimed that (Shannon) *information is not enough* (Brier 2008).

Bateson information – is the concept of information that involves *a difference that makes a difference* (Bateson 1972: 321). It is a widely referenced and recognized definition of information and is considered well integrated into the biosemiotic fold. This is the definition of information that is used and developed in this paper.

Biological, heritable, or intrinsic information – is the type of information that is directly linked with the genome and is deemed acquired by variation and natural selection. Francis Crick (1958) proposed the existence of "The Central Dogma" which argued for the existence of intrinsic information in the workings of the genome (Barbieri 2012 & 2013).

Functional information – is a set of signs that encode the functions of the organism (Sharov 2010: 1058; Sharov 2016).

Non-heritable learned or creative information – is that portion of information that we acquire by the cognitive process and is stored in nervous systems and brains, and acquired by observation and instruction, or created by cognitive variation and individual or cultural selection (Pattee 2013: 12).

Measured physical information – meaning experimental observation or measurement of a physical system in the context of a theory of natural laws (Pattee 2013: 12). And,

Ecological information – is the information that organisms of all kinds are receptive to, due to existing informational patterns that are present in the environment and have a semiotic character (Heras-Escribano & de Jesus 2018).

To establish whether one or another definition of information is the most inclusive one needs to ask whether or not it can explain the phenomena of the others. We propose Bateson's definition of information is the most encompassing, because of its general applicability.

While many of the above cited scholars refer to the definition of information by Gregory Bateson, none go beyond citation and cursory analysis. This paper engages with the definition of information by Bateson in order to discover its objective and subjective elements. A salient starting point is the identification by Bateson that "The unit of survival is a flexible organism in its environment" (Bateson 1972: 457). Thus, contextualizing the existence of all living beings, including humans. Leading to the identification of the autopoietic homeostatic nature of the human organism (Maturana & Varela 1987; Varela 1991), in the context of *a flexible organism in its environment*. And, considering human distributed cognition from an organism-in-its-environment perspective (Cardenas-Garcia & Ireland 2017) in developing a systematic approach to a dynamic concept of information: i.e. Bateson information.

The rest of the paper is divided into six sections. *First*, the theory of communication is put in perspective by looking at how John Wilkins, long-ago, coded information for secret communication, as well as how more recent efforts led to Claude Shannon and his mathematical theory of communication. *Second*, the definition of information by Bateson is presented as preliminary to permit a closer examination of its elements. *Third*, the role of the lone autopoietic homeostatic human-organism-in-its-environment as a cognizing being in a process of distributed cognition is shown to be central to information. *Fourth*, the social autopoietic homeostatic human-organism-in-its-environment is shown to impact how information influences the communication process. *Fifth*, the whole Batesonian informational process is put in perspective so as to attempt an approach to understanding how a Unified Theory of Information (UTI) may come about. *Last*, a summary and some conclusions are presented putting the fundamental problem of the science of information in perspective.

2. Information as Coded Communication

One of the earliest accounts of what can be considered a definition of information and its application to communication is that by John Wilkins, whose primary interest was in cryptography (Gleick 2011). In a book entitled *Mercury: Or the Secret and Swift Messenger. Shewing, How a Man may with Privacy and Speed communicate his Thoughts to a Friend at any distance* Wilkins wrote,

> For in the general we must note, That whatever is capable of a competent Difference, perceptible to any Sense, may be a sufficient Means whereby to express the Cogitations. It is more convenient, indeed, that these Differences should be of as great Variety as the Letters of the Alphabet; but it is sufficient if they be but twofold, because Two alone may, with somewhat more Labour and Time, be well enough contrived to express all the rest (Wilkins 1694: 131-132)

And,

> Concerning which, in the General it may be concluded, that any Sound, whether of Trumpets, Bells, Cannons, Drums, &c. or any Object of Sight, whether Flame, Smoak, &c. which is capable of a double Difference, may be a sufficient Means whereby to communicate the Thoughts. (Wilkins 1694: 133)

These passages are striking. Firstly, because they provide a basis for thinking about the creation of a code to communicate at long distances (i.e. cryptography) and secondly, that Wilkins' insight is a pre-cursor to Bateson's definition of information.

It is significant that Wilkins mentions that "whatever is capable of a competent Difference, perceptible to any Sense, may be a sufficient Means whereby to express the Cogitations" because (1) it implies he is concerned with coding complex messages using a "competent Difference", and (2) this "competent Difference" may be obtained using "any Sound" or "Object of Sight" with at least the capability of a "double Difference" to allow cryptographic communication to occur. It might be surmised, from the above quotes, Wilkins did not limit communication to sound and sight only, but rather as something including all of our senses; depending on circumstance. This seems to recognize the primacy of our five most important senses in communication and information. Wilkins is clearly ahead of his time in proposing a binary communication coding system. Such a system became a reality more than a century later in the 1830s, when work in England and the United States resulted in the development of the telegraph permitting long distance communication using dots and dashes. This does not take into account the binary system using 0 and 1, based on Boolean algebra (Boole 1854), or the connection made between electrical circuits and Boolean logic (Shannon 1938) that has become the basis for digital computation and communication systems. These latter developments have defined how information tends to be comprehended, and are key to our current omnipresent concern with communication and information as something which is stored and shared.

Shannon's (1948) landmark paper prompted establishment of the discipline 'Information Theory'. The First International Symposium on Information Theory took place in London, at the end of September 1950 (at which Shannon was a major participant), comprising topics typically associated with the field of 'Cybernetics'. Information-theoretic ideas had been developed previously, for example, by Fisher (1935), Gabor (1946), and Wiener (1948), driven by the need to develop systems that function on the basis of transmitted and processed data (such as automatic artillery installations). This prompted the need to quantify measurements of different kinds that would allow one "to discover the method which will give us the maximum amount of information for a given outlay of time or space or other resources" (MacKay 1969: 10). Prior to this time the need to provide a quantitative/objective appraisal of information might have existed but was not a priority. There was an implicit understanding (qualitative/subjective) of information as something that added to your existing knowledge, i.e., "when 'what we know' has changed" (MacKay 1969: 10). In summary, the advent of systems whose input is information, reflecting the need to continue to pursue the often-unstated goal of trying to reproduce ourselves and extend our capabilities, requires newer and better ways of defining and measuring "information" on a quantitative/objective basis.

In an effort to better examine the need to accomplish this, Figure 1 shows a block diagram of a communication system that underlies the Mathematical Theory of Communication proposed by Shannon (1948) that characterizes the sharing of a message incorporating information between two parties. The *Information Source* initiates the communication process by the creation of the message to be transmitted. The *Transmitter* may be characterized as the point at which an agreed upon coding takes place such as that implied in the Morse code. After which, the message gets transmitted by means of a *Channel* in the form of a *Signal*, which may incorporate a *Noise Source*. This is typical of any signal that is launched into a cable or the airwaves, which accumulates noise from multiple sources in its path, some predictable, some not. The *Receiver* then receives the signal and decodes it, allowing its reception and interpretation at its *Destination*. It may be even argued that this communication system is of a general nature and each and every communication includes all of these steps.

One aspect of this communication system is that it can be analyzed mathematically in great detail, even incorporating probabilistic prediction in order to recognize the originally sent message out of all possible messages that might have been sent. But there is one aspect that this communication system does not take into account, and that is the semantic content of the message. Shannon was clear about the limitations of his theory and stated that "the semantic aspects of communication are irrelevant to the engineering aspects" (Shannon and Weaver 1949: 8) though in some instances the engineering aspects may reveal or imply semantic content. It is also clear that only a human being at the *Destination* can make use of this semantic content, and this has resulted in confusion as to how exactly the concept of "information" should be used because it is a concept that is content and context dependent. In short, the communication process may be likened to the process of conveying, or transmission of, messages incorporating information, but it is not the information itself. To further explore the issues associated with content and context the next section reconsiders the definition of *information* provided by Bateson; and which Wilkins seems to have anticipated in pursuing cryptologic communication.

