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Finding an information concept suited for a universal theory of information☆

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ABSTRACT

The view argued in this article is that if we want to define a universal concept of information covering subjective experiential and meaningful cognition - as well as intersubjective meaningful communication in nature, technology, society and life worlds - then the main problem is to decide, which epistemological, ontological and philosophy of science framework the concept of information should be based on and integrated in. All the ontological attempts to create objective concepts of information result in concepts that cannot encompass meaning and experience of embodied living and social systems. There is no conclusive evidence that the core of reality across nature, culture, life and mind is purely either mathematical, logical or of a computational nature. Therefore the core of the information concept should not only be based only on pure logical or mathematical rationality. We need to include interpretation, signification and meaning construction in our transdisciplinary framework for information as a basic aspect of reality alongside the physical, chemical and molecular biological. Dretske defines information as the content of new, true, meaningful, and understandable knowledge. According to this widely held definition information in a transdisciplinary theory cannot be 'objective', but has to be relativized in relation to the receiver's knowledge, as also proposed by Floridi. It is difficult to produce a quantitative statement independently of a qualitative analysis based on some sort of relation to the human condition as a semiotic animal. I therefore alternatively suggest to build information theories based on semiotics from the basic relations of embodied living systems meaningful cognition and communication. I agree with Peircean biosemiotics that all information must be part of real relational sign-processes manifesting as tokens.

1. Where to start the development of an information concept?

The view argued in the present paper is that if we want to define a universal concept of information covering subjective experiential and meaningful cognition - as well as intersubjective meaningful communication in nature, technology, society and life worlds - then the main problem is to decide, which epistemological and ontological framework a transdisciplinary concept of information should be based on. One of the main deep problems in defining a universal information concept is, that all the ontological attempts to create objective concepts of information such as Claude Shannon's (Shannon and Weaver, 1963/1948), Norbert Wiener's (Wiener, 1965/1948) cybernetics and John Archibald Wheeler's "it from bit" (Wheeler, 1994) results in concepts that cannot encompass meaning and experience of embodied living and social systems. But even Carnap realizes that the basic condition of all empirical science was the individual as well as cultural experience of researchers and that the psycho-physical problem is unsolved (Carnap, 1967:32–39).

Shannon (Shannon and Weaver, 1963/1948) and especially Wiener's (Wiener, 1965/1948) types of mathematical definitions of information related to mathematical or physical concepts of neg-entropy cannot adequately encompass the experiential embodied pragmatic semantic meaningful content of ordinary sign games of living systems and the language games of embodied conscious humans. I have in Brier (1996a, 1996b and 2008) criticized the information-processing paradigm and second-order cybernetics, including Niklas Luhmann's communication theory (Luhmann, 1995), for not being able to produce a

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foundational theory of signification and meaning as they lack a phenomenological first person view. It was not Shannon's intension, but his work has been used that way. I do not find convincing evidence that the core of reality across nature, culture, life and mind can be proven to be of a purely mathematical, logical or computational nature. It was never Shannon's intension of going further than the statistical-probabilistic technical aspect of human communication and he underlined that there was no concept of meaning connected to his theory. It is the work of Wiener and Schrödinger that makes the connection between the mathematical and the physical concepts of communication. Never the less there has not been much attention on the difference in Shannon and Wiener's definition of information as entropy and as neg-entropy. But it is the last definition that paves way at the transdisciplinary idea of information. The first move in this direction can be seen in Brillouin 1962 (first version 1956). Wiener (1965) pointed out that Information is information, neither matter nor energy! His theory of cybernetics connects statistical information with thermodynamically entropy and information thereby becomes negentropy (also used by Schrödinger (1944/2012)). Information as negentropy in the self-organizing systemic complexity paradigm becomes the organizing and sometimes creative aspect of nature. Prigogine (1980, 1996 and Prigogine and Stengers, 1984) developed this idea of self-organization through his theory of dissipative structures. In developed forms of general system theory the organizing power of neg-entropy is combined with the principle of emergence and is used as explaining how life and consciousness arose from matter through self-organization as a theoretical explanation how matter became alive through emergence. Bateson (1972, 1979) developed a non-technical and more wide-ranging concept of cybernetic information in a cognitive and an ecological direction based on Wiener's cybernetic view of information as negentropy. He defined information as “a difference that makes a difference” for a cybernetic mind. He attempted to link information and meaning in an ecological cybernetic mind. Here are the basic criteria for the cybernetic informational mind: 1. The system shall operate with and upon differences.2. The system shall consist of closed loops or networks of pathways along which differences and transforms of differences shall be transmitted. (What is transmitted on a neuron is not an impulse; it is news of a difference).3. Many events within the system shall be energized by the responding part rather than by impact from the triggering part.4. The system shall show selfcorrectiveness in the form of negative feedback in the direction of homeostasis and/or in the direction of runaway. Self-correctiveness (negative feedback) implies trial and error.

The strength in Bateson's work was that he developed a non-technical and attempted to link information and meaning in an ecological cybernetic mind-framework including the whole biosphere, as well as culture and social systems. Through a functionalistic concept of cybernetic mind, Bateson further develops the idea of the biosphere as the ultimate cybernetic mind and thus finding “the pattern that connects”. This view was later supported by James Lovelock's (Lovelock, 1972, 2000, 2009) vision of the whole biosphere as one self-regulation system, which he called Gaia after the classical Greek god for Earth and the great mother of all. But in this ultimate cybernetic vision of self-regulating systems, there is no theory of the role of experiential mind. Thus I do not find any of the approaches building on objective pan-computational or/and Pan-informational metaphysics or paradigms are able to explain and model human meaningful social communication and information exchange in nature and machines at the same time.

The dominating transdisciplinary theory of signification and communication in nature, humans, machines, and animals, is the information-processing paradigm of cognitive science (Gardner, 1985) used in computer informatics and psychology (Lindsay and Norman, 1977; Fodor, 2000) and in library and information science (Vickery and Vickery, 1987). It is also found integrated with system theory and cybernetics as well as a general renewal of the materialistic evolutionary worldview (e.g., Stonier, 1997) and as a pan-informational and pan-computational paradigm for al processes in nature, culture, society and technology (Se papers in Dodig-Crnkovic and Burgin (2010) and Davies et al. (2009)).

As Thomas Nagel (2012) I see no way of developing a theory, which can lead to a explanatory model encompassing the living, experiencing body and its consciousness' integration with communicational networks such as natural and artificial languages in humans (Brier, 2010) if we start in mathematics and physics in the form of the present idea of objective conception of information bits and thermodynamically defined energy. Therefore I find it unavoidable that we must start in a way that includes the “experiential life world” of Husserl and Merleau-Ponty.

The core of the information concept should not only be based on pure logical or mathematical theory and rationality concepts like game theory or probability theory or the Turing computation concept and various ways to define bits. Even Bateson's (1972 and 1979) definition of information as a difference that makes a difference for at cybernetic mind lacks a basic theory of experiential consciousness and emotions or what the phenomenologists call the “life world”. Thus I find C.S. Peirce (CP, EP, W)[1] attempts to broadening the view by working towards showing that *logic is semiotic* – meaning that formal logic is only one aspect of logic - very promising.

Thus logic and rationality is an aspect of the pragmatic semiotics of cognition and communication of all living being. I therefore find it necessary to add biosemiotics to transdisciplinarity if we want to encompass living nature as well as the machine and the human experiential mind a transdisciplinary theory of signification, cognition, and communication. Thus we need to be able to include perception, signification and meaning construction from the start on as a basic aspect of reality alongside the physical, biological and social. Semantics becomes important.

