Perspective

Infoautopoiesis and consciousness

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Abstract

There is a need to demystify the concept of information to understand consciousness from a fundamental perspective. This is possible to do using the explanatory potential of infoautopoiesis or the process of self-production of information. Infoautopoiesis allows a human organism-in-its-environment to uncover the bountifulness of matter and/or energy as expressions of their environmental spatial/temporal motion/change, i.e., as *information* or Batesonian *differences which make a difference*. Leading to the realization that self-produced information is not a fundamental quantity of the Universe. Rather, it is internally generated and subsequently externalized information relevant to individuated satisfaction of physiological and/or relational needs of the human organism-in-its-environment. Sensorial percepts play an important role in making the external environment meaningful. Individuated, internal, inaccessible, semantic information is the essence of consciousness, and may be externalized or syntactically shared with others using gestures, pictographs, language, music, figurines, writing. We create and live in an environment surrounded by our syntactic, artificial creations, since self-produced information is the primary element that allows humans their unique existence.

Keywords: Infoautopoiesis, consciousness, information, cybernetics, homeorhetic, semantic; syntactic

1. Introduction

Information and consciousness are two concepts that appear to elude definition and explanation. Information is believed to exist everywhere in the environment and is postulated to be the source of everything in the Universe (Barbieri, 2012, 2013; Battail, 2009, 2013; Bayne & Chalmers, 2003; Brier, 1999, 2008; Burgin, 2010; Chalmers, 1995, 2020; Clark & Chalmers, 1998; Floridi, 2010, 2011; Hidalgo, 2015; Koch, 2009, 2019; Lloyd, 2006; Pattee, 2013; Rovelli, 2016; Stonier, 1997; Umpleby, 2007; Vedral, 2010; Wiener, 1948; Yockey, 2005). This widely held but erroneous perspective can be summarized as "it from bit" (Wheeler, 1991). Consciousness in its potentially more accessible manifestation (easy problem of consciousness) reflects its functionality, e.g., decoding speech from recordings of neurons firing; while its most inaccessible form (hard problem of consciousness) reveals its subjective nature, i.e., what it is like to feel a particularly personal experience (Chalmers, 1995, 1996, 2020; Clark & Chalmers, 1998). Connecting these two concepts appeared like an unsurmountable task until the Integrated Information Theory (IIT) promoted the view that consciousness is measurable and inherently related to processing and integration of information (Koch & Crick, 1990; Tononi, 2008; Tononi & Edelman, 1998; Tononi & Koch, 2015; Tononi & Sporns, 2003; Tononi et al., 1996). Though many dissenting voices exist they are unable to provide alternative explanations (Bayne, 2018; Brogaard et al., 2021; Horgan, 2015). Thus, the need for alternative explanations that use information as a basis to explain consciousness.

This paper reexamines the connection between information and consciousness under the light of infoautopoiesis (info = information; auto = self; poiesis = production), seeking an alternative explanation to consciousness while factoring in the role of information. Underlying the process of infoautopoiesis is the Batesonian definition of information as 'a difference which makes a difference' to a living being (Bateson, 1978). Infoautopoiesis is the individuated sensory commensurable, self-referential, recursive, interactive, homeorhetic feed-

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back process relevant to all living beings in their endless quest to satisfy physiological and/or relational needs (Cardenas-Garcia, 2020). Thus, naturalizing the factual observation that self-produced information is not a fundamental quantity of the Universe and putting sensorial percepts as the source of signals that play an important role in making the external environment meaningful.

To discuss the process of infoautopoiesis and its implications for consciousness, this paper is divided into several sections. Firstly, the concept of information is naturalized by examining its etymological origins as well as Gregory Bateson's characterization as 'a difference which makes a difference.' Next, a brief introduction to consciousness is presented to frame its prior characterizations and understand its broad scope. Subsequently a critical examination of the mathematical theory of communication by Claude Shannon helps us to put in perspective the syntactic nature of the messages that are transmitted. Successively, the process of infoautopoiesis is presented as central to the self-production of information. This includes consideration of the human organism-in-its-environment; its simulation to understand the basic requirements of its functioning; the auto-generation, processing and transmission of information; and how consciousness and information are related. Leading to discussion on the relationship between infoautopoiesis and consciousness and relevant conclusions.

To discuss the process of infoautopoiesis and its implications for consciousness, this paper argues for a '*bit from it*' or bottom-up perspective. Where 'it' is understood as matter that develops into life that can self-produce information (bit). It is this capacity for self-production of information (infoautopoiesis) that signifies life, consciousness and meaning.

2. What is information?

The concept of information, even from a cursory examination of the literature, has great diversity. Because of its broad applicability in many fields of knowledge a wide range of criteria seem to apply in its study (Bawden & Robinson, 2022; Burgin & Hofkirchner, 2017; Capurro & Hjørland, 2003; Shannon et al., 1993). **Table 1** typifies the diversity and criteria used by researchers. These various types of information certainly prove its diversity, but what might be ideal is to identify more general characteristics of information that naturalize its meaning. If we look at the etymology of the word information, we find its Latin roots in the word *informatio*, which comes from the verb *informare* (to inform) in the sense of giving shape to something material, as well as the act of communicating knowledge to another person (Capurro, 2009; Capurro & Hjørland, 2003; Díaz Nafría, 2010; Peters, 1988). Also, in parallel to its etymological origins, Bateson defines information as 'a difference which makes a difference' (Bateson, 1978). The common dynamic of these two approaches to information is an implied interactivity.