3. A Close Inspection of Bateson Information.

Everything should be made as simple as possible, but no simpler.
Albert Einstein[1]

Before embarking on a close examination of the definition of information by Bateson it is worthwhile noting that the colloquial expression "I know it when I see it" is applicable to the concept of information. A notable example is the famous dictum by Norbert Wiener: that "Information is information, not matter or energy. No materialism which does not admit this can survive at the present day" (Wiener 1948: 132). Stated in the context of a definition of information that parallels that of Shannon. More recently, Hofkirchner states:

> Equally, no unifying scientific information concept is available. We are accustomed to living with a multiplicity of diverse, and even contradictory, concepts of information. These are used throughout the edifice of natural, social and human, and engineering sciences, not to mention everyday thinking. (Hofkirchner 2013: 4)

And proposes:

> Thus, the task of an as-yet-to-be-developed Science of Information is to study the feasibility of, and to advance, approaches toward a Unified Theory of Information and toward a unifying concept while constantly being aware of a potential failure of the project. (Hofkirchner 2013: 4)

This last statement serves to summarize the state-of-the-art in defining the *Science of Information*. So, let us begin by looking to Bateson to provide some guidance as to a theory of information that may have general applicability, to begin the process of developing a *Unified Theory of Information (UTI).*

Bateson is well-known for stating that, "In fact what we mean by information – the elementary unit of information – is a difference which makes a difference..." (Bateson 1972: 321). There are two salient characteristics to this definition. It implies that information is (1) an elementary (objective) unit, and (2) it is self-referential in nature, and thus subjective. It seems that this is an attempt by Bateson to frame the debate about information around these two issues, but not much progress occurred afterwards and Bateson got caught up in the unproductive negentropy debate (Qvortrup 1993). This definition, which has captured the imagination of many, has a simple and general nature which can serve as a starting point for a UTI (Capurro and Hjørland 2003; Hofkirchner 2008 & 2013b; Pattee 2013). So, let us engage in the process of looking more closely at the two salient characteristics of the definition of Bateson information, one quantitative/objective, and the other qualitative/subjective in the next two sections.

3.1 Quantitative/objective Bateson information

Information Theory has a short but sizable history. Discovery of the electromagnetic spectrum impacted the development of communication technologies, such as the telegraph and wireless transmission, and incited interest in Information Theory. Shannon's mathematical theory of communication quantifies the notion of information, defining it as a quantitative/objective mathematical construct. The result is that information may be encoded using binary digits or bits. Bits are generally regarded as the most elementary units of information, which are amenable to efficient machine processing and transmission. The quantitative/objective aspect of information, which is amenable for electromagnetic processing and transmission, is that portion of information that human beings *distil* and code (as bits) to communicate as effectively as possible with other human beings (See Shannon & Weaver 1949). The constraint imposed by the absence of semantic content is inherent to this coding process, and is symptomatic of any process of communication that needs information to be distilled and coded. This argument also applies, and may be extended backwards in time, to humankind's earliest forms of communication: a topic that will be addressed later. In summary, it is possible to define the quantitative/objective aspect of information explicitly for transmission as part of a process of communication. Consequently, what is typically referred to as "Shannon information" is the quantitative/objective aspect of information. This implies that Bateson information subsumes Shannon information, and not, as is commonly believed, that Shannon information is primary [see for example, the work by MacKay (1969), Dretske (1981), Stonier (1997), Capurro and Hjørland (2003), Brier (2008), Vedral (2010) and Burgin (2010)]. To conclude this section,

[1] Quote generally attributed to Albert Einstein, see for example: https://www.colorado.edu/physics/EducationIssues/Electrodynamics/documents/homework_FA11/Relativity_review.pdf (Accessed: August 18, 2018)

Shannon information is a quantitative/objective difference, which may be as simple as the difference between 0 and 1, or fully dark to fully light. Perceptible information (Just Noticeable Differences or JND) is a necessary but not a sufficient condition for a living being to notice a difference (Cárdenas-García et al. 2018).

3.2 Qualitative/subjective Bateson information

A possibly more significant question is: why does a specific *difference make a difference* to a living being? Or, from a qualitative/subjective perspective: what causes a living being to make distinctions in these differences? And, do these distinctions allow a human organism to discover meaning in making distinctions? To answer these questions requires the identification of a fundamental or primary *motivation* for the living being to notice a difference. In other words, these questions go to the heart of determining the *motivation of the motivation* for all organisms, including the human organism. Since all living beings are geared to notice differences, whether consciously or unconsciously, there needs to exist a *self-referential motivation*, implied in Bateson's statement, for that to occur. A living being perceives its environment using its sensory apparatus, which in the case of a human being amounts to its five key senses: touch, sight, hearing, taste and smell. From the perspective of JND, for human beings, the sensed percept has to meet the criteria of having sufficient amplitude to be detectable and also to be within the dynamic range of the sensing organ, e.g., in the visible light electromagnetic spectrum (400–700 nanometers), or the frequency range of human hearing (20 Hz to 20 kHz). Also, the signal has to be not too fast, nor too slow. If too fast, the sense organ will not register it; if too slow, the sense organ will ignore it, i.e., living beings avail themselves of specialized organs to notice these differences. In short, it is the motivated detection of sensory differences in a dynamic environment that allows a human being to construct an internal or endogenous world of meaningful qualitative/subjective information.

3.2.1 The living being needs to be motivated, consciously or unconsciously, to notice a difference

The *motivation of the motivation* for a living being to notice a difference is the need, whether conscious or not, to self-referentially satisfy its physiological and social needs. Physiological and social needs of a human organism are as basic as the need to take a breath, to eat and drink, to dispose of matter detrimental to its functioning, and to engage with another human being to help it survive at the early stages of its life. We self-referentially start and end our life out of the womb by gasping for air. Satisfaction of the physiological and social needs of the organism[2] keep it in homeostatic balance in its environment, mostly in the form of reflex actions, if it is to survive and prosper. It is worth noting that the notion of physiological needs is an evolving self-referential notion. For example, human eating habits may change over time due to the aging process, or even the learning process that every human being undergoes; apart from cultural constraints that influence the development of eating practices. The process of noticing differences *motivates the finding of meaning* in the generation and processing of information, due to positive and negative feedback processes engaging the living being, resulting from the ever-present and recurring basis of physiological and social needs. In short, the phylogenetic and ontogenetic development of human beings is subject to the satisfaction of physiological and social needs in a qualitative/subjective informational process which by its very nature is ever-present and self-referential.

When referring to the self-referential nature of the qualitative/subjective informational process and to better understand its nature, it is worthwhile to contrast it with that used in language. In the context of language, self-reference is used to denote a statement that refers to itself or its own referent, such as "This sentence is false". Such use is generally found to be contradictory and not useful. The type of self-reference that we would like to pursue in the time domain is that found in Spencer-Brown (1969) and commented on by Varela,

> But we should pay attention to the fact that the double nature of self-reference, its blending of operand and operator, cannot be conceived of outside of time as a process in which two states alternate, and thus retrieving Spencer Brown's interpretation. True as it is that a cell is both the producer and the produced which embodies the producer, this duality can be pictured only when we represent for ourselves a sequence of processes of a circular nature in time. Apparently our cognition cannot hold both ends of a closing circle simultaneously; it must travel through the circle ceaselessly. Therefore we find a peculiar equivalence of self-reference and time, insofar

[2] The word "organism(s)" is used mostly in reference to human-organism(s). If there is consideration of other organisms, it will be made explicit in each particular instance.

> as self-reference cannot be conceived outside time, and time comes in whenever self-reference is allowed." (Varela 1975: 20)

Similarly, spatial self-reference can be identified by referring to the idea that a map is *not* the territory it represents (Korzybski 1994: 58), whereby each consecutive cognitive interaction with either the map or the territory leads to a new self-referential appreciation of the map or the territory, respectively.

