

# Toward a Systemic Notion of Information: Practical Consequences

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(Version: September, 2011)

## Abstract

Our main purpose in this paper is to start a process of a systemic definition of the notion of information and to provide some initial practical consequences of it. We will try to do so by means of 1) providing a *conceptual* definition, following Ackoff's description and method of such a kind of definition<sup>1</sup>, and 2) following Peirce's conception of "meaning", where the *practical consequences* should be included.<sup>2</sup> To our knowledge, no attempt has been done, up to the present, neither to find a Peircean meaning to the notion of information, nor to start a process of describing a **systemic** notion of information. Consequently, we will try to identify and integrate the different definitions, senses, and uses of the term "information". To integrate we should first differentiate what is to be internally integrated, and externally related to other essential concepts (e.g. entropy, negentropy, communication, form, etc.) Consequently, we will 1) macro-typify the main conceptions of "information" as **subjective** and **objective**, 2) provide adequate description and analysis of each type, 3) relate them to essential concepts or notions, 3) integrate them in the context of a systemic notion of information, via cybernetic co-regulative and synergic loops, and 5) show the respective *pragmatic consequences*, as required by Peirce, for the description of any meaning, and by a *pragmatic-teleological* systemic epistemology, as described by Churchman.<sup>3</sup>

**Keywords:** Information, Data, Form, Entropy, Negentropy, Communication Theory, Information Theory, Systemic Definition, Information Systems, Informing Sciences.

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<sup>1</sup> R. Ackoff, R., 1962, *Scientific Method: Optimizing Applied Research Decisions*. New York: John Wiley and Sons.

<sup>2</sup> C. S. Peirce (1839-1914), 1958, *Collected Papers of Charles Sanders Peirce*, 8 vols. Cambridge, Mass. Volumes I-VI, edited by C. Hartshorne and P. Weiss and first published 1931-5, have been re-issued in 1960 as three volumes. Volumes VII and VIII (edited by A. W. Burke) were published in 1958.

<sup>3</sup> C. W. Churchman, 1971, *The Design of Enquiring Systems: Basic Concepts of Systems and Organization*. New York: Basic Books, Inc. Pub.

## 1. Introduction

Tsze-lu asked,

"If the Duke of Wei made you an advisor, what would you address as the very first priority?"

Confucius replied,

"The most important thing is to use the correct words."

"What?" Tsze-lu replied. "That's your first priority? The right words?"

Confucius said,

"You really are simple, Yu. The Sage keeps his mouth shut when he doesn't know what he's talking about!

"If we don't use the correct words, we live public lies. If we live public lies, the political system is a sham.

"When the political system is a sham, civil order and refinement deteriorate. When civil order and refinement deteriorate, injustice multiplies. As injustice multiplies, eventually the electorate is paralyzed by public lawlessness.

"So the Sage takes for granted that he use the appropriate words, and follow through on his promises with the appropriate deeds.

"The Sage must simply never speak lies."<sup>4</sup>

The meaning<sup>5</sup> of "information systems" has been growing in plurality and complexity. Several authors pointed out this fact, described the phenomena and tried to bring some order to the perceived chaos in the field. Eli Cohen and Elizabeth Boyd<sup>6</sup>, for example, after describing the attacks on the Information Systems (IS) field, for "its lack of tradition and focus" and the "misunderstandings of the nature of Information Systems", examine "the limitations of existing frameworks for defining IS" and re-conceptualizes Information Systems and tries "to demonstrate that it has evolved to be part of an emerging discipline of fields, Informing Science."<sup>7</sup>

Our main objective in this essay is to participate in the process of conceptualization and re-conceptualization of "information" required in the area of Information Systems, and Informing Sciences. We will try to do that by making a first step in the description of a

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<sup>4</sup> *The Analects of Confucius*, Book 13, Verse 3. Translation made by James Endres Howell (Berkeley's Teaching Effectiveness Award); accessed on August 20, 2010 at [www.ocf.berkeley.edu/~jendres/lunyu/](http://www.ocf.berkeley.edu/~jendres/lunyu/); and referenced by Tom Schneider in his article titled "Pitfalls in Information Theory", accessed on August 20, 2010 at <http://www.ccrnp.ncifcrf.gov/~toms/pitfalls.html>

<sup>5</sup> The concept of "meaning" is increasingly being discussed in the context of logic and mathematics, where sentences are meaningful or not depending on whether they conform to specified rules or not, or whether they are consistent or not with other sentences, etc. But, in this essay we are not using the word "meaning" in the context of formal logic, because human communication cannot be reduced to logic. We will use the word "meaning" as it is commonly used in speech and written languages, because this is the way it is used in the area of Information Systems and Informing Science.

<sup>6</sup> E. B. Cohen, 1997, "IS as an Evolving Field," *Proceedings of the World Multi-Conference on Systemics, Cybernetics, and Informatics*, Caracas, Venezuela, July 7-11, 1997, Ed. by N. Callaos, C.M. Hoong, and E. Cohen; Cohen, E. B. and Boyd E. C. (1999). "Introduction to Informing Science," *Proceedings of the World Multi-Conference on Systemics, Cybernetics, and Informatics*, Vol. 8, pp 451-456; Orlando, Florida, July 31-August 4, 1999, ed. by Torres, M., Sanchez B. and Wills, E.; and E. Cohen, 1999, From ugly duckling to swan: Reconceptualizing information systems as a field of the discipline informing science. *Journal of Computing and Information Technology*, 7(3), pp. 213-219, which also has been published as E. B. Cohen, 2000, "From Ugly Duckling to Swan," *Informing Science: The International journal of an Emerging Discipline*; accessed on August 10<sup>th</sup>, 2010 at <http://inform.nu/WhatsIS.htm>.

<sup>7</sup> E. Cohen, 1999 and 2000, op. cit.

systemic notion of information, i.e. by identifying a *comprehensive* and *related* set of the main conceptions of information, its main uses, and the meaning of its principal associated terms.

We are using the word “meaning” as a set the different ways it is used, and the set of senses a word has, including its pragmatic sense; which Peirce formulated when he pointed out that “in order to ascertain the meaning of an intellectual conception one should consider what practical consequences might conceivably result by necessity from the truth of that conception; and the sum of these consequences will constitute the entire meaning of the conception.”<sup>8</sup> When Peirce talks about “consequences”, he is referring to the *relation (consequentia)* between the pair of antecedent and consequent, not just about the consequent (*consequens*). So, accordingly, we will try to analyze the antecedents, by means of Ackoff’s approach to conceptual definitions<sup>9</sup>, and then we will try to relate them to the respective consequents. In this way the *meaning* we will be looking for the term ‘information’ will include both: its *conceptual* definition(s), as well as its respective *practical consequences*, in general, and especially in the fields of Information Systems and Informing Sciences. This will provide input for establishing the direction of a *systemic meaning of the notion of information*, where the associated concepts and uses of the term are internally related to each other, and externally related to its conceptual context, in general, and to its practical consequences, in particular.

Information, interest in information, and talk about information has been everywhere, especially since the publication of Shannon’s “Mathematical Theory of Communication”<sup>10</sup> in 1948. Since then, and due to the huge success of Shannon’s theory in communication systems engineering, the term ‘information’ has widely and increasingly been used, but not always with a clear idea of its meaning. As Dretske<sup>11</sup> and Lewis<sup>12</sup> pointed out, few books concerning information actually define it clearly. And, Mingers adds: “Information systems could not exist without information and yet there is no secure agreement over what information actually is.”<sup>13</sup> The word ‘information’ is one of the most used, and much abused. Different scientific disciplines and engineering fields provide diverse meanings of the word, which is becoming the umbrella of divergent, and sometimes dissimilar and *incoherent homonyms*. When concepts are not clear, the use of homonyms might be intellectual and pragmatically dangerous.

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<sup>8</sup> Peirce, 5.9

<sup>9</sup> Ackoff,

<sup>10</sup> Claude E. Shannon, 1948, “A Mathematical Theory of Communication,” in *The Bell System Technical Journal*, Vol. 27, pp. 379–423, 623–656, July, October, 1948; reprinted with some correction at <http://cm.bell-labs.com/cm/ms/what/shannonday/shannon1948.pdf> (Accessed on August 23<sup>rd</sup>, 2010).

Published also in C. E. Shannon and Warren, 1963, *The Mathematical Theory of Communication*; Urbana and Chicago: University of Illinois Press.

<sup>11</sup> F. Dretske, 1981, *Knowledge and the Flow of Information*; Blakwell.

<sup>12</sup> P. Lewis, 199, “The Decision Making Basis for Information Systems: The Contribution of Vickers’ Concept of Appreciation to a Soft Systems Perspective”, *Journal of Information Systems*, 1 (1), 33-43.

<sup>13</sup> J. Mingers, J., 1997, “The Nature of Information and Its Relationships to Meaning,” in R.L. Winder, S. K. Probert and I. A. Besson, (eds), *Philosophical Aspects of Information Systems*. London: Taylor & Francis, pp. 73-84; p.73.

For a long time there has been no consensus about the meaning of the term or the concept of ‘information’, in spite of the huge success of Shannon’s “Mathematical Theory of Communication” (which has also been named “Mathematical Theory of Information” by many authors). On the contrary, there has been a surprising level of consensus about this lack of consensus. Some examples of authors referring to this lack of agreement with regard to the meaning of ‘information’, since Shannon provided his mathematical definition of ‘information’, are the following:

- In 1972, Gatlin affirmed that “To be honest, information is an ultimately undefinable or intuitive first principle, like energy, whose precise definition always somehow seems to slip through our fingers like a shadow.”<sup>14</sup>
- In 1981 Dretske affirmed that “It is much easier to talk about information than it is to say what it is you are talking about. A surprising number of books, and this includes textbook, have the word *information* in their title without bothering to include it in their index.”<sup>15</sup>
- In 1986, Palmer and Kimchi remarked, “We know that information is not the same as Shannon’s measure of informativeness, but we still don’t know what it is or how it is related to his formulation. This is a rather embarrassing situation.”<sup>16</sup>
- In 1991, Devlin pointed out that “Like the Iron Age man [who is able to make iron devices and knows when a given metal is iron, but cannot answer in precise terms the question ‘what is Iron?’] Information age Man can recognize and manipulate ‘information’ but is unable to give a precise definition as to what exactly it is that is being recognized and manipulated.”<sup>17</sup>
- In 2007, Collins, referring to ‘information’ asserted that “despite its status as a technical term, the word now rarely receives explicit definition...‘Information’ became a term whose technical uses became increasingly difficult to differentiate from its everyday meaning.”<sup>18</sup> Collins affirms that the term ‘information’ is “an apparently technical term that had to bear such a theoretical weight and had such diverse uses that it became impossible to define it in narrow technical terms.”<sup>19</sup>

It is intellectually risky to confuse the meaning of ‘information’ with one, or a group, of its senses. If we accept that the ‘meaning’ of a term is described by the “set of its senses” (as L. J. Prieto<sup>20</sup> affirmed), then to equate, or confuse, the meaning of information with

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<sup>14</sup> L. Gatlin, 1972, *Information Theory and the Living System*; New York: Columbia University Press; p. 25. Quoted by T. Stonier, 1997, *Information and Meaning: An Evolutionary Perspective*; London: Springer.

<sup>15</sup> Dretske, , p.ix

<sup>16</sup> Palmer, S., & Kimchi (1986). The information processing approach to cognition. In T. J. Knapp, & L. C. Robertson (Eds.), *Approaches to cognition: Contrasts and controversies* (pp. 37–78). Hillsdale, NJ: Erlbaum. Quoted by A. Collins, 2007, “FROM  $H = \log S^n$  TO CONCEPTUAL FRAMEWORK: A Short History of Information,” in *History of Psychology*, Volume 10, Issue 1, Pages 1-74; p. 2

<sup>17</sup> K. Devlin, 1991, *Logic and Information*; Cambridge: Cambridge University Press; p. 2

<sup>18</sup> A. Collins, 2007, “FROM  $H = \log S^n$  TO CONCEPTUAL FRAMEWORK: A Short History of Information,” in *History of Psychology*, Volume 10, Issue 1, Pages 1-74; p. 1. Prepublication version accessed on August 25<sup>th</sup>, 2010 at [www.psych.lancs.ac.uk/people/uploads/alancollins20080725T151027.pdf](http://www.psych.lancs.ac.uk/people/uploads/alancollins20080725T151027.pdf)

<sup>19</sup> Collins, , p. 4

<sup>20</sup> L. J. Prieto: *Tratado del Lenguaje*: Buenos Aires, Ediciones Nueva Visión, 1965; Vol. 1, pp. 105-53.

one of its senses, or a group of them, is to equate, or to confuse, a set with one of its elements or with one of its proper (or strict) sub-sets. This is intellectually misleading and might end up in a hidden non-sense. A synecdoche, with which a part is put for the whole, is a figure of speech that can provide an expressive power in literature or poetry, but it might be dangerously confusing in reasoning and logical inference.

From a logical perspective, equating or identifying “information” with one of its species, might also be intellectually misleading. Confounding genre with species might generate hidden nonsense. It is evident that if we define men as “rational animals”, we cannot affirm that “animals are men.” “A is B” does not necessarily mean “B is A.” Despite of this logical evidence, we can still find, in some literature about the notion of information, authors denoting with the term of “information” species of the “genre information” and, then, making conclusion about the species and the applying these specific conclusions to the “genre of information”. We can predicate from “information-as-genre” to “information-as-species” but vice versa is not always the right thing to do. We can predicate from the genre “animal” to the species “man”, but vice-versa is not necessarily right: “Men are rational” (for example) does not imply that “animals are rational”. But animal’s predicates can always be applied to any of its species. This is so evident that it seems a waste of time to write it and to read it. But, as we will see below, some authors are at risk of these kinds of errors when they *reduce the meaning of “information” to one of its senses*.

Other authors seem to confuse, identify, or reduce the notion of “information” to one way of *measuring* it. The concept of “volume”, for example, is different from “gallon” or “litter”, although we measure volume by units of gallons, liters, etc. A gallon is a measure of volume, but “gallon’s predicate” cannot be necessarily predicated from “volume”. Sometimes, we measure a “*cause*” by one of its “*effects*”. Voltage, for example, can be measured by the electric current it creates, which, in turn, can be measured by the magnetic effect it creates, and then by the displacement of a magnet, caused by the electromagnetic field. No author identifies, let alone confuses, the concept of voltage with electrical current, or with a magnetic field, or with a magnet displacement. A “bit” is a measure of information (or some kind of information). Should we reduce the concept, or the notion, of information to this way of measuring it? A “bit” is a highly useful way –and perhaps unique one— of measuring “information” in the context of signal codification and transmission. Does that mean that we should equate or identify “information” with “bits”? Should we consider anything impossible to be measured by bits as a no-information? Should we find another word for the “information” not subject to the measurement of “bits”? Should we call it knowledge? Is there any kind of knowledge if no predication is made or if no verb is being used? Is there any difference between “*data*” and “*information*”? Are they the same? Are they different species of the same genre? Is one a species of the other? Are they related? If so, how are they related? Is there any difference between “*knowledge*” and “*information*”? How are they related?

We will try, in this essay, to provide some hints with regards to these kinds of questions.

## 2. Approach Used for Defining and/or Describing Meanings

Elsewhere<sup>21</sup>, in a meta-defining process, we identified more than 30 different definitions of 'definition', and several meanings of 'meaning'<sup>22</sup>. We concluded, then, that a systemic definition should be done as comprehensive as possible, including the essence of as many definitions as possible, and to do it with as few words as possible and with a brief text. Here we attempt a systemic definition, or identify a systemic 'meaning' of the term 'information,' which would have the following characteristics:

1. From the epistemological perspective, a systemic definition is oriented toward a *pragmatic-teleological* truth, as that of Singer-Churchman.<sup>23</sup> This will be achieved by means of:
  - 1.1. Taking into account the "*telos*", "*the purposes of the definer*", as Ackoff stressed it<sup>24</sup>. Our purpose is to capture the conceptual essence, maximizing the number of different definitions, uses, and senses of the term, which essence is sought to be covered, which is the concept of information in the case of this essay.
  - 1.2. Relating the definition to past and present usage of the word in order to serve the *pragmatic communications needs*, as it was also stressed by Ackoff.<sup>25</sup>
  - 1.3. Trying to make the definition *operational, as suggested by Ackoff*<sup>26</sup>, Bridgman<sup>27</sup>, and Stevens<sup>28</sup>, in order to be useful in a pragmatic context. These three authors emphasize the importance of providing measurement (s) for the operational definitions. We will do this when possible. When we do not, we will try to provide some guidelines oriented to increase the operational effectiveness in the context of Pierce's notion of meaning which we referred to above. It is necessary to notice that we will not reduce our inquiry regarding the notion of information to definitions that allow *measurement* of what is being defined. Measurement is important for scientific operations, especially in positivistic approaches, but we think that a systemic approach of enquiry regarding the notion of information should also comprehend other forms of

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<sup>21</sup> N. Callaos, 1995a, *Metodología Sistémica de Sistemas: Conceptos y Aplicaciones (Systemic Systems Methodology: Concepts and Applications)*; Work presented for the academic rank of Titular Professor at Universidad Simón Bolívar, Caracas, Venezuela; chapter 2, pp. 35-36.

<sup>22</sup> See also, for example, C. K. Ogden and I. A. Richards, 1989, *The Meaning of Meaning*; San Diego, Harcourt Brace Jovanovich, Pub. (First published in 1923)

<sup>23</sup> Churchman, C. W. 1971, *The Design of Enquiring Systems: Basic Concepts of Systems and Organization*. New York: Basic Books, Inc. Pub.

<sup>24</sup> Ackoff, op. cit.

<sup>25</sup> Ibid.

<sup>26</sup> Ibid.

<sup>27</sup> P. W. Bridgman, 1927, *The Logic of Modern Physics*; New York: The Macmillan Co.; and 1938, "Operational Analysis", *Philosophy of Science*, Vol.5: 114-131.

<sup>28</sup> S. S. Stevens, 1935, "The Operational Basis of Psychology," *American Journal of Psychology*, Vol. 47: pp. 323-330.

supporting operations, especially if those are not in the context of positive science, but in the context of other scientific methodologies, or in the context of engineering, managerial and other professional operations or activities.

2. From the methodological perspective, the variety of past and present usage of the word being defined should be structured by means of a logical infra-structure, or by means of a bootstrapping process.<sup>29</sup> In this way the definition will be *comprehensive*, *open* and *adaptive*, both as a product and as a process, and we will have the bases that might support a progressive "spiraling" process according to the *Evolutionary Paradigm*<sup>30</sup>.

Ackoff stressed the fact by which "*historical analysis of the use of a concept can often reveal a trend in the evolution of the concept or a consistent theme of meaning which persist through numerous variations.*"<sup>31</sup> This is why he exhorts to initiate a scientific defining process by formulating a *tentative definition* based on the evolving core identified by a historical analysis. It is our experience that Ackoff's suggestion is a valuable and a practical one, and that taking it to an extreme, by going to the etymological meaning of the word being defined, is also helpful because it would suggest a pre-tentative definition. The *suggestive* effect of historical linguistic analysis has been stressed by several authors. Collin Cherry, for example, affirms that "Real understanding of any scientific subject must include some knowledge of its historical growth; we cannot comprehend and accept modern concepts and theories without knowing something of their origins—of how we have got where we are."<sup>32</sup> Being the root of different senses or meanings, the etymological definition frequently suggests a general concept from which more specific ones are generated through history. This is why we think that the etymological source may help us in abstracting a general definition from the varieties of the specific ones that appeared through history.

Consequently, we will follow Ackoff's (and Cherry's) suggestion of a brief historical description oriented to a 'conceptual definition' (in its Ackoffian meaning) as a first step in both: scientific inquiry and effective information systems engineering. We will also try to include, in our enquiry, suggestions and general guidelines oriented to Peirce's definition of meaning as conceptual support for professional activities related to human communication and information.

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<sup>29</sup> Alvarez de Lorenzana, J. M., 1987, "On Evolutionary Systems". *Behavioral Science*, Vol. 32: 19-33.

<sup>30</sup> Alvarez de Lorenzana, , and E. Laszlo, E., 1987, "Evolution: The New Paradigm", *World Futures*, Vol. 23: 151-160

<sup>31</sup> Ackoff, op. cit. p. 148

<sup>32</sup> C. Cherry, 1982, *On human Communication: A Review, A Survey and a Criticism*, An MIT Press Classic, Cambridge, Massachusetts: The MIT Press, p. 32. See C. Navarte, C., 1981, *Problemas de Método y Teoría*. Santiago de Chile: Universidad de Chile; p. 158; who also makes similar affirmation regarding the importance of the history of a concept for an adequate comprehension of it.

### 3. The Notion of Information

*“[S]ome of us should venture to embark on a synthesis of facts and theories, albeit with second-hand and incomplete knowledge of some of them – at the risk of making fools of ourselves.”<sup>33</sup>*

In our opinion, “information” should be characterized as a notion because of the lack of consensus and the diversity regarding its senses, definitions and meaning. The term “notion” includes the sense of “concept” but it is not reduced to it. A notion is “(1): an individual's conception or impression of something known, experienced, or imagined (2): an inclusive general concept (3): a theory or belief held by a person or group.”<sup>34</sup> We prefer to characterize “information” as a notion, because the senses of the meaning of “*notion*” include what we can ‘*note*’ with regards to the term of “information”. The term “notion” means a “general concept; a mental representation of a state of things;... a thought; a cognition;...In the Lockian philosophy, a complex idea;...In the Hegelian Philosophy, that comprehensive conception in which conflicting elements are recognized as mere factors of the whole truth...an opinion; a sentiment; a view; especially, a somewhat vague belief, hastily caught up or founded on insufficient evidence and slight knowledge on the subject...The mind; the power of knowledge; the understanding.”<sup>35</sup> Sir W. Hamilton, in his *Lectures on Logic* affirmed that “Concept or *notion* are terms employed as convertible; but, while denote the same thing, they denote it in a different point of view. Conception, the act of which concept is the result, expresses the act of comprehending or grasping up into unity the various qualities by which an object is characterized; *notion*, again, signifies the act of apprehending, signaling—that is the remarking or taking note of the various notes, marks, or characters of an object which its qualities afford; or the result of that act...The term *notion* like conception, expresses both an act and its product.”<sup>36</sup>

The first note we are taking regarding “information” is that it is a notion, not necessarily a concept, because:

- It cannot be conceived as just a concept because no philosopher or scientist, to our knowledge, has comprehended or grasped up into *unity* the various qualities by which “information” is characterized. Had anyone comprehended or grasped up the unity of the different ways in which information is conceived, there would be an adequate level of consensus about what information actually is or what it should be. What we actually can apprehend with regards to information is its various notes, marks, or characters. So the first note we would like to take note on

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<sup>33</sup> E. Schrödinger, 1944, *What is Life? With Mind and Matter and Autobiographical Sketches*, Cambridge: University Press, 19<sup>th</sup> printing, 2010; p. 1

<sup>34</sup> Merriam-Webster, 1999, *Merriam-Webster's Collegiate Dictionary*; third edition, Springfield, Massachusetts, Merriam-Webster, Inc

<sup>35</sup> Whitney, D. W. (Ed.), 1969, *The Century Dictionary and Cyclopaedia*, Century Co; p. 4027

<sup>36</sup> Quoted by Whitney, op. Cit.



is that “information” is a notion, not necessarily a concept. It cannot be consensually conceived, but a related set of its notes can be identified. Consequently, according to Sir W. Hamilton’s conception of “concept” and “notion”, information would be a notion.

- According to Hegel’s conception of “notion”, information would also be a “notion”, because we are to recognize the conflicting conceptions produced regarding “information.”
- Since the term “information” is associated with many different, but mostly related aims, definitions, ways of demarcating what differentiates it from what it is not, etc., “information” is certainly a complex idea and, as such, according to Locke’s philosophy, it would be a notion.
- Ferrater-Mora affirms that “conception” may refer to the *production* of a reality, a mental object, while “notion” is usually the *reception, acknowledgment or representation* of some reality, object, or phenomenon.<sup>37</sup> If we conceive “information” as a concept, we might be limiting its domain to a prescriptive one, or to one of the ways of measuring it. This kind of perspective excludes a descriptive one where science might be presented according to what people actually think information is.<sup>38</sup>

Following Ackoff’s suggestion with regards to describing the *history* of a “concept” (as a first step for its scientific definition), we will try to capture the characteristics and notes of “information” which are more related to the *aims* of this essay; which, as we mentioned above, is also one of the characteristics of a scientific definition according to Ackoff.<sup>39</sup>

#### 4. Information and Data

Information has been frequently defined as “*interpreted data*” and, as such, the same data might cause different interpretations. Agnar Aamodt, for example, affirms that “*Knowledge is always within a reasoning agent...When we, correspondingly, view information as interpreted data, it only makes sense to talk about data in a book. The information itself has to come from an interpretation process who uses its knowledge in order to understand and thereby ‘transform’ data into information...Hence, when we in conversation with human being refer to “the information in a book”...we implicitly assume that the interpreter is ourselves or another human being with a similar cultural (and therefore interpretative) background.*”<sup>40</sup> Jan Aidemark affirms that “definitions of

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<sup>37</sup> J. Ferrater-Mora, 1969, *Diccionario de Filosofía*, Buenos Aires: Editorial Sudamericana; Vol.II, p. 290.

<sup>38</sup> Elsewhere we made a similar argument with regards to the notion of ‘science’ (N. Callaos, 2011, *Expansion of Science*, unpublished work in progress.

<sup>39</sup> Ackoff, See paragraph 1.1. above.

<sup>40</sup> A. Aamodt, 1993, “A Case-Based answer to Some Problems of Knowledge-Based Systems,” in E. Sandewall, and C. G. Jansson (Eds.) SCAI '93: Scandinavian Conference on Artificial Intelligence - 93:

information as interpreted data...are not uncommon in the area of information systems.”<sup>41</sup> Many other authors refer to ‘information’ as ‘interpreted data.’<sup>42</sup>

Different persons, with different cultural backgrounds, or with different aims, might associate different information to the same data. (Even different artificial expert systems, with different knowledge bases, might associate different “information” to the same data).

This kind of definition (information as interpreted data) is frequently found in Information Systems textbooks, especially those oriented to Information Systems Development and Managerial Information Systems (MIS). Data in a MIS should provide some meaning to some manager in order to fulfill its *raison d’être*, its reason or justification of existence. An interpretation, in this context, is, by its own nature, *subjective*, i.e. related to a *subject*, a “mind, ego, or agent of whatever sort that sustains or assumes the form of thought or consciousness.”<sup>43</sup> Consequently, it is easy to conclude that according to this kind of definition there is no information system (IS) without a subjective sub-system, i.e. any IS should have at least two subsystems: a physical *objective* (mechanical and/or electronic data processing sub-system) and a *subjective* one (biological/human data/information processing: a user, a manager, etc). We will examine these two subsystems with more details below (section 12), as well as the relationships between them.

Some authors are a little bit more explicit and precise in their definition of information. They describe it as “*data plus meaning*” or “*meaningful data*.”<sup>44</sup> Etymologically, the term “data” means “things given or granted.” Data is the plural of “*datum*,” a Latin term, which is the past participle of “*dare*” (to give); and “datum” means “thing given or

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Proceedings of the 4th Scandinavian Conference on Artificial Intelligence, Electrum, Stockholm, Sweden, 4-7 May 1993, Vol. 1; pp. 168-82; p. 171. Italics are Aamodt’s.

<sup>41</sup> J. Aidemark, 2002, “Information Planning for Knowledge Work – The flexibility approach, in *ECKM - European Conference on Knowledge Management*; pp. 29-42; p. 31.

<sup>42</sup> Kleinn and Ståhl, for example affirm “we will not expand on the multitude and complexity of definitions of the term “information” but restrict ourselves to the simple and basic view of information as *interpreted data*,” in C. Kleinn and G. Ståhl, 2006, *Forest Inventories Generate Scientifically Sound Information on the Forest Resource, But Do Our Data and Information Really Matter?* In *2006 Proceedings of the Eighth Annual Forest Inventory and Analysis Symposium*. Accessed on August 8<sup>th</sup>, 2010 at *2006 Proceedings of the Eighth Annual Forest Inventory and Analysis Symposium*. See, as another example, C. J. Romanowski and R. Nagim, *A Data Mining Approach to Integrating Product Life Cycle Information in Engineering Design*, accessed on August 8, 2010 at [http://www.iienet.org/uploadedFiles/IIIE/Technical\\_Resources/Archives/2260.pdf](http://www.iienet.org/uploadedFiles/IIIE/Technical_Resources/Archives/2260.pdf). Another example can be found in M. Bowman, A. M. Lopez Jr., J. Donlon, and G. Tecuci, 2001, “Teaching Intelligent Agents: Software Design Methodology,” *The Journal of Defense Software Engineering*, Jun 2001 Issue. Accessed on August 8<sup>th</sup>, 2010 at <http://www.stsc.hill.af.mil/crosstalk/2001/06/bowman.html>

<sup>43</sup> Merriam-Webster’s *Collegiate Dictionary*, 1999, Springfield, Mass: Merriam-Webster Inc. Third Edition.

<sup>44</sup> See, for example, P. B. Checkland and J. Scholes, 1990, *Soft Systems Methodology in Action*; New York: John Wiley and Sons; and J. Mingers, 1997, “The Nature of Information and Its Relationships to Meaning,” in R.L. Winder, S. K. Probert and I. A. Besson, (Eds.), *Philosophical Aspects of Information Systems*. London: Taylor & Francis, pp. 73-84.

granted.”<sup>45</sup> The Century Dictionary<sup>46</sup> provides three senses of the word ‘datum’: “1. A fact *given*...2. A fact either indubitably known or treated as such for the purposes of a particular discussion; a *premise*. 3. A preposition of *reference*, by which other positions are defined.” Consequently, a ‘datum’ is a *given fact, a premise (a given starting point for reasoning or for a discussion), or a reference, a given initial position from which other positions are to be inferred*. In any of its three senses, “datum” is a ‘given’ (fact, premise, or position) which initiates a process. In the context of this essay ‘datum’ is *what initiates an informing process*. In the context of information as “*data plus meaning*”, ‘datum’ would be *what initiates an informing process oriented to produce a meaning*.

On the other hand, the term “meaning” is derived from the Middle English “*menen*,” akin to Old High German term “*meinen*,” i.e. “to have in mind.”<sup>47</sup> This etymology of the term has been mostly maintained to the present time. So, “to mean” is defined as “to have in mind as a purpose” and as “to serve or to intend to convey, show or indicate; to signify.”<sup>48</sup> “To signify” is a Latin rooted term equivalent to the Old High German rooted “to mean.” Consequently, the term “meaning” has been defined as “the thing one intends to convey especially by language” or “the thing that is conveyed especially by language”; and “meaningful” is defined as “having a meaning or purpose”, “full of meaning”, “significant”.<sup>49</sup> Consequently, ‘information,’ in its sense of “meaningful data,” would be defined as “significant data”, “data full of meaning”, “data having a meaning or purpose,” and as “data plus meaning”<sup>50</sup> would be defined as “data plus significance,” “data plus the thing conveyed by it in the mind.” Then, *in this sense*, it is easy to make the same conclusion we did above: since *information is something that should be in the mind of someone, information (especially in the context of Information systems or Informing Sciences) is always in a person, in a subject, i.e. it is subjective*.