Table 1 Types of information due to diversity of criteria and applicability

Type of Information	Description	References
Shannon or Syntactic	Underlies the Mathematical Theory of Communication proposed by Shannon. Postulates sending a syntactic message to another. The semantic content is irrelevant to the engineering problem.	(Shannon 1948)
Bateson	*a difference which makes a difference* to someone	(Bateson 1978)
Biological, heritable, or intrinsic	Linked with the genome and acquired by variation and natural selection. The Central Dogma of Biological Science implies the existence of intrinsic information in the workings of the genome.	(Crick 1970), (Barbieri 2012, 2013)
Functional	Encodes the functions of the organism as a set of signs.	(Sharov 2009, 2016)
Non-heritable learned or creative	Acquired through individuated observation and instruction, cognitive variation and individual/cultural selection and stored in our central nervous system and brains.	(Pattee 2013)
Measured physical	Experimental observation or measurement of a physical system in the context of a theory of natural laws.	(Pattee 2013)
Ecological	Organisms of all kinds use it in existing informational patterns in the environment and have a semiotic character.	(Heras-Escribano & de Jesus 2018)

Its etymology reflects the human capacity to interact recursively with environmental matter and with other similar beings to achieve an end. The Batesonian approach manifests the human ability for sensorial commensurable spatial/temporal comparison (between two instances) in pursuit of the satisfaction of its physiological (internal/external) and/or relational needs. The first, objective "difference" is sufficiently large in magnitude, yet suitably slow to be detectable by human sensory organs. The second, subjective 'difference which makes a difference' is assessed by the human organism as able to satisfy its physiological (internal/external) and/or relational needs. These "differences" reflect the dynamic self-referential, interactive and recursive acts of the human organism-in-its-environment in an ascending virtuous cyclical spiral of sensation-information-action. In summary, information is not a fundamental quantity of the Universe but rather, the most important element created by human organisms-in-their-environment to discover themselves in their environment.

Another important aspect of Batesonian information is that "difference" and "idea" are found to be synonymous and homeorhetic (Bateson, 1978). Also, the endless self-referential, recursive, and interactive cycle of sensation-information-action related to Bateson's 'difference which makes a difference,' is illustrated by the actions of a woodcutter on a tree:

"Consider a tree and a man and an axe. We observe that the axe flies through the air and makes certain sorts of gashes in a pre-existing cut in the side of the tree. If now we want to explain this set of phenomena, we shall be concerned with differences in the cut face of the tree, differences in the retina of the man, differences in his central nervous system, differences in his efferent neural messages, differences in the behavior of his muscles, differences in how the axe flies, to the differences which the axe then makes on the face of the tree. Our explanation (for certain purposes) will go round and round that circuit. In principle, if you want to explain or understand anything in human behavior, you are always dealing with total circuits, completed circuits. This is the elementary cybernetic thought." (Bateson, 1978)

This description evolves from Bateson's cybernetic perspective of the world. The woodcutter performs self-referencing, interactive, and recursive labor to harvest wood to use to build a fire for warmth and/or food preparation. A description applicable to many

job tasks pertinent to shaping matter in our environment. The use of the word cybernetics is done not in its homeostatic sense of the word, but rather, in a homeorhetic sense. This implies that the activities of the woodcutter tend to converge towards a dynamic trajectory where the activity of the woodcutter follows a moving and developing target during the activity, i.e., shaping the surface of the tree to make it fall. Repetition of an activity such as cutting down trees generally leads to skill improvement and efficiency. Unlike homeostatic adaptations that tend to return to a state of equilibrium.

In summary, the naturalization of information allows us to identify information as something palpable in our daily living. Information is something that we impart to matter and other living beings, noticing differences that permit the control of those actions. In addition, we internalize those changes as ideas that help us promote the ever-expanding cycle of sensation-information-action-sensation.

3. Consciousness or the mind-body problem

Consciousness is intrinsically linked to the mind-body problem, a problem of fundamental importance in philosophy (Horgan, 2018, 2019). The mind-body problem asks whether the human mind and body are two separate entities or whether they have interconnections and dependencies. Indeed, what is the balance between human mental and physical attributes? A more nuanced account states, *Adequate explanation in any cognitive science must at some stage address the matter-mind problem, that is, the problem of symbol reference or how the world and our images of the world are coordinated* (Pattee, 1982, 2012a). In other words, human beings can internalize their sensory perceptions of the environment around them in a correlated manner to derive meaning from their perceptions. The exact nature of how this process is accomplished is what is difficult to pinpoint, but we anticipate that information is an important link.

In this regard, it is worth quoting Bohm (1989), "Questioner: Would meaning and reality exist without consciousness? Bohm (1989): "*I don't know. But what is consciousness without meaning? Consciousness is meaning. The content of consciousness is meaning, right?"* In this way it is possible to connect the mind-body problem with consciousness, information and meaning. Furthermore, it is possible to connect Bohm (1989) to the previously enunciated concepts of information by quoting him at length,

"*Meaning is inseparably connected with information. The operative notion here is that information has to do with form. Literally 'to inform' means 'to put form*

into' something. First of all, information has to be held in some form, which is carried either in a material system (e.g., a printed page) or in some energy (e.g., a radio wave). We find that in general a pure form cannot exist by itself, but has to have its subsistence in some kind of material or energetic basis; and this is why information has to be carried on such a basis. Thus, even the information in our sense impressions and in our thought, processes has been found to be carried by physical and chemical processes taking place in the nervous system and the brain.

What is essential for a form to constitute information is that it shall have a meaning. For example, words in a language that we cannot read have no meaning, and therefore convey no information to us. Gregory Bateson has said, 'information is a difference that makes a difference'. But to be more precise, we should put it this way: Information is a difference of form that makes a difference of content, i.e., meaning. (For example, a difference in the forms of letters on a printed page generally makes a difference in what they mean.)" (Bohm, 1989)

Bohm (1989) implies that information is physical (Landauer, 1991). Further, information can exist internally and/or externally to a human being. But most importantly, Bohm (1989) implies that information is a carrier of meaning for the human individual. In explaining how information is related to meaning Bohm (1989) uses the concept of 'active Information' as well as pointing out that DNA is "*a case in which the notion of active information does not depend on anything constructed by human beings*" (Bohm, 1989). While Bohm (1989) singles out human beings in his assessments, greater generality of these observations can be achieved by including all living beings. In this instance, a differentiation between semantic and syntactic information allows this, as will be shown below. For the moment we observe that syntactic information appears to be equivalent of active information.

4. Infoautopoiesis

Having identified the mediating role of information as a self-referential, recursive and interactive cycle of sensation-information-action, between the human organism-in-its-environment and matter/energy, it becomes necessary to detail how the generation of information is carried out, the different types of information that exist and the function that they fulfill.

This brings to the fore the process of infoautopoiesis (info = information; auto = self; poiesis = production), a self-referential, sensory commensurable, recursive and interactive individuated homeorhetic feedback process (Cárdenas-García, 2020). Infoautopoiesis is a sensation-information-action-sensation… process immanent to Bateson's *difference which makes a difference*, engaging all humans in their efforts to satisfy their physiological (internal/external) and relational needs, elucidating how they interact with their environment and how these interactions are constitutive of information generation, information exchange, information relations and life.