But a semantic probability information theory like Bar-Hillel and Carnap's (1953) and Bar-Hillel (1964) is not enough, because it imagines a formal language consisting of all sentences that might be true in a given possible universe (cf. Bar-Hillel, 1964: 224) as the basis for its probability models. This is problematic since Chomsky has pointed out that all natural languages have the intrinsic capacity to generate an infinite number of well-formed sentences and, that no natural language has a finite determinable number of sentences that could serve as a basis for determining all true sentences or any reliable kind of probability models.

Thus information in the theory I want to develop is not ‘objective’, but relativized in relation to the sender's as well as the receiver's knowledge. This makes it difficult to operationalize the idea of probability in reality if not on some kind of Bayesian foundation. This makes it difficult to produce a quantitative statement that is more reliable than a qualitative analysis based on some sort of relation to the human condition. We seem to have to combine both.

[1] I uphold the tradition of referring to Peirce's work with the abbreviation: **CP** for collected paper (see Peirce (1931–58). *Collected papers*. **EP** for *Essential Peirce* (see Houser and Kloesel (1992). *The Essential Peirce. Selected Philosophical Writings, Volume 1* (1867–1893) and Peirce Edition Project (1998). *The Essential Peirce. Selected, Philosophical Writings, Volume 2* (1893–1913)), **W** for Writings (see Peirce Edition Project (1982-2009) *Writings of Charles S. Peirce: A Chronological Edition* 1857–1892 Volume 1–8.

The alternative to start in mathematics and physics is to build information theories from the basic context of human meaningful communication. This is what Machlup's (1983) famous analysis of information promotes. Beginning from a traditional humanistic viewpoint, Machlup suggests that only people can send and receive information all other uses of the word information are metaphors no matter if we go up in the social realm of institutions or down into biology, chemistry, physics and computer science (Brier, 2013).

But then what about other living systems, are then not communicating? In *Knowledge and the Flow of Information* (Dretske, 1981) Dretske defines information as the content of new, true, meaningful, and understandable knowledge produced in cognition and communication. Gibberish and sentences uttered or written in a foreign language that we have not mastered fail to convey information; furthermore, telling a person something s/he knows already does not count either as real information in this theory, nor do false statements. An informative message for Dretske must convey new and comprehensive knowledge. But most of cognition and communication is not formed in natural language, but is embodied signs of which humans are not always conscious aware and animals never are. With the growing acceptance of living systems as sentient beings we need to include them in a general theory of information that has an experiential and interpretational aspect based on the living body and here semiotics seem to be the obvious theoretical choice.

2. Why add semiotic to information theory?

Semiotics (from the Greek word for sign) is the doctrine and science of signs and their use and interpretation. It is thus a more comprehensive system than language itself and can therefore be used to understand language in relation to other forms of communication and interpretation, such as nonverbal forms. One can trace the development of semiotics starting with its origins in the classical Greek period (from medical symptomatology), through subsequent developments during the Middle Ages (Deely, 2001), and up to John Locke's introduction of the term in the seventeenth century. But contemporary semiotics has its foundations in the nineteenth century with Charles Sanders Peirce (1839–1914) and Ferdinand de Saussure's (1857–1913) semiology. Then were working independently of each other, developed different conceptions of the sign. Where Saussure's semiology has been integrated in the development of linguistics and analysis of cultural products, including computers, the development of semiotics as a broad field that includes nonverbal as well as paralinguistic signs is nevertheless mostly based on Peirce's framework, which is therefore adopted here.

Semiotics is a transdisciplinary doctrine that studies how signs in general - including codes, media, and language, plus the sign systems used in parallel with language - work to produce interpretation and meaning in human and nonhuman living systems such as pre-linguistic communication systems. In the founding semiotic tradition of Peirce, a sign is anything that stands for something or somebody in some respect or context or to explain further, a sign is a medium of perception and communication of a form in a triadic (three-way) relation. The representamen (the phenomenon acting as sign vehicle) refers to its object, which determines it, and to its interpretant, which it determines, without being itself affected. The interpretant is the interpretation in the form of a more developed sign in the interpreting and receiving mind or quasi mind. The representamen could be, for example, a moving hand that refers to an object for an interpretant; the interpretation in a person's mind materializes as the more developed sign "waving," which is a cultural convention and therefore a symbol (Peirce, 1931-1958).[2] All kinds of alphabets are composed of signs. Signs are mostly imbedded in a sign system based on codes, after the manner of alphabets of natural and artificial languages or of ritualized animal behaviors, where fixed action patterns, such as feeding the young in gulls, take on a sign character when used in the mating game.

Ever since Eco (1976) formulated the problem of the "semiotic threshold" in trying to keep semiotics within the cultural sciences Peircean semiotics has developed further into the realm of biology, crossing threshold after threshold into the sciences. Although semiotics emerged in efforts to scientifically investigate how signs function in culture, the twentieth century witnessed efforts to extend semiotic theory into the non-cultural realm, primarily in relation to living systems and computers. Because Peirce's semiotics is the only one that deals systematically with non-intentional signs of the body and of nature at large, it has become the main source for semiotic theories of the similarities and differences among signs of inorganic nature, signs of living systems (biosemiotics; see Favareau (2010); Kull et al., 2009), signs of machines (especially computer semiotics; see Andersen (1997)), and the cultural and linguistic signs of humans living together in a society that emphasizes the search for information and knowledge (Brier, 2008). Resulting developments have then been deployed to change the scope of semiotics from strictly cultural communication to a biosemiotics that encompasses the cognition and communication of all living systems from the inside of cells to the entire biosphere, and a cybersemiotics that in addition includes a theory of information.

3. Biosemiotics and its controversies

Thomas A. Sebeok (1920–2001) extended semiotics to cover all animal species-specific communication systems and their signifying behaviors under the term zoösemiotics (Sebeok, 1965, 1972.). Later Sebeok concluded that zoösemiotics rests on a more comprehensive biosemiotics (Sebeok and Umiker-Sebeok, 1992). This global conception of semiotics equates life with sign interpretation and mediation, so that semiotics encompasses all living systems, including plants (Krampen, 1981), bacteria, and cells in the human body (called endosemiotics by Uexküll et al., 1993). Although biosemiotics has been pursued since the early 1960s, it remains controversial in much of the sciences as well as the humanities, because many linguistic and cultural semioticians see it as requiring an illegitimate broadening of the concept of code and sign from culture to nature, but they often forget the deep differences between the semiology of Saussure so fundamental to linguistics and Peircean transdisciplinary semiotics (Brier, 2014).

A code is a set of transformation rules that convert messages from one form of representation to another. Obvious examples can be found in Morse code and cryptography. Broadly speaking, code thus includes everything of a more systematic nature (rules) that source and receiver must know a priori about a sign for it to correlate processes and structures between two different areas.

[2] It is important to be aware of that Peirce's semiotic and pragmaticist paradigm of science is neither a monist or a dualist world view – and thus somewhat different from the received worldview of present science – but is a triadic, Synechist, Tychist and Agapist philosophy, which is built on phenomenology and mathematics and view logic as semiotic. See Houser and Kloesel (1992) and Peirce Edition Project (1998) or Brier (2008). Thus Peirce's sign is a triadic nearly unending semiotic process connected to a network of other types of ongoing semiosis (the semiotic web). All objects of perceptions are sign process and only some of those are things. Signs are as real as matter. See also Deely (2001), who declared Peirce to be the first true post-modern in that he broke with the Cartesian dualist tradition that dominated (and still dominates a lot of) modern philosophy, philosophy of science and much thinking in the sciences in the area of brain science and cognitive research.