A similar conclusion might be derived from the etymology of the word “information.” “Inform” originated from the Middle English term “*enforme*”, derived from the Middle French term “*enformer*”, which evolved from the Latin term “*informare*.”<sup>51</sup> This Latin term means: “shape, form an idea of.”<sup>52</sup> To form an idea is always in the mind of a person, of a subject. *On the other hand, “informare” is a composite of “in-” and “formā”*. The last term means “shape, mold” The term ‘in-’ “is used in combination

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<sup>45</sup> C. T. Onions (Ed.), 1996, *Oxford Dictionary of English Etymology*, Oxford: The Clarendon Press.

<sup>46</sup> W. D. Whitney and B. E. Smith, 1911, *The Century Dictionary: An Encyclopedic Lexicon on the English Language*; New York: The Century Co., vol.III, p. 1462. Emphasis added.

<sup>47</sup> Merriam-Webster,

<sup>48</sup> Ibid.

<sup>49</sup> Ibid.

<sup>50</sup> The concept of ‘meaning’ has been researched and studied by several authors (see, for example, Ogden and Richard’s classic *The Meaning of Meaning*, cited above), in a very detailed, analytical and profound way. Elsewhere (Callaos 1995a), trying to make a systemic definition of “meaning” and to find the meaning of “definition”, we made a thorough description of these researches and studies, and one of our conclusions was the one we briefly described here (N. Callaos, ob. cit)

<sup>51</sup> Merriam-Webster, op. cit.

<sup>52</sup> T. F. Hoad, 1993, *The Concise Oxford Dictionary of English Etymology*; Oxford: Oxford University Press. See also C. T. Onions (Ed.), 1996, *Oxford Dictionary of English Etymology*, Oxford: The Clarendon Press.

mainly with verbs and their derivatives, with the senses of ‘in, into, within’.<sup>53</sup> Accordingly, “to inform” would mean “to form in,” “to form into,” “to form within.” **Who** forms *what*, *for what*, and *into-what* (or *where*)? We suggest that *the diversity of meanings that are found in the literature with regards to the notion of “information” are because of the different ways the above question is, implicitly or explicitly, answered.* If this suggestion is plausible, then we might have found a systemic conceptual infrastructure for a coherent notion of “information”; or, at least, cohesive clusters of meanings (sets of senses), of it.<sup>54</sup> A person [the who] identifies and chooses expressive (audio or visual) forms [the what] when trying to communicate with other (s) [for what], who get into his or her mind the expressed forms [into-what]. Depending on who or what we are referencing to, the term “information” would be understood in different senses. As we will see below, information has different significations depending if we are referring to the *sender subject*, or the *receiver subject*, or the *physical media* used to achieve the communication between them.

“Cicero uses ‘*in-formare*’ to render the epicurean notion of ‘*prolepsis*’, i.e., a representation implanted in the mind.”<sup>55-56</sup> Agustin uses “*in-formare*” with a similar meaning. Recently, an increasing number of authors are presenting comparable meanings. Boland for example concluded “...information is the inward-forming of a person that result from the engagement with data.”<sup>57</sup> Consequently, according to this kind of conceptual perspectives, “information” is associated with what a *person* forms into his *mind* (or *brain* via neural nets), as a *representation* of the external world, via sense-data, with a purpose oriented by his *knowledge* instinct, which according to Leonid Perlovsky “is related to adaptation, and in the long run to survivability.”<sup>58</sup> The knowledge instinct has been established by Leonid Perlovsky for humans and higher animals. He affirms that “The process of matching mental models-representations in memory to bottom-up signals coming from sensory organs is necessary for perception; otherwise an organism will not be able to perceive the surroundings and will not be able to survive. Therefore humans and high animals have an inborn drive to fit top-down and bottom-up signals. We call this

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<sup>53</sup> Hoad, op. cit.

<sup>54</sup> An analogy might also be suggested relating the four items of the question above to the four Aristotelian causes: Efficient cause (who formed), formal cause (what is formed), teleological cause (objective of the forming entity), and material cause (into-what, where it is formed)

<sup>55</sup> R. Capurro and B. Hjørland, 2003, “The concept of Information,” Annual Review of Information Science and Technology, (ARIST), Ed. Blaise Croning, Vol. 37, Chapter 8, pp. 343-411. Quoted by P. Adriaans and J. Van Benthem, 2008, “Introduction: Information is what Information Does,” in P. Adriaans and J. Van Benthem (Ed.), *Philosophy of Information*, Amsterdam: Elsevier; pp. 3-26; p.4.

<sup>56</sup> Claartje van Sijl affirms that “*prolêpseis*...are physical modifications of the mind and cannot be passed on as such to other persons.” This conception of *prolêpseis* was shared by the Epicureans and the Stoics, but the later conceived *prolêpseis* as associated with ‘*lekta*’, (mental states revealed by utterances) “which facilitate the linguistic expression of our thoughts.” In Claartje van Sijl, 2003, “*Prolêpsis* according to Epicurus and the Stoa: English summary of master thesis,” accessed on August 32, 2010 at [www.phil.uu.nl/~claartje/summ.pdf](http://www.phil.uu.nl/~claartje/summ.pdf)

<sup>57</sup> R. J. Boland, 1987, “The In-formation of Information Systems,” in R. L. Boland and R.A. Hirschheim (eds.), *Critical Issues In Information Systems Research*. New York: John Wiley and Sons; cited by Cohen, E. B. (2000) “From Ugly Duckling to Swan,” *INFORMING SCIENCE: The International journal of an Emerging Discipline*. Accessed on August 10<sup>th</sup>, 2010 at World Wide Web: <http://inform.nu/WhatsIS.htm>

<sup>58</sup> L. Perlovsky, 2001, *Neural Networks and intellect: Using Model-based concepts*; Oxford: Oxford University Press; p. 423n4.

mechanism the instinct for knowledge ... This mechanism is similar to other instincts in that our mind has a sensor-like mechanism that measures a similarity between top-down and bottom-up signals, between mental models and sensory signals.”<sup>59</sup> In the context of this perspective we might suggest that “information” (in the subjective sense we are referring to here) is produced by *inborn processes of “matching mental models-representations in memory to bottom-up signals coming from sensory organs” or sense-data.*

Consequently, it is evident that according to the etymological meaning of “information” and to several authors (since at least Cicero), the term “information” is used to refer to “a ‘form-into’ a mind”.<sup>60</sup> This interpretation converges with conclusions made by several authors by means of other kind of analysis. Dervin, for example, points out that “Since it is assumed that all information producing is internally guided and since it is generally accepted that all human observing is constrained, sense-making further assumes that *all information is subjective.*”<sup>61</sup> “Information is understood not as a thing but as a *construction*”.<sup>62</sup> Dervin recognizes that there is objective information, but he places it in quotation marks as “ ‘some information’ out there, external to human beings, but created by them.”<sup>63</sup> So, what Dervin is saying is that any information originates from a subjective source and is transformed by other subjective processes, performed by the receiver. *What might be called ‘objective information’ is a representation of the real information, which is a subjective one in its origin and essence* (we will include this extension in the meaning of the term ‘information’ later, with the name of ex-formation<sup>64</sup>, and in the context of a systemic notion of information). Neill makes an analogous emphasis: “knowledge representation—he says—is not knowledge but rather representation of knowledge.”<sup>65</sup> Therefore, the conclusion is evident: information is generated inside the mind of a person, a subject. It is not an objective entity independent of any person. It is dependent on the person where it is generated by the data stimulus, as well as on his/her individual experience. This is a very important conclusion, which many authors of Information Systems books, or papers, do not seem to be taking into account. But, the term “information” might also mean something else, something objective, even physical, as we will show below.

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<sup>59</sup> L. Perlovsky, 2010, “Mathematical Equivalence of Evolution and Design,” presented at the General Plenary Session of the 14<sup>th</sup>, Multi-Conference in Systemics, Cybernetics, and Informatics: WMSCI 2010; Orlando, Florida, USA, June 29-July 2, 2010.

<sup>60</sup> As we will see below, from the perspective of other authors we will conclude that “information” may also be conceived as “extra-mental forms”, or “forms-into physical realities.”

<sup>61</sup> Dervin B., 1983, “An overview of Sense-Making Research: Concepts, Methods and Results to Date”; presented at the *International Communication Association Annual Meeting*; Dallas, May, 1983, Seattle: School of Communications, University of Washington; p. 4 (Dervin’s emphasis).

<sup>62</sup> Ibid.

<sup>63</sup> Ibid.

<sup>64</sup> The meaning with which we are using the word “ex-formation” will be clarified along this essay. It will be different to the meanings with which it has been used by other authors, whom will be referenced later.

<sup>65</sup> S. D. Neill, S. D., 1992, *Dilemmas in the Study of Information: Exploring the Boundaries of Information Science*; New York: Greenwood Press; p. 34.

Kochen defined information as “*decision-relevant data*”<sup>66</sup>, which makes of it something requiring a special kind of subjectivity, a strict subjectivity that excludes the possibility of inter- or trans-subjectivity, due to the personal nature of “decision” and “relevant decision.” *Decisions are always subjective, and relevancy is always related to a given subject.*

It is to be noticed that, in the senses of “information” given above, a subjective reception of the data is a *necessary* condition for in-formation generation, but it is not a *sufficient* one. To receive data related to my first name, for example, does not generate information ‘in me’. To have the data related to the first name of a person I just met, does generate information ‘in me’, especially if I have some kind of interest in such a person and in knowing his or her first name. So, not every kind of data generates subjective information in any person. The received data should generate relevant cognitive content, or a new idea, in the receiving subject, in order to produce in-formation in his or her mind. Consequently, it is important to find out the additional conditions that data should comply with, in order to be informative.

Gregory Bateson (1904 – 1980) affirmed that “what we mean by information... is a *difference which makes a difference.*”<sup>67</sup> But, what kind of difference are we referring to? Luciano Floridi associates the “difference” with the data, and provides us with an essential condition, for the data to be transformed into information. He points out that information is provided when data *answer* an explicit or an implicit *question* made by the data receptor: “To become informative for an intelligent being a datum must be functionally associated with a relevant query.”<sup>68</sup> Accordingly, *data, to be informative, should be associated with a relevant question*, and—in Floridi’s terms—information consists of “*datum and relevant question... Computers certainly treats and ‘understand’ data; it is controversial whether there is a reasonable sense in which they can be said to understand information.*”<sup>69</sup> Computers might process data, but information is processed by the computer user, the individual, the person, the subject. According to Floridi “A datum is anything that makes a difference: a light in the dark, a black dot in a white page, a 1 opposed to 0, a sound in a silence...A datum can be defined as an answer without question: 12 is a sign that makes a difference, but it is not yet informative, for it could be the number of astrological signs, the size of a pair of shoes or a name of a bus route in London. We do not know which...12 become informative when once we know it is the answer to the question ‘how many apostles were there?’ ”<sup>70</sup>

As a way of doing an additional step in our attempt to pinpoint the nature of information and data, as well as the contrast between both concepts, it is good to try to integrate our

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<sup>66</sup> M. Kochen, 1983, “Information and society”, in Martha E. Williams, *Annual Rev. Sc. Techn.* 18 (1983) pp. 277-304; p. 278. Cited in S. D. Neill, 1992, *Dilemmas in the Study of Information: Exploring the Boundaries of Information Science*; New York: Greenwood Press.

<sup>67</sup> G. Bateson, (1904 – 1980), 1972, , *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution and Epistemology*, University of Chicago Press; pp.457-9; italics added.

<sup>68</sup> L. Floridi, 1999, *Philosophy and Computing, An Introduction*; London: Routledge, Taylor and Francis Group; p. 106.

<sup>69</sup> *Ibid.* Emphasis added.

<sup>70</sup> *Ibid.*

conclusions above with, Bateson's definition, and Floridi's erotetical one (i.e. a definition made according the logic of question and answers, according to erotetic logic). Doing so, we can draw the following conclusions:

- A datum is a '*given*' thing, not any 'given' thing, but the one that makes a *difference*. So, the genre of data is "to be given" and the characteristic that makes it specific (a species in such a genre) is that it should make a difference.
- Information is a *cognitive content*, not any cognitive content, but the one related to the *association of data and a relevant question*, be it implicit or explicit. So, the genre of information is cognitive content and the characteristic that makes it specific (species in such a genre) is the relevant question that the data answer.
- *Data* and information are two sides of the same coin: Data is the *objective* (including physical and mental objects<sup>71</sup>) side of the coin and *information* is its *subjective* side. This relation might be seen as analogous to the relation between the *signifier* (the objective side of a *sign*) and the *signified* (its subjective side), in semiotic terms.

Fletcher T.H. Cole (referencing Capurro and B. Hjørland<sup>72</sup>) affirmed that there is not a "great deal of attention being paid to the concept of data as such, compared with that paid to its troublesome cousins, 'information' and 'knowledge'." <sup>73</sup> Consequently, the author proposes to take "data" as a topic, i.e. as a notion or a concept which nature should be researched; and, after examining the present situation regarding "data", affirms that "The main outcome to locate conceptualizations of data in the account of those who handle it is to conclude that the concept-in-use is not one, but many." <sup>74</sup>

Balsun-Stanton and Bunker<sup>75</sup>, represents another example of authors who are recently making an emphasis on the importance of examining the nature of "data". They affirm that a Philosophy of Data (PoD) is important in the discipline of Information Systems, and propose to explore the roots of "data" among other related disciplines, as for example, Philosophy of Information, Information Science and Technology, Semiotics, Philosophy of Science, Philosophy of Technology, Information Theory, Information Systems, etc. They suggest that the essence of data lies on the intersection of these kinds of disciplines.

Brian Petheram discusses the close relationships between Information Systems modeling and the Philosophy of Information, claiming that "by focusing on modeling as a key

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<sup>71</sup> We will explain below what is related to mental objects (Section 11)

<sup>72</sup> Capurro and B. Hjørland, 2003,

<sup>73</sup> Fletcher T.H. Cole, 2008, "Taking "Data" (as a Topic): The Working Policies of Indifference, Purification and Differentiation," paper presented at the *19th Australasian Conference on Information Systems*; 3-5 Dec 2008, Christchurch; accessed on September 1, 2010 at <http://www.bsec.canterbury.ac.nz/acis2008/Papers/acis-0122-2008.pdf>

<sup>74</sup> Ibid.

<sup>75</sup> B. Ballsun-Stanton and D. Bunker, 2009, "Philosophy of Data (PoD) and Its Importance to the Discipline of Information Systems," *Proceedings of the Fifteenth Americas Conference on Information Systems*, San Francisco, California August 6th-9th 2009; accessed on August 31, 2010 at [www.ballsun.com/amcis2009Ballsun-StantonBunker.pdf](http://www.ballsun.com/amcis2009Ballsun-StantonBunker.pdf)

process of information systems development, ... the deployment of something akin to a 'philosophy' is inevitable.”<sup>76</sup> Referring to Petheram’s article, Balsun-Stanton and Bunker affirm that “he [Petheram] also shows the tight binding between the philosophies of the designers and programmers of data models and the models themselves, the outcome of which is to unconsciously influence the end-users’ interactions with their data. His [Petheram’s] contribution is to demonstrate that there is an acknowledged link between philosophy and data, that this link is underexplored, and is worthy of development.”<sup>77</sup> In our opinion, a Philosophy of Data (PoD) would certainly be an intellectual support for the Philosophy of Information, and vice versa. Any further clarification regarding the notion of data would certainly help in the clarification of the notion of information, and vice versa.

## 5. Information and form

As a way of capturing more of the essential nature of “information”, it is suggested to examine the meaning of ‘form’, because, as we mentioned above, ‘information’ derives from *a composite of ‘in-’ and ‘formā’*. The term “form” (which etymologically signifies: “shape, mold,”) means “the shape and structure of something as distinguished from its material.”<sup>78</sup> Horacio used the term ‘*formā*’ to describe “shoe last”; Ovid employed it as ‘mold’ or ‘stamp for coins’; and Cicero applied it to something opposite to the notion of content.<sup>79</sup>

The notion of form has a long philosophical, logical and methodological history, and this is not the place to cover it, not even succinctly. So, we will draw just some crude thumbnail sketch of its most basic meaning that is related to our purpose in this essay. Greek philosophers used the term ‘form’ to distinguish between external and internal figures. So, *from its very beginning, form was related to a mental figure*, or to the non-tangible figure of an object. The Greek term “εἶδος” (*eidōs*) has been translated to Latin as “*idea*” or “*formā*”, i.e. “*idea*” and “*form*” were taken as synonyms in order to translate *eidōs*. In this context, “in-formation” would mean “in-idea” or “in-ideation”.

Ferrater-Mora distinguishes three basic senses of the term “form”: the philosophical, the logical and the methodological.<sup>80</sup> From a philosophical perspective “form” is contrasted with “figure”. In this context, “figure” (μορφή, *morfé*) is conceived as the external aspect of an object, and “form” (εἶδος, *eidōs*) as its internal aspect, or its essence. This seems to be a *polar opposition* between two aspects of an object: an object has both of them: the

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<sup>76</sup> Petheram, B., 1997, “Backing into philosophy via information systems,” in R. Winder, S.K. Probert and I.A. Beeson (Eds.) *Philosophical aspects of information systems*, Taylor & Francis, Inc., 113-116; referenced by B. Ballsun-Stanton and D. Bunker, 2009, op. cit.

<sup>77</sup> B. Ballsun-Stanton and D. Bunker, 2009, op. cit.

<sup>78</sup> Merriam-Webster, 1999,

<sup>79</sup> E. M. Hobart and Z. S. Schiffman, 1998, *Information ages: Literacy, numeracy, and the computer revolution*. Baltimore: Johns Hopkins University Press. Referenced by Collins, , p. 4.

<sup>80</sup> Ferrater-Mora, op. cit Vol. I, p. 716



external *morfé* and the internal *eidos*,<sup>81</sup> the external figure and the internal form. This in turn seems to be analogous (but not equivalent) to the pair data-information, where information is understood as a cognitive reality and data as an externally given physical reality.

In its logical sense, the term “*form*” is understood (in Classical Logic) as that something that does not change in judgments, while its “content” may change. For example, in the judgment “Socrates is mortal”, “is” is the unchangeable form, while “Socrates” and “mortal” are the changeable content. In First Order Predicate Logic, “quantifiers” are examples of unchangeable “form” (hence the name of Formal Logic) and “variables” represent what is changeable. Consequently, in *Formal Logic*, “*form*” represents what is permanent, unchangeable, in contrast to what is variable, non-permanent, and changeable.

In its methodological sense, the term “form” has been used to represent a “way”, a “method” of knowing. Cassirer<sup>82</sup>, for example, affirms that two principal kinds of methods have been mainly used in trying to understand or to conceive reality: 1) those based on the “cause” and 2) those based on the “form”. Old and medieval philosophies and sciences have been oriented by the second one, and modern and present philosophies and sciences have been oriented mainly by the first one. But, the crisis in the contemporaneous sciences originated some deviations from the modern cause-based sciences. The use of the concept of structure, *gestalt*, field, totality, wholeness, system, emergent properties, patterns, etc. are examples of studies oriented by the “form” and not by just the “cause”. Simultaneously, the *efficient cause* is being complemented by the *final cause*, as is the case of the pragmatic-teleological approaches to Engineering Philosophy, Systems Engineering, System Sciences, etc.; “*form*” and “*telos*” seem to be re-emerging in contemporary philosophy and science, not to substitute the efficient cause, but to complement it.

Consequently, it is not a farfetched idea to re-take the Aristotelian Notion of the Four Causes and to try reinterpreting it under the light of the present scientific and philosophical advancements. It would probably be a fruitful idea to re-conceive the notion of “information” by means of the Four Aristotelian Causes; which might provide the conceptual structure to achieve a systemic coherence among the different senses that have been associated with the term of “in-formation”. Combining the material (physical), efficient, formal, and final cause could provide the conceptual coherence needed for the basic conceptual infra-structure that might support the variety of the senses found in the meaning of “information”. We will expand this suggestion a little bit below as related to Plato’s notion of Form, and Bertrand Russell interpretation of it.

Plato’s Theory of Forms is the base of his realist ontology of universals. Plato believed that in all chairs, for example, should be an essence, a form, which is what they have in common. A concrete chair is a chair, because it “participates in” the Form of chair.

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<sup>81</sup> Ferrater-Mora, op. cit Vol. I, p. 658

<sup>82</sup> referenced by Ferrater-Mora, op. cit., Vol. I, p. 658

Plato's "Forms are ideal 'patterns', unchanging, timeless, and perfect."<sup>83</sup> Plato's "forms" exist independently of thought and since they are incorporeal and imperceptible "we can come to have knowledge of them only through thought."<sup>84</sup> The mental patterns we have, which are related to the Forms (that have non mental existence) are imperfect and temporal. Mental patterns are 'shadows' of the real Forms. Real Forms are distilled in our minds where mental ideas imperfectly represent them. In this context, "*In-Formation*" would be the thought processes and products by means of which we imperfectly apprehend in our mind the perfect real Forms. If there is any kind of order or forms out there, then "information" might mean not just 'interpreted data', or 'data plus meaning' but also "in-forms," "in-orders," "in-pattern," "in-organization," i.e. mental forms, orderings, patterns, or organizations.

Bertrand Russell affirms that Plato's Theory of Forms "is partly logical and partly metaphysical. The logical part has to do with the *meaning* in general words."<sup>85</sup> Consequently, Plato's Theory of Forms is relevant in this essay because 1) we are trying to find the *meaning* of "information" and 2) because the notion of "*form*" is an essential ingredient of this meaning. Russell provides a concise and clear description of Plato's conception of "form". Referring to the logical part of Plato's theory, he says that "the arguments in its favor...are strong and quite independent of the metaphysical part of the doctrine."<sup>86</sup> To briefly explain the logical part of this doctrine, he wrote: "There are many individual animals of whom we can truly say 'this is a cat.' What do we mean by the word 'cat'? Obviously something different from each different cat. An animal is a cat, it would seem, because it participates in a general nature common to all cats. Language cannot get without general words such as 'cat,' and such words are evidently no meaningless. But if the word 'cat' means anything, it means something which is not this or that cat, but some kind of universal cattiness. This is not born when a particular cat is born, and it does not die when it dies. In fact, it has no position in space and time; it is 'eternal.' "<sup>87</sup> Analogously, we might suggest that if the word "form" means anything, it means something which is not this or that particular form, this triangle or that circle, this logical form or that one, but some kind of universal form-ness. This is not born when a particular form is born, and it does not die when it dies. Logic is not born with any particular logic, and it does not die with it. In fact, it has no position in space and time; it is "eternal". By means of analogical and plausible reasoning, we might paraphrase Russell saying that if the word "information" means anything, it means something which is not this or that information, this or that definition of information, but some kind of universal in-formativeness; which is not born when a particular information, or definition of information, is born, and it does not die when it dies. The property of in-formativeness has no position in space and time; it may be thought as "eternal." Recent theories related to the universality of "information" seem to be coherent with a platonic perspective of "information." On the other hand, it is evident that the word "information" (and its use in

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<sup>83</sup> R. Audi, (General Editor), 1999, *The Cambridge Dictionary of Philosophy*; Second Edition, Cambridge: University Press; p.315.

<sup>84</sup> Ibid., p. 710

<sup>85</sup> B. Russell, 1945, *The History of Western Philosophy*, New York: A Touchstone Book, Simon & Shuster; p. 121 (italics added)

<sup>86</sup> Ibid.

<sup>87</sup> Ibid.

everyday, scientific, technological and philosophical languages) predates posterior senses, definitions, and uses of the term.

According to Plato's Theory of Forms, Aristotle's Logic, and, in general, Traditional Predicate Logic, this cat is an animal; that cat is also an animal, but an animal is not necessarily a cat. ***If "H is information" is true, it does not necessarily imply or mean that "Information is H"***. Although, this is evident in Logic some authors in the information literature do not seem to be alert with regards to this issue. Mathematical definitions of information, for example, should be taken with care because they might generate this kind of confusion in some readers and even in some authors. We will return to this issue later in this essay.

Below are several important points Aristotle introduced. Aristotle introduced several aspects which will be important for us below, in following sessions. He expanded the meaning of 'form' to include the objective world in its domain. He worked with the pair matter/form in an analogous way to what later would be the pair content/form. A physical object has matter and form, tangible and intangible presence. As we said above, he also conceived four causes: the material, the formal, the efficient, and the final. The final cause (the purpose) determines the idea, the form, and the efficient cause acts on the material cause in order to produce what is sought for, i.e. the form and, consequently, the '*telos*', the end. In this way, ***the form, which can be a mental idea first, might generate its physical-objective counterpart, and vice versa***. This conception is very important in our attempt to transcend the implicit and explicit controversy with regards to the meaning that "information" has, or should have, as well as to cohesively relate its *subjective* and *objective* conceptions, or its mental and physical perspectives. Our purpose in identifying this kind of relationships is to present a hypothesis regarding *a systemic integrative meaning of information*; which is among our main aims in this essay.

Actually, in human communication, the production of information would require a 1) *telos* related to the sender and the receiver, i.e. a purpose in the sender to communicate, and a purpose in the receiver to receive the message (final cause); 2) an idea, a form, an information, to be communicated (formal cause); 3) physical means to be used in order to transmit the idea (material cause); and 4) the human energy required for the exteriorization of the idea and the physical energy required to transmit it between two subjects (efficient cause).

The Scholastic controversy<sup>88</sup> with regards to the issue of whether matter and form can be separated might also be illustrative to our purpose. Can a *mathematical form* that describes, or defines, "information" be separated from its empirical domain as to represent or to model any kind of information no matter if its substratum is organic or inorganic, mental or non-mental, subjective or objective, physical or non-physical, logical or non-logical, etc.? Can we measure information with a mathematical form (or model) independently from what is being measured? Is there a *Universal* mathematical form of measuring information? Can information be conceived as a Platonic Form which is manifested in different (and imperfect) ways in the tangible empirical world? Some

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<sup>88</sup> Ferrater-Mora, op. Cit., p. 718.

authors seem to be, implicitly or explicitly, holding this kind of conception when they try to reduce any kind of information supported by any kind of reality with a given mathematical form, definition, or conception of information. Can we represent any kind of information by a mathematical form?

Another Scholastic controversy regarding the *unity* or the *plurality* of the form (in metaphysical and theological contexts) is also interesting and suggestive. Aquina, for example, conceived the Unicity of Form, while John Peckham affirmed the plurality of forms. By analogical thinking, it is not plausible to see similarities with what some authors are proposing regarding a unique concept of “information” permeating the whole Universe. Seth Lloyd, for example, affirms, in his book, *Programming the Universe*, that “The conventional history of the universe pays great attention to energy: How much is there? Where is it? What is it doing? By contrast, by the story of the universe told in this book, the primary actor in the physical history of the universe is *information*. Ultimately, information and energy play complementary roles in the universe: Energy makes physical systems do things. Information tells them what to do.”<sup>89</sup> Then, Lloyd adds “Energy and information are by nature (no pun intended) intertwined.”<sup>90</sup> Hence, energy and information cannot be separated. Is there any similarity with Aquinas's doctrine of the inseparability of matter and form? If we are referring just to The mathematical form by means of which we are defining “information”, are there any analogies with Aquinas's doctrine of the “Unicity of Form”? Are we talking about a unique mathematical form of defining information? Are we referring to “information” and “meta-information” unicity, or universal unity? Are we back to some kind of scholastic controversy but under the light of new scientific concepts and theories?

Francis Bacon conceived the “notion of form” as the essence of nature and, consequently, a very important one, especially in the inductive inferences required by physical science.<sup>91</sup> “Natural science is split up by Bacon into physics and metaphysics. The former investigates variable and particular causes, the latter reflects on general and constant ones, for which the term *form* is used. *Forms* are more general than the four Aristotelian causes and that is why Bacon's discussion of the forms of substances as the most general properties of matter is the last step for the human mind when investigating nature... At the summit of Bacon's pyramid of knowledge are the laws of nature (the most general principles). At its base the pyramid starts with observations, moves on to invariant relations and then to more inclusive correlations until it reaches the stage of forms.”<sup>92</sup> Consequently, Bacon conceives “forms” as “laws of nature”, “the last step for the human mind when investigating nature”. Combining the etymological meaning of “information” with the way Bacon conceived “form” we can conclude that, in a Baconian sense, **“information” might be interpreted as inductive inferences we make from our observations, or sense data**. We communicate these “inductive inferences” by means of

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<sup>89</sup> Seth Lloyd, 2007, *Programming the universe*; New York: Vintage Books; A Division of Random House, Inc; p. 40 (Lloyd's italics)

<sup>90</sup> Lloyd, p.44

<sup>91</sup> Ferrater-Mora, op. cit., p. 718

<sup>92</sup> *Stanford Encyclopedia of Philosophy*; 2003 “Francis Bacon”, (First published Mon Dec 29, 2003), accessed on September 18<sup>th</sup>, 2010 at <http://plato.stanford.edu/entries/francis-bacon/>

communications systems (symbols which meaning are agreed on by convention, codes, languages, etc.) supported by physical communications systems (vocal cords, air waves, eardrums; telegraph; phone switches, signals and cables; electrical and/or computing communication systems, etc.) If we find a way of measuring one important property of electrical and/or communications systems, is it alright to call this property “information.” As it is known (and as we will briefly describe it below) Shannon found a very useful measure for engineering efficient electrical communication systems oriented to support communications systems, but is it alright to call “information” this measure with no distinctive adjective? Is it alright to call “information” one way of measuring one of the properties of one of the physical means of those that supporting human “information” communication processes? We will try later to suggest answers to some of these questions and propose different terms which may generate less confusion and, as a consequence, less potential non-sense.

For Kant, “form and matter are equivalent to structure and content. (a) Matter is identified with sensation, and forms with conceptions which order sensation. (b) Space and form are presented as the pure forms of sensibility. (c) The categories are presented as pure forms of the understanding.”<sup>93</sup> Hence, from a Kantian perspective, forms are associated with conceptions, concepts, conceptual structures, and categories.<sup>94</sup> Combining the etymological meaning of in-formation with the Kantian perspective of form we might suggest that information is associated with 1) conceptions, which, as such, are formed by a human cognition to order sensations (sense-data); or with 2) conceptual categories, which, as such, are a priori forms of understanding by means of forming concepts and ordering sensations or concepts. Consequently, from this suggested perspective, **in-formation is associated 1) with a priori and a posteriori concepts, and orders; and 2) with conceiving and ordering.**

*One of the basic reasons why human beings communicate with each other is to get informed and to in-form others, i.e. to get external forms into their minds (or brains, via neural nets) and to contribute to, or influence, processes by means of which other human beings get in-formations, i.e. external forms into their minds or brains.*<sup>95</sup> To achieve this

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<sup>93</sup> W. L. Reese, 1996, *Dictionary of Philosophy and Religion*, New York: Humanity Books; Expanded edition; p.235.