4.1 Infoautopoiesis and the human organism-in-its-environment

The representation in **Figure 1** shows a human ORGANISM-in-its-ENVIRONMENT and INFO-AUTOPOIESIS illustrating the self-referential, interactive and recursive process of sensation-information-action-sensation between the ORGANISM and the ENVIRONMENT. The direction of the arrowheads in the image of the human organism-in-the-environment in **Figure 1** shows that the flow begins as ENVIRONMENTAL NOISE; it then transforms into Sensorial Signals after detection and transduction by the SENSES; which are then converted, in the box identified as INFOAUTOPOIESIS, into useful/meaningful information for the organism-in-its-environment; and, as a result elicit an ACTION that is exerted on the environment and identified as an ACTION RESULT.

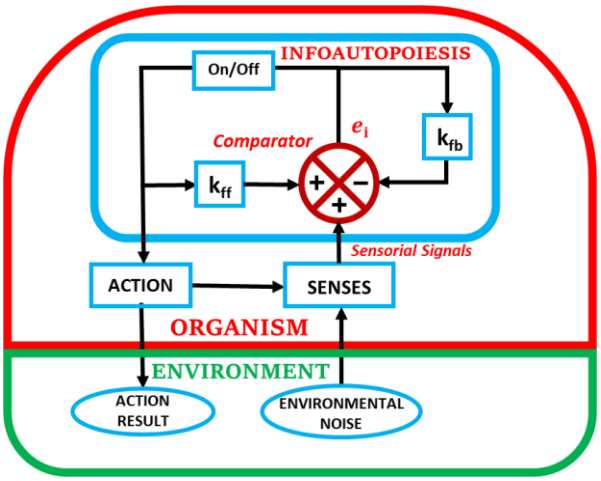

Figure 1 *The human ORGANISM-in-its-ENVIRONMENT and INFOAUTOPOIESIS. Adapted from Cárdenas-Garcia (2020).*

Since its unicellular beginnings in the womb, the human organism-in-its-environment lives in a milieu where ENVIRONMENTAL NOISE is the norm. The ability of the human ORGANISM-in-its-ENVIRONMENT to distinguish what is relevant to satisfy its physiological (internal and external) and/or

relational needs are what guides its actions. This is a constant for human beings during their lifetimes and drives an always changing homeorhetic becoming.

An internal and external circuit are distinguished in the dynamic of the human organism-in-its-environment. The internal homeorhetic cybernetic self-referential circuit is the one that makes effective the definition of information of Bateson (1978) as '*a difference that makes a difference*' and is represented in **Figure 1** as a box identified as INFOAUTOPOIESIS. The external circuit allows the organism to influence its environment in a self-referential, interactive and recursive way in line with the internal circuit. This external circuit is defined to begin from the ENVIRONMENTAL NOISE, which is admitted and processed by the organism in the INFOAUTOPOIESIS box in response to its physiological (internal/external) and/or relational needs which results in an ACTION that impacts the environment as an ACTION RESULT, as well as the SENSES of the human organism. The feedback of the ACTION into the human organism is by way of the SENSES and the ACTION RESULT that cuts through the ENVIRONMENTAL NOISE since it is an expected signal by the human organism-in-its-environment. The self-referential, interactive and recursive cycle of sensation-information-action between the ORGANISM and the ENVIRONMENT in this external circuit allows for achievement of greater efficiency of the ORGANISM in dealing in space and time with its ENVIRONMENT.

The sensorial signals identified in **Figure 1** result from the sensory interaction of the organism with its environment from which comes the ENVIRONMENTAL NOISE or white noise that impacts the SENSES. In this figure when we talk about SENSES, we are not only talking about the five most common senses: touch, sight, smell, hearing and taste; but also, that these SENSES have millions of sensory elements throughout our body. It should be noted that each sensory element acts in a way that is commensurable when activated repeatedly by the ENVIRONMENTAL NOISE according to the specificity of its sensory capacity. For example, a sensory element may be attuned to only measure temperature. AMBIENT NOISE must be of sufficient intensity (strong enough to be detected yet not so strong that it damages the sensory organs) and duration (long enough to be differentiated yet not so short as to be ignored), apart from being of interest to the organism to generate sensorial signals. The motivation of the human organism-in-its-environment to recognize a particular characteristic of the ENVIRONMENTAL NOISE or white noise impinging on the SENSES is the satisfaction of its physiological (internal/external) and/or relational needs. For example, an infant in its gestation phase outside the womb seeks its mother's nipple to feed. That does not necessarily mean that the infant realizes what she is doing, or even that seeking a nipple means she is hungry or seeks nourishment, even if her hunger is eventually satisfied. It only knows that it instinctively must look for something that feels like a nipple, rejecting all other sensory artifacts. Indeed, it uses constitutive absence (Deacon, 2008) as a beacon to satisfy its unspecified needs. This also means that the generation of information might run the gamut from voluntary to involuntary. **Figure 2** serves to illustrate the occurrence of involuntary infoautopoiesis, i.e., that our perceptions of our environment are not fully under our control, and neither are the resulting interpretations or actions. In this example, viewing the image in **Figure 2**, which displays an optical illusion to show involuntary infoautopoiesis, leads from a short-lived static image to an image which does not stop moving.

