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Information is primary and central to meaning-making

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Abstract. There is the misconception that the concept of information is not applicable to meaning-making in living beings. What is more generally believed is that Peircean semiosis provides a more robust framework to explain meaning-making. This involves the production, exchange, and interpretation of signs as the basis for meaning to an organism. Semiosis establishes a continuous and developing occurrence of triadic relations between a representamen (sign), an object (the other), and an interpretant as the organism engages with its umwelt, resulting in the appearance of meaning as a factor in its life. However, it is not clear that Peircean semiosis is the most fundamental process by which meaning-making may be instantiated in nature. Here we show that information defined by Gregory Bateson as 'a difference which makes a difference' can more fundamentally serve as a basis for meaning-making. Both its etymological origins and Bateson's dictum naturalize the concept of information to identify its cybernetic dynamic motivated by constitutive absence, or the ability of an organism to find in its environment what it teleologically deems missing. This implies an ability to interpret its environmental surroundings. Furthermore, detecting a difference is the most fundamental of acts, revealing that information is the basis for meaning-making for an organism, allowing any level of intricacy in its interpretative capabilities. Indeed, Peircean semiosis is shown to be a special case of informatic meaning-making. In short, information provides a firm foundation for meaning-making for living beings.

Keywords: Jakob von Uexküll; Gregory Bateson; Charles Sanders Peirce; umwelt; biosemiotics; infoautopoiesis; information; semiosis

1. Introduction

Biosemiotics is fundamentally centred in the contributions of three individuals: "first and foremost, the semiotic logic of Charles Sanders Peirce (1839–1914), together with the proto-semiotic Umwelt theory of Jakob von Uexküll (1864–1944) and the bio-cybernetic thinking of Gregory Bateson (1904–1980)" (Ireland

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2024: 30). The purpose of the article is to examine the influence of each of these three notable individuals to gain insight into meaning-making. In particular, the article aims to scrutinize the belief that the concept of information is unsuitable for application to meaning-making in living beings. It also poses the question whether Peircean semiosis provides a more robust framework for meaning-making, involving the organismic production, exchange, and interpretation of signs. Indeed, semiosis is argued to provide a continuous and developing occurrence of triadic relations between a representamen (sign), an object (the other), and an interpretant as the organism engages with its umwelt, resulting in the appearance of meaning as a factor in its life.

However, information, defined as "a difference which makes a difference" (Bateson 1978: 453), may be advanced as another basis for meaning-making. Both its etymological origins and Bateson's dictum naturalize the cybernetic dynamic of information and uncover its motivation of satisfaction of physiological and/or relational needs in interpreting its environmental surroundings. Furthermore, detecting a difference is the most fundamental of acts for any organism. As a result, Peircean semiosis is shown to be a special case of informatic meaning-making. The next three sections explore the concepts of the umwelt, semiosis, and information as sources of meaning-making.

2. The umwelt

Using a biological perspective, Jakob von Uexküll argues for the organism as subject as opposed to the physiological approach of organism as machine, stating: "We no longer regard animals as mere machines, but as subjects whose essential activity consists of perceiving and acting. We thus unlock the gates that lead to other realms, for all that a subject perceives becomes his *perceptual world* and all that he does, his *effector world*. Perceptual and effector worlds together form a closed unit, the *Umwelt*." (Uexküll 1992: 320) Fig. 1 shows a model of this approach, demonstrating how all individuated organisms interact with their environment.

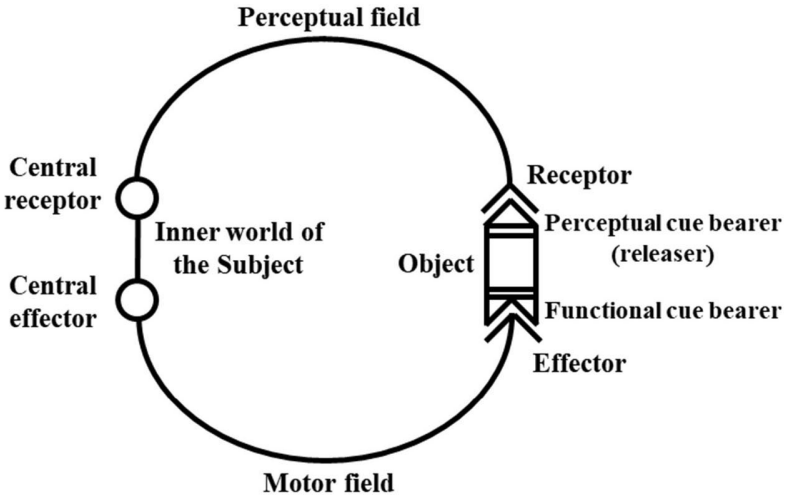

Figure 1. Functional cycle (adapted from Uexküll 1992: 324).