<sup>94</sup> “A system of categories is a complete list of highest kinds or genera. Traditionally, following Aristotle, these have been thought of as highest genera of entities (in the widest sense of the term), so that a system of categories undertaken in this realist spirit would ideally provide an inventory of everything there is...Skepticism about the possibilities for discerning the different categories of ‘reality itself’ has led others to approach category systems not with the aim of cataloging the highest kinds in the world itself, but rather with the aim of elucidating the categories of our conceptual system. Thus Kant makes the shift to a conceptualist approach by drawing out the categories that are *a priori* necessary for any possible cognition of objects. Since such categories are guaranteed to apply to any possible object of cognition, they retain a certain sort of ontological import, although this application is limited to phenomena, not the thing in itself.” *Stanford Encyclopedia of Philosophy*; 2009, “Categories”, (First published Thu Jun 3, 2004; substantive revision Mon Jan 5, 2009); accessed on September 19<sup>th</sup>, 2010 at <http://plato.stanford.edu/entries/categories/>

<sup>95</sup> Based in the etymological and traditional meaning of “information” we might pre-hypothetically think that two persons communicate with each other by means of interactive *in-forming* and *ex-forming* processes. Below we will try to clarify the meaning with which we are using the term “ex-formation.”

objective they use different means, symbols which meanings they agreed on via conventions, natural languages, codes, cryptography (when they want to keep secret the information they are communications), physical communication systems, computing processes, etc. Accordingly, *to be in-formed and to in-form is the end, and communications systems are means*. Different means are used simultaneously or as alternatives. Some means are parts of larger means. Electrical communications systems are part of larger socio-technical communication systems. The whole and its parts are more or less effective in supporting the informational objectives of the systems' end users.

Reviewing some of the literature related to the notion of information few questions raise in our mind, some of which were raised before. Shouldn't we take care to not confuse the communicational end with its means? Is it alright to confuse one part of the communicational systems with the whole where it is mechanically or organically inserted? Is it acceptable to identify the 'data' to be, or being, transmitted in a communicational process with the concept of 'information'? Is it adequate to name a part with the same name of the whole? Is that not an implicit use of synecdoche in a technical, conceptual, and non-rhetorical context? Would that generate confusion and hidden non-sense in meta-information processes? Is it not misleading to refer to a species with the same name of its genre and with no additional adjective?

“IS-A” and “HAS-A” are very well known logical relationships, which are much used in computing as, for example, in database design and object programming. The concepts of file, its records, and its attributes are distinguished with three different names. By both logical and analogical thinking, shouldn't we be doing a similar thing between informational systems and processes, as *wholes*, and informational subsystems and sub-processes as *parts and between genre and its species*? *Is it alright to use the word “information” for what is transmitted in human communication systems, and to use the same word “information” as a measure of a property of some of its physical parts*”? *From the conceptual, or logical, perspective, is it alright to use the same term for designating a genre and one of its species? Doesn't that represent a source of potential conceptual confusion, miscommunications, misguiding, and misinforming?*

## 6. Information and Human Communication

The concepts, or notions, of “information” and “communication” emerge and are used in many disciplines; including psychology, cognitive sciences, economics, linguistics, semiotics, and communications engineering. Awareness about the universality of these concepts have existed for a long time, but with the emergence of the mathematical definitions and theories regarding both concepts, and the accelerated innovations in Information and Communication Technologies, an increasing pressure has been mounting toward the reduction of both notions to their mathematical definitions in Communication Engineering; and, hence, to the physical perspectives of the related processes and products. This is why Cherry affirms (and explicitly emphasizes that he will do so by using italic fonts) that *“the various aspects of communication [and information], as*

***they are studied under different disciplines, by no means form a unified study; there is a certain common ground which shows promise of fertility, nothing more.***<sup>96</sup>

Consequently, it is not wise to review, evaluate, or judge an article from the unique perspective of the reviewer or from definitions given by any author, no matter how prestigious is this author and no matter how important and useful have been his, or her, mathematical definitions, in a given discipline. Shannon's mathematical theory of communication and mathematical definition of information, for example, should be restricted to the domains of *Electric Communication Engineering* and *Physics*, and be used just as inspiring analogical means in other disciplines, especially those related to *human communications*.

In physical informational processes, and specifically those related to electronic signals transmission and processing, the meaning shared by the communicants, as well as the purposes involved in the communicational process, are not taken into account. But, in human communications, the essential ingredients are the shared meanings and communicant purposes involved. *Physical processes and technological systems support human communications or part of it, but human communication cannot and should not be reduced to it.* Information and Communication technologies might be a *necessary condition* in the present process of Globalization, but they are definitely *not a sufficient one*. Consequently, the conception, the notion, and the theories of human communication cannot, and should not, be reduced to its physical components, or to the electronic signal processing and transmission involved. The whole should not be reduced to some of its parts. *Necessary conditions should not be taken as also sufficient ones.*

The essence of *natural* human communication, including the linguistic one (and what makes it differ from the ways other animals communicate), is "The ability to create common conceptual background—joint attention, shared experience, common cultural knowledge."<sup>97</sup> ***Human beings communicate through what is common to them, in order to make common what is not common yet.*** Human communications is "a fundamentally cooperative enterprise, operating most naturally and smoothly within the context of (mutually assumed common conceptual ground, and (2) mutually assumed *cooperative communicative motives*...Specifically, human cooperation is structured by what some modern philosophers of action call *shared intentionality* ... [which] is what is necessary for engaging in uniquely human forms of collaborative activity in which a plural subject 'we' is involved: joint **goals**, joint **intentions**, mutual knowledge, shared beliefs...The skills and motivations of shared intentionality thus constitute what we may call the cooperative infrastructure of human communication."<sup>98</sup>

Consequently, shared *intentions*, *motives*, and *goals or objectives* are essential ingredients of the infrastructure that supports human communications.

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<sup>96</sup> C. Cherry, p. 2 (Italics are Cherry's; emphasis added)

<sup>97</sup> M. Tomasello, 2008, *Origins of human Communication*, Cambridge: Massachusetts: The MIT Press, p. 5

<sup>98</sup> *Ibid.*, p. 6-7 (italics and emphasis added)

The starting point and forming part of the essence of human communication processes are mental ones, and, as such, they are necessarily *intentional*. According to Brentano<sup>99</sup>, a *mental (psychic) phenomenon is—unlike the physical ones—an intentionality, i.e. they refer to an object, or objective*. A perception is always a “perception of” something; for example, a conscience—as Husserl<sup>100</sup> emphasized—is always a “conscience of” something.

Mental phenomena, unlike physical ones, *exist* always *in* the mind (and/or in the brain). This is why the scholastics called them “*in-existence*” which should not be confused with “non-existence” or absence of existence. In its scholastic sense, “in-existence” means “existent-in” other things<sup>101</sup>. Brentano emphasized this scholastic sense: “this intentional existence—he wrote—is exclusively characteristic of mental phenomena. No physical phenomenon manifests anything similar. Consequently, we can define mental phenomena by saying that they are such phenomena as to “intentionally include an object within themselves.”<sup>102</sup> *Since human communications requires mental phenomena, they intentionally include objects in themselves. These objects are the ideas, the in-formation to be shared, the signs to be used to ex-press them, and the receiver (s) with whom these are intended to be shared with.* In the context of human communication, the scholastic sense of in-existence, or existence-in the mind, might be associated with ***in-formation as intentional formation-in-the-mind, or intentional form existing-in the mind.***

Jonathan Cohen affirms that “mental states differ from most other entities in the world in having semantic and intentional properties: they have meanings, they are about other things, they have satisfactions- or truth-conditions, they have representational content.”<sup>103</sup>. Since the notion of information has been used in both human and physical communication, several authors are trying to generalize the intentional as a natural phenomenon, and not just as a mental one. Jonathan Cohen affirms that there have been “several attempts to naturalize the intentional in terms of information [...] One of the systematic attempts to understand the intentional content in terms of information occurs in Fred’s Dretske’s seminal *Knowledge and the flow of Information*”<sup>104</sup> And he adds that “Many contemporary philosophers believe that informational theories are the most promising proposals for reconciling naturalism with intentional realism.”<sup>105</sup> We will try to address this issue with more details in a next version of this essay or in another one.

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<sup>99</sup> Franz Brentano; *Psychologie Vom Empirischen Standpunkt*; II, 1. (Translated to Spanish by J. Gaos and quoted by Ferrater-Mora, op. cit. 1969, )

<sup>100</sup> Edmund Husserl; 1900, *Logische Untersuchungen*, Halle, Germany. (Translated to Spanish by Morente-Gaos and quoted by Ferrater-Mora, op. cit.)

<sup>101</sup> See, for example, William of Ockham; “Inexistentia” in Leon Baudry: *Lexique Philosophique de Guillaume d’Ockham*, 1958, p.121 (Quoted in José Ferrater Mora, 1980, op. cit. vol.2, p.1680.

<sup>102</sup> Brentano, , vol. I, Book II, Ch. I (Quoted by Bruce Aune, “Intention” in *The Encyclopedia of Philosophy*; New York: Macmillan Pub. Co. and The Free Press, 1967, Vol. 4, pp. 198-201.)

<sup>103</sup> J. Cohen, 2004, “Information and Content,” in L. Floridi (ed.): *Philosophy of Computing and Information*; Malden, Massachusetts: Blackwell Publishing, pp. 215-227; p. 215.

<sup>104</sup> Ibid. pp. 215-6. J. Cohen is referring to the same Dretske’s work we referred about above.

<sup>105</sup> Ibid. P. 223.



The concept of “intention” is a central notion in phenomenology, which strongly opposes any kind of reductionism, and any way of isolating the subject from the object. The perceiver/knower is always perceiving/known something. To be a perceiver/knower is to be related to what is perceived/known. To be a subject is to be necessarily related to an object; and to be an object is to be related to a subject. There is neither an isolated subject (as such) nor an isolated object (as such). In the case of the communicational intention, the sender is always *immediately* related to a common language (or any other shared sign system) which is *mediating* between him, or her, and the receiver. Consequently, the sender, receiver, and what is common to them are not be separated or reduced to each other. This aspect of the phenomenological intellectual perspective is in complete harmony with the systemic approach we were following and which will be shown in more details below, especially in section 11.

The characteristic of “intention”, relating subject and object (be it language or the receiver), generates ambiguities in the meaning of the term, which is sometimes used to refer to the subject’s mental potential, act or content; and other times it is used to refer to the object (language, technological support system, the receiver) or to the circumstances or conditions. This equivocalness of “intention” has been recognized since the scholastics<sup>106</sup>, up to the present<sup>107</sup>. Since the notions of human communication and intention are so strongly related and conjoined, it is not surprising that the senses of the notion of communication and information (in the context of human communication) are also so equivocal, as we will show below, and especially in section 10, where we will resume our findings with regards to this issue.

Resuming with terms that will be the mostly used in this essay we can notice that the notion of “intention” relates the knower with the known, the perceiver with the perceived, and the subject with the object. We might add that in the context of human communication, the notion of “intention” relates the communicators, the message/information sender with its receiver, the informer with the information, and this, in turn, with the informed. Consequently, we will include the notion of “intention” into the more analytical context we will develop below (e.g. figures 4, 5, 6, and 7).

As we mentioned above, according to Michael Tomasello,<sup>108</sup> *motives* and *objectives* are also, along with *intention*, basic ingredients in the human communication infrastructure. He concludes that the most basic motives in human communication are three: 1) a request of requesting help or information, 2) offering help or information, and 3) providing information with the objective of sharing emotions, feelings, and attitudes.<sup>109</sup> The communicator might have any of these three kinds of basic objectives in human communication, or a combination of them. To achieve his/her *objectives*, the communicator has several *means*. The most immediate and necessary means he/she has is the language and/or any other semiotic systems, which simultaneously *potentiate* and

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<sup>106</sup> See, for example, in St. Thomas Aquinas and St. Bonaventure. (Referenced by José Ferrater-Mora, 1980, op. cit., vol.2, p.1680

<sup>107</sup> See, for example, Bruce Aune, 1967,

<sup>108</sup> M. Tomasello, 2008, op. cit.

<sup>109</sup> Ibid., p. 87.

restrict his/her ex-pression possibilities. Ideas, forms, and in-formation existent-in and/or processed in his/her mind are to be ex-pressed as to have external existence so it can be accessed by the receiver. The communicator tries to externalize his/her internal ideas, feelings, and/or thought via forms which are in (internal to) his/her mind (subjective information) by means of words and non-verbal signs. Consequently, he/she is restricted to: 1) the internal forms he/she has in his/her mind and in his aptitude in using them effectively, 2) the capacity (and noise level) of the external means transporting his words and other kind of messages, and 3) the level of commonality shared by the receiver as well as his/her intention, aptitude, attitude, and objectives in the communicational process. Consequently, from the communicator or message sender perspective, he/she has a communicational *objective*, verbal and non-verbal signs repertoire from which he/she must *select* (decide) the most adequate ones in order to *maximize* his/her communicational effectiveness while subject to the mentioned *constraints*. To make the best decisions in the context of objectives and constraints is at the very essence of the Operations Research (and Management Science) conceptual framework, and at the center of human problem solving.

“Man is a goal-seeking organism ... A great bulk of what we do in life involves us in talking, arguing, soliloquizing.”<sup>110</sup> Explicit, or implicit, decisions are continually being made regarding the selections of what we estimate are the most effective means for achieving our objectives. Human communication is a means used by human beings to achieve their objectives, but, in many occasions, it also is an end in itself which requires effective means to be accomplished. In general, the relationship between means and ends is a cybernetic one; with co-regulative negative feedback (and feedforward) loops and synergic, co-developing positive feedback loops (figure 1).

The means include: 1) *what* should be done (the way, the form of achieving the ends, plans, methodologies), 2) the *resources* to be used and their limits, which will restrict the *selection/decision* domain, and 3) the activities required for the respective *implementation*. Objectives, decisions to be taken to achieve them, restrictions of the resources to be used, and implementation activities represent the conceptual infrastructure of Operations Research. By analogical thinking, and plausible reasoning, these basic ingredients that relate objectives with means might also be associated to the Aristotelian Cause: teleological, formal, material, and efficient cause.

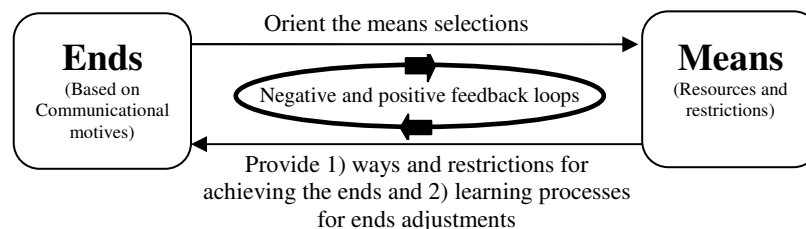


Figure 1

<sup>110</sup> C. Cherry, , p. 103.

The Operation Research general approach to human problem solving, and its conceptual infra-structure, can be applied as an ingredient in understanding how human beings have been solving their communicational problems. In this conceptual structure, and in the domain of ends-means logic, means should be subordinated to its ends. The learning process generated by the implementation of the means might advise the learner to modify, change or even eliminate the previously sought end, but *the means should always be subordinated to the ends. Otherwise, we might create confusions, create problems instead of contributing to solving them, find unfeasible solutions, or solve some problems but creating others in the context of the “solution.”* In the Operations Research Approach, *objectives*, and *means (resources and their restrictions)* should be clearly and explicitly differentiated in order to adequately relate them in a verbal or mathematical modeling of any problematic situation. Analogously, ends and means in human communication should not be confused, or reversed in their subordinating relation. *Physical communicational channels are means, not ends. Electronic data processing is a means not an end in itself.* Abstractions that prove to help in solving problems in physical communications channels are not necessarily adequate for dealing, understanding, or providing support to human communications. In any case, the problem, as a whole, should not be reduced to a special solution of one of its parts. Human Communication processes should not be reduced to efficient solutions found for their physical channels.

When the problem is a communicational one, ends and means (resources and restrictions) are seldom the same between communicants. Taking into account this fact, the diagram in figure 1 should be redrawn as in figure 2. Some **common** cognitive and physical means are required in the **communicational** processes between (and among) **communicants**. The more common means are shared, the more *efficient* is the communicational process. And, the more ends are shared; the more *effective* is the communicational process.

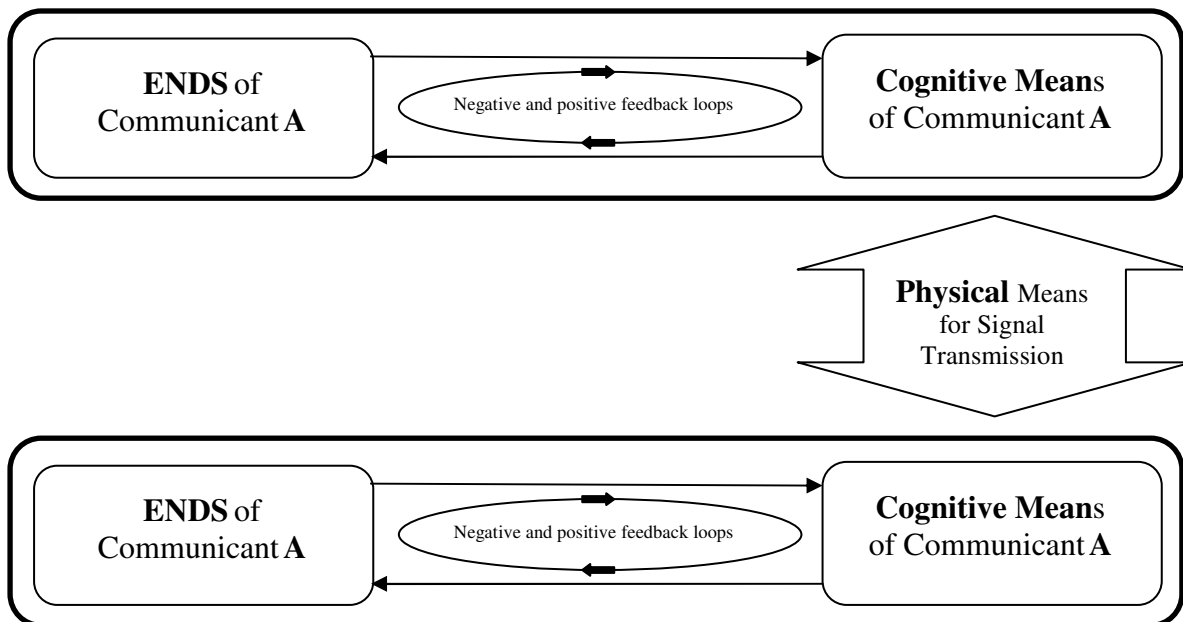


Figure 2

The physical means relating two (or more) communicants might be natural and/or artificial ones. Engineers, who provide the design and implementation of communication supporting technologies, or artificial communication systems, also have their objectives when doing their engineering activities and they use specialized means in their activities. Among these means are scientific theories, abstraction processes, and mathematical definitions and modeling, all of which require conceptual definitions with such a precision and specification as to allow the engineer to measure the associated properties. Consequently, the concept of “information” has been, as we will see in the next sections, highly specified in the context of *communication technologies, i.e. technologies that support and enhance human communication. **Communication and Information Technologies are means, the objective is human communication, and this fact should be reiterated and kept in mind.** Communication and information systems engineers may have different professional objectives and use different means, but they should keep in mind that the technologies they are producing and the systems they are developing and deploying are just means for their users’ objectives.* This seems to be an evident fact, but it is frequently not taken into account, especially in the analysis and synthesis of software-based information systems. Software Engineering is a means in the context of Information Systems, not an end in itself. E-learning software, for example, is a means in the educational processes, not an end in itself; it can be part of educational systems and processes and, as such, *support them, but it should not substitute them.*

When people need information, offers information, or provides information in order to share emotion, feelings, and attitudes (as a consequence of his/her basic motives in human communications<sup>111</sup>), they carry the following basic activities:

1. They *select* the mental forms (ideas, forms-in the mind) they want to inform about. *Restrictions*, in this mental activity, are related to: 1) the speaker’s, or writer’s, previous experience and knowledge, and 2) the syntactical, semantic, and pragmatic levels of the signs to be used in their respective communication<sup>112</sup>. The syntactic-semantic restrictions (rules) are less flexible in scientific thinking and communication; which are more disciplined and restricted by some logical rules, scientific “laws”, theories, conceptual/mathematical definitions, accepted measures and ways of measuring, accepted methods, etc. As it is known in Operations Research, restrictions defines , and/or delimit, a *feasible decisional space* from which the speaker/writer can *select* the mental forms (ideas, forms-in the mind) to be shared. Different scientific disciplines have different *feasible* syntactic/semantic spaces. Overlapping, or commonalities, between these syntactic/semantic spaces allows

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<sup>111</sup> M. Tomasello, 2008, op. cit., p. 87

<sup>112</sup> As it is known, three levels are established in Semiotics (the science of signs). Many good books have been written on Semiotics. Let us here just remind the reader that 1) Syntactics is the study of signs and the relations among them; 2) Semantics is the study of signs and the relations between them and their referents, the objects the signs refer to, the *designata*; and 3) Pragmatics is the study of signs and the relations between them and their users, i.e. the human beings using them.

interdisciplinary communication. Semiotic commonalities between Science and Engineering communicate both of them. Scientific and engineering *semiotic feasible spaces* are more restricted than the semiotic feasible space of natural language, but they should have commonalities with it in order to include the pragmatic level of their communication, as well as their relationships with their human and societal context.

2. They *select* the transmission means to share their ideas, feelings or attitudes, from a *feasible* set of means (face-to-face spoken language, written language, telephone, telegraph, emails, texting, etc). They *ex-press* them in order to transmit them. They *ex-teriorize* them in order to transmit them via external signs (e.g. spoken or written language. We do not transmit our thought, ideas, feelings, or attitudes. We transmit physical signals that represent them via common codes. Words are represented by physical signals. Words are not physical entities. We do not hear or see words, but the physical signals that represent them. Words are linguistic components, not physical entities. Concepts are cognitive, not physical entities. Words and concepts are represented by physical signals according to a shared or a common code.<sup>113</sup> We communicate what is not common to us (via *ex-formation/in-formation*) through what is common to us (common code for interpreting physical signals). A person *ex-press* (*ex-form*) an idea, a concept, a feeling, or an attitude, by means of ***trans-forming mental forms into physical forms***, and in doing so he/she is restricted by his ability in selecting the most adequate phrases, words and, hence, their respective physical embodiment. In this *trans-formation* a person tries to minimize the difference between what he/she is trying to share and with what he/she actually is saying, writing, and/or nonverbal signaling, i.e., in this first communicative step a communicant tries to be as effective (and efficient) as possible when choosing the physical external forms (physical *ex-forms*) to represent his/her internal, mental forms (*in-forms*). The communicational effort of a person depends, at least, on 1) the quantity of options he/she has, 2) the adequacy of the selections made by him/her, 3) and his/her willingness to *ex-press* him/herself adequately, and the efforts and time he/she is willing to invest in achieving his/her communicational objectives.
3. They *select* the recipient(s) or the potential recipient(s) – the ‘audience’, of their message (or the information they want to share) – from a feasible set of possible recipients.
4. The recipient *selects* the meaning of the information received, according to his/her past experience, to the neuronal forms-in his brain, or form-in his/her mind, via 1) a process of pattern, or form, *recognition*, and 2) *cognitive* processes generating new forms in the mind, or neural nets in the brain. Forms already-in the mind (or the brain) are related to the newly acquired or apprehended forms. Before receiving the information, the recipient had what we can call a *prior state of mental (or neural) forms*, and after receiving the information the recipient usually would have a different *posterior state of mental (or neural) forms*. Expectancies, uncertainties, and subjective probabilities related to possible future events are associated to the recipient’s prior state of mental (or neural) forms, which provide the recipient with a

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<sup>113</sup> Adaptation based on Tomasello’s perspective, op. cit.

“certain initial state of preparedness or prior state of beliefs” as Collin Cherry named it.<sup>114</sup> The new information (forms-in the mind) changes the prior state of beliefs to a *posterior state of beliefs*, i.e. it changes the initial preparedness to a new state of preparedness of the recipient 1) for receiving new signs and/or 2) for action; “Such a change we perhaps may interpret as a kind of pragmatic-information content of the signs.”<sup>115</sup> The feasible set of semiotic and praxiological potential alternatives usually change with changes between a priori and a posteriori states of beliefs. This change may include the recipient’s beliefs about the sender’s beliefs, including subjective factors as, for example, confidence, respect, admiration, suspicion, etc.<sup>116</sup> Cherry affirms: “Your hearing of an utterance [or your reading of a text or seeing of visual signs], as a physical event, has then two results; it has changed your state of belief and it has *selected* an overt response in you. This total change of states, mental and physical, we have...[is] identified with the ‘*the meaning of the utterance to the recipient*’.”<sup>117</sup>

5. The recipients *select* the kind of future action to be taken after he/she had received the message, or the information. This selection includes the possibility of no making any selection. If the recipient selects to share some information and/or shows gestures and non-verbal signs evoked by the received information, then he/she could produce a change in the receiver’s state of preparedness for other signs or his/her state of belief; and, consequently, a cyclic goal-seeking process continues, in which both communicants might dynamically change their communicational objectives and/or their respective feasible sets of communicational (cognitive and physical) means, including their states of beliefs.
6. They might *select* a methodology for verifying and validating that the human receiver got the right message, or, at least, a sufficiently adequate one, i.e. 1) the transmission of physical signals was adequate enough with an acceptable level of noise and errors, and 2) the transformation of the physical signals, or forms (physical embodiment of the forms) into the receiver’s mental forms (forms-in the mind of the receiver) are close enough to the initial forms-in the mind of the sender who wanted to share them.

As we can notice from the communicational activities shortly described above, different kinds of **selections** permeate communicational informational processes. The concept of “selection” (along with the notion of “form”) is common to different senses, or interpretations, of the word “information”. *This is why the terms “form” and “selection” can be abstracted from the term “information” as two of the most general properties of the notion of “information”.* This is, in our opinion, why Cherry affirms that “‘Information’ in most, if not in all, of its connotation seems to rest upon the notion of *selection power*.”<sup>118</sup> Selections require decisions in a human being context. Decisions might be made before the respective selections are implemented. Since decisions are

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<sup>114</sup> C. Cherry, p. 250 (italics are Cherry’s)

<sup>115</sup> Ibid.

<sup>116</sup> Ibid.

<sup>117</sup> Ibid. (italics added)

<sup>118</sup> Ibid. p. 244 (italics are Cherry’s)

always restricted to a feasible set of alternatives; so are selections. Referring to Shannon's Theory of Communications, Weaver frequently reiterates that "information is related to one's freedom of *choice* when one *selects* a message."<sup>119</sup> Shannon also emphasizes that his mathematical definition of "information" is "a reasonable *measure of choice or information*."<sup>120</sup> William Dembski affirms that "To generate information is to *rule out possibilities*"<sup>121</sup>. This can only be done by selecting what possibilities to rule out and what possibilities not to rule out. The studies of the authors we have just mentioned are at the syntactic level, and we will return to them in the next section. At the semantic and at the pragmatic levels, selection is a necessary conceptual ingredient in the notion of "information". Cherry affirms that "In the Carnap-Bar-Hillel semantic theory, the information content of statements relates to the selective power they exert upon ensembles of states."<sup>122</sup> At the pragmatic level, a source of information has a certain value depending on its *usefulness* to its users, especially with regards to "the power it gives to the recipient to select his future action, out of a whole range of prior uncertainty as to what action to take."<sup>123</sup> This important issue will be reiterated later, especially in section 12 where we will be stressing the practical consequences of the systemic notion of "information" being presented in the essay.

Resuming, we can point out that human communication requires, at least, 1) *forms-in* the sender's mind, from which to make *selections*, 2) *forms-in* the physical means (physical embodiment of the information) transmitting the physical signals, from which the sender will *select* the most adequate signals, and 3) *forms-in* the receiver's mind, that will allow him/her to *select* future actions. It also requires at least two transformation processes: from mental forms to physical ones, and vice versa. It is very usual that more transformations are made between different physical forms.

So, for those who conceive the concept of information as a *subjective* attribute, i.e. as something depending on the subject perceiving the data, or as something human and *always* existing in the mind of a human being, communication between a human sender and a receiver involves sharing information between these two human beings, by means of physical signal processing. With this perspective, *Information* is related to forms-in the mind of a human being, and *data* are physical forms used to represent mental forms of the sender, and to be '*given*' to the receiver as input for their transformation into forms-in his/her mind. Data are transmitted and processed physically. From the receiver perspective, data are "given" to him/her, but from the sender perspective, data are

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<sup>119</sup> W. Weaver, 1949, "Recent Contributions to The Mathematical Theory of Communications," in C. E. Shannon and W. Weaver, 1949, "The Mathematical Theory of Communication," Urbana and Chicago: The University of Illinois Press; pp. 3-28; p. 9; (Italics added).

<sup>120</sup> Claude E. Shannon, 1948, "A Mathematical Theory of Communication" *The Bell System Technical Journal*, Vol. 27, pp. 379-423, 623-656, July, October, 1948. Reprinted with corrections and published at <http://cm.bell-labs.com/cm/ms/what/shannonday/shannon1948.pdf> (Accessed on September 12, 2010).

Also in C. E. Shannon and W. Weaver, 1949, "The Mathematical Theory of Communication," Urbana and Chicago: The University of Illinois Press; p. 51 (italics added)

<sup>121</sup> W. A. Dembski, 2002, *No Free Lunch: Why Specified Complexity Cannot Be Purchased without Intelligence*; Lanham, Maryland: Rowman & Littlefield Publishers, Inc., p. 125 (italic added),

<sup>122</sup> C. Cherry, op. cit. p. 245.

<sup>123</sup> Ibid.

generated via ex-formation, or trans-formation of mental forms into physical forms or signs. Data communicate communicants; mediate between them in their communicational processes. In this sense, data is the physical counterpart of in-formation, and in-formation is the mental counterpart of data.

On the other hand, for those who conceive (as we will see below) “information” as an *objective* property, i.e. as a universal property like energy and matter, information is everywhere, in and out of their minds, in the biological and the physical world. *According to its objective conception, Information is related to forms that might be physically, biologically, or mentally embodied.* From this perspective, information can be processed by human beings, by biological organisms, by machines, or by the Universe as a whole. Someone might wonder, in such a perspective, what would be the meaning of *data electronic processing*? Is it a species of electronic information processing? What would be the specific difference, i.e. what would differentiate data electronic processing as a species of electronic information processing? What would be the meaning of “databases”? One possible answer is that data can be information *given* to someone, but not given to another, who might generate it, or not perceive it at all. So *data would be a locally relational concept and information universal one.*

The two main perspectives with regards to information, the subjective and the objective one, might both co-exist and be both valid in different contexts, as long as possible confusions are avoided by making it explicit in which sense the concept of “information” is used and, most important, in what sense it is not used. We find this concern in many important authors, who repeat once and again the specific sense in which they are using the word “information”. But, it is a pity that readers and reviewers are still confused and—worst—getting more people in their conceptual confusions and uni-dimensional restrictive and reductionist conception of “information”. We have been pointing to some of these conceptual confusions and we still continue to do so, and reiterating some of them, in this essay, because they are causing harm, not just in the intellectual dimension, but also in the pragmatic one, especially in the development, implementation, and deployment of information systems which are always inserted in the context of human communication, and because they are blocking adequate interdisciplinary communications between disciplinarians from different scientific, engineering, and humanistic areas.