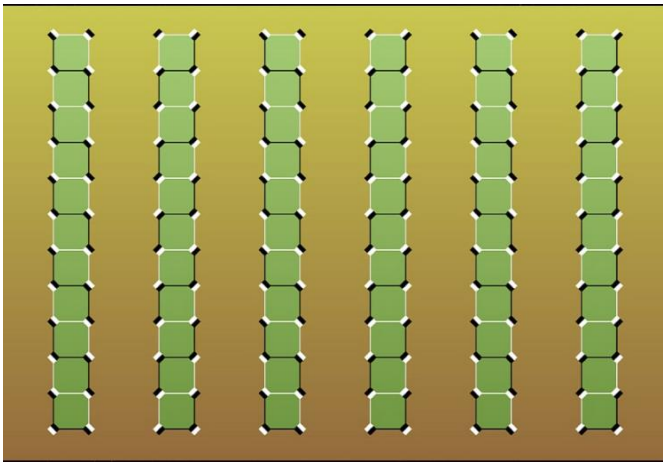

Figure 2 *An optical illusion to show involuntary infoautopoiesis.* Image credit: Akiyoshi Kitaoka

In **Figure 1**, after the sensorial signals reach the box labelled INFOAUTOPOIESIS, a meaning-making box, they are processed and are converted into semantic, meaningful, or internalized (endogenous) information. It is here that after an accumulation of Sensorial Signals the organism deploys its capacity for ACTION that is specific to the ACTION RESULT that is sought on its environment to pursue satisfaction of physiological (internal/external) and/or relational needs. This ACTION leading to an ACTION RESULT may be characterized as syntactic or externalized (exogeneous) information which is a consequence of the externalization of the internalized

semantic information. In other words, an externalized syntactic informational homeorhetic ACTION occurs depending on the internalized semantic information generated by the human organism-in-its-environment due to the acquired sensorial signals identified by the self-referenced needs of the organism. This is a never ending self-referential, interactive and recursive sensation-information-action-sensation… cycle. This arrangement of components serves to illustrate, in a rudimentary way, how the matter-mind problem might be addressed since it shows *how the world and our images of the world are coordinated* (Pattee, 1982; 2012a).

Recent research serves to illustrate this type of voluntary/involuntary behavior, i.e., discovered that bacterial spores *Bacillius subtitilis*, which are partially dehydrated cells, can analyze their environment, despite being in a lethargic state and considered as physiologically dead for years, to survive disadvantageous environmental conditions. However, they continue to generate information from short-lived environmental signals, leaving their dormant state after accumulating a certain number of sensorial signals that confirm that they can activate again and return to life under now more favorable environmental conditions (Kikuchi et al., 2022; Lombardino & Burton, 2022). This is precisely what we want to represent as occurring within the INFOAUTOPOIESIS block of **Figure 1**.

The internal and external circuits define an asymmetrical relationship between the organism and its environment. The ENVIRONMENTAL NOISE that impacts the SENSES of the human ORGANISM-in-its-ENVIRONMENT are not a reflection of the actions of the organism in the environment, although they are related. Our SENSES (touch, hearing, sight, smell and taste) are the only window that allow us the possibility of ACTION on our environment to succeed in satisfying our physiological (internal/external) and/or relational needs. The result of ACTION on our environment is an expression of the externalized syntactic information that results from internalized semantic information. A more detailed treatment follows below.

This means that there is no information in the environment, except for the syntactic information that we externalize. Our SENSES are incapable of identifying information in the environment. We are only capable of capturing sensorial signals using our SENSES that need interpretation to infoautopoietically create internalized semantic information. This is in contradiction to those who believe that information exists in the environment, as noted above.

In summary, infoautopoiesis, the sensory commensurable, self-referential, recursive, interactive homeorhetic feedback process of information self-production is at the center of the capacity of a human organism-in-its-environment to act to satisfy its physiological (internal/external) and/or relational needs.

4.2 A simulation of the organism-in-its-environment

To provide an explanation for how infoautopoiesis may be simulated, we now refer to the elements internal to the box labelled INFOAUTOPOIESIS in **Figure 1**. A Comparator is shown central to feedback and feedforward circuits. The feedback circuit includes a constant k_{fb}, while the feedforward circuit includes a constant k_{ff}. Considering the timing of the signals, at the comparator, the following equation results,

$$e_{i+1} = SS_i + k_{ff}\, e_i - k_{fb}\, e_i \text{ , for } i = 0,1,2,\ldots \qquad (1)$$

where SS_i are the Sensorial Signals, and e_i and e_{i+1} are the resulting values of error (e_i)/ differences/information at two consecutive instances of time, where the index i defines the consecutive time periods. This calculation illustrates how error/differences/information are self-produced by the living organism from sensorial signals that originate in the environment. This goes to the heart of showing that there does not need to be pre-existing information in the environment. The organism is fully capable of infoautopoiesis or self-production of error/differences/information from the sensory signals that it considers relevant to satisfaction of physiological and/or relational needs.

Rewriting equation (1) we obtain,

$$e_{i+1} = SS_i + (k_{ff} - k_{fb})\, e_i \text{ , for } i = 0,1,2,\ldots \qquad (2)$$

which may be further modified to yield,

$$\begin{aligned} &e_{i+1} = SS_i + \Delta k\, e_i \text{ , where} \\ &\Delta k = (k_{ff} - k_{ff}), \text{ for } i = 0,1,2,\ldots \end{aligned} \qquad (3)$$

This final equation is easily programmed to yield a recursively generated output relevant to generation of an ACTION that depends on the sensorial signals and the difference between the feedback and feedforward constants, starting with a value of $e_0 = 0$. No

calculations are performed since they are irrelevant to the current presentation. Further, any simulation that is performed with arbitrarily chosen values of sensorial signals and feedback and feedforward constants is sure to reflect the choices of the programmer rather than that of a fully functioning organism that behaves based on individuated physiological and/or relational needs, see simulations in Burgin & Cárdenas-García (2020) and Cárdenas-García (2020).

In short, what this simulated organism shows is how error/differences/information/ideas (ideas are included since Bateson identified them as equivalent to differences/information) are internally generated from the sensorial signals in the environment by the organism. These internalized error/differences/ information/ideas (semantic or meaningful information) are then used to produce recursive actions conducive to successful interactions with the environment. In other words, the error/ differences/information/ideas are externalized as syntactic information for the benefit of the organism.

4.3 Auto-generation, processing and transmission of information

Figure 3 represents infoautopoiesis as a set of three interlocking circles representing the three types of information that a human organism depicted in **Figure 1** generates, manages and transmits in the process of infoautopoiesis. These circles interact in a triadic relationship involving internalized and externalized information relevant to humans-in-their-environment. Internalized components include the self-production of Personal-Subjective-Relative (PSR-I) and Impersonal-Objective-Absolute (IOA-I) information. Externalized components include Shannon-Distilled or syntactic information. Overlapping external arrows pointing in opposite directions to each of the circles of information represented involve continuous, ever-present processing and recursive interactions between types of information that respond to the needs of the organism (Cárdenas-García, 2018, 2020, 2022; Cárdenas-García & Ireland, 2017, 2019). Each of these types of information is explained below.