Uexküll's example of an eyeless tick shows the versatility of this approach in the tick successfully identifying its prey by odour leading to the tick releasing itself from its perch, detecting a warm-blooded creature by temperature, and finally seeking a hairless spot to burrow and pump itself full of warm blood: "The whole rich world around the tick shrinks and changes into a scanty framework consisting, in essence, of three receptor cues and three effector cues – her *Umwelt*" (Uexküll 1992: 325). Added to these cues is the ability of the tick to survive without food for long periods of time, thus increasing the probability that it will find suitable prey. In this explanation, Uexküll uses the concepts of 'receptor signs' and 'sign stimuli' and alludes to an unknown inductive process to connect the sign stimuli of the receptor organ to the stimulation of the effector organ to act in a specified manner. This unknown inductive process would seem to be the key to meaning-making for the organism. Indeed, this implies the identification of triadic relations between a representamen (sign stimuli detected by the receptor organs), an object (the prey), and an interpretant (action by the effector organs). In short, while it is possible to determine the sign stimuli that affect the organism's receptor organs to respond with its effector organs to achieve its goals, the meaning-making process remains unknown.

3. Semiosis

Many researchers dismiss using the concept of information as the starting point to explain meaning-making (Brier 2008; Kull 2018, 2022, 2023b). It has always been the case that meaning-making in biology is frowned upon because of its subjective nature. What seemed more appropriate, when information became an in-vogue topic, was adaptation of the mathematical theory of communication (Shannon 1948) to biology, purportedly to promote an objective scientific approach. The following quote illustrates the difficulty in making such an information-based approach a reality:

> The concept of meaning has been difficult for biology. As viewed in the science of semiotics, meaning is neither a thing nor a process, but a relation. A biologist would ask: "Where can we find and identify relations if we study just things and processes? In what sense can meaning be real for an organism?" The problem seemed to be temporarily solved by introduction of an information approach in biology. However, there again, the quantification of information left the natural semantics out. (Kull 2023b: 162)

This was not totally unexpected as it was something that Claude Shannon (1948) had anticipated, since he had been explicitly dealing with syntactic information. Søren Brier (2008) also explored the issue of information not being enough. In his *Cybersemiotics* he voices his uneasiness with cybernetic approaches to explain meaning-making, stating:

> What happens is that a stream of random events gets coupled with a non-random selective process. This combination causes particular components to survive, or at least last longer than others. The mutually reinforcing forces within a system or organism can, if they work synergistically all in the same direction, increase that organism's stability in a given environment, among other things through feedback mechanisms. But if this turns into rigid patterns and structures, the system's potential to adapt to changes in the environment decreases. The 'happy mean' lies somewhere between complete stability and utter chaos in a dynamic cybernetics recursive complexity at several inclusive levels. (Brier 2008: 174)

This line of reasoning is echoed by Kull when he states that "[...] we can study the differences that make a difference for other beings. However, this is certainly not enough in order to describe their umwelt." (Kull 2018: 136) Instead, he emphasizes semiosis as a more viable alternative. More recently, Kull (2022: 127) has stated: "Analogically, we can distinguish between meaningful and meaningless functionality. The former is based on sign relations, the latter on feedback mechanisms in

which signs are not involved. Accordingly, organic processes are of two very different classes – without semiosis, and with semiosis." In short, Peircean semiosis is generally regarded as providing a more robust framework for meaning-making.

To get a glimpse of Peircean semiosis we can start with the definition of a sign:

> A sign is anything which determines something else (its interpretant) to refer to an object to which [it] itself refers (its object) in the same way, the interpretant becoming in turn a sign, and so on *ad infinitum.* (CP 2.303)

This definition allows us to think of semiosis as a *process* that engages a living being with its umwelt in an interactive and iterative loop that builds a semiotic scaffold for the organism (Hoffmeyer 2007). This is how meaningful structures are built on top of other meaningful structures for the individuated organism (Simondon, Adkins 2020). It would seem that the problem of meaning-making is identified. However, it is not as straightforward as it appears for semiosis requires explicit specification:

> Semiosis is the sign process itself. Why has it been so difficult to describe it via a formal model? Because it is a clash of operations, it is just the break in formal logic. Semiosis is the process in which the formal consistency interrupts, where it is not determined what happens next, where parts of the model do not fit each other. Semiosis is the process that takes place in the condition of incompatibility. (Kull 2015a: 227)

Also, referring to Charles S. Peirce's and Jakob von Uexküll's models of semiosis, and Juri Lotman's model of communication Kull states: "It is remarkable that despite many efforts, none of these models have been successfully formalized. As we see it, this is due to the same reason that meaning is inaccessible to physics. In order to model semiosis, we need to model the logical incompatibility in flesh." (Kull 2015b: 617) In addition, Kull (2023a: 60) has suggested: "In order to identify whether what is going on is semiosis, we need a model of semiosis that operationally describes its features. As it appears, we do not have such a model yet." Claudio J. Rodríguez Higuera (2023: 105) puts it more explicitly:

> Drawing from Peircean thought, semiosis is introduced to biosemiotics as synonymous with meaning-making. Because a sign is a singular relation that includes some perception and some action, there must be something that unifies multiple signs as we realize that one sign leads to multiple others. But this conceptualization is still tricky and not uniform in its usage because it does not do much explanatory work, if any. Having a working concept of semiosis entails having a

> notion of its origin, internal mechanisms, and, hopefully, its application. Semiosis presented as the action of signs does not clear any of those areas, and presenting it as meaning-making does little to clear them up. For our concept of semiosis to be functional, we need it to do more than being a reformulation. Semiosis, it seems clear, includes sign relations to some degree. We can ask how these come to be and what they do, and if our concept of semiosis is to be strong enough, it will have to shed light on both of these questions.