This is because codes, in contrast to universal laws, work only in specific contexts, and interpretation is based on more or less conventional rules, whether cultural or (by extension) biological. Hoffmeyer and Claus Emmeche (1991) are known for suggesting that species could be understood as code-dual systems shifting between a digital and an analog code (genotype and phenotype). Hoffmeyer, who founded the Copenhagen school of biosemiotics, wrote some of the most important modern syntheses of biosemiotics (Hoffmeyer, 1996, 2008a).

DNA is an example of a biological code. In the protein production system, which includes the genome in a cell nucleus, the RNA molecules going in and out of the nucleus, and the ribosomes outside the nucleus membrane, triplet base pairs in the DNA have been translated to a messenger RNA molecule, which is then read by the ribosome as a code for amino acids to string together in a specific sequence to make a specific protein. The context is that all the parts have to be brought together in a proper space, temperature, and acidity combined with the right enzymes for the code to work. Therefore this only happens inside cells in a way that produces useful three-dimensional protein forms.

An important difference between living and technical systems (such as the computer) is that only living systems develop their own code-based signs. Internally, there is no semiosis in a computer that is not put there intentionally by humans. Sebeok writes of the genetic code, as well as metabolic, neural, and verbal codes. Living systems are self-organized not only on the basis of natural laws but also using codes developed in the course of evolution. In an overall code, there may also exist sub-codes grouped in a hierarchy. To view something as encoded is to interpret it as sign-ment (Sebeok 1992).

I agree with biosemiotics (Kull et al., 2009; Hoffmeyer, 1996, 2008a, b; Favareau, 2010) that signs are real relational processes manifesting as tokens connecting all living beings with each other and with the environment. The meaning of a percept entering through our senses is the result of our interaction with what seems exterior to consciousness. According to Peirce's semiotics the process of the percept is a pure 'Second': a clash between two different phenomena; thirdness in perception emerges with the construction of a cognition, which is the intellect's fallible account of generating meaning from percepts through a generalization operated upon a series of percepts and concepts through a combination of induction and abduction. The perceptual judgment constitutes an irresistible hypothesis for consciousness to – from one or more emotions – make sense through interpretation.

A symbol is a conventionally and arbitrarily defined sign, usually seen as created in language and culture. In common languages, it can be a word, but gestures, objects such as flags and presidents, and specific events such as a soccer match can be symbols (for example, of national pride). Some biosemioticians claim that the concept of symbol extends beyond cultures, because some animals have signs that are “shifters.” That is, the meaning of these signs changes with situations; for instance, the head tossing of the herring gull occurs both as a precoitally display and when the female is begging for food. Such a transdisciplinary broadening of the concept of a symbol is a challenge for linguists and semioticians working only with human language and culture.

To see how this challenge can be developed consider seven different examples of signs such as that a sign stands for something for somebody:

1. as the word black stands for a certain range of color, but also has come to stand for an emotional state;
2. as the flag stands for the nation;
3. as a reddening of face and neck un-intentionally can indicate nervousness;
4. as red spots on the skin can be a symptom for German measles;
5. as the wagging of a dog's tail can be a sign of friendliness for both dogs and humans;
6. as pheromones can signal heat to the other gender of the species;
7. as the hormone oxytocin from the pituitary can cause cells in lactating glands of the breast to release the milk.

Linguistic and cultural semioticians in the tradition of Saussure would usually not accept examples 3 to 7as genuine signs, because they are not self-consciously intentional human acts. But those working in the tradition of Peirce also accept non-conscious unintentional signs in humans (3) and between animals (5 and 6), as well as between animals and humans (5), non-intentional signs (4), and signs between organs and cells in the body (7 Oxytocin has many other communicative functions in the body, so this function is situation specific.

On this basis biosemiotics allows a concept of an “immunological self” and names the combined coding between the immune, the nervous, and the hormone systems as the “biological self”. There has been a well-known debate about the concepts of primary and secondary modeling systems (see, for example, Sebeok and Danesi, 2000) in linguistics, which has now been changed by biosemiotics. Originally, language was seen as the primary modeling system, whereas culture comprised a secondary one. But through biosemiotics, Sebeok has argued that there exists a zoösemiotic system of cognition, which has to be called primary modeling system, because it is the foundation of human language. From this perspective, language becomes secondary and culture tertiary.

4. Cybersemiotics

Life can be understood from a chemical point of view as an autocatalytic, autonomous, autopoietic system, but this does not explain how the individual biological self and awareness appear in the nervous system and is able communicate meaningful. In the living system, hormones and transmitters do not function only on a physical causal basis. Not even the chemical pattern fitting formal causation is enough to explain how sign-molecules function, because their effect is temporally and individual life-historically contextualized.

Sign molecules function also on a basis of final causation to support the survival of the self-organized biological self. As Sebeok (1992) points out, the mutual endosemiotic coding of sign molecules from the nervous, hormone, and immune systems is an important part of the self-organizing of a biological self, which again is in constant recursive interaction with its perceived environment, Umwelt (Uexküll et al., 1993). This produces a view of nerve cell communication based on a Peircean worldview, combining the physical efficient causation described through the concept of energy with the chemical formal causation described through the concept of information, with the final causations in biological systems being described through the concept of semiosis (Brier, 2003).[3] The various receptor ports on

[3] Peirce writes about his development of the concept of final causation after Aristotle in his semiotics paradigm. *It is, as I was saying, a widespread error to think that a “final cause” is necessarily a purpose. A purpose is merely that form of final cause which is most familiar to our experience. The signification of the phrase “final cause” must be determined by its use in the statement of Aristotle that all causation divides into two grand branches, the efficient, or forceful; and the ideal, or final. If we are to conserve the truth of that statement, we must understand by final causation that mode of bringing facts about according to which a general description of result is made to come about, quite irrespective of any compulsion for it to come about in this or that particular way; although the means may be adapted to the end. The general result may be brought about at one time in one way, and at another time in another way. Final causation does not determine in what particular way it is to be brought about, but only that the result shall have a certain general character.* (CP 1.211).

the surface of cell in different tissues are actively interacting with the semiotic molecules. We are not taking about a passive mechanism.

From a cybersemiotic perspective combining a cybernetic informational perspective with a semiotic one, the bit (or basic difference) of information science becomes a sign only when it makes a difference for someone. Thus Gregory Bateson (1904–1980) is seen as a precursor for second-order cybernetics (Bateson, 1972, 1979, 2002), as well as for biosemiotics (Hoffmeyer, 2008b). For Peirce, a sign is something standing for something else for someone in a context.

Information bits are at most pre- or quasi-signs, and, insofar as they are involved with codes, they function only like keys in a lock. Information bits in a computer do not depend for their functioning on living systems with final causation to interpret them. They function simply on the basis of formal causation, as interactions dependent on differences and patterns. But, when people see information bits as encoding for language in a word-processing program, then the bits become signs for them.

Peirce's pragmaticist semiotics (Peirce, 1931-58) therefore seems to be a good place to start looking for a modern transdisciplinary framework for information, cognition and communication sciences, as it has its foundation in a combination of a phenomenological and pure mathematics (Ransdell, 1989; Parker, 1989)! Peirce writes that:

> *Phenomenology, which does not depend on any other positive science, nevertheless must, if it is to be probably grounded, be made to depend upon the Conditional or Hypothetical science of Pure Mathematics, whose only aim is to discover not how things are but how they might be supposed to be,if not on our universe, then in some other. A Phenomenology which does not reckon with pure mathematics, a science hardly come to years of discretion when Hegel wrote, will be the same pitiful club-footed affair that Hegel produced.*
>
> (CP 5. 40).