3.2.2 A comparison is basic to human information acquisition and development

The concept of noticing a difference requires a comparison between at least two spatial and/or temporal instances. This means that at least two elements are required (as Wilkins stated) for this comparison to be made, and which relate to our sense organs distinguishing capabilities. Spatial data may be parallel data from many sources which may be compared (e.g., binocular vision) or not (skin sense organs) at a specific point in time and then as temporal data which is continuously compared to establish invariant coherence (Cárdenas-García et al. 2018). This is where the concept of a sensory map is useful. A *sensory map* is defined as the spatial distribution capture of a specific region of the dynamic environment by a sense organ of an organism at a specified time. So, the difference or *difference/information map* originates from a comparison between two sensory maps. This implies that the always dynamic environment is rich in instances useful in the creation of sensory maps (Martinez-Conde et al. 2004). So, objectively, sensory maps are everywhere there is matter, whether static, changing or moving. Subjectively, their detection corresponds to the ever-present quest to satisfy physiological needs of the organism.

Let us use this notion of *dynamic sensory maps* to put the previously mentioned and particularly influential quote by Wiener in perspective: that "Information is information, not matter or energy. No materialism, which does not admit this, can survive at the present day" (Wiener 1948: 132). While defining information, in this instance, in terms of itself, Wiener does go on to develop a definition of information (see Wiener 1948) that parallels that of Shannon. Further, Wiener's statement implies that information is another fundamental quantity in nature; in addition to matter and energy. But information is not a fundamental quantity of the universe. Organisms either sense moving matter/energy or shift position/perspective: in a sense creating motion. So, information is a product of continuous perception of *dynamic sensory maps*. Yet Wiener's claim has remained unquestioned by many, including physicists, and his affirmation of the fundamental nature of information is taken as gospel. Thus, posing an impossible quandary for materialism and motivating the persistence of information as an independent and/or quantitative/objective entity. Wiener's fundamental point of view, qualifying information as a fundamental quantity in the Universe, is reflected in numerous works, including those by Wheeler (1991), Stonier (1997), Yockey (2005), Lloyd (2006), Umpleby (2007), Burgin (2010), Floridi (2010), Vedral (2010), Hidalgo (2015) and Zukerfeld (2017), among others. Additionally, it rings true in the biosemiotics literature (Brier 1999 & 2008; Battail 2009 & 2013; Barbieri 2012 & 2013; Pattee 2013).

Wiener (1954) refers to this process of dealing with information as follows: "… a name for the content of what is exchanged with the outer world as we adjust to it, and make our adjustment felt upon it. The process of receiving and of using information is the process of our adjusting to the contingencies of the outer environment, and of our living effectively within that environment" (Bynum 2006: 162). The impossible quandary posed by Wiener for materialism (when he states there is information in the environment, when there isn't), is fundamentally resolved when it is recognised that our world is dynamic and the senses of all living beings, including humans, cannot but take notice of this material/physical aspect of moving matter or energy. The identification of differences (i.e. information) in matter and energy is fundamental to our existence. Missing in Wiener's interpretation is that *information is differences*. Differences that human and living beings learn to interpret in satisfying their physiological and social needs. Indeed, Wiener is right, information is "not matter or energy". *Information is differences in matter and energy* detected by living beings. Further, differences/information do/es play the role that Wiener envisioned but not in the way that he envisioned it. Information is not "exchanged with the outer world as we adjust to it, and make our adjustment felt upon it". Rather, in the brain, differences/information take the form of preferred pathways where behaviour and ideation are due to synaptic changes in organization as a result of conditioning, brought about by our sensory and activity experiences, impacting neural network dynamics (Hebb 1949). The brain becomes an ever-evolving organ that reflects the physical world in its organization, but at the same time has the capacity to affect the organization of the world by the actions of the human being in the environment. We might therefore postulate that there is no need to suppose the existence of *agency* for the human organism-in-its-environment, because the *motivations of the motivations* of the organism-in-its-environment are its physiological and social needs. These *motivations of the motivations* are the motive elements to what appear *agential acts* on the part of organisms.

In summary, the almost always moving organism in its never-ending quest to satisfy physiological and social needs contributes to the detection of the invariant structure of matter and energy in the form of sensory maps whose comparison results in difference/information maps that become meaningful to the organism. The phylogenetic and ontogenetic development of the human organism requires the existence of an information generation and processing capability in the human organism that permits progressive development and learning over time. The challenge for any organism is to gain a foothold in the environment that subsumes it, to satisfy its ever-present and changing physiological and social needs. This challenge was met since the time the first organism came into existence and implied a differentiation between itself and its subsuming environment. This qualitative/subjective, self-referential informational capability of the organism-in-its-environment led to the development of complexity in the evolution of living beings.

3.2.3 Information, difference and idea are synonymous

Bateson introduces the relationship that exists between difference and idea by stating:

> I suggest to you, now, that the word "idea," in its most elementary sense, is synonymous with "difference."' Kant, in the Critique of Judgment—if I understand him correctly—asserts that the most elementary aesthetic act is the selection of a fact. He argues that in a piece of chalk there are an infinite number of potential facts. The Ding an sich [thing as such], the piece of chalk, can never enter into communication or mental process because of this infinitude. The sensory receptors cannot accept it; they filter it out. What they do is to select certain facts out of the piece of chalk, which then become, in modern terminology, information. (Bateson 1972: 321)

Several important points are applicable to this quote that attempts to deal with information in an "elementary sense". Foremost is that the word "idea" is synonymous with "difference". This brings into focus the fact that our cognitive process is one that deals well with differences and these differences may be characterized as ideas that we are able to discern, categorize, describe and share orally and otherwise. This information may be categorized as that portion of information that has the potential to become Shannon information, that can be represented in terms of bits of information. It might even be said that the ideas that we are able to share with our fellow human beings are ideas that can be gesturally and/or orally expressed or, after writing was invented, sharing ideas by extending our memory into the world using pictographs, sculptures and writing. Another point that is made using the example of the piece of chalk, generally white in color or encompassing "white light" or light containing all frequencies of visible light, takes the role of every object and represents an object with "… an infinite number of potential facts". This emphasizes the fact that our senses are incapable of accessing the infinite information that is at the reach of our senses (from the differences revealed from the dynamic mass/energy continuum). Lastly, because of this need to ascertain what is in front of us, these senses need to be selective so as to only use the minimal set of information in response to satisfaction of physiological needs, i.e., the organism is unable to process the excess information and needs to "filter out" the excess facts, and to select only "certain facts" from the use of the "sensory receptors" which are "information", with the underlying motivation of satisfaction of physiological and social needs. In the case of the chalk it might be the determination of its outline as revealed by its surroundings that might give meaning to its shape and use.

4. Information and the Organism-in-its-Environment

One advantage of this fundamental and self-referential definition of information by Bateson is its generality and therefore its applicability to every type of situation in which a human being or, more generally, an organism-in-its-environment generates and interacts with information. In the case of a human being, Bateson considers a difference, idea and information as synonymous. In effect, promoting the claim that "Information is physical" (Landauer 1991): i.e., that it exhibits a physical/material existence in its multifarious expressions. Information may be generated, recognized, internalized and then exteriorized by a human being, with a general emphasis that only living beings have the need to access information (Roederer 2003, 2005, 2016).

Another noteworthy aspect of Bateson's definition is that it is a quantitative/objective and qualitative/subjective definition which relies on the organism-in-its-environment to make self-referential distinctions. This goes to the heart of the discussion on information, i.e., information may be viewed from a quantitative/objective perspective and also from a qualitative/subjective perspective in the historical process that involves its recognition, extraction, creation, transmission, preservation, storage and utilization. This historical process is called distributed cognition, or the immanent recursive relationship between life and information, where distributed cognition is the ability of a self-referencing organism to interact with its environment to satisfy its physiological (internal and external) and social

needs to survive and sustain itself (Cardenas-Garcia 2013; Cardenas-Garcia & Ireland 2017). Therefore, there is no purpose to information, except in the context of life and cognition. A human-organism-in-its-environment is in constant recursive interaction with information since inception: from the differences revealed from the dynamic mass/energy continuum. This emphasizes the dynamic nature of life and information.