In short, "the main problem for biosemiotics is the explanation of the origin and evolution of sign" (Kull 1998b: 306). The next section deals with how information may be conceptualized for meaning-making.

4. Information

People generally see what they look for,
and hear what they listen for.
Harper Lee (1960: 134)

The long history of information uncovers an elusive concept that needs clarification (Capurro *et al.* 1997; Capurro, Hjørland 2003; Capurro 2009; Hofkirchner 2008), and involves a dichotomy that needs resolution. For some, information is considered an absolute quantity of the Universe in addition to matter and/or energy, whose existence is predicated upon a postulate which some consider sufficient to bring it into existence (Wheeler 1991; Stonier 1997; Yockey 2005; Lloyd 2006; Floridi 2010; Vedral 2010). For others, it is a relative quantity/quality, "a difference which makes a difference" (Bateson 1978: 453), while "[t]he essence of this definition is that information is something which is generated by a subject. Information is always information for 'someone'; it is not something that is just hanging around 'out there' in the world." (Hoffmeyer 1996: 66) The implication is that there is no information outside living beings interacting with their environments (Gare 2020: 328; Cárdenas-García, Ireland 2019; Burgin, Cárdenas-García 2020; Cárdenas-García 2020, 2022). Clearly, the more reliable choice to perform a more detailed assessment of information is the one dependent not on the enunciation of a postulate but rather on first-hand observation.

4.1. What is information?

The etymological origin is the Latin noun '*informatio*' from the verb '*informare*' ('to inform') in the sense of giving a form to matter and communicating knowledge to others (Capurro, Hjørland 2003; Capurro 2009; Díaz Nafría 2010; Peters 1988). This dynamic perspective suggests that the relationship between an organism and its environment is analogous to Bateson's "difference which makes a difference" (Bateson 1978: 453). Both conceptions of information define a self-referential, interactive, recursive, evolving, and never-ending virtuous dynamic spiral of sensation–information–action. The actions reflect the organismic capacity for relating to their environment motivated by satisfaction of physiological and/or relational needs. Bateson (1978: 458–459) illustrated this dynamism by describing the actions of a lumberjack with 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.

This description illustrates the sensation–information–action loop of living beings. The word 'cybernetic' is used in the homeostatic (returning to a state of equilibrium) and homeorhetic (converging towards a dynamic trajectory) sense. Homeostasis is internal to the organism, but a living being, to seek homeostatic balance, needs to engage in homeorhetic actions to satisfy its physiological and/or relational needs as the man's body maintains a homeostatic balance of vital signs as he chops the wood. Both involve a sensation–information–action loop. This keeps the body within safe bounds of performance, and allows working effectively to accomplish the task of chopping wood. Both instances lead to the continuous improvement of the sensation–information–action cycle and consequent increases in efficiency. Further, as part of this conceptualization of information, Bateson (1978: 453) notes "that the word 'idea,' in its most elementary sense, is synonymous with 'difference'". In other words, every interaction with our environment leads to the conscious and/or unconscious noticing of differences, information or ideas (Cárdenas-García 2023b).

4.2. The fundamental problem of information

In order to demystify the generation of information, it is useful to pose the Fundamental Problem of Information Science (Cárdenas-García, Ireland 2019), i.e. the question of how living beings change and become what they become. In other words, how living beings in a self-referential process develop from a state in which information for the organism-in-its-environment is almost non-existent to a state in which the organism not only recognizes the existence of the environment, but also sees itself as part of the organism-in-its-environment system and is able not only to engage with and navigate through it in a self-referential way, but even to transform it in its own image. This question serves to affirm the individuated centrality of the human organism in the information process and to emphasize the social nature of human relationships in helping us achieve the essence of who we are as living beings.

4.3. The organism-in-its-environment

Fig. 2 shows a representation of an organism-in-its-environment and illustrates the process of sensation–information–action. This description is made relevant to a human organism, but may be made applicable to other organisms as well, depending on the contextual details. An important distinction that needs forceful clarification is that the representation in Fig. 2 is not a model of an organism-in-its-environment. Rather, it is a simulation of an organism-in-its-environment, which is incapable of making predictions as to how an actual organism will behave. This draws attention to what can and cannot be ascribed to an actual organism. The elements within the infoautopoiesis (info=information; auto=self; poiesis=creation/production) box implement Gregory Bateson's homeostatic and homeorhetic cybernetic definition of information as "a difference which makes a difference" (Bateson 1978: 453). This is presaged by the statement "What enters the mind as information always depends on a selection, and this selection is mostly unconscious. In this sense one should not speak about 'getting' information, rather information is something we 'create'." (Hoffmeyer, Emmeche 1991: 122) An interpretation of this statement is that information does not exist in the environment, but is self-produced by the organism.