Thomsen defines phenomenology broadly as 'any systematic project of investigating and describing experience' (Thomsen, 2007, 474) and point to the deep connection the deep continuity of life and mind just as continuity is a central theme for Peirce. According to Peirce, 'Phenomenology ascertains and studies the kinds of elements universally present in the phenomenon; meaning by the phenomenon, whatever is present at any time to the mind in any way' (CP 2.186). It is Peirce's view that Logic requires that any valid study of the whole cosmic process must be thus grounded in phenomenology, and not in any special science such as physics. But logic also draws upon mathematics. How important phenomenology is to the foundation of Peirce's semiotic and philosophical paradigm can be seen from this quote from CP:

Philosophy is divided into a. Phenomenology; b. Normative Science; c. Metaphysics.

> Phenomenology ascertains and studies the kinds of elements universally present in the phenomenon; meaning by the phenomenon, whatever is present at any time to the mind in any way. Normative science distinguishes what ought to be from what ought not to be, and makes many other divisions and arrangements subservient to its primary dualistic distinction. Metaphysics seeks to give an account of the universe of mind and matter. Normative science rests largely on phenomenology and on mathematics; metaphysics on phenomenology and on normative science.
>
> (CP 5.186).[4]

We see that Peirce does not start with objective quantifiable facts collected by statistical models to create patterns or mathematical models for us to unravel cognition and communication. No, he starts in phenomenology, pure mathematics, ethics aesthetics and logic as foundation for any perception of meaning. He writes:

> *This science of Phenomenology, then, must be taken as the basis upon which normative science is to be erected, and accordingly must claim our first attention.*
>
> *This science of Phenomenology is in my view the most primal of all the positive sciences. That is, it is not based, as to its principles, upon any other positive science. By a positive science I mean an inquiry which seeks for positive knowledge; that is, for such knowledge as may conveniently be expressed in a categorical proposition. Logic and the other normative sciences, although they ask, not what is but what ought to be, nevertheless are positive sciences since it is by asserting positive, categorical truth that they are able to show that what they call good really is so; and the right reason, right effort, and right being, of which they treat, derive that character from positive categorical fact.*
>
> (CP 5.39.).

This view is further combined with a process realistic view based on a triadic categorical philosophy attempting to use mathematics as the foundations for its metaphysics, but in a time-irreversible non-deterministic metaphysics, where he has spontaneity and continuity between mind and matter (synechism) as a basic ontological assumption. Peirce suggest that man can be seen as a symbol growing and the world as a big argument and what connects those two and all living being to each other (Bateson's "pattern that connects") is the process of sign-(in)formation. Thus information is attached to signification and sign communication.

Emotions are basic unites of experiential reality (intuitions) and does not carry meaning in themselves as such. "Meaning" must somehow be constructed by the receiver from the information gathered by the interpretation of signs, within certain frames that reality imposes on us for survival and procreation (the situation).

With Peirce I suggest measuring the amount of information that symbols acquire through their individual and cultural history of use; or what Peirce calls the "growth of symbols". This can be seen as a semiotic interpretation and development of Gregory Bateson's cybernetic definition of information as a difference that makes a

[4] Further explanations in CP 1. 120. *If this be so, and if the scheme of classification of the sciences that has been proposed be correct, it will follow that there are but five theoretical sciences which do not more or less depend upon the science of logic. One of these five is Logic itself, which must contrive, by hook or by crook, to work out its own salvation without a full pre-acquaintance with its own discoveries, but which, like any other science, will lay one stone upon another in the erection of its doctrine. This is the last of the five. The first is Mathematics. Mathematics may itself be regarded as an art of reasoning. Perhaps this is not the highest conception of it. But at any rate, mathematics has no occasion to inquire into the theory of the validity of its own argumentations; for these are more evident than any such theory could be. The second of the five is that department of philosophy called Phenomenology, whose business it is simply to draw up an inventory of appearances without going into any investigation of their truth. The third is Esthetics, if I am to take the word of others that there is such a science, I myself being lamentably ignorant of it, as I fear will too plainly appear. The fourth is Ethics; certainly, one of the very subtlest of studies. The whole course of it seems to consist in painfully extricating oneself from one pitfall only straightway to fall into another. It might seem that logic was desirable in this deliberation; but I fear that logic, as a definite theory, can be of no avail until one knows what it is that one is trying to do, which is precisely what ethics has to determine. On the contrary, that has to be settled before one can form any sound system of logic, as we shall see in due time.*

difference and Niklas Luhmann's triple autopoietic theory of social-communication systems, which he attempt to connect to Husserl's phenomenology (Luhmann, 1995). Thus Peirce adds a phenomenological grounding to these cybernetic views that have no theoretical concept for the experiential world that Husserl for instance was trying to model.

Thus I do find the requirements of meaningfulness and truthfulness for semantic information proposed by Floridi (2011) highly necessary, but will add with Piece that also deceptive statements need to have some aspect of truth in them and with biosemiotic I want to enlarge its scope to all living systems.

To sum up then semiosis is an informational process and since mechanical interactions - as they are defined in classical physics - are driven only by kinetic force, rather than information, they are theoretically understood as non-semiotic. It means that we need to integrate information in semiosis as well as matter/energy if we want a universal concept of information (Brier, 2008, 2011, Davies et al., 2009). We thus have to embrace what C.S. Peirce (1994) called cenoscopic science or, to use Cantwell Smith's (1998) modern phrase, *intentional sciences* (further discussed in Brier (2010)). This means that we need to integratively reflect our phenomenological point of departure for knowledge-creation in the sciences. If our transdisciplinary efforts do not do so, but base themselves on physicalism or informationalism, it is going to be difficult to make any real progress in the understanding of the relation between human consciousness, nature, computation, and cultural meaning simply because no theory of consciousness of qualities and meaning can be built from that foundation (Brier, 2012). In the famous book *Chance and Necessity* (1971), Jacques Monod highlighted the apparent epistemological contradiction between the teleonomy of living organisms and the principle of objectivity in science based on the ontological assumption of the natural sciences that there are no intentions or meaning in inanimate nature. Consciousness is not only a product of culture but also a product of the natural evolution of living bodies. Furthermore, we should not view culture as part of a reality outside nature (dualism), but as a special developed part of nature in a broadened naturalism (Brier, 2012; Fink, 2006). I agree with Bateson (1972) and Maturana (1988a, 1988b) that we must commence our understanding of information with the process of knowing. Bateson's definition of information as a difference that makes a difference is very fruitful but a phenomenological foundation has to be developed. His theoretical problem is that he makes nearly every cybernetic system a communicator and a knower, be it a homeostatic machine, an organism, or an ecosystem or organization. But the big difference between computers and humans is this embodied field of meaning in which human communication operates. Computers can only provide pragmatic meaning within a system like chess, for instance, if that meaning is modeled in the computer's own memory. This is why the type of un-personalized, un-embodied logical and mathematical reasoning that has been the foundation of the mechanical paradigm of classical science cannot be the sole support of a transdisciplinary foundation for rationality. The paradox is that the sciences think this domain of conscious sense experiences, meaning, and rationality emerges later in evolution than energy, matter, and information, but we have also shown that it is the prerequisite for the intersubjective knowing process from which the whole idea of science springs. Peirce writes:

> … phenomenology, that is, just the analysis of what kind of constituents there are in our thoughts and lives, (whether these be valid or invalid being quite aside from the question). It is a branch of philosophy I am most deeply interested in and which I have worked upon almost as much as I have upon logic. It has nothing to do with psychology.… it shows so clearly that phenomenology is one science and psychology a very different one … Phenomenology has no right to appeal to logic, except to deductive logic. On the contrary, logic must be founded on phenomenology. Psychology, you may say, observes the same facts as phenomenology does. No. It does not observe the same facts. It looks upon the same world; – the same world that the astronomer looks at. But what it observes in that world is different. Psychology of all sciences stands most in need of the discoveries of the logician, which he makes by the aid of the phenomenologist. I am not sure that it will do to call this science phenomenology owing to Hegel's Phänomenologie being somewhat different. But I am not sure that Hegel ought not to have it named after his attempt.
>
> (CP 8. 295-98).