Computer based (or EDP-based, or software-based) information systems cannot, and should not be des-contextualized from its main function, which is to support human communication. Electronic data processing, software engineering, and electrical communication systems engineering are among the means used in the development of effective information systems. They are not ends in themselves. They *support* information systems, which in turn *support* human communication. Consequently, the objectives of information systems engineers are to satisfy the requirements of the (human beings) users of the respective information systems. The basic cybernetic relationships shown in Figure 1 and Figure 2 between ends and means should be present in the minds of information systems engineers and the ends should be those of the system users, not those of the engineers. *Engineering objectives should be a consequence of the users’*



*objectives for using the system. Means and ends should not be confused, nor should users' objectives be confused with those of the engineers.*

## 7. Information and Communications Theory

As we indicated above, when a person tries to communicate with other (s) he/she transmits acoustic, visual, and electrical signals, i.e. physical embodiments of the messages intended to be shared. A message is based on a cognitive *selection* of ideas and their linguistic representations which result in the respective selection from an alphabet, which is consequently *put in-physical-form* (physical in-formation), i.e. signals as sound, ink, light, electricity, etc. for their respective transmission. The message is reflected as sequential selections of signals. If the same alphabet exists at both transmissions (transmitting and receiving) ends, and the transmission is correct, then the message (and the information) can be shared between communicants. Consequently, reliable physical channels (for the correct signals transmission) are *necessary conditions* for human communication, but they are not *sufficient conditions* for it, as we have shown above. This, even if it is a truism, should be explicitly kept in mind.

Physical channels supporting human communication are the focus of what is called Communication Theory, where the term “information” has a very specific and precise definition. The everyday use of the word “information” is a more general one, where we relate it to adjectives like valuable, timely, reliable, useful, applicable, interesting, precise, accurate, etc. These terms are appropriate when the word “information” is used in the context of human communication. But, these terms are not relevant to the communication engineers whose objective is related to ***efficient and correct transmission of physical signals***, or electrical signals that represent the message to be transmitted. The human purpose, value, usefulness, etc. of the message to be transmitted are not addressed in communication engineering or by the related communication theory. Communication engineers are concerned with the ***efficiency*** and correctness of physical signal transmissions, not with the ***effectiveness*** of what is transmitted. *The effectiveness of communication engineers is not related to the effectiveness of the human communicants* because communication engineers' objectives are related to the ***efficiency and correctness of the physical signal*** to be transmitted and not to the objectives of the human communicants while trying to communicate with each other.

The origin of communication theory is in telegraphy, where the engineering objective was to specify with precision the *capacity* of telecommunication systems to communicate physical signals (physical-form or physical in-formation) in order to make it common to its sender and receiver. Precise specification of this capacity was required in order to be able to *measure* it. It is known that “The first attempt to formulate a measure mathematically was made by Hartley in 1928.”<sup>124,125</sup> Since then, an increasing number of

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<sup>124</sup> Cherry, op. cit. p. 7.

<sup>125</sup> R. V. L Hartley, 1928, “Transmission of Information,” *Bell System Technical Journal*, July 1928, p. 535. Accessed on September 9, 2011 at [www.dotrose.com/etext/90\\_Miscellaneous/transmission\\_of\\_information\\_1928b.pdf](http://www.dotrose.com/etext/90_Miscellaneous/transmission_of_information_1928b.pdf)

authors are showing an objective orientation in their conception of the notion of “information”. Shannon’s mathematical definition of information is at the roots of this perspective, and “Information & Communication Technologies” authors provided its strong impulse. Shannon, in his 1948 paper, “A Mathematical Theory of Communication,”<sup>126</sup> provided a mathematical definition of “information” but, as his co-author Warren Weaver affirmed, “[T]he word *information*, in this theory, is used in a special sense that must not be confused with its ordinary usage. In particular, *information* must not be confused with meaning.”<sup>127</sup> Shannon’s technical and *specific* sense of “information” should not be confused with other specific senses or with the *general* concept or notion of “information.” ***What Shannon defined is information (or a property of it) but information is not necessarily what was defined by Shannon. A is B does not necessarily means B is A.*** This seems a truism, but is not always observed when defining terms by one of its senses and then using the definition for a more general meaning of the same term.

Shannon provided a technical definition of information to be used in the context of engineering physical communication systems. He explicitly excluded any other use of his definition of information in other contexts. He warned the reader with regards to this issue affirming that “Frequently the messages have *meaning*; that is they refer to or are correlated according to some system with certain physical or conceptual entities. These **semantic aspects of communication are irrelevant to the engineering problem.**”<sup>128</sup> Shannon proposed the use of binary digits for *coding* information. Morse’s code is another well-known form of coding and communicating forms or information. Natural languages are also codes used for communication among human beings. Codes are *means* for the communicational *end*. Effective means and their ends are related to each other, but should not be confused with each other. Informational codes, informational transport means, informing processes, and information are related but different concepts. The first two are means for achieving the third, which in turn is a means for the information needs of human beings in the context of their purposes, aims, and objectives. Means are not ends in themselves, and their effectiveness (and, hence, their reason for existing, their “*raison d’etre*”) depends on the degree of their adequateness to their human ends.

Engineering activities are especially oriented to fulfill human needs and requirements. Electrical communication systems, like those designed by electrical engineers, including Shannon, are *means* for fulfilling communicational human *needs* and *requirements*. So, the engineering designs of these systems are, or should be, done in the context of its human being users. Consequently, although the “semantic aspects of communication are irrelevant to the engineering problem,” (numero de cita) the related activities of designing and implementing physical communication systems, *is not irrelevant to the human users of these systems and it is not irrelevant to the notion of “information” in a human context.* Consequently, a comprehensive (systemic) notion of “information” should not be reduced to its technical sense or to the mathematical definition required in engineering of efficient and reliable communication systems by means of *electrical signals*

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<sup>126</sup> Claude E. Shannon, op.cit.

<sup>127</sup> W. Weaver, 1949, op. cit. p. 8 (italics are Weaver’s)

<sup>128</sup> Shannon and Weaver, p. 31. (italics are Shannon’s; emphasis added)

*transportation systems*. Shannon's "concern was with the **transport** of information [related to the code embodied in sequences of electrical signals]—specifically, how much information could be moved from sender to receiver via a noisy channel."<sup>129</sup> To do so, he gave a mathematical definition of "information" (in the technical sense he was using in his engineering problem) relating it to signal probabilities. Leon Brillouin alerted about this kind of information definition naming it "*absolute objective definition, independent of the observer*."<sup>130</sup> "[T]he 'value' of the information, on the other hand—he adds—is obviously a *subjective* element, relative to the observer...elements of human value are ignored by the present theory [Shannon's] . This does not mean they have to be ignored forever, for the moment—he affirms—they have not been carefully investigated and classified. These problems will probably be next on the program of scientific investigation."<sup>131</sup> (introduccion) Consequently, we will keep an intermittent eye on the human value of the "information", on its subjective dimension, while briefly describing (via a thumbnail sketch) how it has been defined in physical communications systems.

The works of Nyquist<sup>132</sup>, Kupfmuller<sup>133</sup>, and Hartley<sup>134</sup> represent the origins of the mathematical definitions of "information", in the context of electrical communication systems. Shannon made it explicit that the Mathematical Theory of Communication he was proposing "is contained in the important papers of Nyquist and Hartley."<sup>135</sup> It was explicit, in all these papers, that the authors were dealing with electrical communication systems and that what they were working on and proposing was limited and restricted to the kind of electronic communication systems they were engineering. Hartley, for example, reiterated that he is presenting a "quantitative measure of 'information' ... which *is based on physical as contrasted with psychological considerations* [...] What I hope to accomplish—he added—in this direction is to set up a quantitative measure whereby the capacities of various [physical] systems to *transmit* [physical] information may be compared...When we speak of the capacity of system to transmit information [via physical code or electrical signals] we imply some quantitative measure of information. As commonly used *information is a very elastic term*, and it will be necessary be necessary to set up for it a more specific meaning as applied to the present discussion,"<sup>136</sup> i.e. to the *transport* of information (in the sense of physical forms) via a code embodied in sequences of electrical signals. Hartley then provides the mental and physical contexts of his later physical considerations. Describing the general context of his engineering problem he affirms that:

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<sup>129</sup> T. Stonier, T., 1997, *Information and Meaning: An Evolutionary Perspective*. London: Springer; p. 7.

<sup>130</sup> L. Brillouin, 1956, *Science and Information Theory*, New York: Academic Press Inc.; p. xi (italics added)

<sup>131</sup> Ibid. (italics added)

<sup>132</sup> H. Nyquist, 1924, "Certain Factors Affecting Telegraph Speed," *Bell System Technical Journal*, April 1924, p. 324; and "Certain Topics in Telegraph Transmission Theory," *A.I.E.E. Trans.*, v. 47, April 1928, p. 617. Referenced in Shannon, op. cit. p. 31

<sup>133</sup> K. Kupfmuller, 1924, *Über Einschwingvorgänge in Wellenfiltern* (Transient phenomena in wave filters). *Elek Nachrichtentech*, 1, 141–152. Referenced by Collins,

<sup>134</sup> R. V. L Hartley, 1928,

<sup>135</sup> Shannon and Weaver, p. 31

<sup>136</sup> R. V. L Hartley, 1928, , pp.535-6. (Italics added)

“In the first place, there must be a group of *physical* symbols, such as words, dots and dashes or the like which by general agreement convey certain meanings to the parties communicating. In any given communication the sender *mentally select* a particular and some *bodily* motion, as of his vocal mechanism, causes the *attention* of the receiver to be directed to that particular symbol. By *successive selections* a sequence of [physical] symbols is brought to the listener’s *attention*. At each selection there are eliminated all the other symbols which might have been *chosen*. As the *selections* proceed more and more possible sequences are eliminated, and we say that the information [that the receiver gets] becomes more *precise*...For two persons who speak different languages the number of [common] symbols available [and which meanings are agreed upon] is negligible as compared with that of persons who speaks the same language.”<sup>137</sup>

It is evident, then, that the context for Hartley is the informational interaction among human beings, and signals transporting systems are *means* for the *end* of supporting human communications. Selection of symbols and sequence of symbols is made by a human being in order to get the attention of another human being and to transmit information to him or her. *Physical* symbols, which by general agreement convey certain **common meanings** allows different human beings to **communicate**. The more symbols with *common* meanings, the more information can be *communicated* among parties. Consequently, a measure of the capacity for transporting symbols (with common meanings), the more information can be communicated during a time period. And the more reliable is the transportation of physical symbols (the larger the percentage of received symbols that are equal to the sent symbols), the higher the quality of the informational communication process. A measure of the physical symbols transportation process is required for engineering, as well as for efficient and effective physical communication systems. This was, and still is, the main objective of communications engineers. The works of Nyquist, Kupfmuller, Hartley, Shannon, etc. have been motivated and oriented by this kind of objective.

Hartley concludes the section (in his seminal paper, “*Transmission of Information*”<sup>138</sup>) titled “*Elimination of Psychological Factors*” affirming that “in estimating the *capacity of the physical system* to transmit information [via physical symbols] we should *ignore the question of interpretation*, make each selection perfectly *arbitrary*, and base our result on the possibility of the receiver’s distinguishing the result of selecting any one symbol from that of selecting other. By this means the psychological factors and their variation are eliminated and it becomes possible to set up a definite quantitative ***measure of information based on physical considerations alone***.”<sup>139</sup> So, it could not be more evident that Hartley was addressing just the physical transportation component of information communicational systems. His alert with regards to this issue could not be more clear, explicit, and precise. We could do a similar affirmation with regards to Shannon. He

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<sup>137</sup> Ibid., p.536. (Italics added)

<sup>138</sup> Ibid.

<sup>139</sup> Ibid., p. 538. (Italics and emphasis added)

made comparable alerts regarding his Mathematical Theory of Communication. It is really surprising that some inattentive readers do not get this alert and try to generalize to non-physical domains the definitions that have been explicitly made for the specific and restricted case of physical systems.

With the objective and the alert given above, Hartley proposes to examine the option of considering the *number of possible symbol sequences* as a measure of the information involved in its transmission. If the number of symbols is S and the number of selections in each sequence is n, then the number of all possible sequences is  $s^n$ . For example if we have two symbols (Y for yes and N for no) and we make 3 selections from these two symbols, we will have  $2^3$  possible sequences, as follow:

YYY, YYN, YNY, YNN, NYY, NYN, NNY, NNN

But, with this measure, Hartley observes, “the amount of information transmitted would increase exponentially with the number of selections and a contribution of a single selection to the total information transmitted would progressively increase...In order then for a measure of information to be of a *practical engineering value* should be it should be of such a nature that the information is proportional to the number of selections.”<sup>140</sup> Hartley affirms that the way human beings deal with this exponential growing of the quantity of information and with the number of selections is by means of limiting this number to comparatively short communicational periods. Examples of successive communicational periods are short consecutive phrases that require short attention spans, notations indicating chunks of texts, etc. But, since Hartley is explicitly removing psychological factors, he proceeds to use other forms of dealing with the exponential nature of the measure he initially proposed. Taking this issue into account, and after observing some other mathematical conveniences, he proposes the logarithm of the *number of possible symbol sequences* as a measure of the information involved in its transmission, i.e. if H is “the amount of information associated with n selections” then:

$$H = \log s^n = n \log S$$

In the specific case where just one selection is made, then:

$$H = \log s = -\log 1/S$$

And if any of symbols in S has the same probability of being selected, then:

$$p = 1/S, \text{ and } H = -\log p \text{ (if and only if } p_1 + p_2 + \dots + p_s = 1)$$

Where p is the equi-probability with which any symbol (belonging to the set of symbols S) would be selected.

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<sup>140</sup> Ibid., P. 539. (Italics and emphasis added)

Based on Hartley's and Nyquist's works, as Shannon explicitly observes, he develops what he called "A mathematical Theory of Communication"<sup>141</sup> in the title of his very seminal initial paper (what has latter been called "THE mathematical Theory of Communication."<sup>142</sup>) As we have already indicated above, Shannon also warned the reader that he is not taking into account the meaning associated with the notion of information because it is irrelevant to the engineering problem he faced when designing physical communication systems. He clearly and explicitly affirmed right at the beginning of his seminal paper that the "**semantic aspects of communication are irrelevant to the engineering problem**" he was facing. So, it is evident again that Hartley and Shannon were dealing with a very *specific* case of information, and not with its *general* meaning. Consequently, what Shannon defined as information should be used just in the context of physical communication systems. Any other application of Shannon's concept of information should be done via Analogical Thinking. Shannon's definition of information is a specific one, which should not be confused with a general one. Accordingly, "*Shannon's-definition-of-information is information*" *but information is not necessarily "Shannon's-definition-of-information."* *Let us repeat once again what seems a truism: "A is B" does not necessarily means "B is A, and it does not imply it,"* as every student of Logics would know. Let us keep Hartley's and Shannon's explicit warning and its logical consequence in mind.

Warren Weaver, referring to Shannon's theory, affirms that the "word information in communication theory relates not so much to what you *do* say, as to what you *could* say."<sup>143</sup> That is, information is a measure of one's freedom of choice when one selects a message. Whose freedom of choice is Weaver referring to? Is he referring to the informing human being? If so, then we are facing a contradiction between the warning given right at the beginning of Shannon's article (which is repeated in Weaver's paper) and what he just affirmed. Is meaning removed from Shannon's definition or not? If Shannon's information is related to "*what YOU could say*", then YOU, as a human being, are meaning something with the information you are transmitting. To remove this apparent contradiction we might think that Weaver is implicitly referring to what the designing engineer thinks with regards to what the user could say. In such a case, the possibilities of message selections (or choice) that the user could make are those that the designing engineer is providing him/her, with. Consequently, *the user's "freedom of choice" is limited to the set of symbols the engineers is providing him/ her, with.* This limitation is not a critical one because a natural language user is also restricted to the words and syntax of the language being used, and the user's knowledge regarding this language. So, it is not critical that the communication engineer decides the set of symbols that the user may use, but *it is conceptually important to notice this implicit fact in order to avoid possible confusion in the reader,* and in those who are trying to apply Shannon's mathematical definition or theory in domains which different to that of the physical communication systems.

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<sup>141</sup> See Shannon's original paper at <http://cm.bell-labs.com/cm/ms/what/shannonday/shannon1948.pdf> (Accessed on September 22, 2010).

<sup>142</sup> See C. E. Shannon and W. Weaver, 1963, *The Mathematical Theory of Communication*; Urbana and Chicago: University of Illinois Press.

<sup>143</sup> *Ibid.*, p. 8

If the communication engineer provides the respective user with just one alternative, there is no “freedom of choice” and, consequently, the user of the communication system cannot use it to inform or communicate a message selected by him, or her. Then, there should be *at least two possible symbols* or messages from which the user can choose an alternative. The communication systems user should have a *minimum* of two alternatives in order to be able to inform anything (at least in Shannon’s conception of information).

The communication engineer can limit the user to two options and let the user to “choose” a sequence of binary “selections” to convey information requiring more than two options, but what the communication engineer should not do is to limit the user’s freedom to choose among the two alternatives by limiting the user to pre-established relative frequencies of the number of times he, or she, can use any of the two alternatives. Consequently, the communication engineer must suppose that the two symbols, or messages, will be used with the same frequency. This means that symbols, or messages, 1 and 2, associated with each of the two choosing alternatives should have a priori probabilities  $p_1 = p_2 = 0.5$ . Similarly, if the user has  $n$  symbols, or messages, from which to choose (and the communication engineer, want to maximize the user’s freedom of choice, not limiting his/her freedom to choose among the  $n$  symbols with pre-established relative frequencies of the number of times he/she, can use any of the  $n$  alternatives) the a priori probabilities should be all the same; which means:

$$p_1 = p_2 = p_3 = \dots = p_n = 1/n$$

Consequently, in order to provide the user with a *maximum* freedom of choice, the communication engineer should provide him with a set of symbols with the same probability (equi-probable) in which each symbol might be selected. As we will see below, this is an equi-probable set of symbols will be identifies as a set of symbols with maximum entropy, or disorder. Hence, we will see that *maximum entropy* in the set of symbols to be used, are required for a *maximum user’s freedom to choose*, which can be related to the *maximum information capacity*; which in turn is not necessarily the same as the quantity of information *delivered*, transported, o received. This will be examined below with more.

If the information provided by choosing symbol  $i$  is *measured* by:

$$-\log p_i \tag{1}$$

And, if there are  $n$  symbols from which selections, or choices, will be made, then the expected value of the measures related to the possible information we can deliver with the set of  $n$  symbols is:

$$-\sum_i p_i \log p_i \tag{2}$$

Where  $p_i$  is the probability of selecting symbol  $i$ .

If all symbols have the same probability, then  $p_i$  is  $1/n$  for all  $i$ . Consequently, the expected value in this specific case will be:

$$-\sum_i p_i \log p_i = -\sum_i 1/n \log 1/n = -\log 1/n = \log n \quad (3)$$

This means that “the amount of information is defined, in the simplest cases, to be measured by the logarithm of the number of available choices.”<sup>144</sup> For this specific case, note the similitude with the definition and formulation made by Hartley.

Shannon tried to identify a “measure of how much ‘choice’ is involved in the selection of the event [the symbols] or of how uncertain we are of the outcome.”<sup>145</sup> In this phrase, Shannon seems to be referring simultaneously to the ‘choice’ to be made by the *sender*, and the ‘uncertainty’ that the *receiver* (or the communication engineer?) has with regards to the outcome of such a choice. In any case, he certainly seems to be looking for the same measure for both “how much choice” the sender has and “how much uncertainty” the receiver has. If we find such a *common* measure, should we *equate* the concept of ‘choice’ with that of ‘uncertainty’? *Can we equate two concepts just because we found a common measure for both of them?*

With the objective of this kind of measure in mind, Shannon examined the possibility of finding a measure  $H(p_1, p_2, p_3, \dots, p_n)$  with the following properties:

1. “ $H$  should be continuous in the  $p_i$ ”
2. “If all the  $p_i$  are equal,  $p_i = 1/n$ , then  $H$  should be a monotonic increasing function of  $n$ .”
3. “If a choice be broken down into two successive choices, the original  $H$  should be the weighted sum of the individual values of  $H$ .”<sup>146</sup>

Shannon affirms that it can be proved that such a measure is of the following form:

$$H = -K \sum_i p_i \log p_i \quad (4)$$

where  $k$  is a positive constant.

Shannon affirms that

“Quantities of the form  $H = -\sum_i p_i \log p_i$  (the constant  $K$  merely amounts to a choice of a unit of measure) play a central role in information theory as measure of *information*, *choice*, and *uncertainty*. The form of  $H$  will be recognized as that of *entropy*, as defined in certain formulation of statistical mechanics, where  $p_i$  is the probability of a system being in cell  $i$  of its phase space. The  $H$  is then, for example, the  $H$  in Boltzmann’s

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<sup>144</sup> Shannon and Weaver, 1949, op. cit, p. 9.

<sup>145</sup> Ibid, p. 49.

<sup>146</sup> Ibid, p 49



famous  $H$  theorem. We shall call  $H = -\sum_i p_i \log p_i$  the *entropy of the set of probabilities*  $p_1, \dots, p_n$ .<sup>147</sup>

Shannon's  $H = -K \sum_i p_i \log p_i$  seems to be presented by him as the *same form* of measuring quantities of *information, choice, uncertainty and informational entropy* (or entropy of the set of probabilities  $p_1, \dots, p_n$ ). If this is possible and makes sense, does it mean that we may equate the concepts of *information, choice, uncertainty and informational entropy*? Shannon also observes the mathematical isomorphism between the mathematical form of measuring information (or informational entropy) and that of the thermodynamic entropy, and seems to be hinting for their identification with each other when he writes: "The  $H$  is then, for example, the  $H$  in Boltzmann's famous  $H$  theorem." Again, should the reader of these Shannon's affirmations conclude that *information, choice, uncertainty, informational entropy, and thermodynamic entropy* are the same concepts, or some kind of synonyms? Should the reader identify informational entropy and thermodynamic entropy just because the isomorphism found regarding the mathematical form is describing them, or describing the way to measure them? Jeffrey Wicken has shown that: "While Shannon's equation is symbolically isomorphic with Boltzmann's equation, the meanings of the respective equations bear little in common."<sup>148</sup> Stonier affirms that: "Citing the work of Brush<sup>149</sup> ... Wicken points out that both Boltzmann and Shannon were independently using equations describing games of chance developed two centuries earlier by French mathematicians."<sup>150</sup>

The words selected by Shannon to refer to his mathematical definition and the identification of different concepts by the same mathematical definition has created semantic and conceptual confusions, and generated significant controversies. Thomas D. Schneider (from the National Institutes of Health), for example, affirms, referring to the words used by Shannon in his communications theory, that "**Information Is Not Entropy, Information Is Not Uncertainty!**"<sup>151</sup> Schneider also affirms that "There are many statements in the literature which say that information is the same as entropy. The reason for this was told by Tribus. The story goes that Shannon didn't know what to call his measure so he asked von Neumann, who said 'You should call it entropy ... [since] ... no one knows what entropy really is, so in a debate you will always have the advantage.'<sup>152</sup> Von Neumann's 'advice' is also reported by Jeremy Campbell,<sup>154</sup> and Floridi.<sup>155</sup>

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<sup>147</sup> Ibid. pp. 50-51 (emphasis added).

<sup>148</sup> J. Wicken, 1987, "Entropy and Information: suggestions for a Common Language," *Philosophy of Science*, 54, pp. 176-93. Quoted by T. Stonier, T., 1997, *Information and Meaning: An Evolutionary Perspective*. London: Springer; p. 13

<sup>149</sup> S. G. Brush, 1983, *Statistical Physics and the atomic theory of matter*, Princeton, New Jersey: Princeton University Press. Referenced by T. Stonier, T., 1997, , p.13.

<sup>150</sup> T. Stonier, T., 1997, , p.13.

<sup>151</sup> Thomas D. Schneider, 2009, "Information Is Not Entropy, Information Is Not Uncertainty!" accessed on September 23, 2010 at <http://www.lecb.ncicrf.gov/~toms/information.is.not.uncertainty.html>

<sup>152</sup> M. Tribus and C. McIrvine, 1971, "Energy and Information", *Scientific American*, vol. 225, No. 3, September, pp. 179-188, referenced in Schneider, 2009,

<sup>153</sup> Schneider, 2009,

<sup>154</sup> J. Campbell, 1982, *Grammatical Man: Information, Entropy, Language, and Life*, New York: Simon and Shuster, p. 32

<sup>155</sup> L. Floridi, 2010, *Information: A very Short Introduction*, Oxford: Oxford University Press, p. 46.

Stonier affirmed that “*a result of Von Neumann advice, the communications engineers and information theorists all became the victims of a bad joke*: that the potential indeterminacy of a message is the same thing as entropy. The confusion still reigns today ... Shannon’s sleight of hand has been attacked by a number of authorities,”<sup>156</sup> among of whom are the authors mentioned above. For example, Hubert P. Yockey, physicist and information theorist, who worked at the University of California, Berkeley, and under Robert Oppenheimer on the Manhattan Project, after carefully examining this issue concluded that “...there is, therefore, no relation between Maxwell-Boltzmann-Gibbs entropy of statistical mechanics and Shannon’s entropy of communications systems.”<sup>157</sup> Should we then differentiate between Shannon’s entropy and Maxwell-Boltzmann-Gibbs’s entropy, i.e. between informational and thermodynamic entropies?

These kinds of confusions and contradictions are even found among the same communications engineers and researchers working on the same kind of engineering problems at the same time. Norbert Wiener<sup>158</sup>, for example, affirms explicitly that “The notion of the amount of information attaches itself very naturally to a classical notion in statistical mechanics: that of *entropy*. Just as the amount of information in a system is a measure of its degree of organization, so the entropy of a system is a measure of its degree of disorganization ... **[The] amount of information, being the negative logarithm of a quantity which we may consider as a probability, is essentially a negative entropy.**”<sup>159</sup> So, does “information equal entropy”, as it has been identified in Shannon’s Theory? Or is it essentially “negative entropy” as Wiener affirmed? We conceive information, at least from a subjective perspective and, more generally, in a biological context, as Wiener’s conceived it. It is almost common sense. Entropy is related to disorder, and information to order. Entropy is related to disorganization, and information is associated with organization. Entropy is related to uncertainty and information is associated with certainty, or a decrease in the level of uncertainty.

In 1956, about eight years after Shannon’s and Wiener’s opposite conceptions regarding the relationship between information and entropy, Leon Brillouin published his book titled *Science and Information Theory*, where he affirmed that “We prove that information must be considered as a negative term in the entropy of a system; in short **information is negentropy** ... Entropy measures the lack of information.”<sup>160</sup> So, it seems that Brillouin takes Wiener’s side, in conceiving information as negative entropy.

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<sup>156</sup> T. Stonier, T., 1997, , p.13 (italics and emphasis added)

<sup>157</sup> Hubert P. Yocke, 1992, *Information Theory and Molecular Biology*, Cambridge University Press. Quoted by Stonier, 1997, , p.13.

<sup>158</sup> Norbert Wiener affirmed “we have made communication engineering design a statistical science, a branch of statistical mechanics...we had to develop a statistical theory of *the amount of information*, in which the unit amount was that transmitted as a single decision between alternatives. This idea occurred at about the same time to several writers, among them the statistician R. A. Fisher, Dr. Shannon of the Bell Telephone Laboratories, and the author.” In N. Wiener, 1948 and 1961, *Cybernetics: or Control and Communication in the Animal and the Machine*, Cambridge, Massachusetts: The MIT Press; p. 10. (italics are Wiener’s)

<sup>159</sup> N. Wiener, 1948 and 1961, op. cir., pp. 11 and 64. (italics are Wiener’s; emphasis added)

<sup>160</sup> L. Brillouin, 1956, *Science and Information Theory*, New York: Academic Press Inc., Second edition, 1962, p.xii (italics and emphasis added)

Consequently, in agreement with Wiener, with Brillouin, and with common sense we think that, if we are to relate information to entropy we should do it according to Wiener's and Brillouin's conceptions, i.e.

$$\text{Information} = \text{Negative Entropy}$$

One way, to avoid some of the confusions and contradictions, is to use another term in Shannon's Theory, instead of "information." Actually, Shannon referred to his theory as a "Mathematical Theory of Communication" and not "Information Theory", as it has been called later. If we prefer to use the word "information" in the context of Shannon's theory, or a similar theoretical context, it would be advisable to refer to it as Shannon's-Information or S-Information, or  $H$  as he symbolized it. Otherwise, the confusion and the contradictions will continue and many reflections and research hours will be wasted. Shannon's mathematical definition of information might also be designated as "*Rarity Information*," because, as Collin Cherry affirmed, "It represents what statisticians would call the 'expected value of the log-probability' of the signs from the sources; it measures its *statistical rarity*."<sup>161</sup> Shannon's "mathematical work should be interpreted with the greatest care...In this mathematical sense, information is measured in terms of the *statistical rarity* of signs."<sup>162</sup>

In the special case of equation (3) and for  $n = 2$  (the *minimum* number of alternatives in order to be able to choose and, hence, to inform), the average of the information that a system (a source) of 2 symbols, or messages, might provide is  $\log_2 2$ , and if the logarithmic base is 2, then  $\log_2 2 = 1$  which is the information unit called "bit", from Binary Unit (not to be confused with "bit" as "binary digit"). One bit, then, is the information measure unit associated with the *minimum* number of alternatives that a user might have in order to be able to inform; i.e. a bit is the information measure unit (if we use 2 as the logarithm), and the minimum quantity of information we can deliver because we need at least two alternatives to be able to communicate anything. With one alternative we can deliver no information at all. Two is the minimum integer larger than one.

This *minimum measure* of information (one bit) is the informing capacity of a two-state system (which can offer two alternatives to choose from) with *maximum entropy*.<sup>163</sup> As we indicated above, one-state system has no information capacity, because its user cannot make any kind of selection, if he/she, is the sender, and can have no information at all if the user is the receiver. Similarly, a two-state (or  $n$ -states) system where one of its states has a probability of one (then, the probabilities of all others are zero) cannot be used for providing any kind of information. Mathematically, the information is  $\log_2 1 = 0.00$  but conceptually is null, no information at all. Since this kind of deterministic system (the

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<sup>161</sup> C. Cherry, , p. 50 (Italics added)

<sup>162</sup> Ibid. p. 14 (Italics are Cherry's)

<sup>163</sup> We are using the word 'entropy' in its general meaning, not necessarily in its thermodynamic one. In this sense, a two-state system has a maximum entropy when we have maximum uncertainty regarding its possible outcome, i.e. it can be in any of its two states with exactly the same (a priori or a posteriori, subjective or objective, axiomatic or empirical) probability.

probability of one of its states is one, while all others have probabilities equal to zero) is not an entropic one, or has zero entropy, then its user can provide no information through it. Consequently, the entropy of the n-state system (used to generate and transport information) should have entropy larger than zero in order to be of any use. This kind of relationships is, in our opinion, what has generated some confusion in some readers who might have thought that the possibility of having the same *measure* (or isomorphic mathematical definition) for entropy and information would equate both concepts. We can use units of gallons or liters to measure the volume of both water and milk, but that does not mean that water is the same as milk. Equal measures of *containers volumes* should not be confused with the respective *contents*. ***“It is always important to distinguish between a physical property (attribute, quality) and a measure, unit, or magnitude of that property.”***<sup>164</sup>

Furthermore, the engineering problem that Shannon effectively addressed is related to communication “channel capacity”, so he was interested in *measuring* “storage capacity of the information source” and the “channel capacity” for transmitting the information delivered from the information source. Before defining information, in mathematical terms (so he can measure it), Shannon explicitly says “The question we now consider is how one can measure the capacity of such a channel to transmit information.”<sup>165</sup> Phrases like “channel capacity”, “capacity of a channel”, “channel has a capacity”, etc. have been mentioned about 80 times in the 55 pages of his seminal paper. **The generation capacity of the information source and the delivery capacity of the communication channel should not be confused with the information actually delivered.**

## 8. Information, Entropy, and Order

Because Shannon related (and mathematically identified) the concepts of Information and Entropy, the ambiguities and controversies associated to the latter added up to the equivocalness of the meaning of “information.”