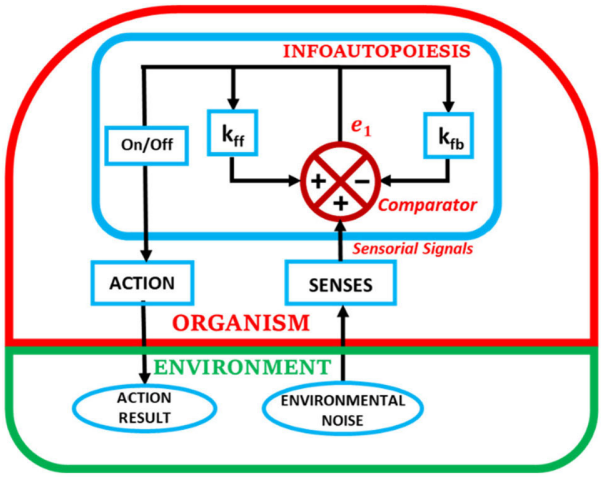

Figure 2. The organism-in-its-environment (the organism is shown in red, the environment in green and infoautopoiesis in blue).

With reference to Fig. 2, I now describe how the elements are selected that impact the process of information self-creation (infoautopoiesis).[2] For the purpose of a didactic explanation, external and internal circuits can be identified. The external circuit connects the environment to the organism: the senses are at the input side of the organism, and the action-capable members produce an action result on the output side of the organism. The internal or infoautopoiesis circuit begins at the point where the senses select sensorial signals to self-create/produce information; and ends where an infoautopoietic action results and acts on the environment.

A fundamental assumption is that all organisms live in a noisy environment that subjects them to environmental noise that varies depending on the environment in which the organism lives and acts. The senses serve as the point of encounter of the external circuit of the organism with environmental noise that is transduced in the senses to become sensorial signals. These sensorial signals are then admitted and processed by the organism in the infoautopoiesis box to self-produce information. This denotes that sensorial signals are *not* information from the environment, but result from the capability of the organism to distinguish and select, from all of the environmental noise, signals relevant to its primary motivation of satisfaction of its physiological and/or relational needs (further expanded below).

[2] See Burgin, Cárdenas-García 2020 for an example of a typical treatment of Fig. 2 as a model of an organism-in-its-environment and the limits of such an exercise.

On entering the infoautopoiesis box, the sensorial signals encounter a comparator which serves as a means continuously to combine signals that involve different time cycles of sensorial signals entering the infoautopoiesis box. The reader can imagine that each set of sensorial signals corresponds to an action potential that impinges on the comparator to generate information at its upper point denoted by the symbol e_1. More specifically, it is possible to write a recursive relationship between time steps i and $i + 1$ at the comparator as follows:

$$(e_1)_{i+1} = (SS)_i - k_{fb}(e_1)_i + k_{ff}(e_1)_i. \tag{1}$$

$(e_1)_{i+1}$ at time step $i + 1$ results from adding sensorial signals $(SS)_i$, feedback $k_{fb}(e_1)_i$ with feedback coefficient k_{fb}, and feedforward $k_{ff}(e_1)_i$ with feedforward coefficient k_{ff}, at time step i. Rearranging this, we get

$$(e_1)_{i+1} = (SS)_i + (k_{ff} - k_{fb})(e_1)_i, \tag{2}$$

which we can express as follows:

$$(e_1)_{i+1} = (SS)_i + \Delta k\,(e_1)_i, \text{ since } \Delta k = (k_{ff} - k_{fb}) \tag{3}$$

The result $(e_1)_{i+1}$ is infoautopoietically produced semantic or meaningful information. Note that it depends on the difference between the feedforward and feedback coefficients. How the organism decides on the selection of values for $(SS)_i$, k_{fb} and k_{ff} is not discernable, since it is something that the organism decides as it interacts with its environment. As can be imagined, the source of sensorial signals is multifarious, since what we conceptualize as senses includes at least sight, sound, taste, smell, and touch. In addition, each of these sensory organs is made up of millions of sensory elements that coordinate and cooperate between each other. What this infoautopoietic process alludes to is that only the organism is privy to what it is able to detect in the environment, as it learns the relevance of the various circumstances and objects that it encounters. This results in a very private/subjective learning process of self-production of semantic information, which corresponds to the discernment of meaning by the organism.

In order fully to describe the process of infoautopoiesis as a meaning-making process we need to consider the relevance of the external circuit in consonance with the internal circuit. The role of the internal circuit is to generate semantic information which is internal to the individual in interacting with an object in the environment. The On/Off box shown in the diagram represents the ability of the organism to respond to the accumulation of semantic information as a result of these interactions until a threshold is reached. Reaching this threshold

implies memory formation pertinent to the accumulated semantic information and results in an action which the organism exerts on its environment; its effect is shown as the action result in the environment. In other words, as a result of continuously examining preselected sensorial signals, the process of infoautopoiesis generates what may be identified as cumulative invariant information (a memory) which results in an action. Once a memory is created, Fig. 2 can account for both the case of a pre-existing memory ($k_{fb} = k_{ff}$) and the development of a new memory ($k_{fb} \neq k_{ff}$). Both instances are based on the same infoautopoietic process and are illustrated next.

