# Knowledge and Cognition

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## Purpose

Our main purpose in this short draft is to present a systemic-cybernetic model that relates 1) the notions[1] of 'Knowledge' and 'Cognition' 2) their essential conceptual *ingredients*, and 3) important constituents of their intellectual *contexts*. Through the identification of these relationships we will try to identify (implicit and/or explicit) cybernetic loops, which might a) support co-regulation (though negative feedback and feedforward) and b) generates synergies and emergent properties through positive feedback.

Given the trans-disciplinary nature of 'Knowledge' and 'Cognition', and the multi-disciplinary domains of "Cognitive Sciences" and "Cognitive Technologies," one of our most important objectives in producing this draft is to make an initial small step that might generate other similar or related works that could produce an intellectual platform for *inter-disciplinary communications* in the related areas or disciplines. This kind of inter-disciplinary communication might generate collaborative inter-disciplinary research, enquiries, and reflections, as well as some instances of, or occasions for, inter-disciplinary education. Consequently, our approach includes a *general* perspective regarding each of the concepts, notions, or terms that will be used in presenting our systemic-cybernetic approach to 'Knowledge' and 'Cognition.' It is not our objective, to present a thorough description of the conceptions with which some basic concepts have been used in different disciplines, or an in-depth analysis of the different meanings and theories related to basic concepts that will be used in this essay. We will borrow and reference conceptual definitions and meanings oriented to our objective, i.e. we will briefly describe and reference the conceptual building blogs supporting our respective interpretations, in the context of suggesting systemic-cybernetic preliminary models, which is the main purpose of this article.

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[1] 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." (Merriam-Webster, 1999, *Merriam-Webster's Collegiate Dictionary*; third edition, Springfield, Massachusetts, Merriam-Webster, Inc) The senses in the meaning of ***"notion" include what we can 'note', (cognate with –*** 'having the same origin of'- ***'cognition'),*** with regards to a term or an expression. The term "notion" means a "general concept; a mental representation of a state of things;… a thought; a cognition;…In Lockean 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 funded on insufficient evidence and slight knowledge on the subject…The mind; the power of knowledge; the understanding." (Whitney, D. W. (Ed.), 1969, *The Century Dictionary and Cyclopedia*, Century Co; p. 4027)

**Intellectual Perspective**

Many intellectual perspectives might be used when referring to Knowledge and/or Cognition. Because of the purpose/objective mentioned above, we will use the notions of 'Knowledge' and 'Cognition' in the context of an interpretative phenomenological perspective, in the very general sense of the term,' i.e. describing and/or interpreting these phenomena as they *appear, are experienced, and/or interpreted.* Our method will be a bottom-up interpretative synthesis[2] based on the interpretations, studies, experiments, and reflections of different authors which will be cohesively combined in the context of model building and meaning identification of the most essential terms that will be used in this article. Consequently, we will not be testing any hypothesis but suggesting models, reflections, interpretations, and meta-interpretations oriented to the purposes of this enquiry.

We will try to focus on essential phenomena (e.g. cognizing, knowing, "the apprehension of the object," or its (similar) forms by the subject, etc.) and the meaning of basic notions (e.g. information, data, forms, perception, knowledge, etc.). From a simplified phenomenological perspective, 'to know' is what happen when a cognitive subject apprehends, capture the knowing object through the cognitive act of knowing. Consequently, we will be referring to the "gnoseological (knowing) subject" and the "gnoseological (known) object" not the *real, physical, or meta-physical* subject and/or object. This would not necessarily exclude, in our description, ideas and reflections presented by some philosophers who were not centered in describing 'knowledge' and 'cognition' as they *appear*, because they also base their reflections on appearances. Who do not restrict themselves to the phenomena of knowing and cognizing do not necessarily exclude this kind of aspects. Consequently, we will include in this draft reflections from thinkers who did not restrict themselves to the said phenomena. The criteria to include this kind of reflections are basically two: 1) to have ***internal coherency*** with other concepts and notions used in our proposed systemic-cybernetic model, and 2) to have an ***external adequacy*** to the purpose/objective described above. In this sense, our approach might be seen as an *eclectic* one in which different conceptual or notional ingredients may be extracted from different intellectual systems, philosophies or theories as long as they are coherent with other ingredients and adequate to the stated objectives. As it is known, eclectic philosophers and thinkers oppose dogmatic intellectual perspectives that exclude foreign ideas no matter how valid, good or adequate they are. An eclectic perspective might provide adequate intellectual support for ***plural epistemologies,***[3] ***scientific pluralism,***[4] and ***Scientific Perspectivism***[5] which are at the center of the intellectual and epistemological values of the conception of the model we are briefly proposing with this short working draft.

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[2] M. Weed, 2005, (revised in 2008) "Meta Interpretation": A Method for the Interpretive Synthesis of Qualitative Research, *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, *6*(1), Art. 37; accessed on March 9, 2013 at http://nbn-resolving.de/urn:nbn:de:0114-fqs0501375.

[3] See, for example, M. G. Piety, 2010, *Ways of Knowing, Kierkegaard´s Pluralist Epistemology*, Baylor, Texas: Baylor University Press.

[4] See, for example, S. H. Kellert, H. E. Longino, and C. K. Waters (Eds.), 2006, Scientific Pluralism, Minneapolis, Minnesota: University of Minnesota Press.

[5] See, for example, R. N. Giere, 2006, Scientific Perspectivism, Chicago, Illinois: The university of Chicago Press.

As we will briefly describe below, the term 'cognition' has been used in several senses, and the associated idea has been conceived in different ways in the context of different theories, and intellectual perspectives. The variety of conceptions and senses found regarding 'cognition' are mainly generated because of 1) its multi-disciplinary nature, and 2) the different sub-processes and intermediated products in which research has been focused according the diversity of purposes associated with different researchers. Consequently, let us start with 1) non-disciplinary and common sense definitions and conceptions provided by general dictionaries, and 2) make some common sense derivations which will be revisited, below, under the light of disciplinary and/or inter-disciplinary conceptions and theories. The objective is to start from a non-disciplinary perspective and, later, modify and/or expanded into by means on disciplinary or inter-disciplinary intellectual perspectives, always under the light of the kind of eclectic approach mentioned above.

Merriam-Webster defines 'cognition' as "the act or process of knowing including both awareness and judgment; also: the product of this act."[6] Cognition then, even in its common sense meaning, includes the senses of 'process' and 'product, as well as what might be understood by the terms/concepts of 'knowing,' 'awareness,' and 'judgment.' As process, cognition have several sub-processes (and sub-sub-processes) associated to products and sup-products and/or intermediate products. Cognitive processes generate products and are also supported by these products. Their processes and products are *cause* and *effect* of each other in a *non-linear* way with *cybernetic* co-regulative (negative feedback and feedforward), co-supporting, and co-enhancing (positive feedback) loops. Actually, cognitive processes are continuously supported by the same products and sub-products they are generating. Both cognitive processes and products might be *means* and *ends* of each other. Figure 1a shows a simple diagram regarding the non-linear cybernetic relationships we are referring to. Figure 1c shows the same simple diagram but oriented to 'knowledge,' which is one of the essential products of cognition processes and which is one of our focus in this article.

As we mentioned above, and as we will show below with some more details, focusing on different sub-processes, oriented by diverse objectives, and/or restricted by various disciplines, researcher and authors generated or a multiplicity of meanings associated with the term 'cognition' and conceived the related concept in various ways and form different perspectives. In this article we will use 'cognition' as an ***embodied, embedded, and extended*** process.[7] The main reasons why we are using this conception of 'cognition' are 1) because it is, in our opinion, the most systemic-cybernetic one and, consequently, it is the most adequate one for meeting a main purpose of this article, and 2) because it includes cognitive technologies as both a final product or an intermediate product that would support more cognitive processes. We will not use this conception as a theory that exclude other competing ones, but as a platform for including other conceptions of 'cognition' as addressing different sub-processes of a more comprehensive conception of cognitive processes. Consequently, conceiving an "*embodied, embedded, and extended cognition"* (EEEC) might provide a meta-perspective where other intellectual or theoretical perspectives might be included in a cohesive (syncretic or eclectic) way.