Like the Danish philosopher Fink (2006), I object to the use of the term "nature" to mean only what the physic-chemical sciences can describe. What we can measure intersubjectively is a part of the reality we call nature. Thus the meaning of a sign, a word, or a sentence has some kind of existence more or less independent of the individual human being. The natural sciences see humans primarily as connected to all other entities and processes in the world by being made of the same "stuff". But inspired by Aristotle Peirce also claims that *forms* exists as well as tendencies or "would-bes". He writes:

> *For the purpose of this inquiry a Sign may be defined as a Medium for the communication of a Form. It is not logically necessary that anything possessing consciousness, that is, feeling of the peculiar common quality of all our feeling, should be concerned. But it is necessary that there should be two, if not three, quasi-minds, meaning things capable of varied determination as to forms of the kind communicated. As a medium, the Sign is essentially in a triadic relation, to its Object which determines it, and to its Interpretant which it determines. In its relation to the Object, the Sign is passive; that is to say, its correspondence to the Object is brought about by an effect upon the Sign, the Object remaining unaffected. On the other hand, in its relation to the Interpretant the Sign is active, determining the Interpretant without being itself thereby affected. But at this point certain distinctions are called for. That which is communicated from the Object through the Sign to the Interpretant is a Form. It is not a singular thing; for if a singular thing were first in the Object and afterward in the Interpretant outside the Object, it must thereby cease to be in the Object. The Form that is communicated does not necessarily cease to be in one thing when it comes to be in a different thing, because its being is a being of the predicate. The Being of a Form consists in the truth of a conditional proposition. Under given circumstances, something would be true. The Form is in the Object, entitatively we may say, meaning that that conditional relation, or following of consequent upon reason, which constitutes the Form, is literally true of the Object.*
>
> (EP2, p. 544, endnote 22).

It means that the sign we perceive are only tokens and they are a product of types or forms, which are thirds, as they provide all the regularity in the world and in our mind. But they are not transcendental eternal idea like Plato's, and not forms in the things as Aristotle suggested, but evolutionary forms developing through evolution of the world and out knowledge.

With Peirce I see no reason to assume that physics has a special privilege to explain what this universal "stuff" is. Rather I agree with biosemiotics (Kull et al., 2009) that signs are real relational

processes, which connect all living beings with each other and with the environment. With Peirce, I prefer the concept of hylé to characterize the basic "stuff" the world is made of as it – in contrast to the modern physical concept of matter – does not carry the indication of matter being completely inert and dead. This concept was fundamental to Aristotle's philosophy but has been moved, in Peirce's semiotic philosophy, into an evolutionary process-oriented paradigm and further developed along semiotic lines. Peirce writes:

> "Uniformities in the modes of action of things have come about by their taking habits. At present, the course of events is approximately determined by law. In the past that approximation was less perfect; in the future it will be more perfect. The tendency to obey laws has always been and always will be growing. We look back toward a point in the infinitely distant past when there was no law but mere indeterminacy; we look forward to a point in the infinitely distant future when there will be no indeterminacy or chance but a complete reign of law. But at any assignable date in the past, however early, there was already some tendency toward uniformity; and at any assignable date in the future there will be some slight aberrancy from law. Moreover, all things have a tendency to take habits. For atoms and their parts, molecules and groups of molecules, and in short every conceivable real object, there is a greater probability of acting as on a former like occasion than otherwise. This tendency itself constitutes a regularity, and is continually on the increase. In looking back into the past we are looking toward periods when it was a less and less decided tendency. But its own essential nature is to grow. It is a generalizing tendency; it causes actions in the future to follow some generalization of past actions; and this tendency is itself something capable of similar generalizations; and thus, it is self-generative."
>
> (Peirce, CP 1.409).

As a consequence of the widely shared perspective that human beings are embodied, feeling, knowing, and culturally formed beings participating in semiosis and language processes, our analysis so far points to the fact that they can be seen as living simultaneously in at least basic four different worlds. One way to describe and classify these worlds – as much as possible in accordance with the currently present received view of the many sciences mentioned – is:

1. The physico-chemical part of the natural world that also constitutes the pure material-energetic aspect of our body.
2. Our embodiedness as the source of life, which we share with other living species. It is a product of ecology and evolution; but also formed by cultural practices.
3. Our world of feeling, will, drives, affects, and thoughts, manifested as mind, consciousness, and self-consciousness. We think it is partly produced by our embodied nervous system and formed by culture most strongly through our childhood. We do not so far have managed to reduce this experiential world to brain physiology. The felt self is not the same as the physiological model we call "our brain"(Mcginn, 2000; Brier, 2013b).
4. The cultural world of language, meaning, power, and technology, such as the informational machines we call computers. Language, pragmatically viewed, connects our perception with our thinking, communication, and acting in the social world.

Each of the four worlds has historically developed its own type of narrative, with its own fundamentalist and reductionist versions vitiating the project of transdisciplinarity. Physicists and chemists tend to view the universe as consisting of matter, forces, and energy. Mechanistically oriented biologists extend this view into their subject area. But non-mechanistically oriented biologists tend to perceive living systems as the basic organizers of reality, possessing self-organizing, self-protecting, self-promoting, and reflective properties as well as perception, instincts, and communication that physics and chemistry cannot (yet?) explain. This view of life as a foundational quality is why I insist that the natural and the life sciences are not the same.

The social and cultural sciences, especially dialectical and historic materialistic perspectives, as well as the radical social constructivist ones, tend to see the world as constructed from social, human, and linguistic interpretations, unless they are dualistic, accepting that nature is just as science describes it (Brier, 2008). Thus, energy-matter-information, life, consciousness, and meaning become separated in different domains or worlds. But this is in conflict with our everyday life world experience. Here they are not in any way absolutely separated. Thus we lack a transdisciplinary wissenschaftliches[5] explanation of how they are integrated. The Cybersemiotic star in Fig. 1 is such a suggestion.

One of the reasons for the separatist tendencies of the received views of natural and social science as well as the humanities may be that the traditions of science and the humanities were established before the theory of evolution became broadly recognized. Thus, the incompatibility of these four dominant views in the Western world's systematization of knowledge is a deep paradox in the modern worldview's attempt to build a "unified narrative" of the world. This is especially the case since it has been broadly accepted in all four worlds that the 'unity of science' idea of the logical positivists failed because it was predicated on the excessively narrow epistemological foundation of verificationism. Karl Popper's critical analysis (Popper 1976) and argumentation for a falsificationist view of scientific knowledge has been accepted as a turning point in the break with the positivist unity of science, but not as providing any final solution to the problem.