The case of a pre-existing reflex arc response of the organism implies that a pre-existing memory is active in the organism. The sensorial signals that motivate the activation of the reflex arc system require that $k_{fb} = k_{ff}$, which means that the organism immediately reaches the threshold required to trigger an action in order immediately to satisfy its physiological and/or relational needs. For example, the sucking reflex of an infant might be randomly activated to start sucking, but if the child is unable to reach the required threshold for repeated sucking, s/he will stop. In the case of reaching the required threshold s/he stops either by satiation, or removal from the nipple that set off the reflex arc action. The sucking reflex of an infant is something that eventually ceases to function, and is replaced by the recognition of the infant as to what needs to happen to satisfy her/his hunger, including using a feeding bottle or her/his hands to feed her/himself. In short, the infoautopoietic learning process of an infant is short-circuited by reflex actions that eventually lead to recognition by the infant of what needs to happen to achieve feeding her/himself. When that occurs, the ability of the organism will be required to develop new memories, and this is achieved by reverting back to values of $k_{fb} \neq k_{ff}$.

In other words, a homeostatic/homeorhetic action occurs depending on the learning of the human organism based on the correspondence between the sensorial signals and the satisfaction of its physiological and/or social needs. The resulting homeostatic/homeorhetic action may be likened to a relevant response by the organism, which is characterized as externalized syntactic information in the form of an action result (this will be clarified below).

This is similar to Uexküll's example of an eyeless tick which upon identifying the odour of its prey releases itself from its perch. The implication in this instance is the existence of triadic relations between a representamen (sign stimuli detected by the receptor organs), an object (the prey), and an interpretant (action by the effector organs). The questions that this approach leaves unanswered are: how do the sign stimuli come about, and what is the process by which the sign stimuli are detected by the receptor organs?

To answer these questions the following quote is helpful:

> Thus, I define semiosis as a process of translation, which makes a copy of a text, suitable to replace the original text in some situations, but which is also so different from the original text that the original cannot be used (either spatially, or temporally, or due to the differences in text-carrier or language) for the same functions. This translation process (i.e., semiosis) requires two types of recognition processes. First, the translation assumes that parts of the original text are recognized (on the basis of pre-existing memory-text) and as a result new structures are built, whereas a certain isomorphism between the original and the new text is retained. And second, there is a recognition process which starts the translation process, which is required for the existence of the whole process on another level, and which at the same time gives an intentional dimension to any particular semiosis. I also state that the one carrying out the translation (the translator, which includes memory) is itself a text, i.e., the result of some translation process. (Kull 1998a: 302)

This assumes that a process of comparison occurs between a sign that exists in memory with the detected sign stimuli. But what remains unanswered is where the sign that exists in memory originates? Further, how is the difference between the pre-existing memory text and the original text evaluated? Would it be appropriate to say that the result is information as 'a difference which makes a difference' that triggers the interpretation action? What this also suggests is that the organism is capable of many connected instances of semiosis.

4.4. The informational origin of signs

As explained above, Fig. 2 above illustrates the process of self-creation of information. When the organism assesses the sensorial signals, these are specific to an object that the organism identifies as worthy of its attention due to its motivation for satisfaction of physiological and/or relational needs. The repeated encounter of the object by way of the sensorial signals leads to invariance in its assessment of the object and triggers the formation of an informational memory that results in an action. The repeated encounter of the same object causes the organism to be more efficient in recognizing the same object ($k_{fb} = k_{ff}$). At the same time, the organism not only recognizes the same object better but may continue to expand its detailed assessment of the object ($k_{fb} \neq k_{ff}$). Thus, the initial informational memory continues to develop as the object might be recognized from many angles, variable geometry and even varying composition. In short, the initial existence of a simple object is detected through 'a difference that makes a difference' and congealed in memory. Each subsequent assessment of difference between the

existing memory and the newly detected corresponding sensorial signals causes this memory to be transformed into a memory that acquires the role of a sign. This comparison process can then be considered to evolve to a process where a sign in memory is compared to a corresponding sign signal that becomes more and more elaborate. In other words, infoautopoiesis is capable of explaining not only the self-creation of information but also the subsequent origin of signs, and meaning-making becomes an unavoidable result.

One aspect that this explanation avoids is the predicament of whether all living beings deal with signs in their interactions. This paper posits that since infoautopoiesis relies on the generation of information as 'a difference which makes a difference' it applies to all organisms, but if an organism requires detailed assessments of objects in its umwelt then signs are the necessary outgrowth of such requirements. This might be a different way of saying that "[t]he 'animal' remains captured by its *Umwelt,* which never becomes present to it *as* an *Umwelt* – although the animal is clearly aware of sense-perceptible aspects of its surroundings." (Bains 2006: 70)

4.5. Teleology and the organism-in-its-environment

A further point that needs elucidation is that many ascribe teleology or "constitutive absence" to the actions of the organism but envelop this explanation with an aura of mystery (Deacon 2007; 2008; 2013). What is described here is an approach that guides the cybernetic actions of the organism through satisfaction of physiological and/or relational needs instead of the more general notion of survival (detecting survival by an organism seems like a tall task requiring sophisticated sensors). If there is constitutive absence it is initially due to the inborn reflexes of the organism that provide a starting point for learning about the environment. It may be likened to a thermostat in a room whose temperature setting always cybernetically guides the working of the air conditioning for the comfort of the occupant. However, a living being is born with the ability to set its own cybernetic parameters in its efforts for information self-production for the purpose of satisfaction of its physiological and/or relational needs. Infoautopoiesis implies the interpretation or generation of semantic information when 'a difference which makes a difference' is determined. Initially, this is not a matter of choosing between alternatives since the organism is initially responsive only to newborn reflexes. This leads to the incessant processing of sensorial signals whose origin the organism does not initially control. When the organism experiences changing differences due to changing sensorial signals, this expands the ability of the organism to give meaning to those differences when a correlated invariance is detected

between the information and the resulting actions that correspond to satisfaction of physiological and/or relational needs. This implies that even a single bit of information might be sufficient to influence actions by the organism. In addition, differences are built on differences, resulting in a hierarchical organization or layering/stratification of differences. Because of the commensurability of differences there is never a need to worry about which differences get stacked on top of each other as they are self-defining and self-discriminating (Cárdenas-García, Ireland 2019; Burgin, Cárdenas-García 2020; Cárdenas-García 2020, 2022).