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[6] Merriam-Webster's College Dictionary, 1999, Tenth Edition Springfield, Massachusetts: Merriam-Webster Inc. p. 223

[7] A. Clark, 2012, "Embodied, embedded, and extended cognition," in K. Frankish and W. M. Ramsey (Eds.), The Cambridge Handbook of Cognitive Science, pp. 275-291

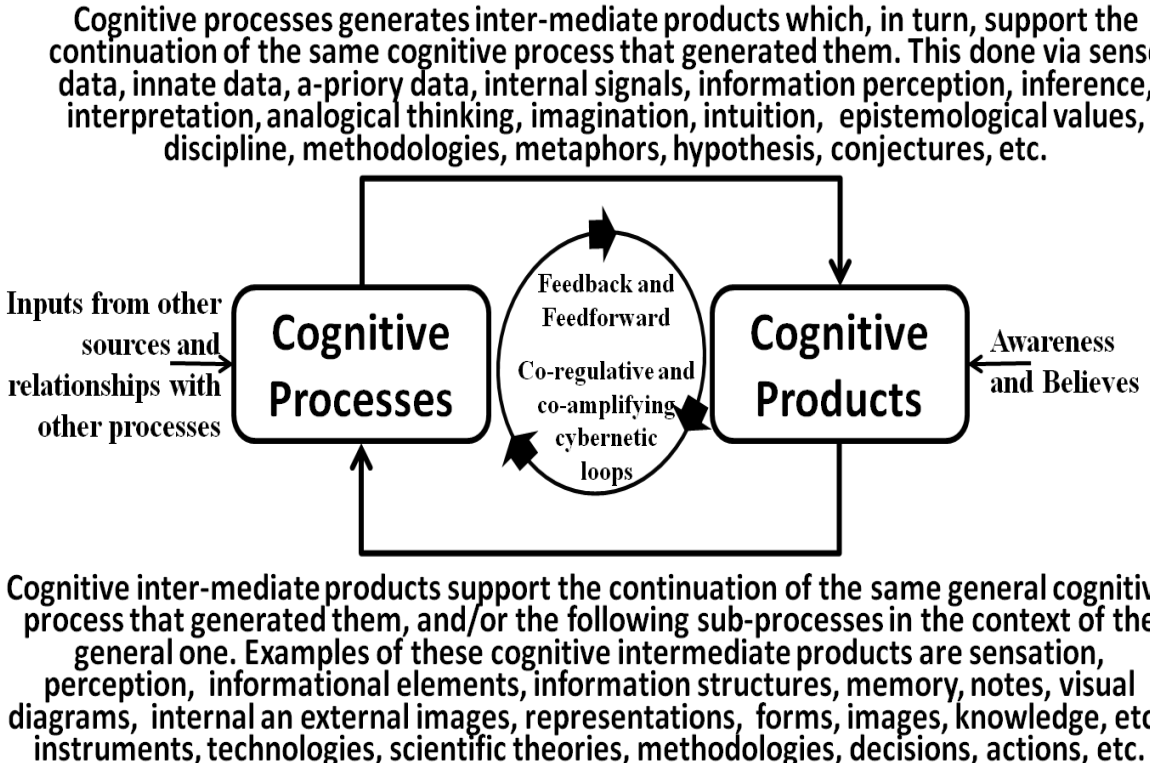


Figure 1a

From an EEEC perspective, mind is, according to Haugeland "not incidentally but *intimately* embodied and *intimately* embedded in its world."[8] Thelen affirms that "to say that cognition is embodied means that it arises from bodily interaction with the world."[9] According to the EEEC conceptual framework, cognition is not limited to the mind or the brain, but it is based on processes that include the brain, the body, and the world. The non-neural body is not just a sensorial platform and an effector system of the brain. Mind and body interact with each other and with the world in the context of cognitive processes. Accordingly, in order to avoid confusions we suggest to use adjective associated to the word 'cognition' in order to refer with more precision to what we are referring to, i.e. to differentiate 'mental' from 'non-mental' cognitions. Mental cognitions are inserted, embodied in the context brain-body systems, and these, in turn, are embedded in the world which include cognitive technologies, external knowledge physically represented by other mental cognitive systems or embodied cognitions (via verbal and non-verbal languages, symbols, signs, etc.). Figure 1b schematizes the EEEC conception of cognition. We will use the term cognition in its EEEC conception, unless we add

[8] J. Haugeland, 1998, "Mind embodied and embedded," in Haugeland, Having thought: Essays in the Metaphysics of Mind; pp. 207-240; Cambridge, Massachusetts: Harvard University Press; p. 237, (author's italics). Quoted and referenced in Clark, op. cit., p. 276

[9] E. thelen, 2000, "Grounded in the World: Developmental Origin of the Embodied Mind," *Infancy*, 1, pp3-28; p4. Quoted and referenced in Clark, op. cit., p. 275.

an adjective to refer a specific kind of cognition, as it is the case of "mental cognition" which is the sense of those who do not accept the EEES perspective.