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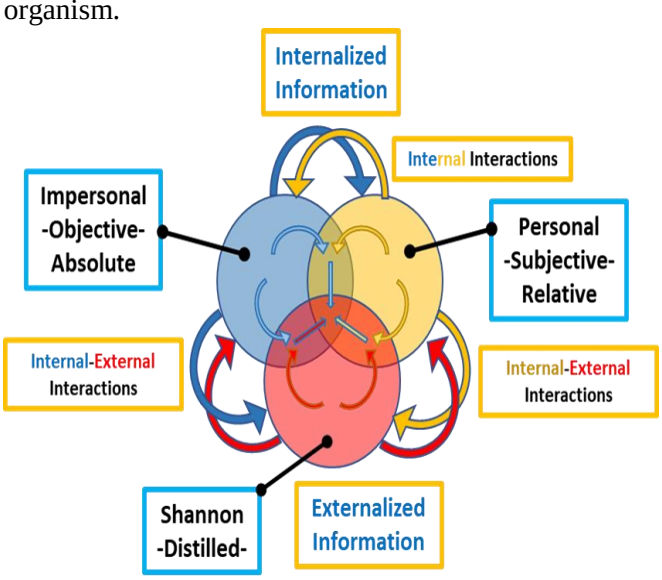

Figure 3 *The infoautopoietic process. Adapted from Cárdenas-García (2022).*

4.3.1 *Personal-Subjective-Relative Information (PSR-I)*

The circle identified as PSR-I or Personal-Subjective-Relative Information, where those three words are taken in the context of the dictionary definition of these terms, relates to a first-person perspective and making a qualitative assessment. PSR-I is intrasubjectively generated information, motivated by the satisfaction of physiological (internal and external) and relational needs, where sensorial percepts, feelings, and emotion play an important role. Emphasizing that the concept of physiological needs is a dynamic concept and should be considered in the context of individuation. As our experiences and tastes throughout our lives accumulate and/or change, so do our physiological needs. The only access to our PSR-I results from externalizing 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 Umwelt proposed by von Uexküll (1992), except that it is specific to the individual.

4.3.2 *Impersonal-Objective-Absolute Information (IOA-I)*

As noted above, interactions between the organism and the environment are asymmetrical. The environment comprises physical objects of a multiplicity of shapes and textures apart from other

living beings. In this process of a developing asymmetrical relationship, the organism encounters physical objects and other living beings that make it realize that some objective accounting must take place if the organism wants to continue with its satisfaction of its physiological and/or social needs. Some physical objects or other living things may have the ability to cause pain/damage to the organism. Thus, the need for the organism to develop predictions about what it believes to be true about the functioning of its environment. Some of these predictions may simply reflect the organism's PSR-I in-its-environment, while others may reflect its experience of pain/harm and pleasure/aid in its interactions. When some actions lead to pain/damage, the human organism-in-its-environment realizes that it co-exists with other subjects and objects. This realization reveals that it has access, however small, to the beginnings of Impersonal-Objective-Absolute Information (IOA-I). These three words are again taken in the context of the dictionary definition of these terms. There is also the connotation that in dealing with IOA-I we are dealing with a quantitative assessment and a third-person perspective.

The interlacing of the PSR-I and IOA-I circles is to express their dependent connection, where IOA-I depends on PSR-I. PSR-I is primary, and IOA-I is secondary. The overlapping arrows between PSR-I and IOA-I serve to emphasize this interdependence, as well as the recurring and ever-present interactions between them. Not all PSR-I can become IOA-I. The part of IOA-I that is outside PSR-I can be regarded as IOA-I potential to develop further. A unique characteristic of individuated PSR-I and IOA-I is that it represents the result of meaning-making, yielding semantic information/content only accessible to the human organism-in-its-environment who is its creator. This implies that individuated PSR-I and IOA-I can only be accessed if its creator is willing to share its contents. Internalized PSR-I and IOA-I are only shared by coded externalized expressions using language, gestures, pictographs, music instruments, sculptures, writing, algorithmic computer coding, etc. This process of externalized communication allows individuals to share their PSR-I and IOA-I.

In short, the human organism-in-the-environment of **Figure 1** is characterized by being able to discover internalized information in the form of PSR-I and/or IOA-I, where its own preferences and beliefs take center stage but can access greater objectivity, avoiding solipsism, in contradiction with (Maturana & Varela, 1987, 1994). Also, it allows for extrapolation of experiences, such as the understanding that a sharp object could hurt us in most circumstances can be expanded to include all sharp objects that have that ability, as it might not be in our best interest to experiment with all sharp objects. The interactive nature of the human organism in its environment promotes the development of an PSR-I/IOA-I interactivity. PSR-I can only influence IOA-I. IOA-I, in turn, can only influence PSR-I. The continuous nature of these actions could lead to losing track of which is primary, PSR-I or IOA-I, as the overlapping arrows may imply.

4.3.3 Shannon-Distilled Information (SD-I)

In **Figure 4** a condensed version of infoautopoiesis of sensorial signals into semantic and syntactic information from previously shown in **Figures 1** and **3**. Sensorial signals are the basis for our interactions with the environment in seeking the satisfaction of our physiological and/or relational needs through a process of infoautopoiesis that enables meaning-making and its externalization in a triadic process involving Personal-Subjective-Relative (PSR-I), Impersonal-Objective-Absolute (IOA-I) and Shannon-Distilled (SD-I) information. Evolving from endogenous (internalized) semantic information to exogeneous (externalized) syntactic information. The depicted externalized, syntactic information by the human organism-in-its-environment depicted in **Figure 4** is in the form of oral sounds.