4.6. Shannon's mathematical theory of communication

Fig. 3 shows at its centre a block diagram of the elements of the general communication system underlying the Mathematical Theory of Communication (Shannon 1948), central to the establishment of Information Theory as a discipline. The information source may be likened to a microphone into which a message is spoken to start the communication process. The transmitter is an encoding device that makes the message generated by the microphone amenable to transmission as a signal over a wired or wireless channel. The channel is subject to accumulation of noise from multiple noise sources. The receiver is a decoding device that reconstructs the original message from the received signal. Finally, the destination is the speaker that blares out the arriving message. Shannon (1948: 379) defines the fundamental problem of communication as "that of reproducing at one point either exactly or approximately a message selected at another point" (Shannon 1948: 379). This engineering analysis was devised to understand and solve the problem of communication, emphasizing the syntactics of communication, not the non-existent semantics of the message. It has nothing to do with infoautopoiesis, except for the unavoidable actions by humans in the conceptualization, design, construction and use of these very useful communication systems that take many forms.

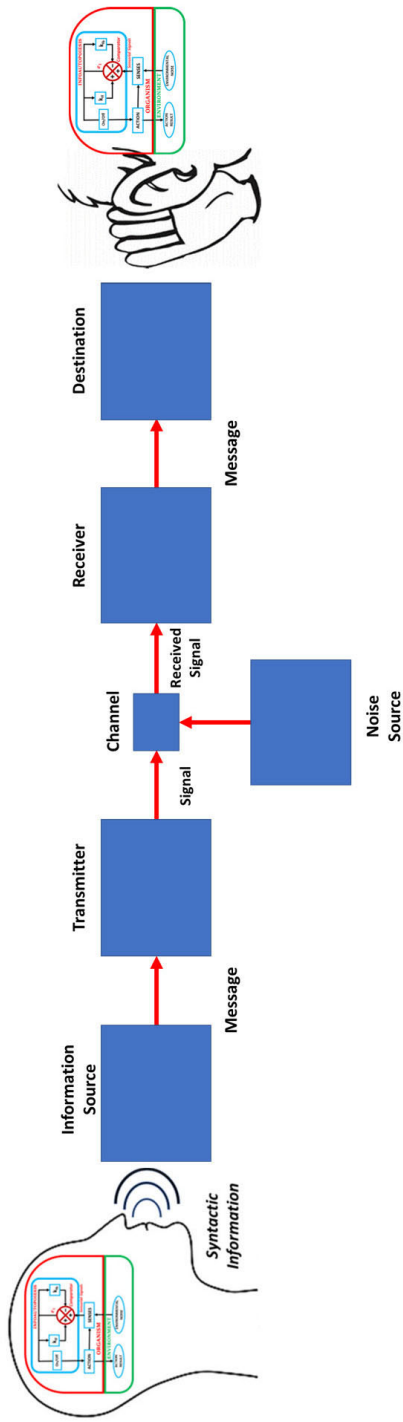

Figure 3. The communication process (adapted from Shannon 1948: 381).

Looking at Fig. 3 we can find in this analysis that we have excluded two important elements without which the communication system is irrelevant: the sender of the message at the left end, and the recipient of the message at the right end. How does the sender of the message synthesize the message, and how does the recipient of the message interpret the message? Note also that this communication system is the one we use anytime we talk directly to another person. This requires that the information source and transmitter are one with the sender. Similarly, the receiver and the destination are internal to the recipient. Notice also that inserted in both heads is the organism-in-its-environment illustration of Fig. 2 to signify this as the source to synthesize and also to interpret syntactic information, in the sender and recipient of syntactic information, respectively. The sender synthesizes and externalizes syntactic information from internalized semantic information. The recipient interprets the externalized syntactic information and generates internalized semantic information in the process, so as to be able to respond syntactically. The same message might have different meanings to different individuals. This is similarly reflected in the field of zoosemiotics as revealed in the following passage:

> The associative ties between signals and their meanings are often arbitrary, as opposed to iconic: thus tail movements in a dog denote friendship, in a cat hostility, and in a horse the presence of flies. Some signals are 'shifters', that is, their referent differs according to the situation: thus the honeybee's directional tail-wagging dance has more than one denotatum, for it designates either a food source or a nesting site, its pragmatic import depending not upon variation in the form of the expression but solely the attendant physical context of an identical gesture pattern. The herring gull's head-tossing has more than one function: it occurs as a pre-coital display, but this is indistinguishable from the head-tossing exhibited by a female begging for food. (Sebeok 1972: 131)