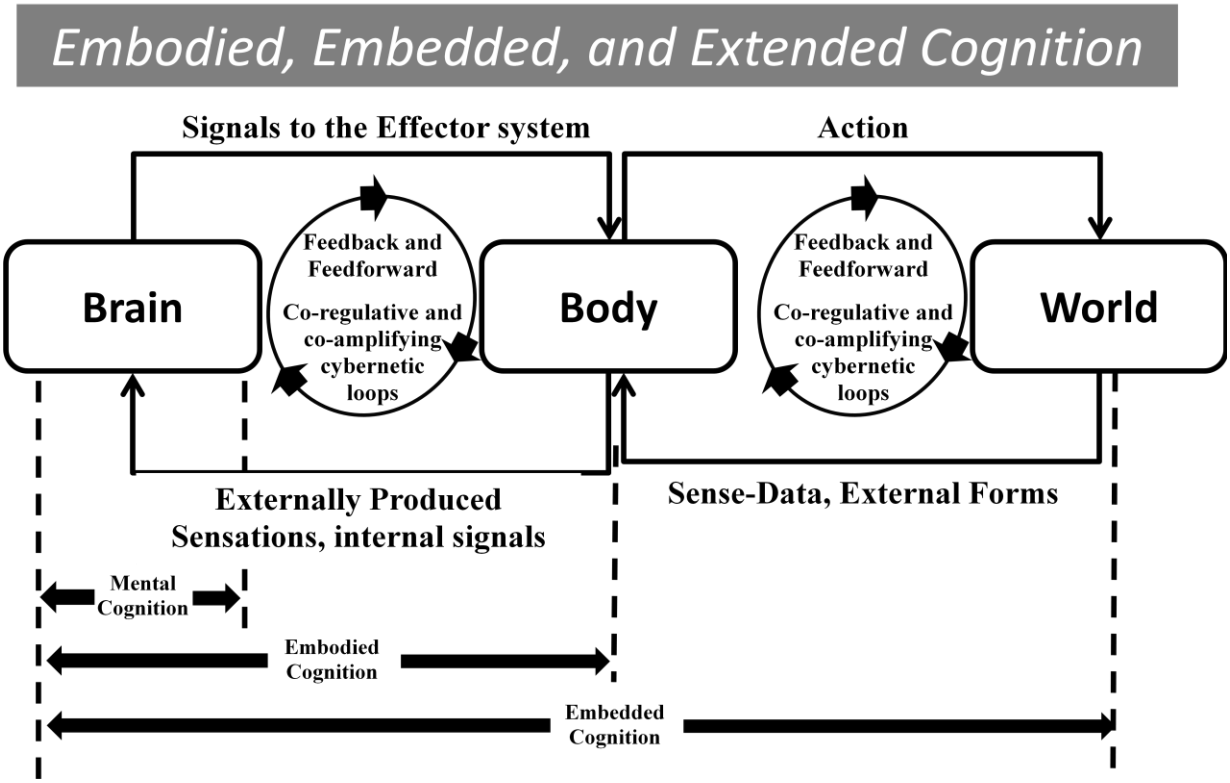


Figure 1b

With regards to the notion of 'knowledge' it is well known that it has been extensively treated in Greek and Medieval Philosophies, but in the context of Ontology, i.e. in the context of trying to answer the question "What is reality?" In Modern Philosophy 'Knowledge' has been examined as a central issue. As it is known, Rationalists (like Descartes, Leibnitz, Spinoza, etc.) conceived the Reason as the *source* of knowledge, and Empiricists (like Locke, Hume, Berkeley, etc) affirmed that the sensorial experience is its *source*. Kant tried to mediate in this Rationalists/ Empiricists controversy conceiving both sources as necessaries for knowledge generation. A priori categories and a posteriori experience contribute in Knowledge formation. With Kant "Knowledge Theory" emerges, although his philosophy cannot be reduced to such a theory. A ***linear*** perspective characterized the different conceptions of 'knowledge'. The philosophical problem was mainly oriented to identify the *source(s)* of knowledge in order to explain the process with which the acquired source is transformed in knowledge. In Rationalism the source is the mind, the cogito; in Empiricism the source is sensorial experience, and in Kant both are necessary sources of processes ending up in knowledge. The three representative paradigms included a 'source' ending up in knowledge. *They differed with regards to the nature of the source but not regarding their linear cause-effect perspective*. What they differ is in the nature of the cause, not in the implied linear cause-effect general process. It is possible to find in some of the representatives of Modern Philosophy implicit non-linearity but in such cases these

nonlinearities are conceived as local and limited ones in the context of a linear whole process. *We suggest that a nonlinear approach might be intellectually more inclusive and comprehensive perspective because it could include the different linear approaches found in the literature as special cases of a more general and comprehensive perspective.*

We can resume saying that the intellectual perspective being used in this short draft is 1) ***eclectically*** oriented, and based on plural epistemology and scientific pluralism, and 2) supported by ***non-linear*** thinking and/or meta-thinking.

In the model that we are hypothetically suggesting, Knowledge and Cognition are cause and effect of each other. They have non-linear relationships. Figure 1c shows a very general visualization of the idea; which will be examined with more details below, providing context especially regarding what we called "inputs from other sources." Let us provide an exploratory reasoning which might support the hypothetical idea we are suggesting.

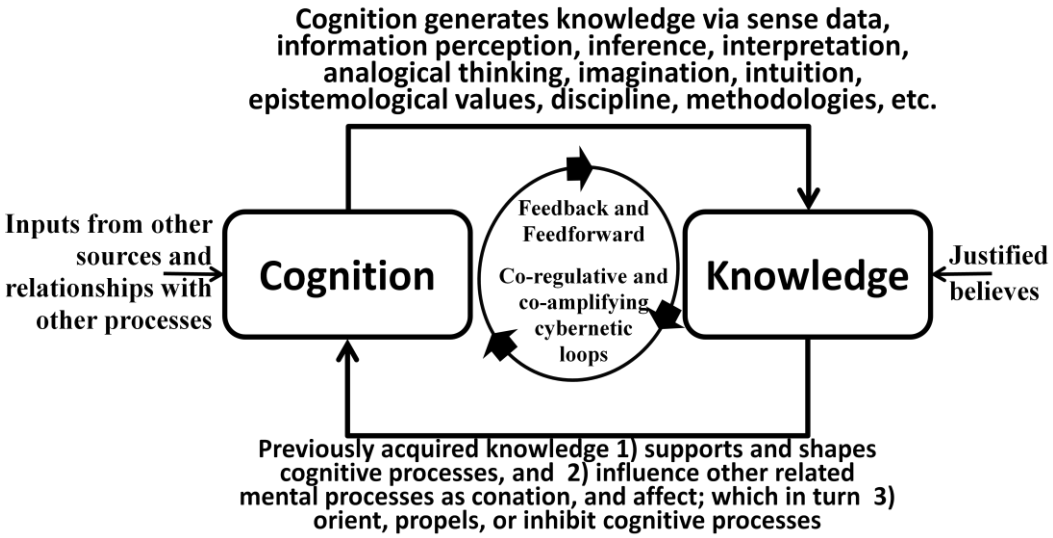


Figure 1c

**The Notion of Cognition: A Systemic-Cybernetic Perspective**

In its general sense cognition is "the act or process of knowing…also: a product of this act;"[10] a "mental act or process, or the product of an act, of the general nature of knowing or learning;"[11] Hamilton affirms that cognition is "the act of acquiring any sort of idea…an act of knowing in the widest sense … [but] discriminated as a function of the mind [and differentiated] from *feeling* and *volition."*[12]James Ward also differentiates cognition form *conation* and *feeling.*[13] But,

[10] Merriam-Webster's Collegiate Dictionary, Tenth Edition, Springfield, Massachusetts , Merriam-Webster Inc. p. 223
[11] The Century Dictionary and Cyclopedia, An Encyclopedic Lexicon of the English Language, New York: The Century Co., Vol. II, p. 1090
[12] Sir W. Hamilton, Metaph. Xxi, cited in The Century Dictionary, Ibid.
[13] J. Ward, Encyc. Brit. XX, 40, cited in The Century Dictionary, Ibid.

as soon as we try to analyze more this concept and what is understood by the term 'cognition,' we find that there seems to be no consensual agreement with regards to its meaning, on its nature, or on a definition of the corresponding concept. Let us provide few examples.

The most comprehensive notion of 'cognition' is found in Biology. In the context of Maturana and Varela[14] conception, for example, all living systems are conceived as cognitive systems. They use the powerful and useful concept of '*autopoiesis*' (self-produced) to define life and then associate this concept to cognition. Accordingly, a bacterium would be a cognitive system. If so, what would be the relation between 'cognition' and 'knowledge'? Several authors affirm that bacteria have only instincts, not what we understand by 'knowledge.' Then, can we define any kind of life as cognitive systems? Are instincts some kind of knowledge? Can instincts be considered as cognitions, some kind of them, or initial phases of cognitive processes? Should unconscious, pre-conscious, or sub-conscious processes be considered as cognitive processes? Should they be conceived as just influencing or related to cognitive processes while not being part of them, or some of its species? With regards to this issue, John Kihlstrom affirms that "we now have good evidence , from a wide variety of research paradigms, that our experience, thought, and action is influenced by mental structures and processes of which we are not aware,"[15] or conscious. So, there seem to be empirical evidence that unconscious, pre-conscious, and/or sub-conscious processes ***influences*** experience, thought, and action. Consequently, it is a matter of conventional definitions whether non-aware processes are cognitive processes or not. It depends on how we define 'influence,' 'part,' 'cognitive processes,' and cognition. Is *part* of a whole what *influences* it? Or it is not part of it but ***relates*** to it, influencing it. We conjecture the second perspective, which will be used in what we will be proposing as systemic-cybernetic models of cognitive/knowing phenomena.