Thomas Kuhn's (1970) work on paradigms and their incommensurability has been generally accepted by philosophers of science and many scientists, changing the revolutionary monoparadigmatic view based on the history of the natural sciences into an acceptance of parallel co-existing paradigms especially in the realm of the social sciences and humanities. I have extended this view to include the social and the life sciences here in order to put all forms of Wissenschaft on an equal standing, because I find it true in an absolute naturalism and a necessary prerequisite for establishing a non-reductionist transdisciplinary view. The Cybersemiotic view thus organizes the sciences and humanities different from anything that has been done before through Peirce semiotic philosophy in a combination with Luhmann's system theory (Brier, 2013a,b,c,d). My suggestion for finding a transdisciplinary commensurable framework for all Wissenschaft is to start in the middle, with our daily lived semiotic, social, and linguistic practice. This is very much the core of Peirce pragmaticism. Near the end of 1896 Peirce accepted "the possible or would bes" as real, because when we say that a knife is sharp, we do not only mean now; we also mean that it would be sharp tomorrow if we tried to cut with it. Peirce thereby rejected the nominalist view that the possible is merely what we do not know not to be true. This acceptance of real possibilities puts Peirce in the Aristotelian wing of the realist camp as a three-category realist, no longer regarding the potential as what the actual makes it to be, and now distinguishing the generality of firsts from the generality of thirds. So, as late as1905

[5] As the concept of science tends to be interpreted as natural or quantitative sciences I prefer the German word Wissenschaft as it – like the Danish videnskab – encompasses the social, the technical and the life sciences and the humanities as well.

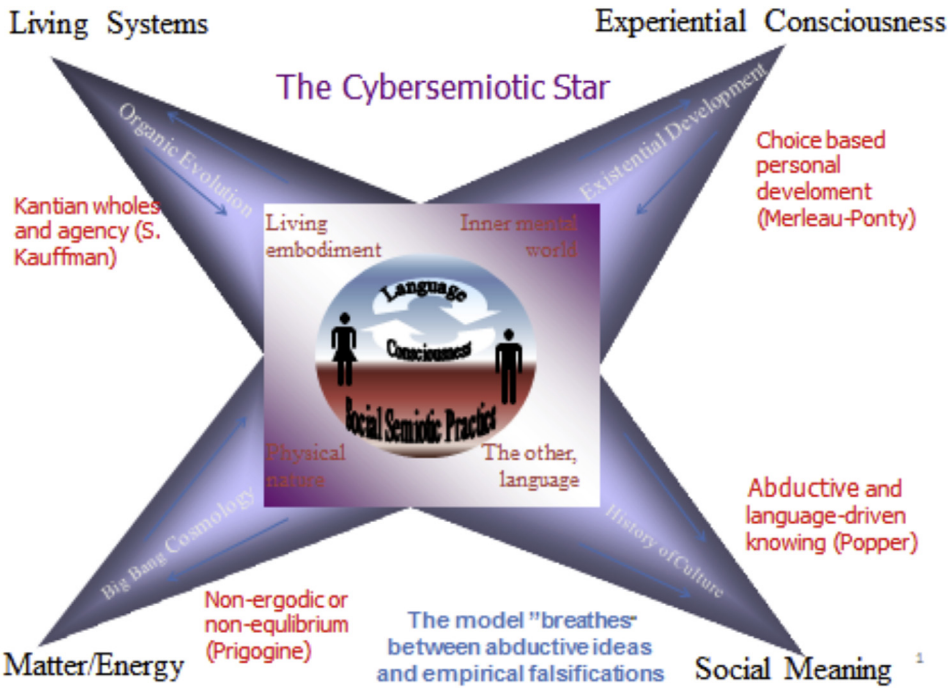

Fig. 1. The Cybersemiotic star: A model of how the communicative social system of the embodied mind produces four main areas of knowledge that can also understood to be prerequisites for interpersonal observation and knowing. Physical nature is usually explained as originating in energy and matter, living systems as emerging from the development of semiotic life processes (for the production of special proteins from DNA in the first cell). They differ from non-living system by being what Kauffman (2012) calls "Kantian wholes". Social culture is explained as founded on the development of new meaning and knowledge in language and practical habits; which is why the history of cultures and societies is not predictable. Finally, there is our experiential world, which in phenomenology is explained as deriving from the development of our individual life world and self-consciousness. All these types of knowledge, which are often considered incommensurable, are seen as having their origin in our primary semiotic intersubjective life world processing of observing and interpreting within social communication and action of which language is a part. The arrows in the arms signifies that interpretation of the worlds are produced intersubjectively and empirical put to falsification test and those, which fails goes back into socio-communications semiotic net and get revised and thereafter tested again in an ever ongoing process of developing of knowledge and skills. Thus the model "breathes" and develops (Developed from Brier (2008)).

Peirce integrated semiotics and pragmatism in the realist view that the communicative and semiotic mind, in combination with a concept of information is that which binds all four worlds together. This semiotic view integrates the sciences' view of reality as well as the cybernetic, informational and systems views of reality into a single model in an attempt to avoid the inner inconsistencies described earlier. Cybersemiotics is built on the idea of Peircean evolutionary, pragmaticist semiotics as well as his phaneroscopy,[6] his three basic categories, his sign typology, and his synechism, tychism, and agapism. What he proposes is a science of phenomenology taken as the basis upon which normative science is to be erected (CP 5.39). At the heart of the Peircean phenomenology is his system of three basic categories; which are basic to understand Peirce's concept of normative science and his theory of signs. Peirce writes:

> *The List of categories…is a table of conceptions drawn from the logical analysis of thought and regarded as applicable to being. This description applies not merely to the list published by me…but also to the categories of Aristotle and to those of Kant*
>
> (CP 1.300).

As it is well-known then Aristotle listed ten categories and Kant twelve as minimum for establishing reliable cognition. Peirce reduces this to three basic simple categories and therefore calls them, *first, second,* and *third,* or *firstness, secondness,* and *thirdness.*

They are defined from a phenomenological stance, so Firstness is, among other things, the category of feeling, but also spontaneity. By this basic term Peirce means an instance of that kind of consciousness, which involves no analysis, comparison as it does not consists in whole or in part of any act by which one stretch of consciousness is distinguished from another. Thus it has its own positive quality: "… A feeling, then, is not an event, a happening, a coming to pass, … a feeling is a state, which is in its entirety in every moment of time as long as it endures" (CP1.306). Firstness, as the category of feeling in this sense, is the category of the pre-reflexive. Getting completely absorbed in the enjoyment of a piece of music, so much that you are forgetting anything else (including reflecting) at the same time, is close to experiencing one or more firsts. When reflection does occur we enter the realm of Secondness, as there is now a difference between me and the experience. This is the category of the actual existent and the category of the other recognized as other. Secondness it is like the knock on the door, the no of another person (free will), the cut of a knife in the finger, the bruising of you toe on something you did not see and the unexpected car collision. It is an object to a subject. Seconds are unique existences, unique in space and time like each grain of sand on a beach or, specific observations as recorded in a laboratory (data) are seconds. The brute thereness might lead us to think of Secondness as the category of the "most real." But it is crucial to understand Peirce that he considers this to be an inadequate analysis. Reality, he held, is more than a matter of discrete events occurring at given points in space-time. It is also a matter of the more or less stable relations between events. Thirdness is the category of relatedness, of law and regularity, of habit, of continuity that binds thinks together for instance the Symphony structure that makes an overall pattern to the music we listened to,

[6] Peirce's name for his brand of phenomenology.

where the single notes and sound are Secondness. It is the thirdness of the cords and harmonies that bind them together on one level and the melody line on another.

The central dynamics in Fig. 1 binding the Cybersemiotic star's arms together is that all thought uses signs as vehicles and all objects of experience are comprised of signs. This constitutes the foundation of a unified theory of signs and sciences among the foundations of which we include phenomenology. Like Luhmann and Peirce, I cannot see how we can avoid it when we ask from what or where come the ability of the observer to produce knowledge and furthermore to reflect consciously on how knowledge is produced in language.