Fig. 3 also hints at a more general interpretation. The process of generating sounds depends on our voice organs which allow us to modulate the air to produce pressure wave differences that result in sound creation. We have learned to use sound creation as speech and it is interpreted as syntactic information because of its organization. In other words, speech is produced by informing or shaping air as pressure waves in our efforts to express our inner semantic thoughts. To generalize, the generation of externalized syntactic information from internalized semantic information may also be achieved by more direct manual in-forming of matter, not only air, into useful objects. This may be construed as engaging in a process of syntactically ordering matter. Correspondingly, irrespective of how matter is ordered syntactically, we should be able to interpret its form and function so that we can use it effectively. The implication is that not only are we able

to communicate by our speech and writing, but we are also able to communicate by our creations in all areas of the Arts and Sciences. This also implies that most of what surrounds us is artificial and identifiable as syntactic information. This finding is demonstrably one of the most important results relevant to information and meaning-making, i.e. internal semantic information unavoidably requires transformation into external syntactic information in an endless process of sensation–information–action.

5. Discussion

The main theme of this work is to question the well-intentioned assertion that "[t]he information has to be 'about' something, or else it cannot help the organism in the competition for reproductive success. Information does not contain the key to its own interpretation. We need to add a theory of interpretation, and this is exactly what semiotics is about." (Hoffmeyer 2010: 368) Notice that the article does not argue for 'competition for reproductive success' but rather for 'satisfaction of physiological and/or relational needs'. Indeed, the topic at hand is to discover the connection between information and semiosis (semiotics), so as to allay any fears that we are talking about two different things and to show that information is the basis for the action of signs as a result of our infoautopoietic nature as living beings.

5.1. Interpretation

The previous sections show that the process of infoautopoiesis involves several instances that can be identified as an interpretation process. The most important instance of interpretation is that related to the self-creation of information from environmental noise. Environmental white noise does not entail the existence of information. Rather, the sensorial signals that are identified by the organism due to its physiological and/or relational needs allow the self-creation of semantic information as an interpretative response. The smallest unit of information is a single bit that can be equated to a sign that is defined as anything that stands for or represents something to someone. This is achieved through the repetitiveness and recursivity of the process of infoautopoiesis. For example, at the beginning of life, a human organism mainly relies on a reflexive existence to build up its capacity to associate signs with objects and their meaningful interpretation. As it gains proficiency, it loses its reflexive capacity and substitutes it with semiosis. However, we must never lose sight of the fact that sensorial signals are always what a human organism is able to detect, as information does not exist in the environment except

as a result of the actions of living beings, and the semiotic processes that have been learned. The result is that recognizable sensorial signals seem to be always reflective of signs or syntactic information that exists because of human actions. As the organism repetitively and recursively interacts with the environment, the complexity of the information as signs or composite bits of information makes for a more predictable world. We currently live surrounded by our artificial syntactic creations that we can easily recognize and use to build our world further. A limitation of our syntactic creations, irrespective of their sophistication, is their inability to produce semantic information, i.e. they are incapable of meaning-making (Cárdenas-García 2022, 2023a). In short, our ability to act in our external world relies on semiosis, because of our capacity for impacting our world through our syntactic information creations that we access through interpretation that yields semantic information.

5.2. Infoautopoietic Peircean triadic information

Although Hoffmeyer recognized the possibility that Bateson's 'information' had the capability of meaning-making, he also identified limitations, as per this passage:

> The annoying thing about Bateson's definition is that it cannot be used to quantify information. Information is associated with an intentional creature of some kind or another, whether it be an amoeba registering a difference in nourishment levels and reacting by extending a pseudopodium toward the spot where the pickings are richest, or a human being seeing a ripe fruit on a tree and stretching out a hand to pluck it. Or––to put it another way––information is based on interpretation and, in this sense, corresponds to signs as defined by Peirce. (Hoffmeyer 1996: 6)

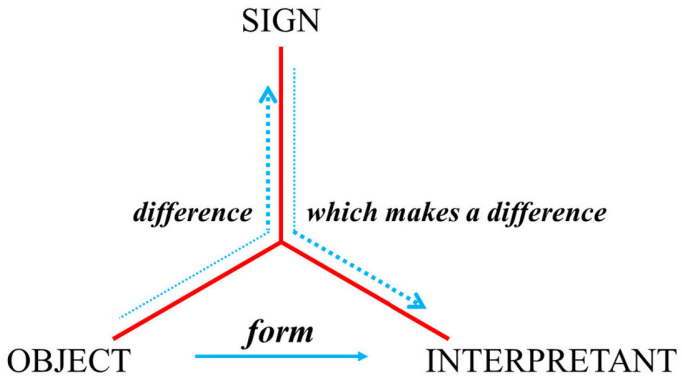

Figure 4. Triadicity of Peircean semiosis (adapted from El-Hani *et al.* 2008: 94).

While the intent in this work is to assert the fact that 'information is based on interpretation', we note that Bateson's 'information' is a relational concept that deals with relative quantification/qualification using commensurability when assessing 'a difference which makes a difference'. Clearly, it identifies the difference found in an unidentified Object, which becomes the Sign, which makes a difference to an Interpretant as depicted in Fig. 4. This shows that Bateson's 'information' identifies the Peircean triad without much difficulty. The identified 'information=difference=idea' can then be used in a hierarchical organization or layering/stratification of 'differences' to achieve any required level of sophistication. By this infoautopoietic approach we have achieved "a model of semiosis that operationally describes its features" (Kull 2023a: 60).