Questions like the one posed above, generated more research regarding the concepts (or notions) of 'autopoiesis,' 'cognition,' and 'life.' Paul Bourgine and John Stewart[16], for example, proposed, in the context of Artificial Intelligence and Artificial Life, 1) a modified definition of autopoiesis and 2) a definition of cognition as follows: "A system is cognitive if and only if sensory inputs serve to trigger actions in a specific way, so as to satisfy a viability constraint."[17] With these propositions they conclude that "the concepts of autopoiesis and cognition, although deeply related in their connection with the regulation of the boundary conditions of the system, are not immediately identical: a system can be autopoietic without being cognitive, and cognitive without being autopoietic."[18] Accordingly, they proposed that "A system that is both autopoietic and cognitive is a living system."[19] They proposed what IS a living systems, but this does not

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[14] H. R. Maturana and F. J. Varela, F.J.,1979, *Autopoiesis and Cognition: The Realization of the Living*, Kluwer Academic Publishers, Dordrecht, Netherlands. Referenced in by V. Dörfler and J. Szendrey, From Knowledge Management to Cognition Management: A Multi-Potential View of Cognition. Accessed on February, 11th, 2013 at http://www2.warwick.ac.uk/fac/soc/wbs/conf/olkc/archive/olkc3/papers/contribution278.pdf. It has been permanently archived at http://www.webcitation.org/6EMZeyrPW

[15] J. F. Kihlstrom, "The Rediscovery of Unconscious," in in H. L. Morowitz and J. L. Singer (Eds), *The Mind, the Brain, and Complex Adaptive Systems*, pp. 123-143; p. 138.

[16] P. Bourgine and J. Stewart, 2004, *Artificial Life* 10: 327–345.

[17] Ibid., p. 327

[18] Ibid.

[19] Ibid.

necessarily mean that all living systems are autopoietic and cognitive systems, because A is B does not necessarily imply that B is A.

It is good to notice that the above definition of 'cognition' provided by Bourgine and Stewart ("A system is cognitive if and only if sensory inputs serve to trigger actions in a specific way, so as to satisfy a viability constraint) does not exclude non-empirical content in cognitive systems. It requires that cognitive processes be ***triggered*** by ***sensory inputs***, but non-sensory input might also be present and might influence and/determine the form acquired by the sensory content.

In the context of Cognitive Psychology, Ulric Neisser[20] provided the following definition of 'cognition'; which concurs with the above definition and interpretation, but it removes the restriction by which cognitive process are present ***if and only if*** they are triggered by sensory input

> "… the term «cognition» refers to all the processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used. It is concerned with these processes even when they operate in the absence of relevant stimulation, as in images and hallucinations. Such terms as sensation, perception, imagery, retention, recall, problem-solving, and thinking, among many others, refer to hypothetical stages or aspects of cognition."[21]

Combining both definitions above we might define 'cognition' as "*processes and/or the intermediate or final products triggered by empirical or non-empirical data (givens); which produce internal forms (information) and are stored, recalled, recognized, and transformed via perception, thought, reflection, etc. into knowledge, imagery, etc., and is used in decision making, problem solving, planning, action, etc.*" This is the definition of cognition that we will use in this article; which concurs with the two given above, one in the context of Artificial intelligence, and the other in the context of cognitive psychology. Consequently, the proposed definition, we are adopting in this article, support both natural and artificial cognition and, consequently, ***cognitive science*** *and* ***cognitive technologies***

In the context of Human Cognition, the proposed definition allows a systemic insertion of cognition in the context of other mental processes which have been identified. In Psychology three component of the mind are usually distinguished: cognition, conation (volition), and affect (feeling).[22] These three mental activities are systemically related. We know and understand through cognition, but a necessary condition for cognitive processes is the motivation to know which is determined by personal ends and objectives, i.e. ***conation propel and orient cognition.*** In turn, cognition may change/modify conation: new acquired knowledge, understanding and learning might change/modify our ends as well as our volition. Consequently, cognition and conation are nonlinearly related to each other, with potential cybernetic loops. On the other hand, *affect* is associated to the *emotional interpretation* of received perceptions and information, as

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[20] U. Neisser, 1967, *Cognitive Psychology*, Meredith Publishing, New York, NY. Quoted and referenced by Dörfler and Szendrey, op. cit.
[21] Ibid.
[22] W. Huitt, W., 1999, "Conation as an important factor of mind," *Educational Psychology Interactive*. Valdosta, GA: Valdosta State University. Retrieved on September 11, 2012 from http://www.edpsycinteractive.org/topics/conation/conation.html.

well as of acquired knowledge. Affect is the *feeling* that a perception, information, and/or knowledge might generate, which depends on past experience. Affect (feelings) might impact conation (motivation, intention, and ends) and, consequently, have effect in cognition. In turn, past cognitional and conational experience might determine affect. Consequently, we can tentatively hypothesize that ***cognition, conation, and affect are non-linearly related in a systemic-cybernetic whole, which what 'mind' might mean***. If we accept this hypothesis, then cognition should not be examined as isolated from conation and affect because its mental context provides (or at least contribute to) its meaning and to the understanding of its respective processes. Figure 2a shows a simplified visualization of systemic-cybernetic relationships among each two components and among the three of them. Figure 2b combines Figure 2b with figure 1, providing it with the mental context and the relationships existing with other mental components.

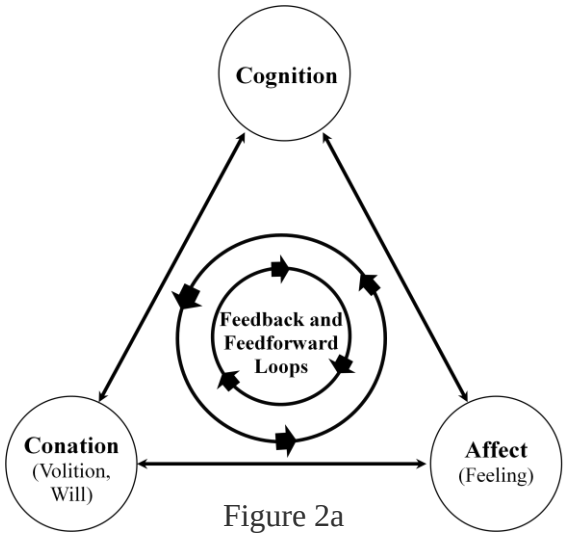


Figure 2a

Co-regulative (negative feedback and feedforward) and co-amplificatory (positive feedback) loops relate and integrate cognition, conation (volition), and affect (feeling) into a whole (with potential synergies and emergent properties) which might form part of what it is meant by 'mind'. In such a case, the external[23] context of 'mind' would also contribute to a comprehensive meaning of it

From both etymological and conceptual perspectives, to examine the 'notion' of 'cognition' is a *meta-cognitive* process. Both terms derive from Latin '*(g)noscēre*', pp. '*nōtus*' which means "a becoming acquainted, a taking cognizance, an examination, an investigation, a conception, idea notion."[24] Cognition derives from co- (together) and '*gnoscēre*' which is an older form of *noscēre*'. Consequently, to examine the notion of cognition is a ***meta-cognitive*** action or process; which might generate knowledge regarding the nature of cognition, which might lead to a hypothetical perspective in meta-knowledge; which, in turn, might influence our apprehension of the nature of cognition, meta-cognition. And so on with potential co-regulative and co-amplificatory cybernetic loops also between meta-cognition and cognition, as well as between

[23] We are not using the word "external" in a spatial-temporal context but in a conceptual one.
[24] The Century Dictionary and Cyclopedia, op. cit. p. 4027

cognition and meta-cognition, and knowledge and meta-knowledge. This would extend figure one in what is shown in Figure 3.