### Ambiguities of the Term Entropy

Entropy has even been associated with mystery. Let us see some examples with regards to this issue:

- Brian Green, theoretical physicist, Professor at Columbia University, “a marvelously talented exponent of Science,”<sup>166</sup> who has “an unparalleled ability to

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<sup>164</sup> C. Cherry, , p. 10 (Italics and emphasis added)

<sup>165</sup> Shannon and Weaver, p. 36

<sup>166</sup> Newsweek’s comment with regards to Greene’s book titled *The Fabric of the Cosmos, Space, Time, and the Texture of Reality*

translate higher mathematics into everyday language,”<sup>167</sup> refers to Entropy as a feature among “...*the deepest unresolved mysteries in physics.*”<sup>168</sup>

- Peter William Atkins, Professor at the University of Oxford and a prolific writer of popular chemistry and textbooks affirms that “Mention of the Second Law [of Thermodynamics] raises visions of ... *infinitely incomprehensible entropy.*”<sup>169</sup>
- Tom Stonier writes: “*Entropy is one of the most misconstrued concepts encountered in the physical and engineering sciences.*”<sup>170</sup>
- Jeremy Campbell pointed out that “Entropy is a word which carries a large historical freight of good physics, profound paradox, dubious analogies, and flights of metaphysical fancy...entropy has been defined in dozens of different ways at various stages of its history. The debate about its ‘real’ nature is still unresolved after more than a century of inquiry and argument.”<sup>171</sup>
- Leon Cooper affirms that the ‘entropy’ means “*nothing.*”<sup>172</sup>
- Arieh Ben-Naim points out that “the word ‘entropy’ is unfortunately a misleading word,”<sup>173</sup> and asks “how come the mystery [regarding entropy] did not vanish with the embracing of Boltzmann’s interpretation of entropy?”<sup>174</sup>
- Arieh Ben-Naim, referring to Atkins’ *The Second Law* book, affirms that after reading it cover-to-cover, it “leaves the reader with the impression that entropy, like life, is hopelessly *difficult to understand and mysterious.*”<sup>175</sup> Consequently, Arieh Ben-Naim wrote a book trying to demystify entropy.<sup>176</sup>

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<sup>167</sup> Publishers Review’s comment with regards to Greene’s book titled *The Fabric of the Cosmos, Space, Time, and the Texture of Reality*

<sup>168</sup> B. Green, 2004, *The Fabric of the Cosmos, Space, Time, and the Texture of Reality*, New York, Vintage Books. A division of Random House. Green affirms that “even when it comes to every day, we are far from full understanding. And among the features of common experience that have resisted complete explanation is one that taps into *the deepest unresolved mysteries in modern physics*, the mystery that the great British physicist, Sir Arthur Eddington called the arrow of time” pp. 12-3 (italics added).

<sup>169</sup> P. W. Atkins, 1994, *The Second Law*, Scientific American Books, New York: W. H. Freeman and Co. Quoted by Arieh Ben-Naim, 2007, *Entropy Demystified: The Second Law Reduced to Plain Common Sense*, World Scientific Publishing Company; p. 192

<sup>170</sup> T. Stonier, 1990, *Information and the Internal Structure of the Universe*, London-Berlin, Springer-Verlag; p 34

<sup>171</sup> J. Campbell, op. cit., p. 32

<sup>172</sup> L. N. Cooper, 1968, *An Introduction to Meaning and Structure of Physics*, New York: Harper and Low; quoted by Arieh Ben-Naim, op. cit. p. 190

<sup>173</sup> A. Ben-Naim, op. cit. p. 190

<sup>174</sup> A. Ben-Naim, op. cit. p. 196

<sup>175</sup> A. Ben-Naim, op. cit. p. 194 (italics added)

<sup>176</sup> A. Ben-Naim, op. cit.

The following short definitions or descriptions of the concept of entropy are examples of the plurality found in the literature with regards to this concept, most of which are related in the context of the natural language being used:

- Merriam-Webster's Collegiate Dictionary<sup>177</sup> (1999, tenth edition, p. 387) provides two senses of the word "entropy" and three synonyms of it, as follows:
  1. "A **measure** of the unavailable energy in a closed thermodynamic system that is also usually considered to be a **measure** of the system's **disorder**, that is a property of the system's state, and that varies directly with any reversible change in heat in the system and inversely with the temperature of the system; *broadly* : the **degree of disorder or uncertainty** in a system"
  2. "a : the degradation of the matter and energy in the universe to an ultimate state of inert uniformity *b* : a process of degradation or running down or a trend to **disorder**."Synonyms: "**Chaos, Disorganization, Randomness.**"

We emphasized the words that most relate the notion of entropy with that of information, i.e. entropy is mostly related to levels of disorder, uncertainty, Chaos, Disorganization, and Randomness, especially when it is related or associated with information. Notice that, in spite of the different connotations of the word "entropy," it is a **measure**, in the first sense given by The Merriam-Webster's Collegiate Dictionary. In the second sense given by this dictionary it is not clear and explicit that entropy is a measure. However, in both senses provided by The Merriam-Webster's Collegiate Dictionary we find the word 'entropy' associated to 'disorder.' Arieh Ben-Naim think that "The association of Entropy with disorder is perhaps the oldest of the three [reasons of the unsettled controversies around the concept of entropy], and has its roots in Boltzmann interpretation of entropy."<sup>178</sup>

- The Oxford Companion to Philosophy provides the following definition and description: Entropy is "A **measure** of unavailable energy in a physical system ... *Entropy is defined in complementary ways*: as the ratio of heat change to absolute temperature; and as proportional to the statistical probability of system's state. The word also labels information theory's average information per symbol, which is defined by a formally similar probability function."<sup>179</sup> Consequently, the two main senses of the word "entropy" (according the Oxford Companion to Philosophy) are complementary to each other and related to Thermodynamics and Information Theory respectively. It is not clear what it is meant by "complementary ways." Does it mean serving to complete each other? Mutually supplying each other's lack? Requiring each other? Potentially substituting each other? Are they potentially equivalents? To try to answer these kinds of questions

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<sup>177</sup> Merriam-Webster's Collegiate Dictionary, 1999, tenth edition, Springfield, Massachusetts, p. 387 (italics are Merriam-Webster's, emphasis added)

<sup>178</sup> A. Ben-Naim, op. cit. p. 196.

<sup>179</sup> The Oxford Companion to Philosophy, New Edition, 2005, Ed. Bby Ted Honsrich; p. 255 (italics and emphasis added)

would very probably generate a plurality of answers that would lead to the sensation that entropy is one of “*the deepest unresolved mysteries in physics,*” “*one of the most misconstrued concepts*” in Science or engineering, or a “*hopelessly difficult to understand and mysterious*” concept.<sup>180</sup> But, in spite of the ambiguities that might be generated by the description provided by The Oxford Companion to Philosophy, a clear and explicit thing emerges again: entropy is a **measure**. The differences and the ambiguities are more related to what is being measured.

- Tamara Horowitz is explicit and clear with regards to the definition of ‘entropy’ as a measure, in both of its basic senses, in Thermodynamics and in Information Theory. She affirms (in the Cambridge Dictionary of Philosophy) that entropy is, “in physics, a **measure** of disorder; in information theory, a **measure** of ‘information’ in a technical sense.”<sup>181</sup> Consequently, it is clear and explicit that (following to Tamara Horowitz definition) entropy is a measure in any of its senses. Can we identify a measure of disorder with the property or the concept of disorder as it sometimes seems to be the case in some authors? Can we identify a measure of a technical and specific sense of information with the concept or notion of ‘information’ whatever it might be? Does ‘entropy’ have ontological reality? Does ‘entropy’ have any real existence? Wouldn’t we be *reifying* a mathematical expression created as a measure of some thermodynamic, informational, or even universal property? Does the liter, the gallon, the inch, the meter, etc. measures have any real existence? Or do they just measure the property of volume or length, respectively? We think that differentiating the measure from the property that is being measured might help in solving mystery and confusion surrounding the concepts of ‘entropy’ and ‘information’. The plurality of conceptual perspectives and confusions surrounding each of these two concepts reinforce each other when both of them are associated or, worse, identified or equated.
- The Nobel Laureate Murray Gell-Mann points out that “entropy can be regarded as a **measure of ignorance**...the entropy of the macrostate measures the degree of ignorance the microstate is in by counting the number of additional information needed to specify it, with all the microstates treated as equally probable.”<sup>182</sup> Again, entropy is defined as a measure, this time as a measure of ignorance, i.e. as a measure of a subjective property, as a measure related to the *observer* as differentiated from the *observed*.
- Ilya Prigogine, a Noble Laureate as well, referring the above Murray Gell-Mann’s texts, affirms that “We believe these arguments are untenable. They imply that it

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<sup>180</sup> See above for the important scientists who referred to the concept of entropy with this kind of qualifying phrases.

<sup>181</sup> T. Horowitz, 1999, “Entropy,” in *The Cambridge Dictionary of Philosophy*, Second Edition, Ed. By Robert Audi, Cambridge: University Press, 1999, pp. 267-8 (emphasis added)

<sup>182</sup> M. Gell-Mann, 1994, *The Quark and the Jaguar: Adventures in the Simple and the Complex*, New York: W. H. Freeman and Co., p. 219-200 (emphasis added)

is our own ignorance, our coarse graining, that leads to the second law. For a well informed observer, such as the demon imagined by Laplace, the world would appear as perfectly time reversible.”<sup>183</sup> According to Arieh Ben-Naim “The reason for these *diametrically contradictory views by two great Nobel prize winners* lies in the *misunderstanding* of the concept of information.”<sup>184</sup> So, misunderstanding the concept of information may lead to a diametrically opposing view with regards to entropy, and—we might add—misunderstandings and controversies with regards to the concept of entropy might lead to a diametrically opposite conceptual perspective with regards to information. Then, there might be a fertile ground for positive feedback loops between entropy and information as both are being controversially being understood and misunderstood.

As we suggested above, if we identify the concepts of information and entropy, the frequently reported “*mystery that has befogged entropy*,” adds up to also contribute to the befogging process of the concept of information, especially when this identification is based on isomorphic mathematical definitions of both concepts, and when this mathematical isomorphism is not taken just as input for *analogical* thinking, but as input for *logical* thinking. It is our opinion that equating both concepts is generating confusions in both of them. Arieh Ben-Naim has already noted that the association of Entropy to Information, or missing information, is one of the three factors contributing to the mystery and incompressibility surrounding entropy. Entropy is defined as quantity of heat divided by temperature. Consequently, if entropy is measured by units of energy over units of absolute temperature in Kelvin scale, i.e. J/K, then, how is it that a *dimensionless* (unit-less) measure of information can be associated, and even equated, with two-unit-based measure? Shannon was aware of this fact and, consequently, “recognized that his *measure* of information becomes identical with entropy only when it is multiplied by a constant  $k$  (...Boltzmann constant), which has the units of energy divided by temperature.”<sup>185</sup> Does that mean then that we can equate both concepts with no further considerations? Even if multiplying by Boltzmann constant we can equate both measures (which is not evident without further considerations) we should not equate both concepts. *Should we equate the concepts of milk and water just because we can have they share the property of volume, or the same volume measure?* The identification of the concepts of entropy and information gets more perplexing when we consider that we have no intellectual support for even just equating both kinds of *measures*. This is why this kind of intellectually non-acceptable situation has baffled an increasing number of authors, taking some of them to propose the differentiation of both concepts by different means. Arieh Ben-Naim, for example, proposes to eliminate the concept of entropy or reduce it to that of information. In his book titled “*A Farewell to Entropy: Statistical Thermodynamics Based on Information*” he explores this possibility and affirms that “‘entropy’ is a misnomer and should be replaced by either missing information or

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<sup>183</sup> I. Prigogine, 1996, *The End of Certainty: TIME, CHAOS, and the NEW LAWS of NATURE*, New York: The Free Press, p. 25

<sup>184</sup> A. Ben-Naim, op. cit., p. 202 (italics added)

<sup>185</sup> A. Ben-Naim, op. cit., p. 204 (italics added)



uncertainty. These are more appropriate terms for what is now referred to as ‘entropy’.”<sup>186</sup>

The problem surrounding the notion of entropy is not just a semantic or a conceptual one, but also, a controversially interpretative one. A fundamental controversy created by the formulation of entropy is related to the conception of a time-reversible universe versus its entropy-based description as irreversible time-oriented processes. This controversy amplified the problematic of equating information with entropy, as Shannon, or as some interpreters, did. Nobel Laureate Ilya Prigogine affirms that “The distinction between reversible and irreversible processes was introduced through the concept of entropy associated with the so called second law of thermodynamics...According to this law, irreversible processes produce entropy. In contrast, reversible processes leave the entropy constant...[We] have inherited two conflicting views of nature from the nineteenth century: the time reversible based on the laws of dynamics and the evolutionary view based on entropy...After so many years, this problem is still with us.”<sup>187</sup>

The different meanings associated with the term of entropy, along its history, add up, in some authors, to the present controversy. We have shown above the different definitions that can be found with regards to the concept of entropy. Accordingly, we can resume saying that the term “entropy” has been mainly associated to the following concepts or connotations:

1. Disorder or uncertainty, in general.
2. Non-Atomistic Formulation of the Second Law of Thermodynamics
3. The Atomistic Formulation of the Second Law of Thermodynamics
  - Molecular disorder
  - Missing information<sup>188</sup>
4. Information source and channel capacity
5. Uncertainty reduction in the information receiver.

Let us now examine a little more some of these conceptual perspectives or connotations that have been associated to the term “entropy”. The remaining associations that have been made up to the present will be worked in a next version of this essay, or in another article.

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<sup>186</sup> A. Ben-Naim, 2009, *A Farewell to Entropy: Statistical Thermodynamics Based on Information*, New Jersey: World Scientific Co. p. xvii

<sup>187</sup> I. Prigogine, op. cit. pp. 18-9

<sup>188</sup> We are using, in (2) and (3), the same terms used by Arieh Ben-Naim, 2007, op. cit. Referring to this issue he affirmed, in note 1, that “By ‘non-atomistic’ formulation, I mean the discussion of the Second Law without any reference to the atomic constituency of matter. Sometimes, it is also said that this formulation views matter as a continuum. The important point to stress here is that these formulations use only macroscopically observable or measurable quantities without any reference to the atomic constituency of matter. It *does not* imply that the formulation applies to non-atomistic or continuous matter. ..were matter really non-atomistic or continuous, the Second Law would not have existed.”

## Scientific Definitions of Entropy

As we said above, in the Merriam-Webster Collegiate Dictionary “entropy” is defined, in its broad and general sense as “the degree of *disorder* or *uncertainty* in a system,” and associated with terms like *disorganization*, *randomness*, and *chaos*. Several scientists and researchers use the term of entropy in its broad and general sense. Although we frequently find authors associating ‘entropy’ to ‘disorder’ (and information to ‘order’), as it is our stance, this association is somehow a controversial one. Let’s see an example of this controversial perspective. As we said above, Nobel Laureate in physics Murray Gell-Mann, for example, affirms that “It [entropy] is a measure of disorder.”<sup>189</sup> But, in the other hand, as we also said above, Arieh Ben-Naim affirms that one of the three causes of the mystery and confusion surrounding the concept of entropy is its association with “disorder” or as a measure of disorder.<sup>190</sup> The association of ‘entropy’ with ‘disorder’ has its origin, according to Arieh Ben-Naim, in Boltzmann’s interpretation of entropy. He adds that his objection to associate “entropy with disorder is mainly that order and disorder are not well defined, and are very fuzzy concepts. They are very subjective, sometimes ambiguous, and at times totally misleading.”<sup>191</sup> This controversy seems to be related to the origin of the term ‘entropy’ (thermodynamic entropy) and to some of the present conceptual perspectives, mainly related to informational ‘entropy’.

Initially, the concept of entropy was generated as consequence of the observation that some amounts of functional energy released from combustion reactions are always lost via dissipation or friction and, consequently, not transformed in useful work. Studies related to this kind of energy loss and to the efficiency in transforming heat (thermal energy) into work, i.e. heat engines operating between two temperatures, lead Sadi Carnot (1796-1832) to discover that, under ideal conditions, “the limiting efficiency depends only on the ratio of the temperatures between which the engine operates, and not on the substance (i.e., which gas or liquid) that is used in the engine. Later, it was shown that the efficiency of Carnot’s idealized engine could not be surpassed by any other engine. This laid the cornerstone for the formulation of the Second Law and paved the way for the appearance of the new term ‘entropy’.”<sup>192</sup>

William Thomson (1824-1907), known as Lord Kelvin, made the first formulation of the Second Law with which stated that “it is impossible to convert heat (thermal energy) completely into work (though the other way is possible, i.e., work can be converted completely into heat)”<sup>193</sup> Rudolf Clausius (1822-1888), who coined the term “entropy” in 1865, made another formulation of the Second Law, which is equivalent to the formulation made by Kelvin. According to Clausius’s formulation, “heat always flows from a body at a high temperature (hence is cooled) to a body at a lower temperature

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<sup>189</sup> Murray Gell-Mann, op. cit., p. 218

<sup>190</sup> A. Ben-Naim, ob. cit, affirms that “The reason, I believe, involves the unsettled controversy [regarding entropy] which arose from the association of entropy with ‘disorder,’ with ‘missing information’ and with the ‘arrow of time’.” p. 196

<sup>191</sup> A. Ben-Naim, op. cit., pp. 196-7

<sup>192</sup> Arieh Ben-Naim, p. 3

<sup>193</sup> Ibid. p. 5

(which is heated up)... no process exists, such that its net effect is only the transfer of heat from a cold to a hot body”<sup>194</sup>

There are many different processes which proceed in one way, and never in the reverse direction: two gases mix spontaneously, an ink drop into a glass of water mixes with the liquid until it is homogeneously colored, etc. But these kinds of processes are not seen in a reversed direction, if left alone with no external intervention. Clausius noticed this fact in many different kinds of irreversible one-way processes along the time axis, conceived the concept of ‘entropy’, and used it in formulating the Second Law in the way it is mostly known, i.e. “entropy *always* increases in a spontaneous process in an isolated system.”<sup>195</sup> In this way, entropy was associated with one-way, irreversible processes of increasing disorder.

Coining the term ‘entropy’, he wrote:

*“I prefer going to the ancient languages for the names of important scientific quantities, so that they mean the same thing in all living tongues. I propose, accordingly, to call S the **entropy** of a body, after the Greek word ‘**transformation**.’ I have designedly coined the word entropy to be similar to **energy**, for these two quantities are so analogous in their physical significance, that an analogy of denominations seems to me helpful.”*<sup>196</sup>

In spite of his stated aim when coining his new concept as “entropy”, the chosen term has been associated to other meanings and has been defined in different ways.

Clausius presented the first mathematical definition of ‘entropy’ as follows:

$$\text{Change of Entropy} = \text{heat supplied reversibly} / \text{temperature} \quad ^{197}$$

An equivalent way to express this classical thermodynamic law is as follows:

$$\Delta S = (\Delta G - \Delta H)/T \quad (5)$$

Where,  $\Delta H$  is the ‘enthalpy’ (the change in heat content at constant pressure),  $T$  is the absolute temperature, and  $S$  is the ‘entropy’.<sup>198</sup> Interpreting this definition, Tom Stonier points out that “Entropy, in fact, is a mathematical expression describing *disorder*,”<sup>199</sup> and to illustrate what equation (5) means he uses a very known example: the different phases the water goes through when it is heated and its temperature raises. The graphic in

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<sup>194</sup> Ibid.

<sup>195</sup> Ibid. p. 9 (Emphasis is Ben-Naim’s)

<sup>196</sup> Quoted by L. N. Cooper, 1968, *An Introduction to Meaning and Structure of Physics*, New York: Harper and Low; referenced by Arieh Ben-Naim, p. 7

<sup>197</sup> P. Atkins, 2010, *The Laws of Thermodynamics: A Very Short introduction*, Oxford: University Press, p. 47.

<sup>198</sup> T. Stonier, 1990, op. cit. p. 34 (italics added)

<sup>199</sup> T. Stonier, op. cit. p. 35

Figure 3 includes a redrawing of the same graphic used by Stonier with regards to this illustrative example.

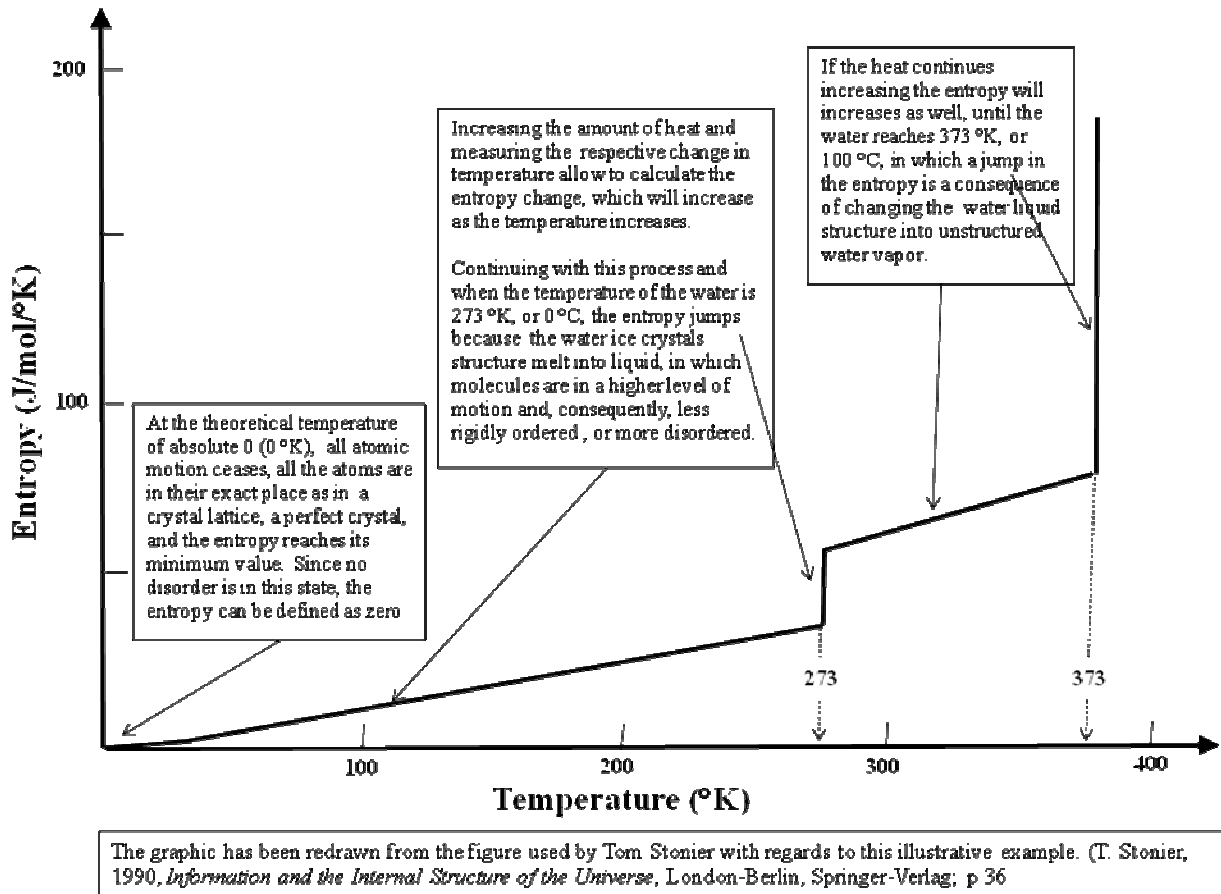


Figure 3

At the theoretical temperature of absolute 0 (0 °K), all atomic motion ceases, all the atoms are in their exact place as in a crystal lattice, as in a perfect crystal, and the entropy reaches its minimum value. Since no disorder is in this state, the entropy can be defined as zero. By means of increasing the amount of heat and measuring the respective change in temperature we can calculate the entropy change, which will increase as the temperature increases, because of the application of heat causes the molecules to vibrate, to increase their velocity and the randomness of their movement. Continuing with this process, and when the temperature of the water is 273 °K, or 0 °C, the entropy jumps because the water ice crystals structure melts into liquid, where molecules are in a higher level of motion and, consequently, less rigidly ordered or more disordered. If the heat continues increasing the entropy will continue increasing as well, until the water reaches 373 °K, or 100 °C, when the water liquid structure turns into the less structured vapor, causing a jump in the entropy.

Thermodynamic entropy produced by heat could be taken as a special case of a more general conception of ‘entropy’ in which entropy will also increase when different kinds of molecules or atoms are mixed at random. An ink drop falling into a glass of water is an example of increasing the entropy of the water molecules by means of randomly mixing them with the ink molecules.

### Entropy, Disorder, and Order

Ludwig Boltzmann (1844-1906), in the context of an atomistic<sup>200</sup> formulation of the Second Law, proposed a statistical interpretation of entropy, the so-called *absolute entropy*. Boltzmann defined entropy as follows:

$$S = k \log W \quad (6)$$

where  $k$  is Boltzmann constant,<sup>201</sup> mentioned above, and  $W$  “is a measure of the number of ways that the molecules of a system can be arranged to achieve the same total energy (the ‘weight’ of an arrangement),”<sup>202</sup> or “the total number of microstates possible in a given physical system, where a microstate defines the energy state of a given particle.”<sup>203</sup> At 0 °K all microstates have zero energy, so all microstates become identical and, consequently, there may be only one microstate (or only one way that the molecules of a system can be arranged to achieve the same total energy) i.e.  $W = 1$  and therefore  $S = 0$ . On the other hand, when atoms and molecules are randomly moving in a gas then there is a larger number of possible microstates than atoms or molecules bound in the context of a crystalline structure. Consequently, in a gas the entropy will be larger.

Erwin Schrödinger (1887-1961) interpreted Boltzmann definition of entropy in a way that allowed him to work not just with the concept of *disorder* but with *order* as well, not just with gases but also with organisms. Based on the “the investigations of Boltzmann and Gibbs in statistical physics,” he interprets and defines entropy as follows<sup>204</sup>:

$$\text{entropy}^{205} = k \log D, \quad (7)$$

“where  $k$  is—he writes—the so called Boltzmann constant ( $= 3.2983 \times 10^{-24}$  Cal./ °C), and  $D$  is a quantitative measure of the atomistic disorder on the body in question ... The disorder it indicates is partly that of heat motion, partly that which consist in different kinds of atoms or molecules being mixed at random, instead of being neatly

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<sup>200</sup> See note 165.

<sup>201</sup> Peter Atkins suggests that this constant “appears here simply to ensure that changes in entropy calculated from this equation have the same numerical value as those calculated from Clausius’s expression.” *op. cit.*, p. 54

<sup>202</sup> *Ibid.*

<sup>203</sup> T. Stonier, 1990, *op. cit.* p. 61

<sup>204</sup> E. Schrödinger, 1944, *What is Life? With Mind and Matter and Autobiographical Sketches*, Cambridge: University Press, 19<sup>th</sup> printing, 2010; p. 72

<sup>205</sup> It should be noticed that Schrödinger does not use the symbol  $S$ , used by Boltzmann, but the word “entropy.”

separated,”<sup>206</sup> as for example the sugar and the water molecules when we dilute the first into the latter.

Schrödinger points out, that if  $D$  is a measure of disorder, then  $1/D$  can be regarded as a measure of **order**. Then, he affirms, “we can write Boltzmann’s equation”<sup>207</sup> as

$$-(\text{entropy}) = k \log 1/D \quad (8)$$

Consequently, negative entropy (or negentropy as we mentioned above) is a measure of order (or organization), and entropy is a measure of disorder (or disorganization).

In the context of his book *What Is Life?*, Schrödinger concludes that “the device by which an organism maintains itself stationary at a fairly high level of orderliness (= fairly low order of entropy) really consists in continually sucking orderliness from its environment.”<sup>208</sup>

Schrödinger provided two senses associated to the word “entropy”: 1) “a measurable physical quantity, just like a length in a rod,”<sup>209</sup> and 2) “a statistical concept of order and disorder.”<sup>210</sup> Integrating both senses we might affirm that, interpreting Schrödinger, entropy is a statistical *concept* by means of which we *measure* a physical *property*, like the length of a rod. But, ***we should not confuse a rod, with its length property, nor with a measure of this property.*** A rod, its length, and its length measure might have a unique physical existence but they are three different concepts (and/or percepts) that should not be confused. Actually, many authors consider the physical existence corresponding just to the rod; and its length property is associated the rod observer, and its measure is associated with the way the observer decided to choose in the respective measuring process. The same kind of situation might be happening with entropy (and information). *The word might be representing a physical existence, a property of a physical existence, or a measure of such a property.* We can find these three connotations of the term in the associated literature, and sometimes they can be found confused with each other. A practical thing to do is to identify the connotation being used by the author according to the context in which it is being used, and if an author is using it indistinctly, and jumping inadvertently from one connotation to another, deriving conclusions from one to another in an implicit confusion of these three connotations of the term, then the reader should be advised to free himself, or herself, from the confusion in order to eliminate unacceptable derivations and conclusions. To scrupulously take care of explicitly referring to the connotation by which the word “entropy” or “information” are being used is definitely relevant to intellectual coherence and practical benefits, by means of achieving effective and efficient communication.

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<sup>206</sup> Ibid.

<sup>207</sup> E. Schrödinger, p. cit., p. 73

<sup>208</sup> Ibid.

<sup>209</sup> E. Schrödinger, p. cit., p. 71

<sup>210</sup> E. Schrödinger, p. cit., p. 72

Schrödinger's interpretation of entropy, and its corresponding mathematical definition, was named by Stonier "Boltzmann/Schrödinger Equation,"<sup>211</sup> which he used to mathematically relate "information" and "entropy", as defined by the Boltzmann/Schrödinger Equation. Based on Schrödinger's mathematical definition of order, and associating order and information, Stonier easily derived a mathematical relationship between information and entropy. He started with Schrödinger's two assumptions, and added two more. These four suggestions are the following<sup>212</sup>:

1. Disorder  $D$  "is equivalent to Boltzmann's original equation."  $S = k \log W$
2. Order "is the reciprocal of disorder, i.e.  $Or = 1/D$ ; where  $Or$  is a measure of order of a system."
3. Information  $I$  "is a function of order"  $I = f(Or)$ . Then he reasoned a fourth assumption.
4. "Information and organization [or order] are directly and linearly related" so that the equation  $I = f(Or)$  may be stated as  $I = c(Or)$ , where  $c$  is a constant.