4.1 The autopoietic homeostatic human-organism-in-its-environment

The human-organism-in-its-environment may be represented preliminarily as a single organism-in-the-environment, as shown in Figure 2. This represented human-organism-in-its-environment is interacting asymmetrically with its surroundings as indicated by the distinctively different double arrows. This is an idealized representation since no human individual lives alone in its habitat. The basic unit of analysis is the autopoietic homeostatic human-organism-in-its-environment (Maturana & Varela 1987) represented by a circle, with an arrow pointing in the counterclockwise direction to indicate the autopoietic or self-productive nature of all living beings. The internal workings of the central nervous system resulting from the interactions with the surrounding environment is conveniently represented by an Internet meme identified as the "Eye of Horus", with the symbols for smell, sight, hearing, taste and touch depicted. The implication being that, in general, the human organism is capable of distinguishing externally and internally generated differences, via these five primary senses. Additionally shown, as tied to the sensory elements, is the development of ideation or the capacity of the human organism to form ideas, thoughts or concepts that allow for human organism higher-level memory formation in dealing with its environment.

To the left of the autopoietic homeostatic human-organism-in-its-environment shown in Figure 2, is a set of three interlaced circles representing the types of information that a human organism generates and deals with. In the general case, these circles or types of information may have a myriad of size relationships, as may be surmised from the explanation that follows. These are labelled, going from top to bottom as: (PSR-I) or Personal/Subjective/Relative Information, (IOA-I) or Impersonal/Objective/Absolute Information and (SD-I) or Shannon/Distilled Information. Overlapping arrows pointing away from and back to each of the information circles imply the ongoing and ever-present processing and recursive interactions between these information types. These processing and recursive interactions are fully dependent on the needs of the human-organism-in-its-environment. Each of these types of Information are now explained in turn.

4.1.1 Personal/Subjective/Relative Information (PSR-I)

The circle closest to the homeostatic organism is identified as embodying Personal/Subjective/Relative Information (PSR-I), and involves the connotation that in dealing with PSR-I (Cardenas-Garcia 2013) we are dealing with a first-person perspective. These three words are used in the context of their dictionary definition. 'Personal' [Dictionary.com - definitions, n.d], "pertaining to or characteristic of a person or self-conscious being: i.e. that is my personal belief".[3] 'Subjective' [Dictionary.com - definitions, n.d], "pertaining to or characteristic of an individual; personal; individual: i.e. a subjective evaluation";[4] and 'Relative' [Dictionary.com - definitions, n.d] referring to something "existing or having its specific nature only by relation to something else; not absolute or independent: i.e. happiness is relative".[5] (See also Cardenas-Garcia & Ireland 2017: 269).

One of the main characteristics of Personal/Subjective/Relative Information (PSR-I) is that it may be considered as intrasubjective arbitrarily generated information, motivated by the satisfaction of physiological (internal and external) and social needs, where feelings and emotion play an important role in the life of an individual. Consequently, the notion of physiological and social needs is dynamic. This is noticeable when considered in the context of individuals, whose experiences and tastes change over a lifetime, affecting their physiological and social needs. No one else has access to our Personal/Subjective/Relative Information (PSR-I) except as a result of the exteriorization of our feelings and/or emotions, which can take many artistic and non-artistic forms such as gestures, language, poetry, symbols, etc. This is comparable to the concept of the Umwelt put forward by von Uexküll (1957), including the allowance for individual specific Umwelt as more explicitly articulated by Tønnessen (2009: 52) in reference to von Uexküll's Umwelt concept (von Uexküll 1928).

[3] Entry "Personal" [Def. 1] in Dictionary.com.

[4] Entry "Subjective" [Def. 2] in Dictionary.com.

[5] Entry "Relative" [Def. 3] in Dictionary.com.

4.1.2 Impersonal/Objective/Absolute Information (IOA-I)

As noted above, the unequal double arrows refer to the asymmetrical interactions between the human organism and its environment. The environment comprising physical objects of a multiplicity of forms and textures, apart from other living beings. In this process of an asymmetrical relationship, the human organism encounters physical objects and other living beings that make it realize that some objective accounting has to take place if it is to continue satisfying physiological and social needs. Physical objects or other living beings that need to be taken into account are ones which might have the capacity to cause pain/harm and pleasure/help to the organism-in-its-environment. This brings forth the need for the human organism to develop predictions as to what it believes to be true about the workings of its environment. Some of these predictions might simply reflect the Personal/Subjective/Relative Information (PSR-I) of the organism-in-its-environment, while others might reflect its experience of pain/harm and pleasure/help in its interactions with its environment. In particular, when some actions lead to pain/harm the organism-in-its-environment takes notice and in so doing reflects that it has access, however small, to the beginnings of Impersonal/Objective/Absolute Information (IOA-I). Here again these three words are taken in the context of the dictionary definition of these terms. 'Impersonal' [Dictionary.com - definitions, n.d] refers to that which is "not personal; without reference or connection to a particular person: i.e. an impersonal remark".[6] 'Objective' [Dictionary.com - definitions, n.d] refers to being "not influenced by personal feelings, interpretations, or prejudice; based on facts; unbiased: i.e. an objective opinion",[7] and, 'Absolute' [Dictionary.com - definitions, n.d] is that which is "viewed independently; not comparative or relative; ultimate"[8] (See also Cardenas-Garcia & Ireland 2017: 270). There is also the connotation that in dealing with IOA-I (Cardenas-Garcia 2013) we are dealing with a quantitative assessment and a third-person perspective.

In short, the organism-in-its-environment of Figure 2 is characterized as capable of discovering Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I), where its own preferences and beliefs take center stage but are capable of gaining access to greater objectivity, whilst avoiding solipsism; in contradiction with Maturana and Varela (1987). The interlacing of the Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I) circles is to express their dependent connection; whereby Impersonal/Objective/Absolute Information (IOA-I) is dependent on Personal/Subjective/Relative Information (PSR-I). Personal/Subjective/Relative Information (PSR-I) is primary and Impersonal/Objective/Absolute Information (IOA-I) is secondary. The overlapping arrows between Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I) serve to emphasize this dependence as well as the recurrent and ever-present interactions between them. Also, not all Personal/Subjective/Relative Information (PSR-I) is capable of becoming Impersonal/Objective/Absolute Information (IOA-I). The part of Impersonal/Objective/Absolute Information (IOA-I) that is outside of Personal/Subjective/Relative Information (PSR-I) may be regarded as the potential for Impersonal/Objective/Absolute Information (IOA-I) to further develop. For example, the realization that a sharp object has the ability to hurt us in most circumstances may be expanded to include all sharp objects as having that ability, since it might not be in our best interest to experiment with all sharp objects. The interactive nature of the human-organism-in-its-environment stimulates development and interactivity between Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I). Personal/Subjective/Relative Information (PSR-I) cannot but influence Impersonal/Objective/Absolute Information (IOA-I). In turn, Impersonal/Objective/Absolute Information (IOA-I) cannot but influence Personal/Subjective/Relative Information (PSR-I). The correlation between these two types of information points to the origins of the scientific method, where Personal/Subjective/Relative Information (PSR-I) influences our beliefs about our world, which are tested by Impersonal/Objective/Absolute Information (IOA-I). Further interactivity leads to new beliefs that again get tested and enhanced by Impersonal/Objective/Absolute Information (IOA-I). This might lead to losing track of which is primary, Personal/Subjective/Relative Information (PSR-I) or Impersonal/Objective/Absolute Information (IOA-I), as the overlapping arrows imply. In the world of

[6] Entry "Impersonal" [Def. 4] in Dictionary.com.

[7] Entry "Objective" [Def. 5] in Dictionary.com.