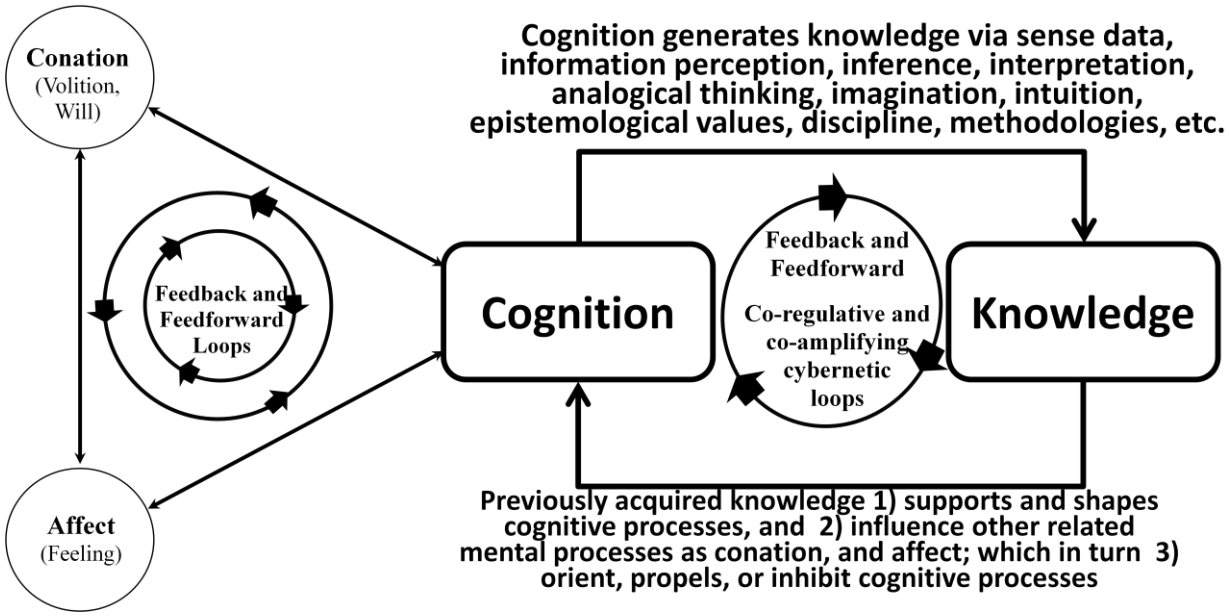


Figure 2b

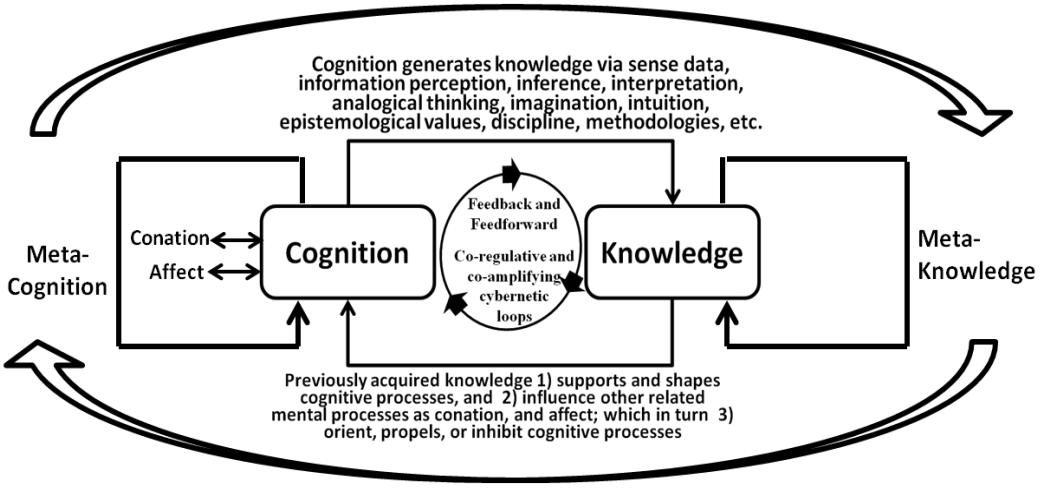


Figure 3

On the other hand, if a notion of cognition (some kind of meta-cognition as we suggested above from the etymological roots of both words) is to be a systemic one, it should include in its cognizance the ***context*** of cognition; which, in turn, includes at least the mental processes of 'conation' and 'affect.' Besides this context, ***internal*** to the mind, there is a context that is ***external*** to the mind which also should be taken into account in a systemic examination of the notion of cognition.

To relate internal and external[25] contexts, and since 1) cognition relates the knower and the known (or what is being known), and 2) the notion of knowledge is systemically related to the notion of information (and data), we will examine the nature and the possible relationships between '*subject*' and '*object*,' as well as the notion of 'information' and its relationships with 'data' and 'knowledge'.

## Data, Information and Knowledge[26]

The notion of information is a very important one in the context of Cognitive Sciences and, specifically in Cognitive Psychology, because, via analogical thinking, cognition is conceived as based on neural information processes. Consequently, because of its strong relationship with both cognition and knowledge let us present some details regarding the *notion of information*. A more comprehensive exploration regarding the notion of 'information' has been presented in N. Callaos, and B. Callaos, 2011, *"Toward a Systemic Notion of Information: Practical Consequences."*[27]

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."[28] Jan Aidemark affirms that "definitions of information as interpreted data…are not uncommon in the area of information systems."[29] Many other authors refer to 'information' as 'interpreted data.''[30]

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[25] As we indicated in a note above, internal/external dichotomy is not meant is a spatial-physical context but in a conceptual one, as related to the knowing subject and/or process.

[26] This section is an adaptation of another one we published in Callaos and Callaos, 2011, Toward a Systemic Notion of Information: Practical Consequences. A shorter version can be found at http://inform.nu/Articles/Vol5/v5n1p001-011.pdf

[27] Ibid.

[28] A. Aamodt, 1993, "A Case-Based answer to Some Problems of Knoweldge-Based Systems," in E. Sandewall, and C. G. Jansson (Eds.) SCAI '93: Scandinavian Conference on Artificial Intelligence - 93: 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.

[29] J. Aidemark, 2002, "Information Planning for Knowledge Work – The flexibility approach, in *ECKM - European Conference on Knowledge Management*; pp. 29-42; p. 31.

Consequently, from this kind of intellectual perspectives, in which information is conceived as a subjective interpretation, we can affirm that ***cognitive processes transform data into information***. By analogical thinking we might also entertain the idea that *cognitive technologies* also transform data into information, though not necessarily human information.

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 the context of a MIS should provide some meaning to some manager in order to fulfill the data's *raison d'être*, their reason or justification of existence. An interpretation, in this context, is, by its own nature, cognitive and *subjective*, i.e. related to a *subject*, to a "mind, ego, or agent of whatever sort that sustains or assumes the form of thought or consciousness."[31] Consequently, it is easy to conclude that according to this kind of definition there is no information system (IS) without a subjective or a cognitive 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, cognitive* one (biological/human data/information processor: a user, a manager, etc).

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.*"[32] 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 granted."[33] The Century Dictionary[34] 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 cognizing or reasoning,) or a reference, a given initial position from which other positions are to be inferred*. In any of its three senses, '*datum*'

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[30] 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 8th, 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/IIE/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 8th, 2010 at http://www.stsc.hill.af.mil/crosstalk/2001/06/bowman.html.

[31] Merriam-Webster's *Collegiate Dictionary*, 1999, Springfield, Mass: Merriam-Webster Inc. Third Edition.

[32] 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.

[33] C. T. Onions (Ed.), 1996, *Oxford Dictionary of English Etymology*, Oxford: The Clarendon Press.