Then, according these assumptions (two made by Schrödinger and two by Stonier), Stonier could easily derive a mathematical relationship between information and entropy, as follows:

Since  $Or = I/c$  then  $D = 1/Or = c/I$ ; and by substituting the term  $c/I$  in the original Boltzmann/Schrödinger equation we obtain  $S = k \log (c/I)$ ; and solving for  $I$ , we have the following mathematical relationship between entropy and information

$$I = ce^{-S/k} \tag{9}$$

We might call equation (9) as Boltzmann/Schrödinger/Stonier Equation, from which we can notice "that the constant  $c$  represent the information constant of the system at zero entropy,"<sup>213</sup> i.e.  $c = I_0$ . Even if  $c$  is a constant within a given system (for example for a crystal of sodium chloride at 0 °K), it is not constant across systems (for example between a crystal of sodium chloride and a crystal of H<sub>2</sub>O at 0 °K). Consequently, equation (9) might also be written as

$$I = I_0 e^{-S/k} \tag{10}$$

Consequently, Boltzmann/Schrödinger equation can be rewritten as

$$S = k \log D = k \log (I_0/I) \tag{11}$$

which shows that *disorder is a ratio between the information content at zero entropy and the actual information of the respective system.*

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<sup>211</sup> T. Stonier, 1990, op. cit. p. 37

<sup>212</sup> T. Stonier, op. cit. pp. 37-38

<sup>213</sup> T. Stonier, op. cit. p. 40

Notice that in Boltzmann's original equation entropy cannot be negative, because, as we indicated above,  $W$  in Boltzmann equation ( $S = k \log W$ ) is the total number (an integer) of microstates possible in a given physical system (where a microstate defines the energy state of a given particle). The minimum integer is 1 (one), which corresponds to 0 °K where all microstates have zero energy, so all microstates becomes identical and, consequently, there can exist only one microstate, i.e.  $W = 1$  and therefore  $S = 0$ . On the other hand, as we said above, when atoms and molecules are randomly moving in a gas, then there is a large number of possible microstates than atoms or molecules bound in the context of a crystalline structure. Consequently, in a gas, the entropy will be equal or larger than zero.

In equation (10) entropy is **zero** when  $I = I_o$  which is in agreement with Boltzmann original equation; **positive** when  $0 < I < I_o$  which is also in agreement with Boltzmann original equation; and **negative** when  $I > I_o$  which is in evident disagreement with Boltzmann's original equation, because of what we indicated above.

This disagreement is reasoned by Stonier as follows:

“It is important to realize that Boltzmann's equations were derived from a study of gases (Boltzmann<sup>214</sup> 1896, 1898) in which  $I$  would never exceed  $I_o$ . Therefore  $S$  would never become negative. Furthermore if one limits the analysis to order/disorder, one would also never observe  $S$  to acquire negative value because once a system was ‘perfectly ordered’ one could not add more order. Nothing could be more ordered than something which is already perfectly ordered. On the other hand, *it would be quite possible to add more information to a system which is already perfectly ordered by making it more complex*. To take a biological analogy, one could take a strand of perfectly ordered DNA and develop it with a protein coat to produce a mature virus.”<sup>215</sup>

Stonier provided a mathematically analytical explanation of what Schrödinger affirmed<sup>216</sup> when he recurred to the analogical thinking of the reader saying that “an organism maintains itself stationary at a fairly high level of orderliness (= fairly low order of entropy) [by means of] continually sucking orderliness from its environment.”

***Consequently, when we are dealing with information in human communication contexts, entropy can be negative,*** and we can affirm, as we did above, that the acquisition of new information is through negative entropy, or negentropy, by means of

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<sup>214</sup> Boltzman, 1896, 1898, Lectures on Gas Theory Part I and Part II, translated by SG Bruch, University of California Pres, Berkeley, 1976; referenced by Stonier, op. cit., p. 41

<sup>215</sup> T. Stonier, op. cit. p. 41 (italics added)

<sup>216</sup> As we quoted him above



which (paraphrasing Schrödinger) human beings would be sucking orderliness or information from their environment.

As we affirmed in the previous version of this essay,

$$\text{Human information} = \text{negative entropy or negantropy}^{217}$$

As it is known, a “bit” is an information measure unit defined as the information *capacity* of a two-state system with *maximum* entropy (equiprobable states). The information *received* by a human being is at its *minimum* for each event provided by a two-*equiprobable*-state system. The less equiprobable the two states of the system are, the more the information might be received by a human being. If an egg falls to the floor, it is expected to break, and if it does break, it provides no information regarding the issue of break-or-non-break. But, if the broken egg suddenly un-breaks and returns to its original unbroken state then the information provided in this case is a very large one, theoretically an infinite one, because the subjective probability of observing a process of un-breaking a broken egg is almost zero, and the logarithm of a number approaching zero, approaches minus infinite and, consequently, the information provided by such a rare event is a very high one (theoretically approaching infinite). Then, 1) the expected value of the information that a two-state system can deliver increases as the probabilities associated with its states move away from equiprobability, and 2) the minimum of the expected value of the information that can be delivered by a two-state system is when these states have the same probability of happening. Then, a “bit” which is, by definition, the average of the information capacity of a two-state system with *maximum entropy*, represents a *minimum* of the expected information that this two-state system might provide. This conclusion may easily be derived from Schrödinger’s interpretation of entropy and from the Schrödinger-Stonier mathematical relationship between entropy and information. The point where a function is at its maximum is the same one where the negative of the same function is at its minimum. This truism should be made explicit because of the confusion that has been surrounding this issue. We will reiterate below a similar reasoning but after explaining concepts such as “spread,” “entropy,” etc.

But, it is good to notice that in the last paragraph we are distinguishing between information *capacity* and information *delivered* to the *receiver*. We have already explained above that from the *sender’s* perspective, the maximum freedom for his/her signal selection requires maximum entropy with regards to the signals from which he/she will make his/her choice in order to express him/herself and to inform. Consequently, *maximum entropy in the set of signals is required for a maximum information capacity (from the sender perspective), while from the receiver’s perspective a system with maximum entropy (with regards to the probabilities of its possible states) provides a minimum information when one of its states is shown to the receiver. But, the more bits the receiver receives, the more information he/she might receive the next time because his subjective probabilities might change because of previous events. If the receiver’s subjective conditional probabilities do not change (as it is the case of receiving random*

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<sup>217</sup> It is to be noted that we are not using the symbols that has been used in very specific definition of information (e.g. *H* for information) and entropy (e.g. *S* for entropy)

*characters or noise) then the receiver will still be receiving a minimum of information with each received bit.*

With regards to the communication systems to be designed by communication engineers, the perspective that should be taken into account is the one related to the engineer and his/her engineering objective regarding the efficiency and the correctness of the signals to be transported. In such a case, Shannon's definitions and mathematical derivations are the most effective means, up to the present, in handling this kind of problem.

It is evident then, that information should explicitly be related to the receiver, or the sender, or the communication engineer problem (along with the physical transportation of the signals) in order to avoid confusions and intellectual energy waste. Having made the distinction among these three perspectives with its associated specific senses of the term "information", a question might immediately be raised: Is there any commonality among these three senses of the term "information"? Is there a genre comprehending the three specific senses we are referring about? If we can have the same measure for these three senses of "information," can we suppose that we are referring to the same common property, or to a *universal* one? These are legitimate questions that might be addressed, in our opinion, by philosophers or inter- or trans-disciplinary scientists or thinkers.

### **Entropy and Intropy**

Returning to the notion of "entropy", the statistical definition of thermodynamic entropy in the general case where a system has different microstates probabilities, its entropy is defined as

$$S = -k \sum_i p_i \log p_i \quad (12)$$

Then, as we indicated above, this statistical definition of thermodynamic entropy is mathematically isomorphic with Shannon's informational entropy shown in (4). The difference is related to what the probabilities are associated to;

- In Shannon's definition, equation (4) refers to the probabilities of the *symbols* used, or to be used, in the *messages* to be sent, transmitted or received. As we indicated above, Shannon explicitly said "We shall call  $H = -\sum_i p_i \log p_i$  the entropy of the set of probabilities  $p_1, \dots, p_n$ "<sup>218</sup> where the probabilities are associated to the relative frequencies of the symbols being used in the message.
- In the thermodynamic entropy definition, the equation (12) refers to the probabilities of the *microstates*.

What is common to both definitions has already been identified by Shannon when he affirmed that " $H = -\sum_i p_i \log p_i$  the entropy of the set of probabilities  $p_1, \dots, p_n$ ." Consequently, we might conclude that

1. " $-\sum_i p_i \log p_i$  is the entropy of the set of probabilities  $p_1, \dots, p_n$ .";

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<sup>218</sup> Shannon and Weaver, 1949, op. cit, p. 51

2. When this “set of probabilities” is associated to microstates thermodynamic properties, then we will refer to “ $-\sum_i p_i \log p_i$ ” as thermodynamic entropy, by definition;
3. And when the “set of probabilities” is associated to the relative frequency of the symbols used in communication, then we will refer to “ $-\sum_i p_i \log p_i$ ” as communicational, or informational, entropy, also by definition.

This kind of nominal distinction that we are proposing is also recommended by other authors by means of other terms. Johannes Peter, for example, proposed to use the term “*spread*” or “measure of spread of the probability distribution function” to refer to what he called “superior expression” of both kind of entropies. Peter affirms that “only when this spread refers to the distribution function of microphysical state properties will be called entropy, when it refers to a quantity or a set of symbols not representing thermodynamical state properties it will be called **information theoretical entropy**, in short **intropy**.”<sup>219</sup> In order to “generalize the notion of information,” Peter affirms that “Information is created by an act, by an event which reduces the a priori spread of any quantity. The numerical difference (*a priori spread minus a posteriori spread*) is called information. In the limit case, the spread is totally removed. This happens when an individual symbol is selected out of a set of a priori possible symbols.”<sup>220</sup> Consequently, information is produced when an act reduces the a priori intropy or the information theoretical entropy. Reiterating what we said above, but using Peter’s terms and conceptual perspective, we can say that in a two-symbol, or two-state, system, with maximum informational entropy, or intropy (i.e. where the two states are equiprobables,  $p_1 = p_2 = 0.5$ ), has by definition 1 bit of information capacity. This means that its spread, or intropy, is 1 bit. The respective limit case (where the spread is completely removed) is when one of the two states is selected, i.e. when the intropy is reduced to zero. Consequently,

$$\text{A priori intropy} - \text{a posteriori intropy} = 1 \text{ bit} - 0 \text{ bit} = 1 \text{ bit}$$

So, as it can be easily noticed, although the measure we are using for a priori intropy, a posteriori intropy, and information is the same, the concepts are different. Intropy (or **information theoretical entropy**) and information (a priori intropy – a posteriori intropy) are not the same concepts. **The concept of “information capacity” is not the same as the “information delivered” by an action**, or selection. The “quantity of information capacity” is equal the “quantity of information delivered” just in the limit case where a posteriori intropy is equal to zero. *In non-limit cases (i.e. a posteriori intropy > 0) both measures are not the same.* We cannot deliver more information than the source capacity, but we can deliver less (or equal, in the limit case) quantity of information. Consequently, the information measure of the *source* should be differentiated from the information measure of the *delivered* information, if we want to avoid confusing ambiguities.

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<sup>219</sup> J. Peters, 1975, “Entropy and Information: Conformities and Controversies,” in L. Kubát and J. Zeman (Eds.), *Entropy and Information in Science and Philosophy*, Amsterdam: Elsevier Scientific Pub. Co.; pp. 61-81; p. 75 (emphasis is Peter’s)

<sup>220</sup> J. Peters, , p. 75-76 (italics added)

Using the diachronic distinction made by Aristotle between *potentiality* (*dunamis*, “capacity to be in a different and more completed state.”<sup>221</sup>) and *actuality* (*entelecheia* or *energeia*, the produced different state), we might say that the source’s entropy (in a communication system), i.e. the source’s intropy, has the *potentiality*, of producing information, and the information produced, by an act (of selection), is its actuality. Aristotles associated his potentiality-actuality diachronic distinction with the synchronic distinction he made between *Matter* and *Form*. The potentiality/actuality distinction is a temporal (diachronic) perspective of the atemporal (synchronic) distinction matter/form. Matter has the potentiality of having different forms, after an act has been produced in the context of a process. By analogical thinking we can easily *associate Intropy with Matter/Potentiality, and Information with Actuality/Form*. We can also notice another way of relating “information” and “form”, as we did with more details above.

S. Mark Cohen affirms “Aristotle thinks that potentiality so understood is undefinable (1048a37), claiming that the general idea can be grasped from a consideration of cases. Actuality is to potentiality, Aristotle tells us, as “someone waking is to someone sleeping, as someone seeing is to a sighted person with his eyes closed, as that which has been shaped out of some matter is to the matter from which it has been shaped” (1048b1-3).”<sup>222</sup>

“This last illustration—Cohen affirms—is particularly illuminating. Consider, for example, a piece of wood, which can be carved or shaped into a table or into a bowl. In Aristotle’s terminology, the wood has (at least) two different potentialities, since it is potentially a table and also potentially a bowl. The matter (in this case, wood) is linked with potentiality; the substance (in this case, the table or the bowl) is linked with actuality.”<sup>223</sup> By means of analogical thinking we might say that a two-state system has two different potentialities, since it is potentially head and also potentially a tail, H or T, 0 or 1. In Aristotelian terms, “The form is the **actuality** of which the matter is the **potentiality**.”<sup>224</sup> Analogously, we can conceive “***Intropy (information theoretical entropy) as potentiality and information as its actuality.***” *Both can have the same kind of measure unit (a bit, for example) but they do not represent the same concept.* Potential and Kinetic Energy can be converted into each other and can be measured by the same units, but they do not represent the same concepts. The concept of Gravitational Potential Energy, for example, should not be confused with Kinetic Energy generated by a falling object, in which it might be actualized or converted. Analogously, Intropy can be actualized into information, and both can be measured by the same kind of unit, but this does not necessarily mean that they are the same concepts. Actually, they can be seen as opposites (polar opposites), requiring necessarily each other, but this does not mean that they are to be confused as concepts. *A decrease in Intropy may cause an informational increase, and vice versa.* If this is the case, then Information may be equated with the

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<sup>221</sup> Quoted in S. M. Cohen, 2008, “Aristotle’s Metaphysics,” in *Stanford Encyclopedia of Philosophy*, accessed on January 2, 2011, at <http://plato.stanford.edu/entries/aristotle-metaphysics>

<sup>222</sup> Cohen, The references made by Cohen are related to Aristotle’s Metaphysics, Book Z

<sup>223</sup> Ibid.

<sup>224</sup> S. M. Cohen, 2000, *An Outline of Metaphysics Z*; accessed on January 15<sup>th</sup>, 2011 at <http://faculty.washington.edu/smcohen/zetaoutl.htm>. Emphasis is Cohen’s.

negative Intropy or (as we indicated above) negative entropy, in terms used by Norbert Wiener and Leon Brillouin, or negentropy, as the latter coined it.

Let us now apply these concepts to a two-state system; in order to address some critics we received with regards the 2002 shorter version of this paper<sup>225</sup>.

The expected value of the *potential information*, or *Intropy* (Shannon's entropy) of a two-state system is:

Potential Information (for two-state system) =  $-p_1 \log p_1 - p_2 \log p_2$ , where  $p_1 + p_2 = 1$

It can be shown that the maximum potential information, or Intropy (Shannon's entropy) is obtained for  $p_1 = p_2 = 1/2$ . Consequently, the maximum *potential information*, or Intropy, or Shannon's entropy is:

Maximum Intropy (for two-state systems) =  $-1/2 \log 1/2 - 1/2 \log 1/2 = -\log 1/2 = \log 2$

And, if the logarithmic base is 2, then

Maximum Intropy (for two-state systems) =  $\log_2 2 = 1$  bit (binary unit)

A two-state system Intropy, Shannon's entropy, or Shannon's *Potential Information* can deliver a maximum of 1 bit of actual information, but it needs a *selection act* to deliver his capacity of one bit; i.e. the selective act transform one bit of *potential information* into one bit of *actual information*. If there is no selection act the potential information still equals one bit and the actual information still equals zero bit. As soon as a selection action happens, the (delivered) actual information becomes one bit and the potential information goes to zero bit. If we select one state between the two states of a two-state system, the probability of the selected state goes to 1, and the probability of the non-selected states goes to zero; as soon as we select one state, Shannon's entropy (or intropy) goes to zero because the system went from two states to one state, i.e. the system is no more a probabilistic but a deterministic one. Delivering, or actualizing one bit from a system with an information potential of one bit leaves the system with no potential information. This means, in general, that the more information is actualized, the less is the potential information of the system. In other words, for the same system:

Its initial potential information – its posterior potential information = Delivered (actual) information

This is another way of saying what was affirmed above, i.e.

A priori intropy – a posteriori intropy = 1 bit – 0 bit = 1 bit of delivered information

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<sup>225</sup> N. Callaos and B. Callaos, 2002, "Toward a Systemic Notion of Information: Practical Consequences," *Informing Science: An International Journal of an Emerging Transdiscipline*, Volume 5 No 1; pp. 1-11.

A fair coin has a maximum Shannon's entropy, or Intropy, of one bit, and can deliver 1 bit of information, each time it is flipped. If it is not flipped (conserving its maximum entropy) zero bit is delivered, i.e. **a maximum Intropy is associated with a minimum of delivered information**, and vice versa: a maximum of delivered information is associated with taking the delivering system to its minimum Intropy (Shannon's entropy).

Up to the present we differentiated between two kinds of information: potential and actual information, i.e. Intropy (Shannon's entropy) and delivered information after a selective act, or a priori and a posteriori of Intropy (Shannon's entropy) after a selective act. These two kinds of information are negatively related. The delivered information, after the selective act, can be differentiated with the name as **negentropy**. This differentiation solves, in our opinion, several confusions created by the undifferentiated use of both senses of the term "information" where one of them (potential information or information capacity as Shannon "adjectived" it) can be equated with Shannon's entropy (Intropy), but the other one (actual or delivered information) cannot be equated with Shannon's entropy, but with its diminishment.

### **Probability: Interpretative Plurality**

As we indicated above, Johannes Peter proposed to use the term "spread" or "measure of spread of the probability distribution function" to refer to what he called "superior expression" of both kind of entropies: that which related to thermodynamics (Boltzmann/Schrödinger's equation) and that which is associated with information mathematical definition (Shannon's equation), or Intropy. In other words, Johannes Peter proposes the locution "measure of spread of the probability distribution function" to refer to the **genre** in which 1) thermodynamic Boltzmann/Schrödinger entropy and 2) Shannon's entropy are two **species**.<sup>226</sup>

A spread of **probabilities** is what is common to both kinds of entropies. But, the concept of probability is also interpreted in different ways. Consequently, we have different interpretations and ambiguities at the **genre level** as well. Several authors have alerted about the variety of interpretations of the concept of probability. Paul Humphreys, for example, affirms that "Unlike many concepts, it is unprofitable to view 'probability' as having a unique meaning. Instead there exists a number of distinct, albeit related, concepts ... none of these captures all of our legitimate uses of the term 'probability', which range from the clearly subjective ... through the inferential ... to the obviously objective. It is often said that what all these interpretations have in common is that all are described by the same mathematical theory ... and it has always been the task of any interpretation to conform to that theory. But this saying does not hold up under closer examination."<sup>227</sup> Another example of the different interpretations and disagreements with regards to the concept of probability is what Leonard Savage affirmed: "It is unanimously agreed—he says in his book *The foundation of Statistics*—that statistics depends somehow on probability. But, as to what probability is and how it is connected with

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<sup>226</sup> See footnotes 219 and 220.

<sup>227</sup> P. Humphreys, 2000, "Probability, Interpretation of," in Concise Routledge Encyclopedia of Philosophy, p. 712.

statistics, there has seldom been such complete disagreement and breakdown of communication since the Tower of Babel. *There must be a dozen of different interpretations of probability* defended by living authorities, and some authorities hold that several different interpretations may be useful, that is, that the concept of probability may have different meaningful senses in different contexts.”<sup>228</sup>

The differences found in the interpretation of the term probability might generate sometimes implicit confusions and even controversies with regards to the meaning of the word, the term, or the concept of probability. This kind of implicit confusions, ambiguities, and controversies might also add up to the ambiguities associated with the terms “entropy” and “information”.

In the next version of this essay, or in a different article, we will address this issue by briefly describing the existing ambiguities and controversies associated with the concept of probability. Here we will just mention some basic differences existing in different interpretations of the term “probability” which might mostly impact the interpretation of the concept of entropy and information. These differences might be resumed as follows:

- **Subjective and objective probabilities:** Subjective probability is associated with the degree of *belief*, or *certainty*, of a subject. It has also been associated with its degree of *ignorance* with regards to possible objective events. Evidential and Bayesian probabilities are examples of subjective probabilities. Subjective probabilities do not always follow the third axiom of the Mathematical Theory of Probability, which is applied to objective probabilities, and usually is also applied to subjective probabilities without previously verifying that the axioms of this theory are being fulfilled in the problem being addressed. Subjective probabilities are associated to what we above called **subjective information**. Frequency based, propensity interpretation, and inductive probabilities are examples of objective probabilities, and are associated with what we referred to above as **objective information**. Subjective probabilities are usually associated with the informing and the being informed **subjects**, i.e. with the subjects sending and receiving the communicating message; and objective probabilities are associated with the physical communication means they used in their communications in order to physically transport the intended message.
- **A priori and a posteriori probabilities:** an a priori probability can be determined by a logical examination of the space of possibilities. A posteriori probability is determined after observing the outcome of the related events. Frequency based, propensity interpretation, and inductive probabilities are examples of a posteriori probabilities. A priori information is sometimes associated with a degree of beliefs and judgments, and a posteriori information is usually associated with what has been frequently observed. A priori and a posterior probabilities might also be associated with what we called above a priori and a posteriori Intropy (Shannon’s Entropy).

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<sup>228</sup> L. Savage, 1972, *The foundation of Statistics*, Dover Publications; 2 Revised edition; p. 2, (italics added).

- A priori and a posteriori probabilities might be related to both subjective and objective probabilities. Consequently there are at least **four sets of interpretations** that might impact the meaning of entropy and information adding up to the plurality of interpretative perspectives (and the consequent confusions and controversies) already associated to the concepts of entropy and information, which we have been showing in this essay.

## 9. Resuming some Important Issues and Consequences

Our objectives in this section are 1) to resume some important issues we have described above with more details and 2) to provide context for the next session by means of adding other related aspects to what is being resumed.

Shannon's mathematical definition of information opened the doors for many scientific and technological advances. Huge and tremendously promising fields with names such as "Quantum Information," "quantum computing," "Quantum cryptography," etc. are emerging as a result of this definition that objectified (and even reified) information.<sup>229</sup> In this emerging field, traditional information theory (based on Shannon's) is being combined with quantum mechanics in order to formulate a new Quantum Information Theory. But, Shannon's Information Theory also opened the door to a lot of abuse of the word "information" and dangerous twists of the related concept. Shannon made a mathematical definition of "information" in order to **measure** it, in the context of electronic communication systems. Consequently, the following should be kept in mind:

- Shannon did a **mathematical** definition, not a **conceptual** one. Many authors emphasized the huge difference between these two definitions. Leibniz, for example, distinguished emphatically between **real** definitions and **mathematical or nominal** ones. The former "shows clearly that the thing is possible, while the latter do not," the former is not arbitrary, while the later is.<sup>230</sup> Shannon's definition is arbitrary. What is the justification of the logarithmic function if not its mathematical suitability for measuring communications channel capacity? This arbitrariness does no harm at all when we use it to *measure* a given property or a quality of a thing. But, to try to equate it to the real thing, to its nature and essence, is highly dangerous, because it might be very misleading.
- We cannot confuse a **measure** of a thing with the thing being measured, let alone confusing the **metric**, with the thing measured by it. We should not confuse the centigrade scale we use to measure the temperature with the temperature. Similarly, we should not confuse Shannon's metric, or the measure we achieve with it, with the concept of information. Furthermore, if the metric were

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<sup>229</sup> see, for example, T. Siegfried, 2000, *The bit and the Pendulum*; New York: John Wiley and Sons, Inc., for a popularizing description of this new area.

<sup>230</sup> G. Leibniz, *Thoughts on knowledge, truth and Ideas*; G., 4, 424-5; D., p.30, quoted and referenced by F. Colpeston, 1985, *A History of Philosophy*; New York: Image Books, Doubleday; Vol. IV, p.276



measuring one of the properties of a thing, existence, or essence, what would happen with the other properties, if they exist? We should not confuse a part with the whole to which it belongs. We cannot define a whole by means of one of its parts. **Synecdoche** is a good means for poetic, rhetorical, or metaphorical expressions, but it could be dangerous for conceptual reasoning and communications.

- Many authors have been severe critics to Shannon's definition of information, although "Shannon never claimed to have developed a theory of information. Instead Shannon considered his contribution to have been a theory of communication, i.e. a theory of information **transport**;"<sup>231</sup> or more precisely, a *theory of physical signals transport*. As we indicated above, Cherry pointed out that the formula derived by Shannon for the average information contained in a long series of symbols is really a measure of the statistical **rarity** or '**surprise value**' of a course of message signs. Referring to Cherry's interpretation of Shannon's mathematical definition of information, Stonier affirms that "This is hardly a true measure of information content of a message."<sup>232</sup> Bar-Hillel pointed out that Shannon's Information Theory would be better called a "Theory of Signal Transmission" as this is its subject matter.<sup>233</sup> But, we think this proposition is not feasible anymore because, since then, many authors have referred to Shannon's theory as Information Theory, and a term's meaning includes the way it has been used. Taking into account that an increasing number of authors are using the term information in Shannon's sense, and are calling his theory Information Theory, the probability of reversing this situation is very slim. Consequently, we propose: 1) to systemically extend the original subjective meaning given above in order to include Shannon's definition, 2) to systemically extend Shannon's definition as to include the subjective perspective, or 3) to do both extensions in order to converge them in a **Systemic Information Theory**.

Shannon's Theory provided the grounds for a strong support to the **objectivist** position, where information is conceived as independent from their human senders and receivers, and as a **neutral reflection of real world structure or order**. The identification of information with negative entropy, or **negentropy**, gave the foundation of the increasing emphasis in the objectivist conception of information. Shannon found out that his equation was isomorphic with Boltzmann's equation of entropy. So, equating both of them, he equalized information to entropy, but, as we have mentioned above, other important authors, like Norbert Wiener and Leon Brillouin, related the new mathematical definition of information to negative entropy or negentropy; which made some sense, because since entropy is conceived as **disorder**, negative entropy and information (its mathematical isomorphic) might be both seen as **order**. Then, anyone who conceives an

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<sup>231</sup> T. Stonier, 1997, p. 13 (emphasis is Stonier's)

<sup>232</sup> Ibid.

<sup>233</sup> Y. Bar-Hillel Y., 1955, "An Examination of Information Theory", *Philosophy of Science*, 22, pp. 86-101. Reprinted as Bar-Hillel, 1964, *Language and Information: Selected Essays on their Theory and Applications*. Addison-Wesley; pp. 275-97,

independent order in the Universe would accept that information, its ‘synonym’, is independent, from any subject. This explains the increasing number of authors endorsing the objectivist position. Some of them are radical objectivists; they have what it might be referred to as a physicist conception of information. They equate the ubiquity of information in the physical world to energy and matter. Let us take just one example. Stonier—for example—asserts “the description of **all physical systems** entails not only the parameters which define the amount of matter and energy, but also the quantity of information. Furthermore, any changes in the systems **must** take into account not only changes in matter and energy, but also changes in the information content of the system.”<sup>234</sup> “Just as we ascribe to matter the mass we encounter in our universe, and to energy the heat—Stonier continues stressing—so must we ascribe to **information** the organization (or lack of it) which we encounter in all systems.”<sup>235</sup> “The idea—Stonier affirms—that **information is an intrinsic component of all physical systems** requires a reevaluation of the laws of physics.”<sup>236</sup>

On the other hand, in the world of information technologies, the locution “information processing” is frequently used indistinctly with “data processing”. At the beginning of computing, the locution used the most to refer to computer systems processing was “Electronic **Data** Processing” (EDP), which was, in our opinion, the right term to use. But after the appearance of the expression “Management Information Systems” (MIS), which is also a very adequate one because it refers to managerial, hence human, information, an increasing number of vendors, first, and then consultant and academics later, started using “information processing” as synonym of, and instead of, “data processing”. The original cause of this switch in the locutions’ use was surely due to marketing variables. The word “information” sounded more actual (actual? mejor usar “current at the time”) than the term “data”, because of the prestige of MIS then. This fact was reinforced by the explicit, or implicit, semantic effort to differentiate the software in the realm of **data** bases, **data** base management systems (DBMS) and **data** base servers, from applications software, and middleware. Data processing in the latter is frequently called “information processing”, and the expression “data processing” is usually used in the DBMS and data server realm. This way of using the word “information” contrasts and is in conflict with its meaning in the realm of MIS, DSS (Decision Support Systems) and EIS (Executive Information Systems). In MIS/DSS/EIS realm, information is always **subjective**, but in the non-applications software and middleware (NAS/MW) realm, information is always **objective**, in the sense of electronic data processing. **The confusion between these two senses of the term is very dangerous, both intellectually and pragmatically.** We will draw, below, some conclusions in regards to this alert.

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<sup>234</sup> Stonier, 1997, op. cit., p. 12 (emphasis added)

<sup>235</sup> Ibid. (emphasis is Stonier’s)

<sup>236</sup> Ibid. (emphasis added)

## 10. Toward a Systemic Notion of Information

Subjectivist and objectivist conceptions of information are definitely **opposite**, but we propose that they are not as **contradictory** as they are – explicitly or implicitly – supposed to be. In our opinion they are **polar opposites**. To be in contradictory opposition, “subjective” should be equated to “non-objective” and “objective” to non-subjective”, but this is not necessarily the case. The Systems Approach **dissolves** the objective-subjective dichotomy and focuses on what **relates** and **communicates** them, i.e. what is **common** to both of them. For C. West Churchman<sup>237</sup>, the Systems Approach focuses on the subject’s action on the object. Singer-Churchmann’s **pragmatic teleological truth** is based, not on the subject and his/her reasoning, not in the object and the empirical data received from it, but on the *action* of the subject on the object. As long as the action achieves its objectives, the action will be a truthful one. Elsewhere<sup>238</sup> we noticed that the background of this epistemological position is placing truth in what **relates** the subject to the object, what makes them a **system**, not a **set**. In the “Rationalism vs. Empiricism” conflict each epistemological position focuses and places the truth in basically one part of the system subject-object. Churchman’s Systems Approach places it in a relation between them. We explained with details<sup>239</sup> the necessity in going further in the direction established by Churchman, noticing that there is also an “action” of the objective world on the subject, by means of his or her empirical **sensations** and then his/her **perceptions** of the world. Hence, we proposed a **distributed notion of truth**, located not just in the Subject (e.g. Rationalism), not just in the Object (e.g. Empiricism), not just in the action of the subject on the object (e.g. pragmatism), (i.e. in one of the relations that relates them), but also in the “action” (impression, effect) of the object on the subject, via sensations/perceptions. Based on this systemic perspective we showed that **the truth is related to the whole system**: In both of its **parts** and in both of its **relations**, i.e. distributed in the subject, the object and in what relates them (perception and action).<sup>240</sup> This systemic notion of truth, where subject and object are no more in conflict but in polar opposition, complementing each other in a **creative tension process**, might also be used to relate systemically the objective and the subjective notions of information. Human beings get their **in-formation** from the environment, including other human beings in the context of human communication, and produce **ex-formations**, i.e. inserting new forms into their environment via verbal actions, scientific laws, engineering design, technological innovations, etc.