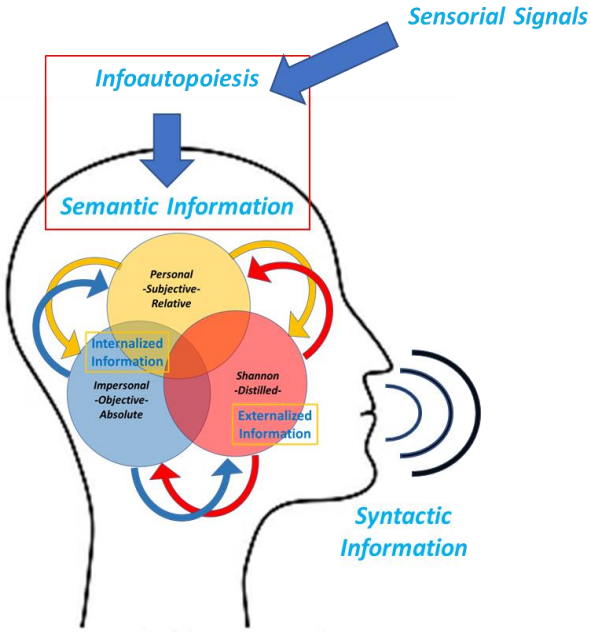

Figure 4 *Infoautopoiesis of Sensorial Signals into semantic and syntactic information. Adapted from Cárdenas-García (2022).*

A further implication is that Shannon/Distilled Information (SD-I) is secondary to PSR-I and IOA-I and that Shannon/Distilled Information (SD-I) cannot exist independently. SD-I is the basis for the existence of this artificial world which we inhabit. A characteristic of an individual's PSR-I and IOA-I is their inaccessibility, no one can have access to our innermost thoughts and feelings. While it can be assumed that the individual PSR-I and IOA-I are extensive in their content, most of us are unable to externalize all our complex emotions, feelings and learning, whether our intention is to make them intelligible to those around us or not. This is why the hard problem of consciousness is badly posed and unresolvable (Chalmers, 2020; Clark & Chalmers, 1998). In cases where an individual falls into a coma or are neurologically incapacitated to communicate or move, alternative approaches are used, which can be described as accessible manifestations of the easy problem of consciousness. This requires detection of neurons firing which are assumed to be reflections of brain functionality using a brain-computer interface (BCI). These techniques run the gamut, from non-invasive and invasive recordings and real-time assessment (Barbosa et al., 2020; Chari et al., 2021; Dingle et al., 2022; Martini et al., 2020; Opie et al., 2019; Opie et al., 2020; Oxley et al., 2021; Soldozy et al., 2020; Tononi et al., 2016). All these approaches, since they rely on instrumentation, which is syntactic in nature, can only produce syntactic information that needs to be interpreted by humans to be useful.

4.4 Flow of information

In short, we can say that internally to the organism, the result is the self-production of semantic information that can be externalized as syntactic information. This externalization of semantic information is done through our organs capable of interacting with our environment. That is, through our organs that allow us to communicate through speech and our limbs that allow us not only to use them to communicate, but also allow us to interact with the world around us to create the tools that allow us to communicate and create all the artifices to make our lives more bearable. If we look closely at **Figure 3**, we see that there are arrows within the three circles that indicate the flow of information to the center of the figure where the information circles PSR-I, IOA-I and SD-I overlap. Perhaps it can be argued that this is the optimal point of the information triad since it represents the point where organisms with an adequate dose of PSR-I and IOA-I express themselves in the most suitable way, choosing the most appropriate means of externalizing SD-I to reach a target audience.

We (all living beings) are the creators of semantic information which we then communicate as syntactic information (call it the syntactic touch: anything that we touch becomes syntactic in nature, like the Midas touch), which are all the artificial creations that we produce and are surrounded by (Cárdenas-García, 2022). We will never be able to produce anything that has the capability for semantic creation. Infoautopoiesis argues that there is no information in the environment, except for the information that living beings produce and put there.

To recap, life, information and consciousness are one and the same. An informatic act is the result of a cybernetic act, i.e., of a homeorhetic comparison, of a 'difference which makes a difference' to a living being. That points to the origin of life and to the semantic nature of information at the outset, which means that semantic information is consciousness, and by its nature is unreachable and impossible to artificially create.

4.5 Infoautopoietic communication

Figure 5 illustrates infoautopoietic communication, i.e., the transformation of Sensorial Signals into semantic and syntactic information, between an individual on the left side of the figure with a similar individual on the right side of the figure. The distillation of PSR-I and IOA-I for externalization and communication transforms PSR-I and IOA-I into Shannon/Distilled Information (SD-I), or syntactic information (Shannon, 1948).

The represented process of communication is of a general nature and follows the depicted sequence: The syntactic information externalized by the individual on the left side of the figure initially gets transformed into electrical signals at the Information Source such as a microphone. The microphone transforms the sound waves into analogue/digital electrical signals which are then fed into the Transmitter. The Transmitter then directs them into a Channel. This Channel may be a wire that carries the electrical signal, or it might involve the generation of electromagnetic waves that are sent into the ether subject to capture by any number of Receivers. Either of these two options may be subjected to random noise from an extraneous Noise Source. Upon detection by the Receiver it is amplified, denoised and, if needed, transformed into an analogue/digital electrical signal. The signal is then sent to the Destination to be inter-