[34] 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.

is a '*given*' (fact, premise, or position) which initiates a process. In the context of this essay '*datum*' *is what initiates an informing process. But the informing (cognitive) process might, in turn, change conation (intention, motivation, and sought objectives) and/or generate new feelings that might change the kind of data the cognizer would be looking for.*

In the context of information as "*data plus meaning*", '*datum*' would be *what initiates a cognitive informing process oriented to produce a meaning, and the acquired meaning might in turn change the data of interest or to be apprehended.* Consequently, data and information might have a non-lineal relationship in which they the 'given' form part of what determine the 'non-given' but generated meaning, which in turn might change the 'given' to be looked for. Hence, data and information might be conceived as two sides of the same coin in which they may co-determine or co-influence each other.

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."[35] 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."[36] 'To signify' is a Latin rooted term similar (not completely equivalent) to the Old High German rooted 'to mean.' 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".[37] Significant is one sense of what is meant by 'meaning'. Consequently, 'information,' in its sense of "meaningful data," might be defined as "significant data", "data full of meaning", "data having a meaning or purpose," and "data plus meaning"[38] 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* (in the context of Information Systems, Informing Sciences, Cognitive Psychology, and knowing processes) *is always in a person, in a subject, i.e. it is subjective.* To convey and to receive a meaning require both cognition and conation. Affect, or feeling, might also be impacted in the receiver as well as influencing the motivation of the sender and even transmitted as part of the intended meaning.

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.*'[39] This Latin term means: "shape, form an idea of."[40] To form an idea is always in the mind of a person, of a subject. *On the other*

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[35] Merriam-Webster,
[36] Ibid.
[37] Ibid.
[38] 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)
[39] Merriam-Webster, op. cit.
[40] 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.

*hand, 'informare' is a composite of 'in-' and 'formā'*. The last term means "shape, mold" The term '*in-'* "is used in combination mainly with verbs and their derivatives, with the senses of 'in, into, within'."[41] Accordingly, 'to inform' would mean "to form in," "to form into," "to form within." ***Who*** forms ***what***, ***for whom/why***, 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' is 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.[42] A person [the who] identifies and chooses expressive (audio or visual) forms [the what] when trying to communicate with other (s) [for whom/why], who get into his, her, or their 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 have shown in the above mentioned detailed study[43], 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."[44],[45] Agustin uses '*in-formare*' with a similar meaning.

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".[46] 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***."[47] "Information is understood not as a thing but as a *construction".*[48] 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."[49] So, what Dervin is saying is that any

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[41] Hoad, op. cit.

[42] 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)

[43] Callaos and Callaos, 2011, op. cit.

[44] 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.

[45] 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 Epucureans 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

[46] 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."

[47] 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).

[48] Ibid.

[49] Ibid.

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'* [50], 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."[51] 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 by his/her individual experience. This is a very important conclusion, which many authors of Information Systems books, or papers, do not seem to take into account. But, the term 'information' might also mean something else, something objective, even physical, as we have shown in other paper.[52]

Other examples of the increasing number of authors who recently are conceiving information as a subjective phenomenon, can be found in Borland and Perlovsky. Boland concluded "…information is the inward-forming of a person that result from the engagement with data."[53] 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."[54] 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 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."[55] In the context of this perspective we might suggest that 'information' (in the subjective sense we are referring to here) is produced by ***inborn (cognitive) processes of "matching mental models-representations in memory to bottom-up signals coming from sensory organs" or sense-data.***

Accordingly, we might possibly suggest that:

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[50] 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.

[51] S. D. Neill, S. D.,1992, *Dilemmas in the Study of Information: Exploring the Boundaries of Information Science*; New York: Greenwood Press; p. 34.

[52] Callaos and Callaos, 2011, op. cit.

[53] 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 10th, 2010 at World Wide Web: http://inform.nu/WhatsIS.htm

[54] L. Perlovsky, 2001, Neural Networks and intellect: Using Model-based concepts; Oxford: Oxford University Press; p. 423n4.

[55] L. Perlovsky, 2010, "Mathematical Equivalence of Evolution and Design," presented at the General Plenary Session of the 14th, Multi-Conference in Systemics, Cybernetics, and Informatics: WMSCI 2010; Orlando, Florida, USA, June 29-July 2, 2010.

- *Data*, what is given, are associated with *external* forms, a priori data, and internal signals generated by body's organs. Regarding this issue, Jerome Singer affirms that "we receive signals and information not only from a consensually agreed outside world but also from sources of stimulation within our bodies,"[56] e.g. heart rate, muscle spasms, pain, etc.

- *Information* is related to *internal (cognitive) initial* representations and associations of external forms and internal signals, via perception.

- *knowing* is a cognitive process and/or product of transforming the initial representations (information acquired via perception) into more complex representations (knowledge), where initial representations are related and combined with previously acquired perceptions and knowledge 1) via *cognition* (inference, imagination, analogical thinking, intuitions, beliefs, etc), *2) oriented by conation* (volition: motive and purpose), and 3) *restricted or potentiated by affects* (feelings) and *believes*.

The newly generated knowledge might impact conation (motivation and objectives), in which case attention might be reoriented for the identification of different data which in turn might change perceptions (via new information) and consequently new cognitive inferences might generate new knowledge, and so on. Figure 4 is a simplified visual description of the non-linear process we are trying to suggest, which certainly include potential co-regulative, co-amplifying, and or co-restructuring cybernetic loops. The very simplified cognitive process shown in Figure 4 is based on what Heinz von Forrester called " '*Cognitive element*' for it represents the minimal case of a cognitive process,"[57] and, consequently, it allows its systemic inclusion in more complex structures that results from relating it to other ingredients of its context. The three basic ingredients of Heinz von Forrester's '*Cognitive element*' are: perception, memory, and inference.

The data might be sense-data and/or what we can call "a priori data," i.e. what is "aprioristically given necessary conditions," for the generation of any kind of perception. Sense-data is input from the 'external' by any of the senses. These include externally represented knowledge via language, symbols, audio-visual means, etc.

We are using "a priori data" or "a priori given" in any of both senses of chronological and/or logical antecedent; i.e. a temporally previous event and/or a logical necessity. In these senses, the "a priory givens" are included not just the notion of 'data', but also in the notions of perception and knowledge. There has been for a long time non-resolved controversies with regards to the reality or the existence of similar concepts (e.g. 'innate ideas'), but since our approach is comprehensive one though a systemic-cybernetics intellectual perspective, with which we are trying to integrate opposing *linear* perspective into a *non-linear* one, then we prefer not to get involved in this kind existing controversies. John Locke, for example, fiercely

[56] J. L. Singer, 1995, "Mental Processes and Brain Arquitucture: Confronting the Complex Adaptive systems of human Thought (An Overview)", in H. L. Morowitz and J. L. Singer (Eds), *The Mind, the Brain, and Complex Adaptive Systems*, pp. 1-9; p. 3. (Author's Italics)

[57] H. von Forrester, 2003, *Understanding Understanding Essays on Cybernetics and Cognition*, New York: Springer, pp. 119-121

opposed Descartes 'innate ideas'. Empiricists, in general, opposed this concept which with different variations was held as essential in Rationalist approaches. Even Locke accepted the notion of 'innate ideas' in logic while maintaining its refusal in the context of genealogical psychology. As it is known, this controversy led Kant to propose an epistemological framework in which he tried to integrate both perspectives. Accordingly, Kant "replaced the doctrine of *innate ideas* with questions about *a priori concepts*, which he characterized in terms not of their origin but of their necessity as conditions of human experience of an objective world. In the 20th century Noam Chomsky argued the necessity for postulating innate ideas to explain the possibility of language."[58]