[8] Entry "Absolute" [Def. 6] in Dictionary.com. The use of "absolute" is made without losing sight of the term "relative", i.e., to emphasize the dynamic nature of the world around us. What is true today might not be true tomorrow. So, what we know today is relative to what we knew yesterday, but on an absolute scale we note that progress is being made. There is certainly an updating that is taking place. So, this progress might be viewed as relative and absolute at the same time, since both instances are concurrently present.

digital information this is similar to losing track of what is imaginary and what is real; such as while playing computer games.

4.1.3 Shannon or Distilled Information (SD-I)

One characteristic of individual Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/ Absolute Information (IOA-I) is its inaccessibility. Individual Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I) can only be accessed if an individual is willing to share its contents. Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I) can only be shared by external expressions that an individual can muster using language, gestures, pictographs, music instruments, sculptures, writing, etc. In so doing, an individual's Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I) is externalized. While individual Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I) may be surmised to be extensive in its content, it is limited when it comes to it being externalized by a willing individual. We are typically unable to externalize all of our emotions, feelings and learnings, whether our intent is to make them intelligible to others or not.

It is in this context that we have to look at the practical accomplishments of Wilkins and Shannon. These two were concerned with the practical transmission of information across long distances. The transfer of a message requires precise definition, so the content can be coded, transmitted, and decoded in order for the receiver to interpret the message as intended; or more precisely, that the message received mirrors the one that was sent. Coding involves distillation of individual Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I), so that the message content can be externalized. The act of distilling Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I) for externalization, transforms said Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I) into Shannon/Distilled Information (SD-I). This implies that Shannon/Distilled Information (SD-I) is secondary to Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I), and implies that Shannon/Distilled Information (SD-I) cannot exist independently. The interlacing of the circles (in figure 2) representing the Personal/Subjective/Relative Information (PSR-I), Impersonal/Objective/Absolute Information (IOA-I) and Shannon/Distilled Information (SD-I) expresses their interdependency. Impersonal/Objective/Absolute Information (IOA-I) is dependent on Personal/Subjective/Relative Information (PSR-I), and Shannon/Distilled Information (SD-I) is dependent on Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I). This is further emphasized by the sets of overlapping arrows pointing away from and back to each type of information, respectively. To put this another way, Personal/Subjective/Relative Information (PSR-I) is primary, Impersonal/Objective/Absolute Information (IOA-I) is secondary (to PSR-I), and Shannon/Distilled Information (SD-I) is the requisite of externalizing Personal/Subjective/Relative Information (PSR-I) and/or Impersonal/Objective/Absolute Information (IOA-I). Note that not all Personal/Subjective/Relative Information (PSR-I) is capable of becoming Impersonal/Objective/Absolute Information (IOA-I), because there are always unrealized personal hopes and dreams. Yet, Impersonal/Objective/Absolute Information (IOA-I) has the potential to further develop and encompass other learnings. For example, if you develop in a scientific setting, you can always continue to develop your experiments in conjunction with your theories to expand Impersonal/Objective/Absolute Information (IOA-I). In a similar way Shannon/Distilled Information (SD-I) may encompass only Personal/Subjective/Relative Information (PSR-I), only Impersonal/Objective/Absolute Information (IOA-I) and a combination of Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I), as represented by the common areas between interlaced circles. This may be understood from the Personal/Subjective/Relative Information (PSR-I) perspective by, for example, the externalizing of feelings through music. From the Impersonal/Objective/Absolute Information (IOA-I) perspective by writing about the dangers of sharp objects, and from the Shannon/Distilled Information (SD-I) perspective by articulating expressible feelings about the death of a loved one. Also, Shannon/Distilled Information (SD-I) has the potential to grow, based on interactivity with the environment. Shannon/Distilled Information (SD-I) allows humans to create a different intersubjective space with each individual that they meet. The more meetings with individuals the greater the potential for Shannon/Distilled Information (SD-I) growth. Personal/Subjective/Relative Information (PSR-I), Impersonal/Objective/Absolute Information (IOA-I) and Shannon/Distilled Information (SD-I) are so intertwined in the way that we live and act out our lives that it becomes difficult to identify whether some things are real or not. For example, superheroes which are the product of human imagination, can serve as role models for children and adults. This might be the reason why Shannon/Distilled Information (SD-I) is seen as primary by many influential scholars

[see for example, the work by MacKay (1969), Dretske (1981), Stonier (1997), Capurro and Hjørland (2003), Vedral (2010) and Burgin (2010)].

Figure 3(a) illustrates a more realistic scenario (combining Figures 1 and 2), where two individuals are shown at the beginning of a process of communication. The individual on the right (individual two) is shown interacting only with the environment. The individual on the left (individual one) is interacting with the environment and is also engaged in a process of communication with individual two; expressed by the solid arrow pointing right; towards individual two. The intertwined Personal/Subjective/Relative Information $(PSR\text{-}I)_1$, Impersonal/Objective/Absolute Information $(IOA\text{-}I)_1$ and Shannon/Distilled Information $(SD\text{-}I)_1$ circles (note: the subscript "1" is in reference to individual one) represent the process of coding Shannon/Distilled Information $(SD\text{-}I)_1$ that is discerned from distilling Personal/Subjective/Relative Information $(PSR\text{-}I)_1$ and Impersonal/Objective/Absolute Information $(IOA\text{-}I)_1$. (Note: details of the process of coding of organism 1 directed toward the environment is shown in Figure 2; the details of the process of coding of organism 1 directed toward organism 2 is shown in Figure 3(b); and, the details of the process of coding of organism 2 directed toward the environment is shown in Figure 3(c).) The coded message then undergoes the process of transmission through a channel, to reception, for decoding and interpretation by individual two. This more realistic scenario reflects human communication scenarios, and is inclusive of any communicative act between two humans. From the occurrence of a sign (be it a gesture, such as pointing, or an utterance), the making of physical marks in the environment (i.e. cave painting), and writing to long-distance digital asynchronous communications; such as emails, texting and voice messages. These are all instances where the communication process has all the elements identified by Shannon. Figure 3(a) illustrates the beginning of a common and repeated occurrence throughout the history of humankind, and which identifies 'the fundamental problem of the science of information'. That being, how a human organism, in a self-referential process, is able to develop from a state in which its knowledge of the human-organism-in-its-environment is almost non-existent to a state in which the human organism not only recognizes the existence of the environment but also sees itself as part of the human-organism-in-its-environment – and which allows the human organism to not only self-referentially engage with the environment and navigate through it, but to even transform it in its own image and likeness. In other words, 'the fundamental problem of the science of information' concerns the phylogenetic development of humankind, as well as the ontogenetic development of human individuals, in an ever changing respective long-term and short-term environment. This process of human organism development is a process in which information is its underlying primary motor.

5. The Social Autopoietic Homeostatic Human-Organism-in-its-Environment

Figure 4(a) represents the more realistic situation in which there are other similar human organisms co-existing in the environment, each of which may be considered just part of the environment to the corresponding organism. The human-organism-in-its-environment with subscript 1 and access to Personal/Subjective/Relative Information, or $(PSR\text{-}I)_1$, is shown to the left, with another human-organism-in-its-environment, with subscript 2 and access to Personal/Subjective/Relative Information, or $(PSR\text{-}I)_2$, is shown to the right. $(PSR\text{-}I)_1$ and $(PSR\text{-}I)_2$ are each shown on the upper right and upper left of the respective organisms. Though Figure 4(a) shows $(PSR\text{-}I)_1$ and $(PSR\text{-}I)_2$ as circles of equal dimensions, this would, in general, not be the case. Organisms that are genetically and experientially dissimilar would most likely need to be represented by correspondingly different size circles. $(PSR\text{-}I)_1$ is in all probability different from $(PSR\text{-}I)_2$. Also shown in Figure 4(a) is corresponding access to Impersonal/ Objective/Absolute Information, or $(IOA\text{-}I)_1$ and $(IOA\text{-}I)_2$, respectively, on the part of each human organism. Similarly, each organism has the ability to distil Shannon/Distilled Information, or $(SD\text{-}I)_1$ and $(SD\text{-}I)_2$, respectively. The asymmetrical recursive interactions between the organisms results in an exchange of Shannon/Distilled Information (SD-I) which occurs in an intersubjective social space, shown in Figure 4(a) by the designated intersection between the two circles described as $(SD\text{-}I)_1$ and $(SD\text{-}I)_2$, respectively, and labelled *Shared Universe*. This shared universe is further identified as an *Intersubjective Space*. This has at least three implications. This *Shared Universe* or *Intersubjective Space* may consist of: 1) Only Personal/Subjective/Relative Information (PSR-I) which comprises a shared first-person perspective; 2) Only Impersonal/Objective/Absolute Information (IOA-I) comprising a shared third-person perspective; or, 3) Both Personal/Subjective/Relative Information (PSR-I) and Impersonal/ Objective/Absolute Information (IOA-I), comprising a combined first-person/third-person perspective.