6. Conclusion

Biology has neglected meaning-making by living beings because of its scientific basis that ignores the subjectivity of organisms. Additionally, a syntactic approach to information has yielded but few results. Peircean semiosis has been proposed as a way to address meaning-making by living beings, where a triadic analysis of sign, object and interpretant seems to provide a way to tackle the meaning-making problem. Semiosis is defined as a process through which multiple signs are part of a chain in a meaning-making process. This approach does not resolve the issue of how signs come into being. It is also difficult to answer the question as to how semiosis applies to unicellular versus multicellular organisms.

Infoautopoiesis allows for meaning-making based on Bateson's concept of information as 'a difference which makes a difference'. Not only is it possible to create a simulation of a general organism-in-its-environment but to also define the roles of semantic and syntactic information. Semantic information is shown as internal to the organism and inaccessible to anyone else. Syntactic information, whose origin is semantic information, is externalized by the organism and requires interpretation by others. The myriad forms of syntactic information are all artificial creations that surround us in the artificial environment, of our own making, in which we live. One implication of syntactic information creation is that it does not have the capacity for creation of semantic information. Undoubtedly, infoautopoiesis provides an explanation of how information is relevant to meaning-making. This is something that Peircean semiosis is unable to achieve even though it is able to point the way. Infoautopoiesis is one more step in the direction of fully developing Jakob von Uexküll's vision for better understanding how meanings and information/signs impact the behaviour and perception of

animals. In short, information is enough not only to explain meaning-making, but also to provide a much-needed analysis of how to achieve meaning-making using semantic and syntactic information generation.

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La información es primaria y central para la creación de significado

Existe la idea errónea de que el concepto de información no es aplicable a la creación de significado en los seres vivos. Lo que se cree más generalmente es que la semiosis peirceana proporciona un marco más sólido para explicar la creación de significado. Esto implica la producción, el intercambio y la interpretación de signos como base del significado de un organismo. La semiosis establece una ocurrencia continua y en desarrollo de relaciones triádicas entre un representamen (un signo), un objeto (el otro) y un interpretante a medida que el organismo se involucra con su umwelt, lo que resulta en la aparición del significado como un factor en su vida. Sin embargo, no está claro que la semiosis peirceana sea el proceso más fundamental por el cual la creación de significado puede ser

instanciada en la naturaleza. Aquí mostramos que la información definida por Gregory Bateson como "una diferencia que hace una diferencia" puede servir más fundamentalmente como base para la creación de significado. Tanto sus orígenes etimológicos como el dictum de Bateson naturalizan el concepto de información para identificar su dinámica cibernética motivada por la ausencia constitutiva, o la capacidad de un organismo para encontrar en su entorno lo que teleológicamente considera faltante. Esto implica una capacidad para interpretar su entorno ambiental. Además, la detección de una diferencia es el más fundamental de los actos, ya que revela que la información es la base para la creación de significado para un organismo, lo que permite cualquier nivel de complejidad en sus capacidades interpretativas. De hecho, se muestra que la semiosis peirceana es un caso especial de creación de significado informático. En resumen, la información proporciona una base firme para la creación de significado para los seres vivos.

Informatsioon on tähendusloome jaoks esmane ja keskne

Valitseb ekslik arusaam, nagu ei saaks informatsiooni mõistet elusolendite tähendusloome puhul rakendada. Veelgi üldisem on uskumus, et tõhusamat raamistust tähendusloome seletamiseks pakub Peirce'ilik semioos. Sellesse kuulub märkide tootmine, vahetamine ning tõlgendamine kui tähenduse alus organismi jaoks. Semioosiga luuakse esitise (märgi), objekti (teise) ja tõlgendi vaheliste kolmetiste suhete kestev ning arenev esinemine organismi suhestumisel selle omailmaga, mille tulemuseks on tähenduse kui organismi elu mõjutava teguri teke. Ent pole siiski selge, kas Peirce'lik semioos on kõige fundamentaalsem protsess, mis esindab tähedusloomet looduses. Käesolevaga näitan, et informatsioon, mida Gregory Bateson defineerib kui "erinevust, mis teeb vahe sisse" võib osutuda veelgi fundamentaalsemaks tähendusloome aluseks. Nii selle etümoloogiline päritolu kui ka Batesoni sentents naturaliseerivad informatsiooni mõiste, tuvastades selle küberneetilise dünaamika, mida ajendab loov puudumine ehk organismi võime leida oma keskkonnast seda, mida peab teleoloogiliselt puudujäävaks. See viitab võimele tõlgendada ümbritsevat keskkonda. Veel enam, erinevuse kindlaks tegemine on ülimalt fundamentaalne akt, milles tuleb ilmsiks, et informatsioon on organismi tähendusloome aluseks, võimaldades igal tasemel keerukust selle tõlgendamissuutlikkuses. Tegelikult näidataksegi, et Peirce'ilik semioos on informatsioonilise tähendusloome erijuhtum. Lühidalt, informatsioon pakub kindlat lähtepinda elusolendite tähendusloomeks.