5. Peirce's transdisciplinary semiotically based information theory

Peirce holds that signs grow in information through the development of their interpretants (CP 3.608, 1908). This binds up information with the interpretations of signs as an ongoing personal and social process. Human communication - which occupies the central position in our model in Fig. 1 – involves a very complex interpretation by the "receiver". A percept enters through our senses and clashes with our mind. A percept is the result of our interaction with what seems exterior to consciousness. Regarding percepts, Peirce writes:

> *The direct percept […] has no generality; […] it appears under a physical guise […] it does not appear as psychical. The psychical, then, is not contained in the percept.*
>
> (Peirce CP 1.253).

According to Peirce's three categories the process of the percept semantic probability informationis a pure 'Second': a clash between two different phenomena. Thus, it includes Firstness, but not Thirdness, as there is no interpretation of any kind of regularity or meaning yet. Thus, to Peirce, Thirdness in perception emerges with the construction of perceptual fact or the interpretative function in cognition, which is the intellect's fallible production of meaning through a generalization operated upon the percept and most often based on experience of a series of percepts and concepts. This knowledge process of making sense of the immediate perceptual situation beyond logical deduction is what Peirce calls abduction. This perceptual judgment constitutes an irresistible hypothesis for consciousness with regards to making sense through interpretation, a bit in the same way as we make gestalts. According to Peirce percepts are not, in themselves, objects of experience. Though the percept makes knowledge possible, it offers no information, as it does not contain any Thirdness in its immediateness, but is Secondness in it physical clash with the perceptual organ. But experience, understood as the knowing process imposed upon us in the course of living, is "perfused" with Thirdness. Thirdness takes the form of generality and continuity within a fallible account of percepts. "Meaning" must somehow be constructed by the receiver from the information produced by the interpretation of signs, within certain frames that reality imposes on us for survival. Peirce writes:

> *At any moment, we are in possession of certain information, that is, of cognitions which have been logically derived by induction and hypothesis*[7] *from previous cognitions which are less general, less distinct, and of which we have a less lively consciousness.*
>
> (Peirce CP 5.311).

Thus Peirce develops an information theory that starts with a physical event hitting the perceptual organs – i.e., Secondness – but he does not construct a probability-based theory of information as Shannon or Wiener do.

Instead, Peirce develops a theory based on *the logical quantities of extension and intension associated with the concept of symbol* that is so vital for his semiotics. Thus Peirce defines his concept of information directly from his semiotics and its most important species of sign, namely, the symbol. From this basis, he introduces a new way of calculating the value of information conveyed by new propositions as a logical area composed of the informational breadth and depth of the symbol. He writes:

> *In a paper … I endeavored to show that the three conceptions of reference to a ground, reference to a correlate, and references to an interpretant, are those of which logic must principally make use. I there also introduced the term "symbol," to include both concept and word. Logic treats of the reference of symbols in general to their objects. A symbol, in its reference to its object, has a triple reference: First, Its direct reference to its object, or the real things which it represents; Second, Its reference to its ground through its object, or the common characters of those objects; Third, Its reference to its interpretant through its object, or all the facts known about its object. What are thus referred to, so far as they are known, are: First, The informed breadth of the symbol; Second, The informed depth of the symbol; Third, The sum of synthetical propositions in which the symbol is subject or predicate, or the information concerning the symbol. By breadth and depth, without an adjective, I shall hereafter mean the informed breadth and depth. It is plain that the breadth and depth of a symbol, so far as they are not essential, measure the information concerning it, that is, the synthetical propositions of which it is subject or predicate. This follows directly from the definitions of breadth, depth, and information. … we term the information the area, and write – Breadth X Depth = Area."*
>
> (CP 2.418–419, 1868).

Thus symbols have extension, since they denote classes of objects, and intension, as the objects they denote must have certain characters in common. Peirce furthermore suggests measuring the amount of information that symbols acquire through their individual and cultural history of use. This idea is connected to what Peirce calls the "growth of symbols" (Nöeth, 2012). The meaning of a symbol grows and develops through the years it is used in a culture. This growth is also augmented by the combination of terms in propositions as they then interact and change each other's meaning. "No proposition is supposed to leave its terms as it finds them. ...; and there are three objects of symbols the connotative, denotative, informative; it follows that there will be three kinds of propositions, …" says Peirce (W1:277). When an adjective precedes a noun, the logical content of the noun is modified by the adjective. If the noun, "information" is modified by the adjective "physical", then the logical content of the abstract concept of information is modified by what the author understands the term "physical" to mean. Thus, propositions are a further source of the growth of symbols and, in the sciences, synthetic propositions are a source of the acquisition of new knowledge.

Although Peirce's information theory is built on meaningful signs, he still has a realistic information theory. One needs to have empirical reference in order to produce real information. Peirce writes:

[7] Hypothesis is the early term for what he later called abduction.

If there be anything that conveys information and yet has absolutely no relation nor reference to anything with which the person to whom it conveys the information has, when he comprehends that information, the slightest acquaintance, direct or indirect—and a very strange sort of information that would be—the vehicle of that sort of information is not, in this volume, called a Sign

(CP 2.231, 1910).

In other words, analytical statements lack informativity.

The more synthetic a proposition is (i.e., the greater the empirical reference that it has), the more informative it is. Quantity is a measure of the extension of a symbol. It refers to the fact that different symbols "may denote more or fewer possible things; in this regard they are said to have extension." (W1: 187). Thus, the extension of the symbol fish is larger than the one of shark since fish is applicable to more animals than Shark. Quality, on the other hand, is dependent on the intension of a symbol, which is the number of characters attributed to a term. That is a logical quantity. This is a quantity very different from the probability theory underlying Shannon's and Wiener's objective information theories. In this sense, informational implication takes into account all available knowledge and not only the defining characters from which lexical definitions are made up.

This view is also our transdisciplinary key interlinking the various arms of the Cybersemiotic star. Peirce is aware of the fact that the amount of information transferred in communication is dependent on the knowledge horizon of the receiver or, rather, interpreter. He writes "If you inform me of any truth, and I know it already, there is no information" (MS 463: 13, 1903). Thus information has to be able to combine with what you already know. "Actual information extends the knowledge horizon of the interpreter. Information is the measure of how much a symbol involves more or less real knowledge" (W1: 187). Thus 'objective' does not means 'interpreter-independent'! Peirce writes:

I do not call the knowledge that a person known to be a woman is an adult, nor the knowledge that a corpse is not a woman, by the name 'information,' because the word 'woman' means a living adult human being having female sexuality. Knowledge that is not informational may be termed 'verbal'

(MS 664:20, 1910).

Precisely here is where "analyticity" comes in: Peirce is saying that the concept of adult is contained in Woman: thus, to say "A woman is an adult" is to make an analytic statement. Thus information is a process in which the symbol of shark, for instance, as a concept with a content that I know, is constantly undergoing development. When I see a documentary showing me many different species of sharks, that I did not know before, like hammerheads, then my symbol of sharks grows, because I have added information to my conception of the species shark by increasing the quantities of extension or intension of the symbol connected to it, which now include hammerheads within there scope. Peirce writes:

An ordinary proposition ingeniously contrives to convey novel information through signs whose significance depends entirely on the interpreter's fa-miliarity with them; and this it does by means of a 'predicate,' i.e., a term explicitly indefinite in breadth, and defining its breadth by means of 'Sub-jects,' or terms whose breadths are somewhat definite, but whose informa-tive depth (i.e., all the depth except an essential superficies) is indefinite, while conversely the depth of the Subjects is in a measure defined by the Predicate.