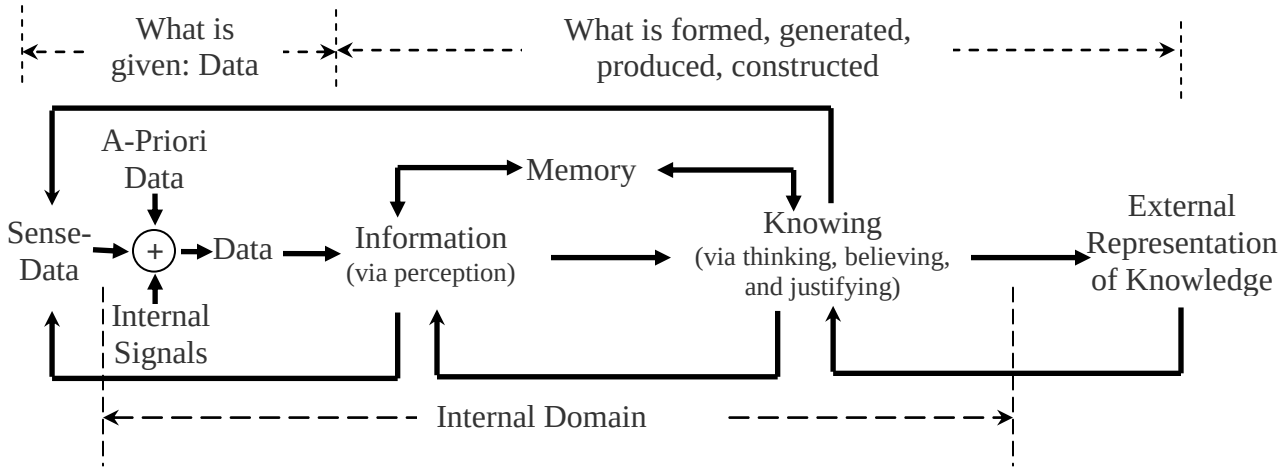


Figure 4

More examples of what we are calling "a priori given" could be found in:

- the Kantian pure or transcendental apperception which is a necessary condition for any kind of perception, and
- Wundt conception of 'apperception' (who derived it from Leibniz's and Kant's apperception) "referred to the active synthesizing function of consciousness."[59]

**Perception:** The objective of this sub-section is to describe the meaning with which the word 'perception' is used in figure 4, before continuing with the description of the relationships, commonalities, and differences among data, information, and knowledge. This is not the place to make a comprehensive exploration with regards to the theories and studies related to 'perception.' Such a goal would require a different essay and probably a book written by different authors because the different ways in which 'perception' phenomena have been approached in different disciplines and even in the same discipline. Our objective in this paper is to suggest the meaning which will be used in this article, and to provide the reasoning supporting

[58] Britannica Online Encyclopedia, Innate Idea, accessed on February 16, 2013 at http://www.britannica.com/EBchecked/topic/288470/innate-idea

[59] J. Brockmeier, 1998, "Wundt, Wilhelm (1832-1920)" in Routledge Encyclopedia of Philosophy, General Editor: E. Craig, London: Routledge, Vol. 9, pp. 798-802; p. 799.

our suggestion without losing sight regarding the main purpose of this article, which we mentioned above.

In Figure 4, we are using the term 'perception'[60] in its most comprehensive meaning but related to the above mentioned Heinz von Forrester's '*Cognitive element*', i.e. as distinguished from 'memory' and 'inference.' We are using the word 'inference' in the sense of 'conscious or attentive inference.' We are using this restricted sense of inference in order not to exclude from the notion of 'perception' potential ingredients as pre-attentive (pre-conscious), unconscious, or subconscious cognition which some authors associate as some kind of inference. Again, it would depend on the meaning we associate to the word 'inference.' We prefer to use this term in its most comprehensive meaning, because of the eclectic intellectual perspective (we briefly describe above) based on scientific pluralism and plural epistemology. We believe that this intellectual perspective is the most adequate one for a comprehensive systemic-cybernetic approach.

Philosophical debates and controversies about perception are ancient. We will not provide, in this paper, a review of the different ontological, epistemological, psychological, and cognitive approaches to perception, because it is not among our objectives. But we will explore some issues that are relevant to our purpose and provide some alerts to the reader regarding conceptions used regarding the notions of ´perception´. We will try to do that as briefly as possible.

'Perception,' in the context of Heinz von Forrester's '*Cognitive element*' can be conceived as "***direct*** apprehension of an objective situation,"[61] as Ferrater-Mora shortly defined it, and because Heinz von Forrester differentiates But, the term 'direct' has a diversity of more restricted meanings in what has been called "direct perception" Regarding this issue, Alva Noë, for example, affirmed that

> "The claim that perception is direct has been advanced by a small but distinguished minority of philosophers and psychologists, including J. L. Austin, J. Gibson, J. McDowell, Ulrich Neisser, Hilary Putnam, Peter Strawson, and perhaps also Aristotle, William James, and Thomas Reid. Perception, it is argued, it is a form of *noninferential awareness* of the sort of things that we normally take ourselves to be aware of when we perceive, such as everyday objects and events."[62]

Alva Noë provides a condensed presentation of the arguments against, and in defense of, "direct perception' in Contemporary Philosophy and Cognitive Science, then concludes affirming that

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[60] From Latin from Latin '*per'* (which means "through, during, by means of, on account of") and '*capere'* (*which means* "to grasp, take"); Online etymology Dictionary, at www.etymonline.com

[61] J. Ferrater-Mora, 1969, *Diccionario de Filosofía*, Buenos aires: Editorial Sudamericana, Vol. 2, 391 (Emphasis added)

[62] A. Noë, Queries for Macmillan, ECS paper no. 170; accessed on February 17, 2013 at http://socrates.berkeley.edu/~noe/directperception.pdf, p. 1 (Italics added)

> "The debate about direct perception is *ongoing*. It takes place at the foundations of contemporary thought about perception. For science, as we have seen, what is at stake is our basic analysis of what vision is and our account of the level at which perceptual phenomena are to be studied. For philosophy, what is at stakes is our understanding of the nature of experience, and of the role of experience can play as a source of knowledge."[63]

It is good to notice that Alva Noë use, in the first text above, the phrase "perception is direct" which has a different meaning than the phrase "direct perception," which he uses in the second text above. In the second case the term 'direct' is used as ***adjective***, and in the first case as a ***predicate***, a ***substantive predicate***. In the first case "direct perception" means a species of the genre 'perception.' In the second case, the phrase "perception is direct" is an affirmation related to any kind of 'perception.' We suggest that this kind of ambiguities add confusion to an already debated and controversial issue. The phrase usually used is "direct perception" and Ferrater-Mora, mentioned above, uses de phrase "direct apprehension." Consequently, we propose that the term 'direct' should be used as adjective, not as substantive predicate. And, if we use it in this sense then the ongoing controversy might be solved by means of eclectically conceiving the perception process in two parts: 'direct perception' and what we can call 'indirect perception.'

In Gibson's[64] theory of direct visual perception, the term 'direct perception' means (according to John Frisby) that "the structure of the environment can be recovered *directly* (hence the name of the theory) from invariants without the recourse of memory and inferential processes."[65] Consequently, Gibson's 'direct perception' would be, as we suggested above, part of what we are meaning by "perception" in this paper, and also part of what Ferreater-Mora is meaning when he define perception as "direct apprehension of an objective situation." There is no contradiction as it might seem at a first sight because Ferrater-Mora is referring to '***apprehension***' which is different and should not be confused with the notion of '***recovering***' *directly* the environment structure without recourse of memory and inferential processes.

Accordingly to hat we proposed above, Gibson's 'direct perception' would be a first phase of what we are referring as 'perception' process. One of the sources of confusion or controversies regarding the meaning of 'perception' might be related to its two main senses: as *process* and as *product*, and as product, it could be referring to the *initial product* and the *final product*. Since the meaning of 'initial' and 'final,' in this context depend on what we are meaning by sense-data, and knowledge and what differentiate 'perception' from knowledge', hence the plurality of conceptions regarding the term, concept, or notion of 'perception.'