Each individual may have her own Shannon/Distilled Information (SD-I) universe that has the potential to be shared, but the need for communication and the forming of communities requires the building of a *Shared Universe*. This sharing results in the forming of bonds between individuals, which may be widely shared by the community. In this process of sharing, the (SD-I) universe of each individual requires its reduction by the amount of the *Shared*

Universe. This shared space may be complementary, collaborative, harmonizing and/or conflicting, contradictory, counterpart, inverse, contrasting.

It is worthwhile noting that a generic Shannon/Distilled Information $(SD\text{-}I)_i$ and Shannon/Distilled Information $(SD\text{-}I)_{i+1}$, referring to two organisms,[9] that interact to create a (Shared $SD\text{-}I)_j$[10] does not necessarily have to agree with a (shared $SD\text{-}I)_{j+1}$; which may result from interaction of a $(SD\text{-}I)_{i+2}$ and $(SD\text{-}I)_{i+3}$[11]. Indeed (shared $SD\text{-}I)_j$ in all probability is nothing like (shared $SD\text{-}I)_{j+1}$. For example, (shared $SD\text{-}I)_j$ might be the result of interactions between two scientists, and (shared $SD\text{-}I)_{j+1}$ might correspond to the interactions between two people in love. There is no secret formula that determines that (shared $SD\text{-}I)_j$ is more relevant or in some way better than (shared $SD\text{-}I)_{j+1}$. Societal dynamics specific to the individuals involved, in a specified time and space frame, sorts that out. The use of this approach may be shown to be applicable in Information Ethics (Cárdenas-García 2018).

Another case shown in Figure 4(a) relates to the interactions that are relevant to organism 1 and 2 with respect to inorganic elements in the environment. A *Shared Universe* may also be ascribed to these relationships, since a well-known and not unusual practice is to consider inert objects as having supernatural properties or even personality: i.e. a rabbit's foot, a crucifix or even a crystal with medicinal/spiritual properties. This case has been more extensively discussed elsewhere but with a more limited scope than the one presented here (Cardenas-Garcia and Ireland 2017: 276-277). As a result, we repeat the relevant parallel arguments below, but with the necessary changes that the enlarged scope of the present work demands.

This interaction with the environment is illustrated in Figure 4(a) by the set of circles to the lower left of organism 1, as well as to the left of the arrows showing the asymmetrical relationship of organism 1 and the environment. Figure 4(b) shows the details of these interactions. Similarly illustrated for organism 2, is a set of circles shown to the lower right of organism 2, as well as to the right of the arrows showing the asymmetrical relationship of organism 2 and the environment. Figure 4(c) shows the details of these interactions. These circles also illustrate how a *Shared Universe* is created between the respective organisms and nonliving environmental matter.

It is enough to consider organism 1 for analysis, as a similar analysis would apply to organism 2, but with dissimilar results. Specifically, as mentioned above, Figure 4(b) shows that Shannon/Distilled Information $(SD\text{-}I)_1$ and Shannon/Distilled Information $(SD\text{-}I)_E$ (subscript E refers to the Environment) generate a *Shared Universe*. The discussion above argues that organism 1 is capable of creating Shannon/Distilled Information $(SD\text{-}I)_1$, but it is not clear that nonliving environmental matter has a similar capacity to act as another organism to create Shannon/Distilled Information $(SD\text{-}I)_E$.

By using Silva (2013: 84), in the context of Berger and Pullberg (1965), we realize that organism 1 (in exhibiting Personal/Subjective/Relative Information, or $(PSR\text{-}I)_1$, and Impersonal/Objective/Absolute Information, or $(IOA\text{-}I)_1$, in the expressed Shannon/Distilled Information $(SD\text{-}I)_1$), engages in *objectivation;* by embodying its intentionality in the products it manufactures. This results in *objectification* and organism 1 distancing itself from said products. For example, let us consider the fabrication of a rabbit's foot. The human (organism 1) that manufactures the rabbit's foot might become *alienated* from its creation, no longer recognizing that it has had a role in not only making but in ascribing meaning to the reason for the manufacture of the rabbit's foot: i.e., as a source of luck for its owner. Finally leading to the *reification* of the rabbit's foot, where the created object is alien to the human (organism 1) that made it and is ascribed to have its own reasons for its existence. It is in these last two stages where we are able to attribute a (shared SD-I) between organism 1 and nonliving environmental matter E, creating the possibility of a "Shared Universe".

Figure 5 shows the more realistic scenario, paralleling Figure 3(a), where the process of two-way communication is included. The main objective of Figure 5 is to better illustrate how a *Shared Universe* or *Intersubjective Space* comes into being. Once again it is useful to emphasize that the process of communication is an interactive process between many individuals in human society. Figure 5 shows the complexity of the process in the development of a societal *Intersubjective Space*. Note that reference needs to be made to Figure 4(a), Figure 4(b) and Figure 4(c) to

[9] The subscripts i and i+1 refers to two different organisms: i.e. if i = 1 (organism 1) then i + 1 = 2 (organism 2).

[10] The subscript j is used to refer to the Shared Universe (or Intersubjective Space j) between organism 1 and organism 2.

[11] The subscript j+1 is used to refer to the Shared Universe (or Intersubjective Space j+1) between two different organisms, whose shared universe does not match that of organism 1 and 2.

discern the details of the interactions between organism 1 and organism 2, organism 1 and the Environment E, and organism 2 and the Environment E, respectively.

In summary, the experiences of the organism-in-its-environment include both qualitative/subjective and quantitative/objective aspects leading to the organism-in-its-environment discerning its second-order cybernetic existence: i.e. the organism-in-its-environment notices itself observing the environmental niche in which it dwells, and in so doing takes notice of its own existence; irrespective of any interactions it might have with similar organisms-in-its-environment. This illustrates the richness of the Fundamental Problem of the Science of Information. Namely, how a self-referential process allows a human organism to develop from a state in which its knowledge of the human-organism-in-its-environment system is almost non-existent, to a state in which it not only recognizes the existence of the environment but also sees itself as part of the human-organism-in-its-environment system. Allowing self-referential engagement with and navigation through the environment. While transforming the environment to allow better access to resources and comforts. Let us look at several examples that further illustrate the fundamentals of the information-rich process which engages human beings with each other and with their environment.

5.1 Examples

Mother/caretaker and child – The notion of a *Shared Universe* or *Intersubjective Space* may be exemplified by the interactions between mother/caretaker and child, which requires constant self-referential and recursive interactions: including suckling, touching and caring. This is an asymmetrical exchange, whereby the dependency of the child on the mother/caretaker might imply that the *Shared Universe* consists of Shannon/Distilled Information (SD-I), containing mainly Personal/Subjective/Relative Information (PSR-I) on the part of the child. Conversely, the needs of, and expressed by, the child are accommodated by the mother/caretaker, whose observations incorporate Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I) in the Shannon/Distilled Information (SD-I) conveyed. This is a complex and complementary relationship. The mother/caretaker acts to interpret the needs of the child in accommodating its Shannon/Distilled Information (SD-I) to the needs of the child.