(CP 4.543, 1905).

So it is not the lexical definition of "shark" that carries the information, but all the other things I know about sharks' behavior, size, colors, way of movement, prey, and how many thousands of them we catch each day and eat in shark fin soup. Peirce underlines that "the information of a term is the measure of its superfluous comprehension" (W1: 467), which is all the extraneous world knowledge I have about sharks, including if I have been bitten by one. In other words, information is all the knowledge "outside" the lexical definitions! Indeed, Johansen (1993, 148) has suggested that "*One way to define information is this: the set of characters which can be predicated of a symbol minus the characters contained in its verbal definition*."

But, what if one of my students includes something undetermined living underwater looking like a fish and which might possibly be a whale in her symbol or conceptualization of fish - is there then no information? Peirce would conclude that, in this case, we are dealing with the possible, which he considers to be real but having to do with propensities rather than certainties: "that is possible which, in a certain state of information, is not known to be false" (CP 3.442, 1896). Moreover, "the Possible, in its primary meaning, is that which may be true for aught we know, that whose falsity we do not know" (CP 3.374, 1885). As Peirce holds a fallibilist view of science combined with a pragmaticist and realistic view of knowledge, he must conclude:

"The cognitions which…reach us…are of two kinds, the true and the untrue, or cognitions whose objects are real and those whose objects are unreal. And what do we mean by the real?…The real, then, is that which, sooner or later, information and reasoning would finally result in, and which is therefore independent of the vagaries of me and you"

(CP 5.311, 1868).

Thus Peirce produces a new transdisciplinary theory of information connected to his semiotic theory of cognition and communication, which differs substantially from the usual conceptions. Nöth (2012, 139) explains:

In modern linguistics, the intensions of words are described in the form of semantic features, whereas their extension is studied in a reference semantic framework. For Peirce, however, extension and intension cannot be separated from each other since the extension or denotation of a symbol "is created by its connotation" (W1: 287), that is, through the predicates attributed to a subject term. We can only determine the referent (denotatum or extension) of a word if we know its meaning (intension or connotation) and vice versa: we must know the referent if we want to specify its semantic features…

Thus, Peirce's theory combines the concepts of meaning and information within a framework of pragmatic realism established on a semiotic understanding of cognition and communication. In this way, he builds bridges between the four different and often incommensurable worlds we mapped in Fig. 1. Peirce's theory can be modernized by combining it with Luhmann's communicative systems theory, which introduces autopoiesis at the level of biology, psychology, and social communication (Brier, 2008, 2011). Luhmann and Peirce both share the idea of form as the essential component in communication. Peirce (MS: 793:1–3) writes:

[…] a Sign may be defined as a Medium for the communication of a Form. […]. As a medium, the Sign is essentially in a triadic relation, to its Object which determines it, and to its Interpretant which it

determines. […]. That which is communicated from the Object through the Sign to the Interpretant is a Form; that is to say, it is nothing like an existent, but is a power, is the fact that something would happen under certain conditions.

In Peirce's dynamic process semiotics, a form is something that is embodied in an object as a habit. Thus, form acts as a constraining factor on interpretative behavior or what he calls a real possibility in the form of a 'would-be'. Thus the form is embodied in the object as a sort of disposition to act (Nöeth, 2012). Laws are not absolute and mechanical but developing forms in the continuum of mind and matter and our ever developing fallibilist knowledge of which symbols is an essential feature:

Once you have embraced the principle of continuity no kind of explanation of things will satisfy you except that they grew. The infallibilist naturally thinks that everything always was substantially as it is now. Laws at any rate being absolute could not grow. They either always were, or they sprang instantaneously into being by a sudden fiat like the drill of a company of soldiers. This makes the laws of nature absolutely blind and inexplicable. Their why and wherefore can't be asked. This absolutely blocks the road of inquiry. The fallibilist won't do this. He asks may these forces of nature not be somehow amenable to reason? May they not have naturally grown up? After all, there is no reason to think they are absolute. If all things are continuous, the universe must be undergoing a continuous growth from non-existence to existence. There is no difficulty in conceiving existence as a matter of degree. The reality of things consists in their persistent forcing themselves upon our recognition. If a thing has no such persistence, it is a mere dream. Reality, then, is persistence, is regularity.

(CP 1.175).

Although it has been common to notice a considerable similarity to some features of Whitehead's philosophy, a study in depth of each one shows wide differences between them. Both philosophers look for the discovery of relational structures, but their methods were far apart. Peirce seeks metaphysical laws founded on those of logic, phenomenology and mathematics and he seeks an understanding of metaphysics as a science among the sciences contrary to Whitehead for whom metaphysics seek a more general truth than sciences seek. Whitehead and Peirce agree in seeking modes of dependence and relatedness in the universe rather than absolutes, and in contrast to Kant both philosophers deny any problematic distinction of noumena from phenomena. Both declare on a phenomenological and empirical basis that reality is wholly open to us. For Peirce this is why he is a pragmaticist. He writes:

As to reality, one finds it defined in various ways; but if that principle of terminological ethics that was proposed be accepted, the equivocal language will soon disappear. For realis and realitas are not ancient words. They were invented to be terms of philosophy in the thirteenth century, and the meaning they were intended to express is perfectly clear. That is real which has such and such characters, whether anybody thinks it to have those characters or not. At any rate, that is the sense in which the pragmaticist uses the word.

(Peirce CP 5.430).

6. Conclusion

When scientific methods are applied to information, cognition, and communication, we are only left with codes, grammar, phonetics, programs, formal language, copy machines, adaptors, but the analysis of meaningful relations is lost amidst all the formal technicalities. Contrary to reductionist loss of meaning Cybersemiotics, following in the footsteps of Peirce, whose semiotics allows us theoretically to distinguish between the information the sender intended to be in the sign, the (possible) information in the sign itself and the information the interpreter gets out of the sign, instead of the idea that the information is the same in all three.. The knowledge in the sign must be interpreted for a full semiosis to happen and for the receiver in order to acquire the information imparted by his or her interlocutor. As such, it is central to any conception of knowledge and information. As Peirce writes then signs have the "active power to establish connections between different objects, especially between objects in different Universes" (CP 6.455; 1908).

We must accept that experience and meaning are just as real as matter. This does not mean that what physicists call the "world" or "reality" as such is imbued with meaning. It means that their concept of "world" and "reality" is unable to reflexively encompass the embodied psychological and social foundation of knowledge. Thus their idea of reality does not take our full measure as conscious, linguistic and social creatures. It lacks an embodied phenomenological foundation in the understanding of Wissenschaft. From a semiotic viewpoint, we can see man as a parasite of symbols (Nöeth, 2012), because we use them to create our perceived selves as self-conscious, cultural communicative beings. Peirce points out that self-reproduction and self-replication are not only characteristics of organisms and chromosomes, but also of symbols. Signs replicate through and in their tokens. Replicas of symbols in their acoustic or written form are indeed dead things (phenomena of Secondness), but symbols as genuine Thirdness live on as self-replicative beings. It is within that wider reality of life connecting subjects in language and social actions to nature and technology that information is created. "Meaning" in the form of the Thirdness of taking habit must somehow be constructed by the receiver from the information gathered by the interpretation of signs, within certain frames that reality imposes on us for survival and procreation. Thus, in the Cybersemiotic transdisciplinary frame for interdisciplinarity the sign process is viewed as transcending the division between nature and culture, between the natural sciences, the life sciences, the social sciences, and the humanities and between phenomena that are exterior and those that are interior to human consciousness.

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