**A systemic notion of information would place one kind of information not just in the subject, or just in the object, but in both of them and in what relates them.** Objective and subjective information relate to each other as north and south poles, as masculine and feminine categories. They do not **exclude** each other, because they do not contradict each

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<sup>237</sup> C. W. Churchman, 1971, *The Design of Enquiring Systems: Basic Concepts of Systems and Organization*; New York: Basic Books, Inc. Pub.

<sup>238</sup> N. Callaos, N., 1995b, “Metodología Sistémica de Sistemas: Integración de la Macro-Estructura” (“A systemic Systems Methodology: Macro-Structure Integration”) in *Metodología Sistémica de Sistemas (A Systemic Systems Methodology)*; Universidad Simón Bolívar, Caracas, Venezuela, Chapter 12.

<sup>239</sup> Ibid.

<sup>240</sup> More details regarding this issue will be provided below where we suggest a systemic perspective or the concepts, or notions, of “subject” and “object.”

other. They **require** each other. They are dynamically related in a never-ending creative tension process, where they feedback and feedforward reciprocally by means of the relations of perception and action. The subject perceives order and organization in the object (and from other subjects, who want to share information) and, consequently, receives some information (with its respective noise), allowing him/her to act on this order, 1) by means of his/her experience/knowledge and rational/emotional filters, and 2) by re-ordering it according to his/her objectives. Then the subject acts on the objective world and other subjects by means of his/her verbal and written language (trying to share their results with more people according to their objectives and restricted by the means accessible to them), and participating in the creation of knowledge, social organizations and the technological world. In doing so, he/she sends information to the objective and inter- and transpersonal worlds, augmenting and/or modifying the information in them. These worlds will act back on the subject, through his/her empirical sensations/perceptions, re-initiating the cycle briefly described. These cycles, with their respective feedback and feedforward loops, have been going on and will go on through human history, in a *dynamic creative tension process, where the subject re-creates and is re-created by his objective world, by means of re-receiving and re-sending information*. It is an irrelevant question, in our opinion, to ask about the origin of the information, whether it is objective or subjective in its origins. This kind of question is consequence of lineal thinking. It is not legitimate and makes no sense in a non-lineal thinking or a non-lineal dynamic process or systems, which is the essence of our systemic definition of information.

There have been some extensions made in both, objective and subjective conceptions of information, that would support our attempt into integrating—although not unifying—both positions in a systemic notion. The most important to our purpose here are the following:

- Some authors suggested that Shannon's equation would also be effective in measuring subjective information, if we replace the objective probability included in it by a subjective one. In this way subjective information could be measured as a minus logarithm of the subjective probability that a given subject has in regards to the appearance of given signal or a sign. This extension had a very good consequence: it showed the Information Technology community how wrong it is to confuse data with information. *A signal or a datum is mathematically the independent variable in Shannon's equation and information is the dependent variable*. Both notions are different, and to confuse, or identify them, might generate non-sense. This extension served as the basis of many experiments in subjective information, but it measures just the uncertainty aspect, or—as we said before—the rarity of the signal. Consequently, some authors, like Ackoff, proposed to name this kind of information “rarity information,” in order to differentiate it from what has been called “semantic”, “pragmatic”, and “social” information. So, Shannon's equation could be used to, at least, measure some kind of subjective information, or one aspect of it. This supports a partial integration of both positions.

- In the other direction, some authors in the subjective perspective accepted that even if information is always generated by a subject, it could be transmitted to an object. Although, some of these authors would say that what has been transmitted is not the real information, but some kind of it, or as Dervin (referenced above) named it, in quotation marks, “ ‘some information’ out there, external to human beings but created by them.”<sup>241</sup>
- Authors from the objective side made also similar extension. Even insisting that information is in the physical world, some accept that human beings can superimpose their order on the perceived external one and filter/modify it, producing some kind of subjective order or information.

Consequently, we are noticing that by extending their meanings and/or des-radicalizing their respective positions, some authors are initiating processes that might culminate in the integration of both positions. So, a systemic meaning of information and/or research efforts oriented to a Systemic Information Theory, could surely serve as a catalyst for the integration process.

These different conceptions of information (subjective, objective, extended subjective, extended objective, hybrid, integrated notion based on a distributed perspective by means of which information are in the subject, in the object as well as in the relationships among them) are just part of the ambiguity sources related to the term of information. There are other sources of the equivocalness regarding the term “information”. The semantic and conceptual confusions and contradictions that could be found in what has been written with regards to the notion of information and what has been seen as its related concepts: entropy, uncertainty, probability, etc. are a consequence of the ambiguities of the terms used in representing essential conceptual ingredients in the intended definitions of “information”. Among the most representative of these terms, or concepts, with different senses and meanings are the following. We are not presenting in this essay the required conceptual details for all the ambiguities found in the literature. Above we have shown details with regards to some of them, which will be summarized in the next sub-section along with short descriptions of those which will be examined with more details in a future version of this essay, or in another article. We will differentiate between the equivocalness inherent to the same term “information” and the equivocalness of other terms frequently used in its definition.

### **Intrinsic Equivocalness of the Term “Information”:**

As we have shown above, in its origin, “to inform” meant “to form in”, “to form into”, “to form within”. But **Who** forms **what**, **for what**, and **into-what** (or **where**)? As soon as we start looking for answers to these questions we start getting different senses of the word “information”. Accordingly, as we have shown above, we will have at least the following conceptions of “information”:

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<sup>241</sup> B. Dervin, 1983, , p. 4

- **Subjective information**, if the respective forms are in the mind (or related to neural networks) of a subject. The subjective information has also its internal equivocality:
  - The information **sending** subject
  - The information **receiving** subject
  - The subject **observing** the communicational process: the **engineer** subject or the **linguist** subject.
- **Objective-physical information**, if the respective forms are embodied into physical transport systems, or in the Universe.
- **Objective-Biological information**, if the respective forms are embodied in biological organisms, or in their DNA.
- **Integrated Information**, if the respective forms are *distributed* among subjects, objects, and the relationships among them, and flowing among them by means of the respectively required *transformations*. This conception is related to our systemic proposal. This perspective requires the explicit specification of what kind of information we are talking about, in order to avoid the equivocality of the term, i.e. to the genre “information” we should add its specificity (adjective) when we are referring to a specific localization of the distributed informational flux.

### Different uses of the Term “Information” which might mislead the reader

In spite of several authors emphasizing that they are mathematically defining the term “information” as *measure*, this definition is frequently used to refer to the *property* of what is being measured, and even to the *thing* whose property is being measured. Sometimes it is even used as a *unique measure*, or *universal property*, or a *universal thing*. All these uses might be accepted as long as they are not confused with each other. The centimeter, which is a *measure* unit, by means of which we can measure the *length* of a *rod* should not be confused or equated with the property of length or with the rod. If information is a *measure* of the *content* of a *message*, it should not be confused with the *content* or with the *container*.

### Semiotic Equivocalness

If we interpret the concept of “information” from a semiotic perspective, as many authors did, we can differentiate among three different senses of the term “information”:

- **Syntactic Information**, if we are referring to the relations among the signs.
- **Semantic Information**, if we are referring to the relations between the signs and their respective referents, designata, or denotata.
- **Pragmatic Information**, if we are referring to the relation between the signs and their users.

## **Compounded Equivocalness**

The intrinsic and semiotic equivocality mentioned above amplify and compound each other. The subjective information, for example, might also have three kinds of information:

- **Subjective-Syntactic:** relationships among the mental signs of a subject, or grammar),
- **Semantic-Subjective:** relationships between the subject's mental signs and the intended referents, designata, or denotata, and
- **Pragmatic-Subjective:** Relationships between the subject's mental signs, and his/her respective action or behavior.

An analogous compounding might be done between the syntactic-semantic-pragmatic levels of a semiotic perspective with objective conceptions of information.

## **Equivocalness of the Term Entropy**

Above, we referred to the ambiguities that are found in the literature associated with the notion of entropy, and we quoted some authors' affirmation with regards to this issue. Here we will just try to make a schematic resume of the main senses of the term, ambiguities sources, and conceptual controversies:

*Can there be negative entropy?* From Boltzmann's definition of entropy, it makes no sense to talk about negative entropy. But from the interpretation of other authorities, as for example, Erwin Schrödinger, Norbert Wiener, Leon Brillouin, Tom Stonier, etc. it does not just make sense to conceive negative entropy, but it is also necessary to do it in order to interpret some phenomena, like life, which are different to the gases thermodynamics which are the phenomena addressed by Boltzmann in the definition he made of entropy. A harsh critique we received with regards to the first version of this essay was based on a strict adherence to Boltzmann's definition and with the exclusion of many other interpretations also made by authorities on this issue. Any open-minded perspective with regards to the concept of entropy should include, at least, the following senses of the word:

- Thermodynamic (physical) entropy
- Informational entropy
- Biological entropy, which would include the possibility of negative entropy
- General meaning: disorder, uncertainty; which is how it is interpreted by a majority of authors and authorities, including Nobel Laureates.

Is entropy a measure or a property? Is it just a mathematical (nominal) definition of some property? If so, are we not reifying this mathematical definition into a material property? Any answer to this kind of questions might have some scientific, epistemological, or ontological value as long as they are not inserted in an implicit context that might mislead the reader. The context in which the word or the concept of entropy is being used should

be *explicit*, and de-contextualization should be avoided if minimum level of rigor and clarity are to be met, in order to avoid misleading and confusing the reader.

### The Notion of Probability

As we very briefly mentioned above, the concept of probability is the independent variable in both, the mathematical definitions of information and entropy. Consequently, the interpretational diversity associated with the notion of probability is transmitted to the notions of information and entropy, adding up to their equivocalness and ambiguities. As we noticed above, at least two opposing perspectives can be found frequently in the associated literature: *Objective* versus *subjective* probability and *a priori* versus *a posteriori* probability. This means that we have at least four main senses associated with the meaning of the term “probability”, i.e. objective a priori, objective a posteriori, subjective a priori (based on beliefs), and subjective a posteriori (based on experience).

A systemic notion of “information” (as well as of “entropy” and probability”) should, in a first phase, differentiate among the different senses, uses, interpretations, and conceptions of the term, in order to try to relate them in a second phase. These two phases might be conducted in parallel, not necessarily in series. In this essay we are trying to make an initial step oriented toward a Systemic Notion of Information. More research and reflections from different disciplines (as well as from inter-, cross-, and trans-disciplinary perspectives) should be made, but, meanwhile, let us suggest a systemic perspective of “subject” and “object” in order to provide a conceptual background for a systemic perspective of “information” and then draw some practical consequences from what we have explored up to the present and what we will explore in the next section.

## 11. A Systemic Perspective of the Notions of Subject and Object<sup>242</sup>

As we have shown above, one of the most fundamental sources of ambiguities or disagreements is related to the **subjective** or the **objective** nature of ‘information’, ‘entropy’, and ‘probability.’ Since this source of ambiguities, miscommunication, and controversies affects not only the concept of ‘information’ but also its most related concepts, with which it is associated or identified (entropy) or being functionally dependent (probability), it is recommendable to include a brief description and reflections regarding the problematic surrounding the notions of ‘subject’ and ‘object’, as well the relationships between them.

Edgar Morin affirms clearly and emphatically that “Subject and object are *indissociable*...Our path is cleared on one side by micro-physics where subject and

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<sup>242</sup> This section is based on N. Callaos, 1995, *Metodología Sistémica de Sistemas: Conceptos y Aplicaciones (Systemic Systems Methodology: Concepts and Applications)*; Work presented for the academic rank of Titular Professor at Universidad Simón Bolívar, Caracas, Venezuela; chapter 12, pp. 389-415; and some texts are adaptation from others included in a non published work in progress: N. Callaos, 2001, *Expansion of Science*.



objects become *relation*...and in the other by *cybernetics* [especially Second Order Cybernetics] and the concept of self-organization.”<sup>243</sup>

Elsewhere we made some conclusions regarding the ‘indissociability’ and necessary relatedness of subject and object, observer and observed, from a conceptual perspective as well as from experience. In 1976 we suggested, for future research and as a consequence of our conclusions, that knowledge should be conceived as *relative* to the observer and would depend on “*object and subject*” in what we called New OR/MS<sup>244</sup> methodology, as opposed to the idea that “knowledge is *absolute*” in what was then the current methodology.<sup>245</sup> What we suggested for a long-term research program on OR/MS methodology can be generalized for a long-term research program in the nature of science, meta-science, and Philosophy of Science, as we did later in 1995<sup>246</sup> (when we described some of the results achieved after following our 1976 suggestion); as well as for the nature of information, entropy and probability, which is part of what we are trying to do in this essay. Most of the work we did in this 1976-1995 time period was via action-research in the area of software-based and/or human based information systems. The diversity of the systems studied, analyzed, designed and/or implemented allowed us to make some general formulations in the context of a Systemic General Systems Methodology.<sup>247</sup> Using as basis, both, a detailed historical study and the experience and knowledge apprehended from approximately 100 action-research projects in Information Systems we proposed to extend Singer-Churchman’s Pragmatic-Teleological truth to a *distributed* truth which also systemically relates subject-based rationalistic epistemologies (Descartes, Leibniz, Spinoza, etc) and object-based empiricist epistemologies (Locke, Hume, etc). In other words, instead of using an either/or epistemological perspective based on subject, object, or action oriented truth, we proposed a *plural epistemology* where—as we briefly suggested above—truth is based on the subject, the object and two kinds of relationships between them: the pragmatic-teleological action/transformation and the perception/information, where the subject is also transformed. The basis for proposing the integration of these four perspectives was the experience and knowledge we apprehended through the direction of about 100 action-research, action-design, and action-learning projects, where each project lasted an average of one year. With a reflective practice approach we applied, in the context of action-research/design/learning, a combination of what Churchman called Consensual Truth, Analytical Truth and Pragmatic Truth in the context of a systemic-cybernetic perspective of Truth.

Figure 4 schematizes what we presented with details in our developed (and still developing) *Systemic Systems Methodology*.<sup>248</sup>

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<sup>243</sup> E. Morin, 2008, *On Complexity*, (translated by Robin Postel); Cresskill, New Jersey: Hampton Press, Inc.

<sup>244</sup> OR/MS is an acronym used to refer to the related scientific fields of operations Research and Managements Science.

<sup>245</sup> N. Callaos, 1976, *A Conceptual Development of Sociopolitical Information System*; Dissertation presented at the Faculty of the Graduate School of The university of Texas at Austin. p. 124-127

<sup>246</sup> N. Callaos, 1995. op. cit.

<sup>247</sup> Ibid.

<sup>248</sup> Ibid. p. 395

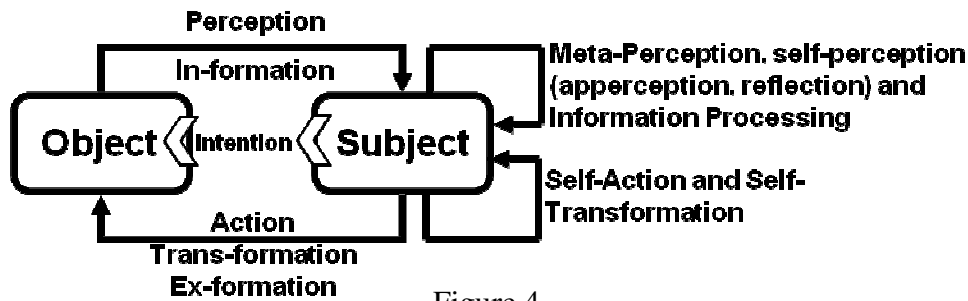


Figure 4

We are contrasting the words ‘in-formation’ and ‘ex-formation’<sup>249</sup> in order to refer to: 1) the ‘forms’ originating from the object (and other subjects) and are **instilled into** the subject, i.e. ‘in-formation’, and 2) the ‘forms’ originating in the subject’s mind (or neural networks), who is **trans**-forming them into physical signals in order to communicate them to his/her external environments, or to **express, exteriorize** them via external objects or to other subjects. The subject may exteriorize his/her mental form via: 1) communicational signals, or verbal action, 1) technological action processes ending in technological innovations or products, or 3) direct physical action. In any case, a form which is internal to a subject’s mind is exteriorized into physical forms or mental forms related to other subjects. In the way we are using the term ‘subject’ we are including observers (philosophers and scientists, for example) and doers and creators (engineers and artists, for example). On the other side of the coin, the term “object” will also include technological and aesthetic objects, and not just what is observed by the observer and what is known by the knower.

Although some authors refer to ‘subjective’ and ‘objective’ in the modern sense of these terms when they relate them to information, entropy, and probability, by no means are we using, in this section, ‘subject’ and ‘object’ in their modern sense, let alone in their Cartesian dualistic sense. Object and subject are, from a **systemic perspective**, highly interrelated via cybernetic loops. Object is what the subject observes and/or mentally or physically structures or construes. We are not using the term “subject” in its sense of “mental substance”, but in its sense of ‘substratum’, substructure’, or ‘infrastructure’, i.e. what underlies and supports our thoughts, what relates our perceptions and ideas in a whole, what structures and construes our mental constructs, what forms, gets informed, and ex-forms.

<sup>249</sup> We would like to alert that we are not using the term “ex-formation” in the sense of “explicitly excluded information” as it was used by Danish physicist Tor Nørretranders in his book *The User Illusion*. Tor Nørretranders used the word *eksformation* in Danish, and Jonathan Sydenham translated it to English in 1998 as ‘exformation’ for the publication of the book in Penguin (Non-Classics), August 1, 1999. Hugh Fox III affirms that Tor Nørretranders used the word Exformation to mean “the information which has been abstracted away, and now is implicitly included in the message,” (accessed on May 6<sup>th</sup>, 2011 at <http://foxhugh.wordpress.com/reference-fiction/science-fiction-dictionary/>). On the other hand, Stanislaw Lem uses the term exformation to designate “information explosion,” (accessed on May 6<sup>th</sup>, 2011 at <http://www.heise.de/tp/artikel/2/2108/1.html>)

We are using the terms “object” and “subject” in their general meaning, not in any of the many specific technical ones they have had in different thinkers and philosophers. With the terms of “object” and “subject” we are trying to distinguish “between thinkers and what they think about. The distinction is not an *exclusionary* one, since subject can also be objects, as it is the case in reflexive self conscience thought, which takes the subject as its intended object. The dichotomy also needs not to be an *exhaustive* distinction in the strong sense that everything is either a subject or an object, since in a logically possible world in which there are no thinkers, there may yet be mind-independent things that are neither subjects nor objects...The dichotomy is an *inter-implicative distinction* between thinkers and what they think about, in which each presupposes the other. If there are no subjects, then neither are there objects in the true sense; and conversely”<sup>250</sup>

Figure 5 visualizes the general meaning of “object” and “subject”, we referred to above, where the distinction made is not exclusionary, where the subject can also be its own object in a reflexive self conscientious thought, which takes the subject as its intended object, i.e., the observer as among the objects observed, as Second Order Cybernetics suggests that should be done. We are including in the diagrams concepts and notions described above with some details, e.g. in-formation, ex-formation, trans-formation, intention, etc.

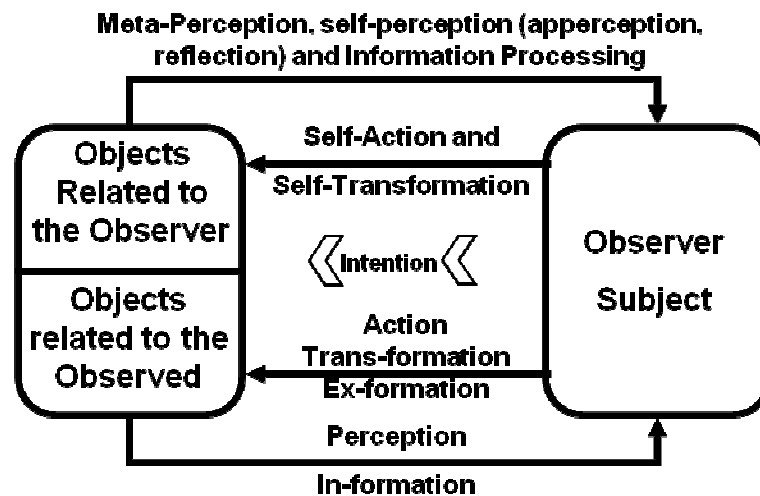


Figure 5

There are two kinds of objects, which might be labeled as ‘*internal* and ‘*external* objects’. Objectives (the object sought) and beliefs are examples of internal or mental objects. Trees are perceived as external, outside of the mind objects. Johnston Estep Walter refers to this two kind of objects as ‘subject-objects’ and object-objects’. He affirms that “In their treatment of objects of thought, idealists altogether neglect and ignore objects-

<sup>250</sup> D. Jaquette, 1995, “Subject-Object Dichotomy;” *The Cambridge Dictionary of Philosophy*; Robert Audi (Ed.); Cambridge: Cambridge University Press; pp. 885-6 (Italics added)

objects. This is consistent with them; since their greatest denial is, that objects external to and independent of the mind or consciousness do not exist.”<sup>251</sup> Radical Constructionists make similar affirmations for similar reasons. On the hand, realists “hold that what idealists say of objects is indeed largely true of subject-objects; but flagrantly untrue of object-objects.”<sup>252</sup> A similar controversy is currently found between constructionists and realists. We would prefer not to take any position regarding this issue because it is beyond the limits and the aims of this essay. This is why we preferred to characterize object-objects as objects that are *perceived* as external to the mind, without taking any position regarding of its existence or on whether it depends or is independent of the subject, the mind, who perceives them. A tree is perceived as an external object, no matter if the tree existence is dependent or not on the perceiving mind or subject.

Geometrical forms (e.g. triangles) and mathematical forms or equations (e.g. Boltzmann’s and Shannon’s) are examples of subject-objects that in-form us as soon as they are apprehended and mentally interiorized by us. Our perception of Mars through a telescope, a bacterium through a microscope, or the trajectories taken by colliding balls or subatomic particles are examples of perceptions of object-object forms, which once apprehended and interiorized become in-formation; which, to be communicated, should be expressed in physical forms (signals) via ex-formation.

Johnston Estep Walter remarked “that our knowledge of object-object [external objects] cannot be immediate as is that of subject-object [internal or mental objects]; because they are not present to the mind as are the latter. It must be some mode [internal forms, information] of mediate or representative or inferential knowledge. We have immediate knowledge of our percepts [internal forms] of external objects, since they are pure mode of mind, and therefore one with and inseparable mode of mind [mental form]; but not the objects themselves. Our knowledge of the percepts is immediate; that of the object mediate ... many realists, in claiming an immediate knowledge or external realities, are certainly in error. They mistakingly pretend to what in fact they do not have and what is impossible; and by doing so weaken the case of realism.”<sup>253</sup>

We might make an analogous reasoning regarding naïve scientific realism, or the reification we explicitly or implicitly find, in the respective literature, regarding the concept (mental form) or mathematical definitions of information and entropy. Scientists do not have immediate knowledge of external physical world. Scientific Knowledge is not immediate, but is mediated at least with mental forms, previous information and knowledge. *Our senses, instruments, theories and experimental designs mediate between the knower and what is to be known*, between the internal and the external forms. The subjective side and the internal objects of the observer (e.g. subjective information) still mediate between him/her and what is observed, what is perceived as the external world. *The observer is part of the observed and the observed is part of the observer*. Internal forms are part of what we perceive as external forms, and vice versa. Information is part ex-formation, and vice-versa. Fuzzy sets and/or fuzzy logics might provide the

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<sup>251</sup> Johnston Estep Walter, 1915, *Subject and Object*, West Newton, PA., Johnston and Penney; p. 75.

<sup>252</sup> *Ibid.*, p. 81

<sup>253</sup> *Ibid.*, p. 84

intellectual support for this systemic-cybernetic perspective. We might say that similarly to the Yin and Yang, the Observer and Observed, In-formation and Ex-formation penetrate and include each other.

Subject and Object, as well as subjective and objective information, are (as the Aristotelian metaphor of “surface” and “color” indicates<sup>254</sup>) different concepts but they always exist together. Their existence depends on each other, but they are very different concepts. So, as in the case of surface and color, we should conceptually differentiate them in order to apprehend their real joint existence. Subject and Object always exist together, depend on each other existence, and interact with each other through different kinds of relations, the most important of which are indicated in Figures 4, 5, 6, and 7. The subject perceives and gets in-formation from a reality in which he/she participates by being part of it and by acting on it and contributing into its transformation, via ex-formation. The subject contributes in transforming a reality that is in turn transforming him/her. Parts of this reality are other subjects and objects that result from a conjunction of fragments of the reality conceptualized according to the subject’s existential *ends* and cognitive *means* (previously acquired internal forms: concepts, notions, perceptions, mental constructions, etc). The objects, as perceived and conceived by the subject, result from a conjoining of the subject’s ‘external’ environmental forms (generated from other subjects and external objective reality) and his/her ‘internal’ cognitive forms or constructions.

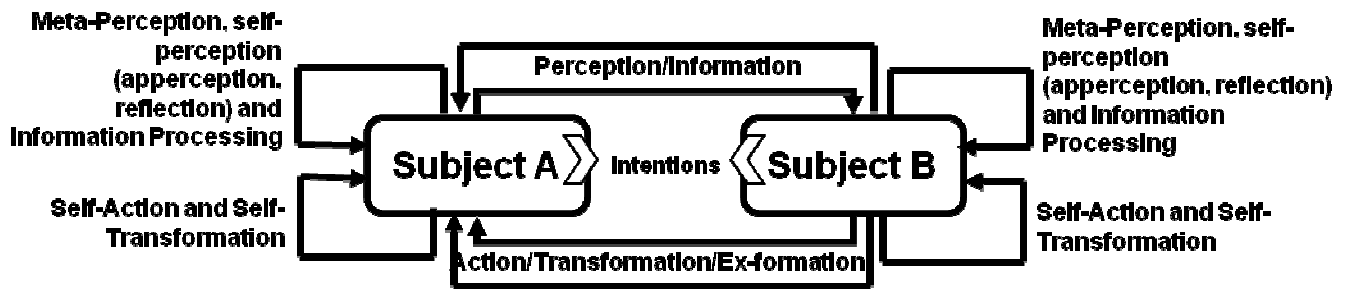


Figure 6

As a consequence of a systemic perspective (as the one described above and schematized in figures 6 and 7) where subject and object are cybernetically related, we might suggest a systemic-cybernetic perspective of **subjective** and **objective information** like the one schematically shown in Figures 8 and 9; which schematize what we have been describing above.

<sup>254</sup> The concepts of surface and color are completely different (one concept leads to Geometry, and the other to an important part of optics) but there is no perceivable surface without color, and there is no color which is not on a surface. This metaphor has been related to Aristotle but we could not verify it in the Aristotelian writings we were able to read.