Toolmaking – One characteristic that differentiates humankind from other animals is toolmaking. It is well known that other animals use readily available elements in the environment as tools (such as sticks or rocks), and even engage in rudimentary toolmaking using their extremities to hold materials while shaping them. However, there are no instances where a sequence of toolmaking operations, by animals, results in a refined tool. This differentiation between human beings and other animals may be viewed from the perspective of Personal/Subjective/Relative Information (PSR-I), Impersonal/Objective/Absolute Information (IOA-I) and Shannon/Distilled Information (SD-I).

The primitive use of tools is generally associated with satisfaction of physiological and social needs, such as making access to food easier (i.e. the production of hunting and fishing artifacts, and the invention of agriculture,) and facilitating food consumption (i.e. cooking with fire). Obtaining a regular food source to satisfy physiological and social needs is motivated by the constantly recurring communal need for ingesting food as a source of energy. Hunger is certainly a source of constant Personal/Subjective/Relative Information (PSR-I) generation, which also influences Impersonal/Objective/Absolute Information (IOA-I) in obtaining food/energy, and leads to Shannon/Distilled Information (SD-I), which drives the manufacture of hunting tools and the development of hunting plans; whether as an individual or in groups. Human beings have certainly shown that they are more capable of externalizing their PSR-I and IOA-I to generate SD-I for the design, manufacture and use of toolmaking for many human-oriented pursuits than other animals.

Science and scientific collaboration – Consider the case of two scientists that are working on similar problems and wish to engage in a collaborative effort. Each brings to the table their unique personal experiences in experimental and theoretical aspects of their research, which clearly reflect their genetic and experiential uniqueness as individuals: i.e., their unique and individual Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I). In coming together, they get to know their strengths and weaknesses within their disciplines and even in the social aspects of their interaction. The result is at least some semblance of agreement between the two, if their collaboration is to be a success. These areas of expressed or unexpressed agreement may be referred to as their *Shared Universe* or *Intersubjective Space* as a result of intersecting Shannon/Distilled Information $(SD\text{-}I)_1$ and $(SD\text{-}I)_2$. Within that *Shared Universe* might be beliefs, observations or experimental results that might be considered more objective since at least these two individuals are in agreement. But this does not preclude the possibility that their agreement might be related to things like the earth being at the center of the Universe: i.e., beliefs that might be currently recognized as true, but which in time are replaced by more general findings. Of course, some of their findings

in the *Shared Universe* may be solidly backed research that has found expression in very precise and elegant mathematical expressions, while other findings might reflect hopes for the future in the form of intuitive and half-baked theories that have an inconclusive mathematical structure. All of these findings, if shared, are (SD-I). In summary, the fact that a finding or point of agreement between two living beings is within the scope of a *Shared Universe* does not necessarily mean that it is easily transformed into information that is externalized and formalized for consumption by pertinent media or machines. Further, it should be noted that science is an enterprise in which the Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I) of scientists or practitioners become SD-I observations that a group of individuals share; but it all starts with the PSR-I of individuals.

Digital information – Another way of looking at Shannon/Distilled Information (SD-I) is as information that can serve as input into a machine for further processing, and takes a digital form. This is true of almost all current content that exists and is part of our lives; such as music, cell phones, radio and television. SD-I is the basis for all of these machines, which require widespread use of digital computers. The objective of these technologies allows the processing and manipulation of Shannon/Distilled Information (SD-I) to gain some advantage. For example, if we take a digital black & white photograph, we can manipulate the clarity of the image or even incorporate part of the image in another digital photographic image. Thus, SD-I is information over which we have complete access and control, and which serves us well in communicating between ourselves, within certain limits. While we may have control over the content or ideas in digital media, we might not have access to direct manipulation of such coded information, which may take the form of bits in a digital image. We may require specialized software or hardware to have full access to the coded information. Otherwise, if the coded information is in the form of physical depressions, such as the case of a Compact Disc (CD) the use of specialized equipment, such as a CD player, is required to decode and play the digital content; because the information requires complex equipment to be manipulated and expressed.

6. Discussion

A question that sometimes drives me hazy: am I or are the others crazy?
Albert Einstein (Seelig 1956: 194)

The approach followed in this paper, in examining the concept of information, begins with Wilkins and his pursuit of practical cryptological problems in his search for solutions to coding secret communications. A fundamental finding by Wilkins is that communications require, at a minimum, a binary coding system. Several centuries later Shannon develops the mathematical theory of communication, which takes advantage of Boolean algebra and its application to digital electrical circuit theory incorporating binary digits (bits). Bits are used as fundamental elements to facilitate the transmission of messages. Shannon's mathematical theory of communication identified the engineering problem of sending bits of information optimally, considering the presence of noise. There is an implicit understanding that the *Information Source* and the *Destination*, as depicted in Figure 1, are able to code and retrieve, respectively, the message in the communication. One implication is that messages have at least two types of information: a purely quantitative/objective, syntactic portion and a qualitative/subjective, semantic or meaningful portion. The purely quantitative/objective portion may be explicitly defined and refined for purposes of efficient transmission of messages, but also searched for and processed to maximize the probabilities of correct message reception. The qualitative/ subjective portion is one where it is assumed the meaning of the message is encoded by the sender and later decoded by the recipient.

The one thing that might be singled out is that both Wilkins and Shannon are concerned with the practical, or engineering, problem of coding messages. What is of interest to Wilkins is the ability to send secret messages, and for Shannon electromagnetic-facilitated communication. In short, Wilkins and Shannon are concerned with sending messages containing information that can be explicitly defined so as to be coded for practical transmission. Their concern is with Shannon/Distilled Information (SD-I).

The concept of information fostered by Bateson takes a fundamental approach that equates information, difference and idea to be synonymous, and requires that the human organism or observer have a self-referential role in the process of information gathering, interpretation and use. In this fashion, Bateson not only includes quantitative/objective information or Shannon/Distilled Information (SD-I) but also qualitative/subjective information or Personal/ Subjective/Relative Information (PSR-I) and/or Impersonal/Objective/Absolute Information (IOA-I) in considering the self-referencing behavior of the human organism.

Maturana (Maturana 2002; Maturana & Varela 1980, 1987) relies on the organism-in-its-environment and interprets said organism as an autonomous but self-referentially closed being. This is a portrayal that needs modification to allow the organism-in-its-environment to have autonomy but to be capable of permitting the creation of Personal/Subjective/Relative Information (PSR-I) as primary information, and Impersonal/Objective/Absolute Information (IOA-I) in the process of interactions with its environment. Leading to a recursive process between (PSR-I) and (IOA-I) that results in emergence of expressions of externalized Shannon/Distilled Information (SD-I). It is (SD-I) that allows humans to become social beings that have access to a *Shared Universe*.

Another wrinkle that has an important role in information gathering, assessment and processing by the human organism, for the most part ignored by researchers, relates to the motivation that drives the human organism. In other words, what fundamentally motivates a human organism to devote its energies to recognize and use information? What is the (most fundamental) *motivation of the motivation* for a human organism? Or, what drives the human-organism-in-its-environment to engage in a process of distributed cognition? Where the distributed cognition of the human organism is defined as the ability of a self-referencing human organism to interact with its environment for the purpose of satisfying its physiological (internal and external) and social needs to survive and sustain itself (J. F. Cardenas-Garcia, 2013; Jaime F Cardenas-Garcia & Ireland, 2017). In other words, the *motivation of the motivation* for a human organism is the satisfaction of physiological and social needs. This is the life process where an immanent relationship exists between the human organism and the subsuming environment: i.e., between human life and information. There is no life without information, and there is no information without life (Battail 2009: 304; Sharov 2010: 1051; Rohr 2014: 435). These statements parallel those by Hoffmeyer & Stjernfelt (2016: 7), Brier & Joslyn (2013: 6), Pattee (2013: 10), Matsuno (2013: 126) and Heras-Escribano & de Jesus (2018: 251) that view life and semiosis as co-extensive.