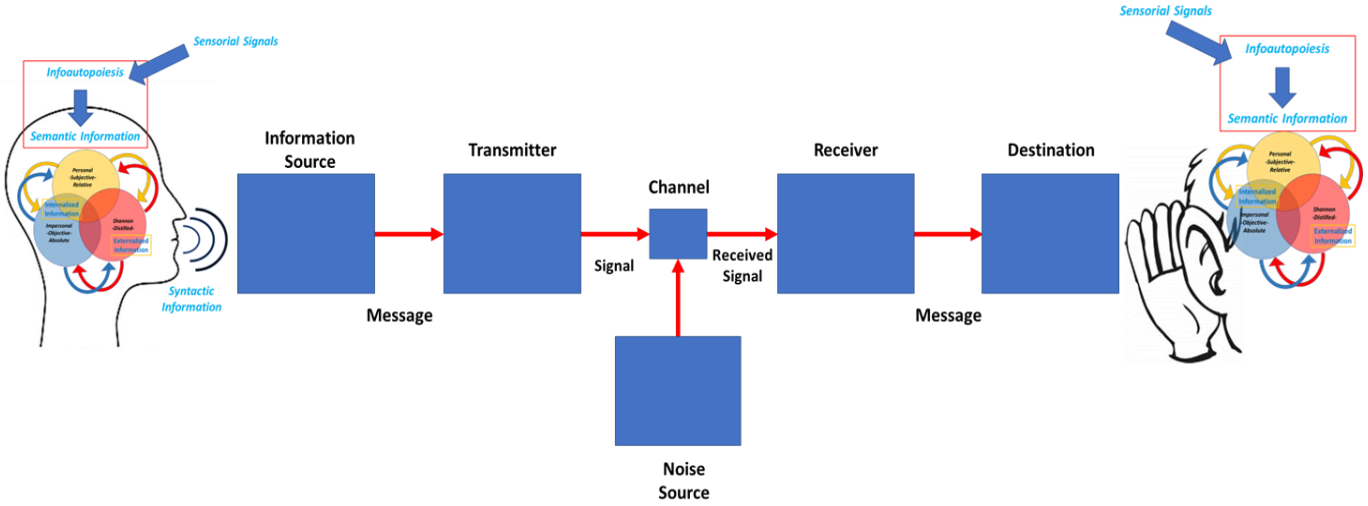

Figure 5 *Infoautopoietic communication: transformation of Sensorial Signals into semantic and syntactic information. Adapted from Cárdenas-García (2022).*

preted into an understandable format to be printed out, or voice synthesized for someone to hear or record the communicated message.

Quoting Shannon (1948), we note that the source of information '... *produces a message or sequence of messages to be communicated to the receiving terminal*.' The transmitter '... *operates on the message in some way to produce a signal suitable for transmission over the channel*.' For example, '... *In telegraphy we have an encoding operation which produces a sequence of dots, dashes and spaces on the channel corresponding to the message*'. The channel is '... the medium used to transmit the signal from transmitter to receiver', which accumulates noise from multiple sources in its path, some predictable, some not. The receiver '... *performs the inverse operation of that done by the transmitter, reconstructing the message from the signal*.' Finally, destination '... *is the person (or thing) for whom the message is intended*."

The '*fundamental problem of communication*' is defined as that of reproducing at one point either exactly or approximately a message selected at another point'. Although messages can be syntactically designed to have meaning, these semantic aspects of communication are irrelevant to the engineering problem, although in some cases engineering aspects may reveal or involve semantic content. One aspect of this communication system is that it can be analyzed mathematically in detail, even incorporating probabilistic prediction to recognize the originally sent message of all possible messages that could have been sent. A typical example is the language corrector on our cell phones that correct us when writing, which can encourage mistakes in what we want to say, so sometimes we choose to blame the word corrector of our cell phone. It is also clear that only a human being at the Destination can make use of the content transmitted syntactically in the messages.

Shannon's purpose in devising this analysis was to understand and solve the communication problem from an engineering perspective by emphasizing the syntactic aspects of communication. The impact of these developments on digital communications is there for all to see. If we are going to naturalize the communication process, we might wonder if there are missing elements that deserve to be included for a more exhaustive analysis. For example, how does the sender of the message produce the message to be encoded for transmission? What is the historical and technical process that allows human beings to develop the technology, design, build and use the apparatus that allows communication to take place? Indeed, how do humans educate and prepare themselves not only to produce advanced technological developments for communication, but to be able to express themselves by taking advantage of their use.

Phylogenetically, not so long ago we lived a hand-to-mouth existence where communication was, at best, by signs and/or direct oral communication. Ontogenetically, we developed from a state in which we could hardly communicate to a state in which oral communication is part of our nature. These questions seem relevant if we want to understand the information from a more general perspective. Having no answers to these questions suggests that we may suffer from *alienation*, or an inability to recognize our work in the products of that labor. We seem to forget that the communication system we are describing is due to our work. In addition, there is a human being on the far left and right of the communication system in **Figure 5**. The human being on the far left generates

a message, because of an internal or endogenous process of creating semantic information, encodes it as syntactic information to externalize it or convert it into Shannon information/exogenous syntactic spoken language, which the communication apparatus then digitally encodes as syntactic information and sends to the human on the far right. After the digitized message acquires noise in the channel, the noise is removed and decoded in the receiver to convert it into synthetic language, which reaches the ears of the human being on the far right. The individual must then decode syntactic and synthetic speech and then decode/interpret the message based on their previous experience and knowledge. This process leads to recognizing syntactic information and interpreting information as semantic information. The same message can have different meanings for different individuals.

A more general interpretation of **Figure 5** is that it defines all types of communication processes, all of which require the externalization of information by the human organism-in-its-environment. This implies that all artefacts produced by humans are syntactic in nature, all needing to be interpreted by other humans by means of Sensorial Signals. They all embody the capability to transform semantic into syntactic information in the process of satisfaction of a need, of design, of the development of the means of manufacture and the finishing process. And this is true of all human creations, whether oral, written, musical, scientific creations, sculptures, humanities and arts-oriented works, etc. Since the design, construction and use of computing machines also fall under the umbrella of syntactic creations it means that the nature of artificial intelligence (AI) is also syntactic. This would seem to put a damper on the potential for the achievement of artificial general intelligence (AGI). Though this does not preclude the development of many interesting AI applications such as *ChatGPT* (Hutson, 2022). This fact is formalized as the Central Dogma of Information which states: 'once semantic information has got into syntactic information it can't get out again' (Cárdenas-García, 2022).

Also, the explanations and practical achievements of science need to be reevaluated since they all result in syntactic creations. Syntactic creations are only able to explain other syntactic elements in our environment. They cannot explain nor create life. Therefore, all attempts to use chemistry to attempt to reproduce life are doomed to failure (Bose et al., 2021; Bose et al., 2022; Criado-Reyes et al., 2021; Dance, 2023; Kawabata et al., 2022; Miller, 1953). To quote Pattee (2012b) as to what might be defined as syntactic elements in nature, "*For my argument here, I will mean by matter and energy those aspects of our experience that are normally associated with physical laws*".

5. Discussion

There is a tendency by most researchers to postulate the existence of information as a mysterious quantity that is to be found everywhere in our environment, except that it is difficult to describe, and no identifiable sense organs seem to detect it. Yet, the notion that information can be identified gives credence to the colloquial expression "*I know it when I see it.*"

Wiener (1948) attempted to be more specific when he stated that "*Information is information, not matter or energy. No materialism which does not admit this can survive at the present day*". While describing information in terms of itself, this points to a general belief among many scientists that information is a third quantity of the Universe besides matter and/or energy. Something that is wholly dependent on a postulate that has no basis in fact.