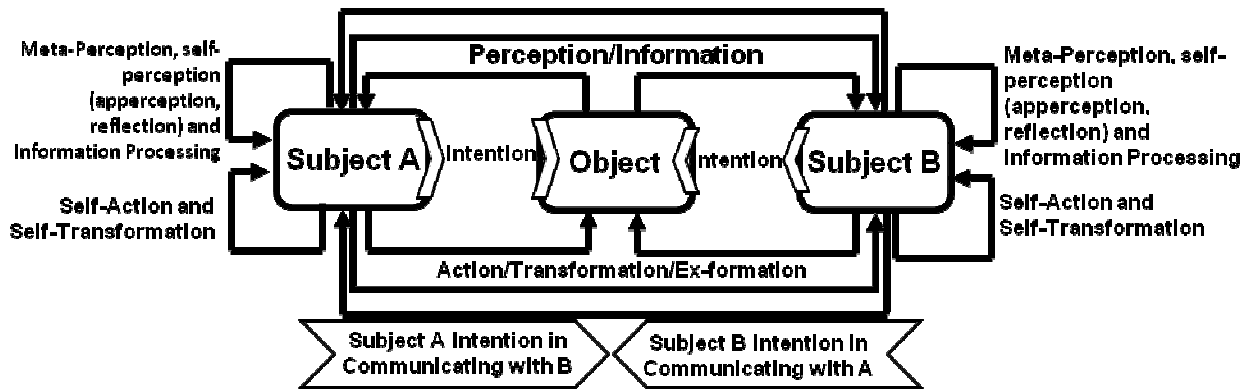


Figure 7

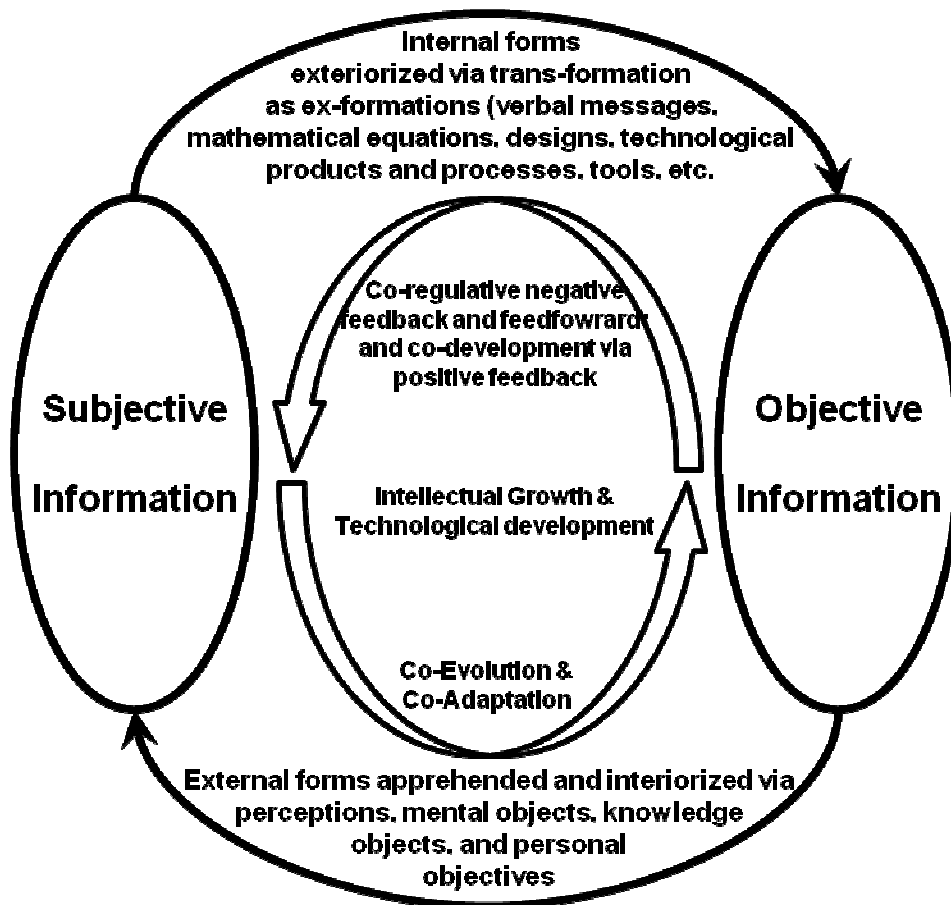


Figure 8

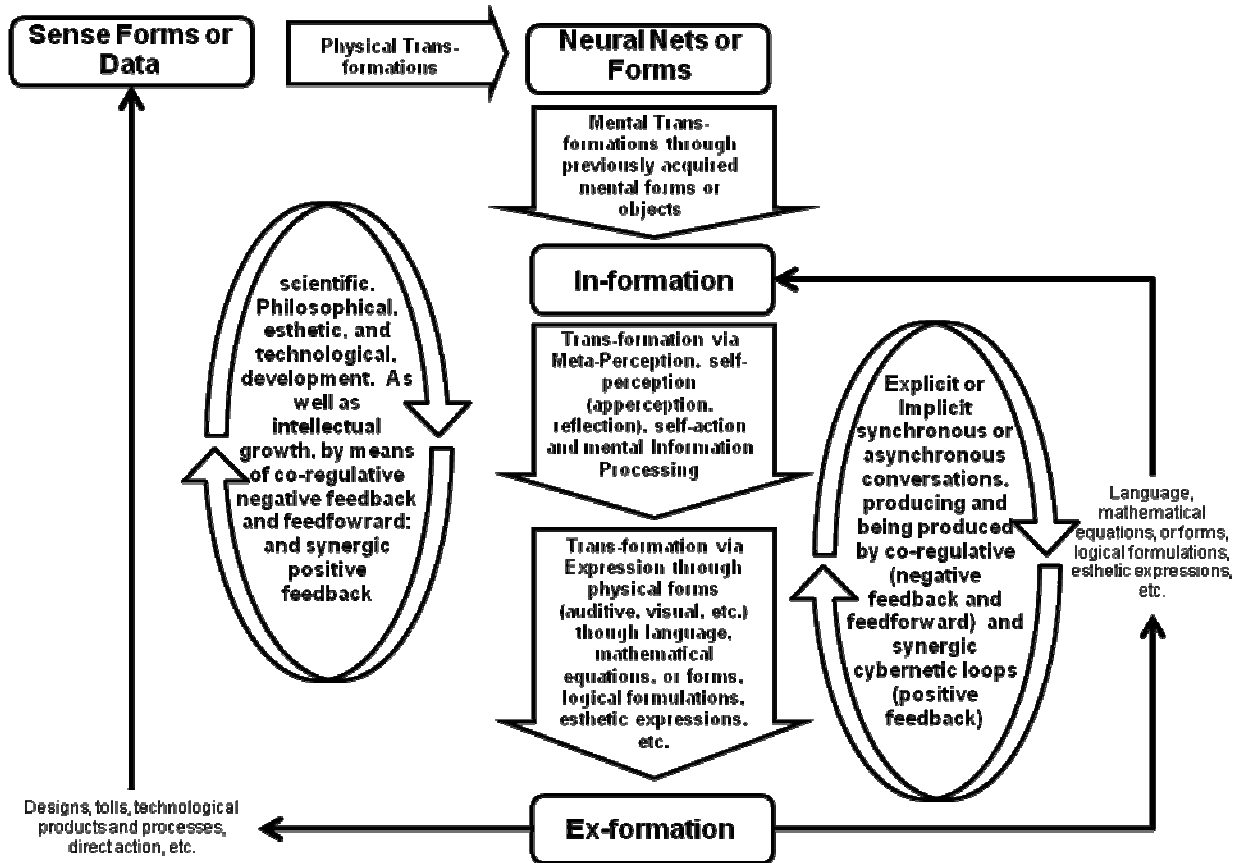


Figure 9

## 12. Practical consequences

As we said at the beginning of this exploratory essay, we are trying to give a first step oriented toward a systemic notion of information that should include a Peircean meaning where it is necessary to draw some practical consequences from what we might have achieved, up to the present, in this version of the essay. These practical consequences could be the following:

1. With the systemic approach we outlined above, we can conclude that in the fields of information systems and informing sciences and engineering, information should be considered four-folded: i.e.
  - The **subject**, the information systems **users**, and the **subjective information** they need.

- The **object**, the **data**, and its **electronic (or biological) processing**. The terms “datum” or “data” are being used here in the sense examined above as “given”. Consequently, this meaning includes:
    - What is usually referred to as organizational data, and what is automatically processed in what has been called **Electronic Data processing**, or also what we can call biological data processing.
    - The organizational approved procedures, which are also “given” by the organizational authorities or decision makers
    - The users’ organizational habits, especially if they need to be modified when the information system is to be deployed.
    - The allocated budget, especially if there is no possibility of increasing it.
    - The allowed maximum time for the development of the system.
    - The quality requirements measured, like for example, the number of defect per kilo lines of code in the first year after deployment.
    - Other possible non-negotiable requirements and restrictions.
  - The **perception/information** relationships, and the way in which the physically objective part of the information system (e.g. its electronic data processing part) will *affect its users from a pragmatic, esthetic, and psychological perspectives*. It should be reiterated here that the same data might produce different kinds of information in different users as well as different emotional, psychological, and esthetical effects. In such a case the interface where the data will be visually structured should be a product of a consensus among the future users of the information systems. Investments in achieving this kind of inter-subjective consensus usually produce more effective information systems. According to our experience, an adequate methodology to achieve inter-subjective consensus among users with regards to subjective issues (e.g. psychological, esthetic, and emotional aspects) are is a necessary condition for the effectiveness of the information systems to be developed, or being implemented.
  - **The action, transformation, and ex-formation** relationships originated by the users upon the system, via queries, data input, etc., or on the system developing process, via requirements, attitudes, contributions made in prototyping sessions, Joint Application Design (JAD) sessions, etc.
2. Consequently, an information system has four essential parts that should be addressed in the analysis, design, implementation, deployment, and maintenance of any information system or informing processes. Figure 10 shows a very simplified scheme of these four parts which should be differentiated, i.e. the data processing subsystem (which might includes Electronic Data Processing (EDP) in the computing-based information systems). Software based on a database is one of the four essential ingredients of a computing-based information system. The human part of the system should also be addressed and ‘programmed’, as well as the



perception/information and the action/transformation/ex-formation relations existing between *data (physical objective information)* and *the subjective information*. To address just the two parts that sometimes are addressed, i.e. Electronic Data Processing (software plus database) and interfaces (visualizing the required data in the required format) produce a *system FOR informing users*; it is not necessarily an information system. The user should be adequately trained and a minimum of his functional, psychological, emotional needs should be met if the system is to be a real information system. Otherwise, the system might not be frequently used or might not be used at all. In such a case, the named information systems is an electronic data processing system, or a system FOR information, not producing subjective information which is the *raison d'être* of the system.

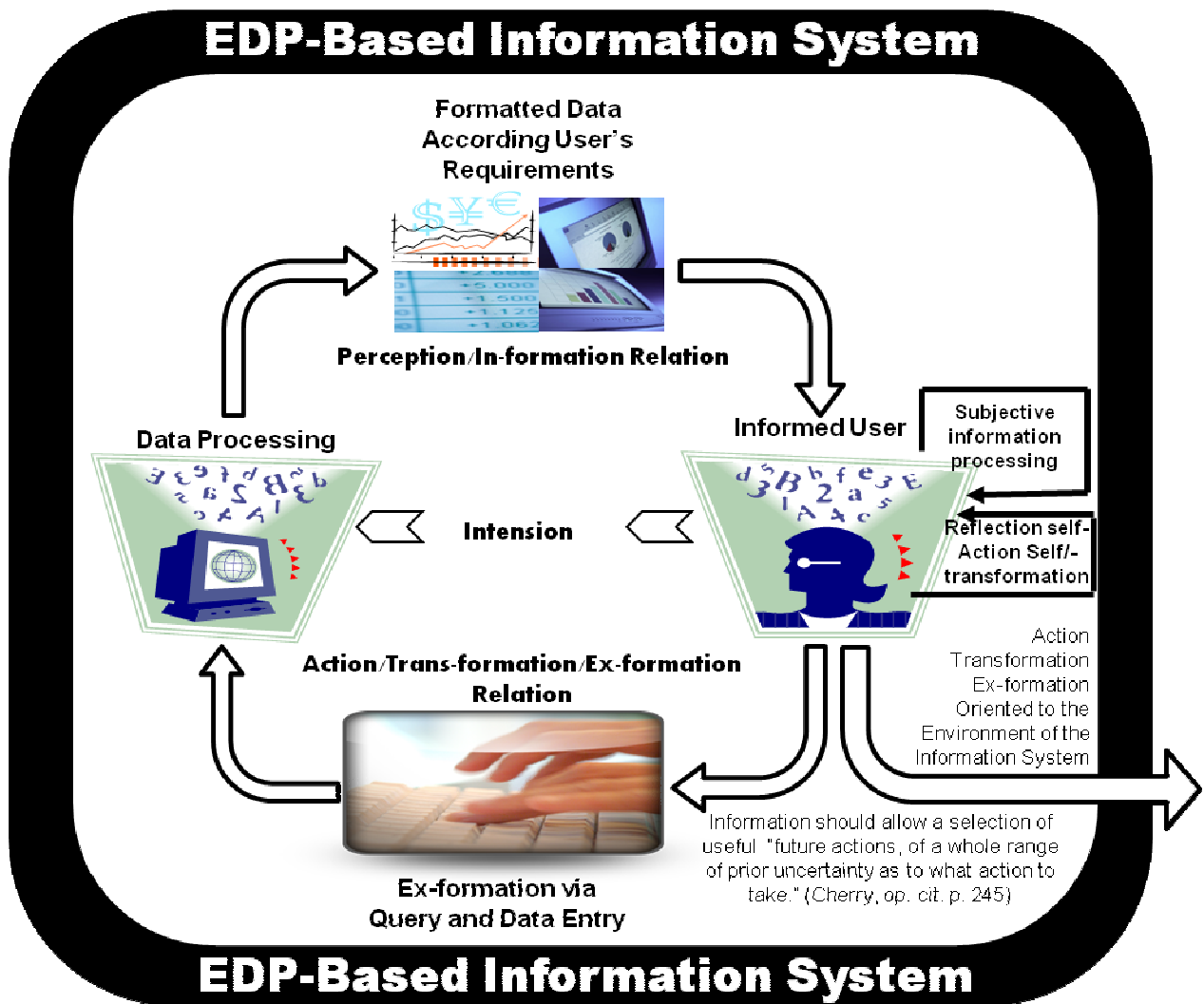


Figure 10

3. As we said above, **subjective** information should be considered as well as **objective** information, along with the informative empirical processes of **sensations/perceptions** and the **actions** taken on the information received, filtering/modifying it as a consequence of pre-established mental objects, objectives, subjective filters, prior knowledge, emotions, feelings, attitudes, values, etc. This is an adequate place to reiterate what we said above, quoting Cherry, that at the pragmatic level, a source of information has a certain value depending on its *usefulness* to its users, especially with regards to “the power it gives to the recipient to select his future *action*, out of a whole range of prior uncertainty as to what action to take.”<sup>255</sup>
4. As we suggested above, in information systems based on electronic data processing, data and information are two sides of the same coin: **the datum is the objective side of the information, and the information is the subjective side of the datum**. In this context, data are transformed into information by means of a subject’s perception and interpretation. **Electronic data processing** in a Computerized Information Systems should be complemented by “**biological data processing**” in order to transform the data in information or, at least, in subjective information in the sense that it will be potentially useful to some subject. Consequently, a computer supported information system should have an electronic data processing sub-system and a biological/human data processing system, adequately related to each other (Figure 10), in order to compose as a whole an information system, in the sense used in areas such as MIS/DSS/EIS. Consequently—let us repeat this because of its huge importance—analysis/synthesis activities should be done for both sub-systems, and not just, or mainly for, the electronic data processing, or the software development, side. Software users should also be “developed” and “maintained” accordingly. If not, we will be developing an electronic data processing system, or a “**system for information**,” a system with the potential of producing information, but not an actual information System, in the sense that the system is producing and processing the subjective information required to increase the efficiency and/or effectiveness of the user-subject. This is especially true in the case of MIS/DSS/EIS, where there is no doubt at all that we are talking about managerial information, i.e. human/subject information.
5. A datum might be **informative** or not informative. A datum with the potential of informing is an informative datum, and non-informative data have no potential information. Our written name has no potential information for us if we find them in our passport, but they surely have a huge informative potential if we see them announced as a lottery winners. In the last case, my written name is—as Floridi<sup>256</sup> would say—an answer to the question: did I win the lottery? Or who won the lottery? In the first case, my written name in the passport is not an answer to any question of

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<sup>255</sup> C. Cherry, op. cit. p. 245

<sup>256</sup> L. Floridi, 1999, *Philosophy and Computing, An Introduction*, London: Routledge, Taylor and Francis Group.

mine, so it is not informative to me. But it sure is informative to the immigration agent. Consequently, *we should distinguish among the concepts of data, informative data and information.* They are definitely not the same, though very related: data is not the same as information (in the sense of subjective information) as an increasing number of authors (especially in the Informatics field) explicitly say and some others implicitly suggest. Ramesh Bangia, for example, affirms (in The Dictionary of Information Technology) that information is the “summarization of data. Technically, data are raw facts and figures that are processed into information, such as summaries and totals. But since information can also be raw data for the next job or person, the two terms cannot be precisely defined. Both terms are used synonymously and interchangeably”<sup>257</sup> A Google search shows that there are at least 90 web pages with this definition of information.<sup>258</sup> It is true that both terms are being used synonymously and interchangeably, but this does not mean that they are synonymous. **To use them as synonyms is to ab-use them.** This is conceptually incorrect and pragmatically dangerous. Furthermore, the Dictionary of Information Technology’s definition of information is incorrect and misleading: **information is not the summarization of data**, and summarization of data is not information. “Summarization of data” is summarization of data. In the best case, it would be **informative data, not information.** To summarize, a data might make it informative, if it is associated with an explicit or an implicit question (or potential question) made by the data receiver. A very important practical consequence we can draw here is: **Informative systems are not the same as Information Systems; Informative Systems are part of Information Systems.** What is usually referred in literature as electronic information processing is (rigorously speaking) **informative data processing.** Developing information systems requires, as a *necessary condition*, the development of an informative system, but this is not a *sufficient condition*, because it will not ensure by itself alone that the respective information systems will be used with a required minimum level of effectiveness. The human part of the system should also be “developed” in order to ensure the existence of the information system. This very important and necessary aspect for successful information systems development is lacking in many academic and industry courses, papers, and books, as well as in the professional/corporative MIS development. This fact would explain most of the practical failures in the development of information systems.

As we have informed elsewhere<sup>259</sup> Gibbs<sup>260</sup> asserted that “some three quarters of all large systems are 'operating failures' that either do not functional as intended, or are

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<sup>257</sup> R. Bangia, 2008, The Dictionary of Information Technology, New Delhi: Firewall Media, Laxmi Publications; p. 328

<sup>258</sup> Among these web pages we found included the following: The PC Magazine Encyclopedia, at [http://www.pcmag.com/encyclopedia\\_term/0,2542,t=information&i=44933,00.asp](http://www.pcmag.com/encyclopedia_term/0,2542,t=information&i=44933,00.asp); Free Online Encyclopedia at <http://encyclopedia2.thefreedictionary.com/Information> (both were accessed on May 8<sup>th</sup>, 2011)

<sup>259</sup> Callaos, N. and Callaos, B., 1995, "Information Systems development Effectiveness and Efficiency", *Proceedings on the 39<sup>th</sup> Annual Meeting of the International Society for Systems Sciences*; Amsterdam, Holland

<sup>260</sup> W. W. Gibss, 1994, "Software's Chronic Crisis", *Scientific American*, September (pp. 86-95); emphasis added.

not used at all...The vast majority of errors in large-scale software are errors of omissions.” The Standish Group<sup>261</sup> showed that, in 1995, 69% of executives perceived that projects’ failure today is the same (23%), more (29%) or significantly more than 10 years ago (27%), while 23% of them perceive that failure is somewhat less, and just 8% perceived them as significantly less. The same research shows that 31.1% of projects will get canceled before they ever get completed, that 94% of the projects have to restart, some of them several times, and that the overall success rate was 16.2% (and just 9% in large company projects). The projects that were not successful, nor failures, according to the study, represented 52.7%. These projects, called “challenged”, overran the initial estimated cost by 189%. Time overrun averaged 122%. “Projects completed by largest American companies have only approximately 42% of the originally proposed features and functions.”<sup>262</sup> Since 1995, there has not been a significant change in these depressing numbers. The Standish report for 2009, for example, affirms in the “*CHAOS Summary 2009*”, that just “32% of all projects succeeding which are delivered on time, on budget, with required features and functions...44% were challenged which are late, over budget, and/or with less than the required features and functions and 24% failed which are cancelled prior to completion or delivered and never used.”<sup>263</sup> In our opinion, confusions between the concept of “data” and “in formation”, along with the extensive ambiguities where the term “information” is used, plays a significant role in such a low level of effectiveness developing software products, especially in those cases where software is developed as a support, or a sub-systems, of a larger information system. Even pure electronic data processing systems (as those used in software controlling physical processes) are developed by human beings by means of methodologies which are basically based on human information processes.

Based on this opinion we developed an information systems methodology<sup>264</sup> which we have been using and re-designing for about 20 years, through which we developed

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<sup>261</sup> J. Johnson, 1995, "Chaos: The Dollar Drain of IT Projects Failures", *Application Development Trends*, January; pp. 41-46

<sup>262</sup> Ibid.

<sup>263</sup> The Standish Group, 2009, *CHAOS Summary 2009*, reported in the Press Release at [http://www1.standishgroup.com/newsroom/chaos\\_2009.php](http://www1.standishgroup.com/newsroom/chaos_2009.php) (Accessed on June 15th, 2011)

<sup>264</sup> See for example, 1) N. Callaos N. and B. Callaos, B., 1991, "A Systemic Definition of Methodology," In *Systems Science in the 21<sup>st</sup> Century; Integrating the New Sciences of Complexity in Service of Humans and their Environment*, (eds. S.C. Holmberg and K. Samuelson) Proceedings of the 35<sup>th</sup> Annual Meeting of the International Society for Systems Sciences; Osterson, Sweden, July 14-20; 2) Callaos N. and Callaos, B. (1992): "A Systemic Methodological Support for Information Systems Analysis and Design". In *General Systems Approaches to Alternative Economics and Values*, (ed. L. Peeno) Proceedings of the 36<sup>th</sup> Annual Meeting of the International Society for Systems Sciences; Denver, Colorado, July 12-17; 3) N. Callaos and B. Callaos, 1994, "A Systemic Methodological Support for Information Systems Analysis and Synthesis". In *Cybernetics and Systems '94*, (ed. R. Trappl), Vol. 1, World Scientific, Singapore (pp. 55-62); 4) N. Callaos and B. Callaos, 1994b, "Designing with Systemic Total Quality," *Educational Technology*, Vol. 34, N° 1, 1994, pp. 29-36; 5) N. Callaos and B. Callaos, 1994c, "Conjoined Co-evolutionary Incrementalism for Information Systems development", in Zupancic, J. And Wrycza, S (eds.), *Proceedings on the Fourth Conference on Information Systems Development - ISD '94*, Bled, Slovenia, September 20-22; 6) N. Callaos N. and B. Callaos, 1994d, "A Systemic Methodological Support for

and implemented about 3 millions of lines of codes, and we deployed these lines of codes in about 40 different corporations. Most of these deployed lines of codes (about 95% of them) have been in operation for about 10 years, and some of these information systems have been operating and being maintained for about 18 years.

Throughout these years we have achieved the following productivity, quality and effectiveness:

- Our productivity average throughout these years has been raised to a level 40% higher than the USA average.<sup>265</sup> **This level of productivity has been contractually warranted in the last 18 years to large Venezuelan corporations who contracted our consulting firm for the development of customized software-based information system.** All these contracts, throughout all these years, have been 100% legally and professionally fulfilled.
- Our quality (number of bugs per thousand lines of code in the first year of system operation) rose to about 35% more than the USA average. In all contracts we signed in the last 18 years with large Venezuelan corporations, **we legally warranted a quality level equivalent to the USA average**, and we fulfilled this kind of quality level always, and in most contracts we had higher levels of quality than those promised in the contract.
- Our effectiveness (percentage of lines of code in use as related to the lines of codes delivered) has been about 98%. In all consulting contracts we signed in the last 18 years we charged just for the used lines of code not for the released number of it. This means that we warranted a 100% of effectiveness, although our real effectiveness has been about 2% smaller. We covered the cost of this 2% of ineffectiveness because we always considered that it is a risk that our consulting firm should take; it should not be taken by our clients. Consequently, our effectiveness has been 100% in the eyes of our clients, but the real effectiveness has been about 98%.

Consequently, we are basing our opinion on these encouraging numbers, when we affirm that the practical effectiveness in the development of information systems depends significantly on avoiding confusions among the different meanings of the term “information” and differentiating it from the concept of “data”, as well as distinguishing between informative systems from information or informing systems. Taking into account these important conceptual distinctions allowed us to put an emphasis on the subjective component of, both, the development methodology and the information systems being developed. Our methodology includes, but it is not

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<sup>265</sup> We used Capers Jones Productivity and quality statistics, which were he based them on one of the largest data base with regards to the USA productivity and quality. See, for example, J. Capers, J., 1996, *Applied Software Measurement: Assuring Productivity and Quality*, McGraw-Hill, 2nd edition.

restricted to, or delimited by, the usual methodologies provided in the books. There is an emphasis on the subjective information in our methodology.

6. As we briefly indicated above, the confusion between objective and subjective information processing is very dangerous, both, intellectually and pragmatically. **Effective methodologies for software development in the NAS/MW<sup>266</sup> realm are not necessarily effective in MIS/DSS/EIS development.** Then, Information Technologies consultants, systems analysts, software development project managers and university professors in software development should be aware about, and make aware, this **homonymy** in the term “information.” Unfortunately this is not the case in the present. The confusion exists, even in prestigious vendors, consultants and authors. It is not unusual to find university professors teaching MIS/DSS/EIS development by means of methodologies that are effective in the NAS/MW realm, but not necessarily effective in their subject matter. Technologies and methodologies used in effective NAS/MW development are *necessary* but not *sufficient* conditions for MIS/DSS/EIS development. In these systems, information is subjective, not just objective. So, the subject (the user) should also be “developed.” **In MIS/DSS/EIS there are two systems to be developed: an objective-information system (or electronic data processing) and a subjective-information system.** The existing confusion about the meaning of information might cause—and usually does cause—the development of just one of the required sub-systems, i.e. the objective-information system. The result of this is that the system developed is an **informative** system, not an **information** system, let alone an **informing** system. An informative system needs an informed user to be an information system. *The process by which an informative system informs a user is an informing system.* If we have no user prepared or “developed” in such a way as to enable the informative system to inform him or her, we will have no information system, no informing process and no informing system. This is a very important conclusion, especially for information systems developers’ education and training. They should be proficient in software development, which is a **necessary** condition, but it is not a **sufficient** one. They should also be proficient in what is required to assure the transformation of the data into information, or the transformation of objective-information into subjective-information. Otherwise they might fail in developing information systems, even if they develop high quality software, or electronic data processing systems.
7. The points above show us how important **triviality** is for information systems and informing sciences students, professors, trainers, consultants, developers and projects managers. This assertion seems to be non-sense and a joke. But, let us analyze the meaning of the term in order to explain our assertion. To do so, it is good to analyze, both, the actual meaning of the word and its etymological sources.

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<sup>266</sup> As we indicated above, NAS is an acronym for “Non-Application Software” (e.g. operational systems) and MW is an acronym for “Middleware” i.e. software that serves as the glue between two otherwise separate applications, it usually connects two different applications, like a database system and a web server.

- In its usual meaning, triviality has a pejorative sense. It means the quality of being trivial, i.e. ordinary and commonplace. But, to be an effective information systems developer it is necessary to have a good **communication**, especially with the system users. This means that the information systems developer has to have a **common** language with them, which means, not just their **business language** (this fact is usually stressed in most courses and textbooks), but also the **ordinary natural language** used as a meta-language. Information systems technical jargon and *computereese* should be removed from the developer-user communication, because it is not common to both of them. **Plain natural language**, be it English, Spanish, or whatever the users' natural language is, should be used; ordinary and commonplace words should be preferred. This not an easy thing to achieve, otherwise there would be no explanation as to why so many computer engineers and information systems developers fail at doing it. An adequate training should be provided to information systems developers, because *it is not so trivial to be trivial*, it is not easy for technical people to speak in a non-technical way, to be understood easily by non-technical people. Developers should be proficient in trivial natural language; they should manage their natural language as well as the artificial language used to program the computer. Otherwise, they are at **risk of developing good software but a bad information system**, a good objective-information system but a bad subjective-information system, a good informative system but a bad information system. This has been the case of many "well" managed software development projects, which ended up with a high quality software, on time and within the approved budget, but the software was never used, or just part of it was used. The following reasoning also contributed to this kind of failures.
- Etymologically, "trivial" derives from the Latin word *trivialis*, and this derives from *trivium*. This word was used in the Middle Age to mean the group of three topics, related to language teaching, which formed part of the curricula. The other four topics taught formed the group named the *quadrivium*. The *trivium* meant the "three ways" to language, to its correct and effective use. These three ways or topics are: Grammar, Dialectic (in the sense of Dialogic) and Rhetoric. **Grammar** teaches to speak well. **Dialogic** provides the art of maintaining a useful dialogue, i.e. a competent communication. And **Rhetoric** provides the means of doing a pragmatically effective use of the language, i.e. obtaining the practical results sought by the use of the language. So many people knew the *trivium* in the Middle Age that its three integrated topics became commonplace. Hence, emerged the word *trivialis* that means "trivial." And, here we have a **bewildering paradox**: what was a commonplace in the Middle Age education is not so common in our time, in professional activities that most need it. **Trivium is not trivial anymore in our time**, in the field of information systems where it is so needed and almost a necessary condition for effective professional activities. It is not being adequately taught in informing sciences and it is not at all included in Computer Engineering or Computerized Information Systems Engineering curricula. *Trivium* is as essential to an Information Systems Engineer performance as it is to a lawyer. While Information Systems curricula designers do not understand this situation,

- the importance of solving its related problems and the real necessity of including, in the respective curricula, a *trivium*, adapted to our times and to the Information Systems field, there will be no strong hope in increasing significantly the future professional effectiveness of the students.
8. In a more general intellectual context (which includes but it is not reduced to the domain on Information Systems: MIS/DSS/EIS) we have already indicated above that **it is intellectually misleading and, hence, pragmatically dangerous to reduce the meaning of “information” to one of its senses**. Consequently, when we are referring to one of the senses of “information” it is important to place an adequate adjective along with the term “information” in order to be explicit about the sense in which the term is being employed.
  9. As we have shown above, a measure should not be identified, or confused, with the property that is being measured, or with the “thing” whose property is being measured. A gallon is a measure of volume and the property of volume is shared by gases, liquids, and solids. Similarly, a bit is a measure of different properties (e.g. spread of probabilities, uncertainty, etc.) that might belong to different entities (e.g. signal entropy, electric signal transportation, informing subject, informed subject, etc.). Consequently, a measure in bit should not be confused with any of the properties that can measure or, even worse, the entities holding any of these properties. Because we can measure information, entropy, negentropy, spread of probabilities, uncertainty, ignorance, etc. with the same measure should not mean that we can equate all these properties as if they were the same thing, or representing the same thing. Shannon’s mathematical equation is a way of measuring something that might be common in several properties, belonging to different entities, but this does not imply that we can identify or confuse these different properties, let alone the entities holding them. Consequently, when we measure “information” in a “spread of signal probabilities,” we are not necessarily using the term “information” in the same sense when we use it as related to a human being, or in its semiotic-semantic, or semiotic-pragmatic sense. When we measure spread of probabilities (or the signals rarity), using the term “information” we are not meaning the same property or entity as when we use the term “information” in Journalism. Both senses of the term might be related but this relation is not necessarily an Identity Relation. To identify what is not necessarily identical might be intellectually misleading and, hence, pragmatically ineffective or even dangerous.

## Conclusions

We tried to give a first step oriented toward a systemic notion of “information” by means of Ackoff’s conceptual definition and Peirce’s conception of “meaning”. In doing so, we described different important definitions, senses, and uses found in the literature with regards to the term of “information”, and we tried to relate them in a conceptual structure, a comprehensive whole, a systemic notion.



We identified two basic stances, or intellectual perspectives, with respect to the nature of information, each one with some subtle distinctions, diverse hues, and differences. Authors debate between the **subjective** and the **objective** nature of “information”. We tried to show that both intellectual viewpoints, in the debate, are **polar** opposites, not **contradictories**. Each dialectical part does not exclude the other but, on the contrary, it requires it (and it includes it) just like the concept of the North Pole requires the concept of the South Pole. We tried to integrate both kinds of perspectives by means of 1) our notion of a **systemic distributed truth**, based on, and derived from, Singer-Churchman’s pragmatic-teleological truth, and 2) **cybernetic loops** of feedback and feedforward, where subjective and objective information would co-determine, co-influence or **co-form** each other in a dynamic and cybernetic whole. The objective world **in-forms** subjects by means of their sensations and perceptions, and subjects **re-form** the objective world modifying its objective information, or negentropy, by means of their actions and **ex-formation**. These actions and ex-formation processes are determined by subjects’ objectives and concepts, which are derived from perceptions based on the same objective information to be modified. This modified objective information causes new perceptions on subjects, who react by modifying objective information, and so on, *ad infinitum*.

Cybernetic loops between objective and subjective information and a perspective of a distributed truth, facilitated our way toward a systemic notion of “information”, which should be: 1) **comprehensive**, i.e. not excluding existent definitions, senses, and uses of the term (one way to work this out is by means of classifying, or typifying, according dichotomies or opposites, as subjectivity and objectivity); 2) **structured**, i.e. relating the elements included in the comprehensive perspective; and 3) based on the **pragmatic-teleological truth**, and, in our case, on our **notion of distributed truth**. Based on this systemic notion of “information”, we derived several pragmatic, practical, and methodological consequences, especially in the case of information systems development. And, we showed how **critical** some of them are for the effective development of effective information systems.

As the title of this essay expresses, we tried to show a way “toward a systemic notion of information” and we made initial steps in this direction. More steps are required to complete the journey—if there is any end to it. These steps might be oriented toward a **more comprehensive review** of the literature related to the concept of information, as well as other neighboring concepts, such as the notion of “probability” which has not been adequately analyzed in this work. Furthermore, inter-subjective flow of information was not part of our research intention in this essay, but it certainly is a very important issue, that might take us to **Habermas’ Communicative Action** and, from there, to Computer Mediated Communication (or human information interchange). Other future steps, in the direction sketched in this paper, might be oriented towards: 1) a **more profound analysis** of the concepts managed in this essay, identifying their philosophical implications and their practical consequences; and 2) a **more comprehensive** integration identifying more related concepts and describing with more details the respective relationships. In other words, a more extensive and deeper research is needed, both, horizontally and vertically.

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