6.1 Toward Unified Information

Based on these observations, we want to posit that information has the following non-exclusionary, overlapping categories as initially represented in Figure 2:

1. **Information content that is Personal/Subjective/Relative or PSR-information (PSR-I)** – This is information content that is endogenous or only available to a specific and unique individual as that person engages in the self-referential process of distributed cognition. This is the perspective that drives all living beings as they live their life. It provides them with a unique and personal first-person perspective in their engagement with the world.

2. **Information content that is Impersonal/Objective/Absolute or IOA-information (IOA-I)** – This is information content that may be characterized as endogenous, or only available, to a specific and unique individual that responds to an engagement with the world; which lends an element of objectivity to his or her existence and provides a third-person perspective.

3. **Information content that is capable of being Externalized or Shannon/Distilled information (SD-I)** – This is information content that is capable of being externalized (oral, written, analog, digital, etc.) or distilled by a human being from PSR- and/or IOA-information. The main characteristic of this type of externalized information by human and other living beings is that by so doing it can be manipulated to advantage. A limiting factor for this type of information is the media in which it gets externalized. For example, if it gets externalized in an oral tradition it only lasts as long as the oral expression exists, either in the environment or in the memory of the individuals involved. If it is expressed in cave paintings or as part of a written tradition, its limit is the existence of the media in which the drawings or text in which it is conveyed lasts without alteration or deterioration. Without going into detail, since this is not the thrust of this paper, it can be surmised that other living organisms also have this capacity for generating SD-I, which is expressed by the secretion of pheromones, bird songs, marking, etc.

One aspect that is very important in this interpretation is that only Shannon/Distilled Information (SD-I), may be exteriorized or recorded in media so as to be capable of being processed in a machine as a result of digitization. There is no possibility of independently accessing human PSR-I and IOA-I. This fundamental result points to a serious limitation that is imposed on Artificial Intelligence (AI) technologies whose intention is the artificial reproduction of the workings of the decision-making processes of living beings with all of its ramifications.

Computing machines can only work on Shannon/Distilled Information (SD-I) that humans are able to *distil*/*externalize* as input to these machines. Computing machines are also the result of the SD-I used to design and to build them. The result is sometimes impressive, such as the generation of *distilled*/*externalized* and elaborate

information (Virtual SD-I) in the form of maps of comprehensible information to humans, such as computer-generated weather maps, or real-time airplane flight maps (Big data); robots with almost human capabilities; Google, Google maps, Google voice and Alexa; and the IBM Watson Supercomputer that is capable of defeating a human in Jeopardy and the game of Go. The result is that computing machines are always subject to our ability to *distil*/*externalize* information to design and manufacture them, as well as creating the software to run them and further process input data/information. Our experience is that our ability to obtain Shannon/Distilled Information (SD-I) from Personal/ Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I) is limited. This does not mean that some amazing AI feats might not be accomplished by machines, but it will require human ingenuity to test the limits of technology in AI. It is also pertinent to point out that developments in Deep Machine Learning[12] may involve new approaches, which rely not only on new computing machines but also on new algorithms that, in their implementation, also tend to allow for, what might be termed, Virtual PSR-I and IOA-I pockets (hidden layers), which might not be recoverable for inspection and scrutiny. Indeed, the Virtual SD-I described above does not exist without the existence and development of human beings; a situation similarly applicable to all other human technological developments. This is not to minimize the role that Virtual SD-I might play.

Note that Figures 2 and 4 show overlapping areas between Personal/Subjective/Relative Information (PSR-I), Impersonal/Objective/Absolute Information (IOA-I) and Shannon/Distilled Information (SD-I), portraying the asymmetrical interactions and complexity involved in these relationships. The overlapping arrows between PSR-I, IOA-I and SD-I also seek to emphasize this aspect. This perspective that considers SD-I as secondary to PSR-I and IOA-I, is different from that of some authors that consider SD-I as primary and other types of information as secondary. [See for example, the work by MacKay (1969), Dretske (1981), Stonier (1997), Capurro and Hjørland (2003), Vedral (2010) and Burgin (2010)]. By taking this stance, that Personal/Subjective/Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I) are primary, and Shannon/Distilled Information (SD-I) is secondary, human beings (and other living beings) are placed central to information. In effect upending current thinking on the subject of information. The result is that Shannon/Distilled Information (SD-I) is now in its right dimension, as secondary to information that living beings discover and process: i.e., Personal/Subjective/ Relative Information (PSR-I) and Impersonal/Objective/Absolute Information (IOA-I).

7. Summary and Conclusions

The field of biosemiotics is rich and diverse in its interdisciplinarity, its dependence on Peircean semiotics, its concern for biological (or intrinsic) information, and its positing that life and semiosis are coextensive. One example of this richness of biosemiotics is that of cybersemiotics (Brier 2008), where Brier "… argues that information (as it is understood in cybernetics) is not enough to explain the phenomena of experience, communication, and knowledge. [Brier suggests] to complement [cybernetics] with the semiotic theory and philosophy of Charles Peirce (1998), which is based on the distinction between three basic categories: Firstness (chaos, potentiality, pure feeling and potential qualia), Secondness (force, will), and Thirdness (habits, symbols)" (Sharov 2010: 1051). This approach to biosemiotics, in effect, combines Shannon information with a Peircean perspective to account for syntactic information and semantic information, respectively. Syntactic information is that element of information which is quantitative/objective, while semantic information deals with the qualitative/subjective or meaningful aspects of information.

In contrast, the goal of this paper is to establish a new *biosemiotic information paradigm* based on the definition of information by Gregory Bateson, which states, "In fact what we mean by information – the elementary unit of information – is a difference which makes a difference..." (Bateson 1972: 321). As explained above, Bateson information incorporates a quantitative/objective perspective with a qualitative/subjective perspective. These perspectives develop into Impersonal/Objective/Absolute Information (IOA-I) and Personal/Subjective/Relative Information (PSR-I), which result in Shannon/Distilled Information (SD-I). Leading to the contention that *Bateson information is enough* to account for syntactic information and semantic information. Or, Bateson information subsumes Shannon information. Additionally, Bateson information may be used to dispute the assertion by Wiener that information is a third fundamental quantity of the Universe. A widespread belief that is not accurate. The idea that *Bateson information is enough* to account for syntactic and semantic information results in the posing of the Fundamental Problem of the Science of Information: i.e., the problem of determining how human beings came to our current state of phylogenetic and ontogenetic development. How a self-referential process leads humans to develop from a state in which its knowledge of the organism-in-its-environment system is almost non-existent to a state in

[12] See for example: http://www.deeplearningbook.org/ (Accessed: April 5, 2016)

which the organism not only recognizes the existence of the environment but also sees itself as part of the organism-in-its-environment system. This impacts our ability to engage with the environment so as to navigate effectively through it. In this process we are able to transform our environment to make it amenable to our distinct needs as living beings. This is what we as human beings do on a daily basis, and are fully dependent on information and the information process. Recognizing this as a fundamental problem that we need to address is the first step leading to a Unified Theory of Information (UTI). The definition of information by Bateson is the key toward such a goal as well as fully supporting the notions relevant to biosemiotic distributed cognition (Cardenas-Garcia & Ireland 2017).

In reaching these conclusions and asserting the importance of Bateson information it is vital to note that the *motivation of the motivation* for human beings and other living beings are physiological and social needs. The implication is that organisms do not engage in agential actions; given the human dependence on satisfaction of physiological and social needs as ubiquitous to and in our actions. Also, due to the nature of the Bateson information generation paradigm it is not discernible that there is biological (intrinsic) information in the genome (Rubin 2017). A noteworthy finding is also that there should be a way to reconcile Bateson information and Peircean semiotics, since in the first instance there does not seem to be any impediment to do so, as several biosemioticians have already noted (Emmeche 1999; Battail 2009; Pattee 2013; Barbieri 2013; Battail 2013; Cannizzaro 2013; Rohr 2014; Auletta 2016; Vitti-Rodrigues & Emmeche 2017; Heras-Escribano & de Jesus 2018).

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