The approach promoted in this work is that information is paramount to the functioning of the human organism-in-its-environment. An etymological perspective ties information to giving shape to matter and using communication as the means to shape the minds of other individuals. While also using Bateson's definition of information as 'a difference which makes a difference,' it makes for the possibility that information may be identified and analyzed. Indeed, both perspectives coincide in promoting a naturalized and dynamic view of information. They promote the view that information is a means to describe change in matter and/or energy, and that humans have an individuated role to play in acting to promote and observe that change. This approach ties the finding of an answer to phenomena that may be observed in the daily lives of humans and how they interact with their environment.

The result is a new paradigm to study information, that of infoautopoiesis, or the self-referential, sensory commensurable, recursive and interactive homeorhetic feedback process immanent to Bateson's 'difference which makes a difference' by which a human organism-in-its-environment pursues satisfaction of its physiological (internal/external) and / or social needs. This yields the discovery that the information process is a never-ending sensation-

information-action cycle that allows us to discover and act on our environment.

The process of infoautopoiesis transforms the sensorial signals of the noisy environment in which all living beings live, through their motivated efforts to satisfy their physiological and/or relational needs to improve their ability to engage in their ever-changing environment. The human organism-in-its-environment, through a triadic process involving Personal-Subjective-Relative, Impersonal-Objective-Absolute and Shannon-Distilled information, can internally generate semantic information that it can then externalize as syntactic information. Our syntactic creations are all the artificial creations that we have created and surround us, some being very rudimentary, but others of great sophistication and technological scope.

Previously it has been possible to make the argument that there exists a connection between the mind-body problem, consciousness, information and meaning. In particular, (Bohm, 1989) states: "*Consciousness is meaning*." Also, **Figure 1** is elucidatory of the possibility of resolving the mind-body problem by illustrating how error/differences/ information/ideas are self-produced from sensorial signals. These error/differences/information/ideas, as images of the world, reflect the meaning that help the human being coordinate its actions in the external environment (Pattee, 1982, 2012a). If "Consciousness is meaning," then consciousness cannot but be produced in the infoautopoietic process. Indeed, the process of infoautopoiesis or the self-production of information is postulated to be the source of consciousness which is the equivalent of the production of error/differences/information/ideas. Generalizing, the self-produced error/differences/information/ideas are always meaningful for the organism and are the equivalent of being conscious for the organism, whether they are the result of voluntary or involuntary infoautopoiesis. Determining differences is the source for satisfaction of our most basic physiological needs such as breathing and eating, changing our surroundings by acting on our environment, and when engaged in discussions with others. This dynamic view of the process of cybernetic human actions, or constitutive absence (Deacon, 2008), may be revealed as engaging every instant of our lives. We might not know exactly what it is that is motivating our sensory engagements, but we cannot deny that satisfaction of physiological and relational needs are drivers. In other words, life is infoautopoiesis is consciousness, or consciousness is infoautopoiesis is life.

The traditional perspective on life is that "life is chemistry" leading to the continuous search for primordial organic molecules as precursors to life (Criado-Reyes et al., 2021; Miller, 1953), although it is then difficult to find the path of how these precursors become life. A current perspective is centred in the search for a 'protoribosome' or a primitive RNA machine capable of linking two amino acids together (Bose et al., 2021; Bose et al., 2022; Kawabata et al., 2022). This in an attempt "to recapitulate a milestone on the road from primordial organic molecules to the ribosome used by the last common ancestor of all living things" (Dance, 2023). While this might be considered a promising approach to discovering the origin of life, the question that needs to be asked and answered is how this mechanism for life becomes part of a cellular structure and what motivates its incorporation? Indeed, what motivates its consciousness or information self-production? The limits to a scientific approach to life have been noted above.

Bohm (1989) notion of '*active Information*' can now be identified as syntactic in nature when we examine all the examples that he presents. Additionally, his reference to DNA as "*a case in which the notion of active information does not depend on anything constructed by human beings*" (Bohm, 1989) may be understood as syntactic information created by a cell (Cárdenas-García, 2022). Thus, establishing that all syntactic information is the results of meaningful actions by living beings that result from the infoautopoietic internalization of sensorial signals from the environment.

This infoautopoietic approach to the study of information allows the examination of many instances where other approaches may fail. Such is the case of artificial general intelligence (AGI) where the potential benefits/dangers are more a matter of speculation, rather than the certainty that infoautopoiesis provides by defining its limits as syntactical creations. Syntactical expressions that are unable to engage in semantical responses. This also impacts the limits of the arts and sciences and what we can understand and achieve in their pursuit.

6. Conclusion

Infoautopoiesis is a new paradigm to understand information in the context of all living beings-in-their-environment. Infoautopoiesis is the process of self-production of information; an individuated sensory commensurable, self-referential, recursive, interactive

homeorhetic feedback process immanent to Bateson's 'difference which makes a difference. A basic premise to infoautopoiesis is that information is not a fundamental quantity of the Universe, yet its importance cannot be underestimated for human organisms-in-their-environment. Humans self-produce information to discover the bountifulness of matter and/or energy as expressions of their environmental spatial/temporal motion/change, as information or 'differences which make a difference,' to satisfy their physiological (internal/external) and relational needs.

Infoautopoiesis defines a connection between the mind-body problem, consciousness, information, meaning and life, and results in the generation of internalized and externalized information relevant to human organisms-in-their-environment. Indeed, *consciousness is meaning*. The self-production of inaccessible internalized or semantic information makes the external environment meaningful. Semantic information is made accessible by communicating through externalized syntactic expressions using language, gestures, pictographs, musical instruments, sculptures, writing, coding, etc. We live in and are surrounded by our artificial creations. This means that all externalized expressions of human created knowledge are syntactic in nature and require re-interpretation by other peers through Sensorial Signals. Syntactic artificial creations surround us and make us believe that information exists in the environment, yet there is no information in the environment or in the Universe independent of humans. Infoautopoiesis is the link between the living and non-living. Despite our ability for externalized syntactic information creation, however sophisticated, we are unable to make these syntactic creations produce semantic information. This includes all human knowledge creations in the arts and sciences. Information cannot but be the primary element that allows humans their unique existence.

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