Perceiving is more immediate than knowing. Non-direct apprehension might lead to knowledge, or other intellectual contents, which require mediated inference, reasoning processes,

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[63] Ibid., p. 5 (Italics added)

[64] J. Gibson, J., 195, Optical Motions and Transformations as Stimuli for Visual Perception, *Psychological Review*, 64, pp.288-295. J. Gibson, 1966,*The Senses Considered as Perceptual Systems,* Boston: Houghton Mifflin. J. Gibson, J., 1979, *The Ecological Approach to Visual Perception,* Boston: Houghton Mifflin. Referenced by A. Noë, op. cit.

[65] J. P. Frisby, 1994, "Direct Perception" in M. W. Eysenck (Ed.), *The Blackwell Dictionary of Cognitive Psychology*, Cambridge, Massachusetts Blackwell Pub., p. 95; (author's italics).

logical/analogical thinking, intellectual imagination, etc.) Perception is a more ***immediate*** cognitive apprehension or awareness of an object (or an objective situation). Several authors emphasize that perception imply non-inferential awareness, while knowledge requires, as a necessary condition (thought probably not a sufficient one) cognitive processes mediating between perception and the achievement of knowledge or probable knowledge or a transitory one. Knowledge is ***mediated*** by cognitive processes and accompanied by ***justified belief***. Different conceptions of what is 'belief' and what is 'justification' are what generate the different stands on what knowledge is or what it should be. Perception ***interfaces*** the knowing subject and the known, or to be known, object; according the intention of the subject. A priori categories and organizing forms might formally mediate in the perceptive act, even in sense-data perceptions. This kind of mediation is not necessarily a chronological (or temporally a sequential) one because it is related to the *forms* by which the *content* (what is given, the data) is collected or apprehended. Expressing the idea metaphorically, we might say that to collect, grasp, or apprehend a fluid content, we will need a container which form will take the form by the apprehended content; hence the term in-formation. Human being lives in a dynamic, continuously changing, and fluid external and internal environment. So, what is given (empirical or rational, sense-data or innate ideas driven) is 'fluid' and to apprehend it a non-fluid and less 'container' is needed. Consequently, the collected fluid (internal and external reality) has the form of its formal and formative container. In this context, we can say that the 'container' is a ***means*** used for the apprehension of the intended object in the internal/external reality, i.e. the form of the container was a medium, mediated, in the process of reality apprehension.

A more detailed exploration will be made below with regards to the relationships between subject and object.

In Figure 4 we are basically referring to 'perception' as "sense perception" but without necessarily excluding other mental perceptions, which might affect and influence (and even distort) "sense perception." Furthermore, we are using this term according to the definition provided by Martin, i.e. "Sense perception is the use of our senses to acquire information about the world around us and to become acquainted with objects, events, and their features."[66] Correspondingly, *external forms are transformed in internal forms, i.e. information*, as visually it has been indicated in figure 4, and will be shown in more figures below. McLaughlin affirms that "Sense perception is a primary means by which we acquire knowledge of matters of fact contingent. We can also acquire such knowledge by, for instance, conscious reasoning and through the written and spoken testimony of others, but knowledge so acquired is derivative , in that it must be based , ultimately, on knowledge arrived at in more primary ways, such by sense perception."[67] Furthermore, we also need sense perception to get this kind of derivative knowledge because it is delivered by means of sense-data, e.g. verbal and/or written language, audio-visual symbols, non-verbal language, videos, e-learning support, etc. McLaughlin also affirms that "We can perceive something without acquiring any knowledge about it; for knowledge requires belief, and we can perceive something without having any beliefs about it."[68]

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[66] M. G. F. Martin, 2000, "Perception," *Concise Routledge Encyclopedia of Phylosophy*, London: Routledge, pp. 664-5.
[67] B. P. McLaughlin, "Epistemic Issues in Perception," *Concise Routledge Encyclopedia of Phylosophy*, London: Routledge, p. 5.
[68] Ibid.

As we suggested above, in-formation is related to external forms which were mentally interiorized, and as we will suggest below, Knowledge is based on meta-forms (form of forms, e.g. related set of forms, abstract ideas: mental forms representing what is common in many forms, etc.). Consequently, to relate some information to a belief, or a set of beliefs, is an instance of meta-form, or knowledge, or (at least) some kind of knowledge. Consequently, McLaughlin's conception of 'perception' is in agreement to the meaning with which we are using this term in both figure 4 and the brief textual description with which we are trying to complement this figures, as well as others to be shown below.

Much of the historical debate regarding the notion of 'perception' is related to contrasting the appearance and the reality of what is being perceived. This is mainly an ontological issue and it will not concern us here, because it is not relevant to our objective or to the phenomenological perspective we affirmed above that will be our intellectual perspective. Consequently, we will be concerned about how objects appear to us and not about the nature of the correspondence of the real object and how it appears to us. But, we certainly should address the issue when an object appear to (is perceived by) different subjects in different ways. A coin might look circular to one observer and elliptic to another if they do not have the same viewing angle. Straight sticks appear as bent at the water line, but a person with the adequate knowledge knows that the stick appear to be bent but actually it is not and he/she can prove removing the stick from the water. Consequently, several objective and subjective factors might influence the ways in which an object appear to us and, consequently, can produce different kinds of perceptions of the same objective situation. This perceptual diversity might lead to knowledge plurality regarding the same objective situation. This is one of the most important reasons why we are using an eclectic perspective in this paper and suggesting ***plural epistemologies***[69] and ***scientific pluralism***[70] as the intellectual and epistemological values supporting the conception of the model we are briefly proposing with this short working draft.

There have been controversies about the ***passive*** or the ***active*** nature of perception. But, both conceptions do not necessarily exclude each other. They might even complement each other, being cause and effect of each other in different phases of the perceiving process. Passive impression from the external world can activate internal processes that might influence the perception of the initial passive impression. This actively 'constructed' percept might change the attention of the perceiver modifying the initial passive impression by another passive one, which in turn might activate another perceptual 'construction.' And so on in a dynamic process. The resulting perception, or percept, may strongly be influenced by the concepts of the perceiving subject. In short, "Perception is deeply imbued with concepts."[71] Many experiments and studies have been confirming the way in which 'perception' is affected by subject's emotions, needs, feelings, as well as social and cultural variables. Margaret resumed this issue including a very representative example of the experiments validating these kinds of influences on perception. She affirmed that:

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[69] See for example, M. G. Piety, 2010, *Ways of Knowing, Kierkegaard´s Pluralist Epistemology*, Baylor, Texas: Baylor University Press.

[70] S. H. Kellert, H. E. Longino, and C. K. Waters (Eds.), 2006, Scientific Pluralism, Minneapolis, Minnesota: University of Minnesota Press.

[71] M. A. Boden, 2006, Mind as Machine: A History of Cognitive Science; Oxford: Clarendon Press, Vol. 1, pp. 303. Boden made this affirmation referencing Bruner, 1957, "On Perceptual Readiness," *Psychological Review*, 64, pp. 123-152.

> "It seemed that the greater the social value of an object, and/or the greater the individual need for it, the more susceptible it was the perceptual biases from 'dynamic' factors. For example Bruner and Goldman reported that children's perception of such an apparently objective matter as the size of a coin was affected both by their knowledge of the coin's face value and their need/desire for money. The size of high-value coins was overestimated, and the poorer children overestimated more than the richer ones did…Bruner and Goldman posited a range of unconscious perceptual 'hypothesis' to explain the bias, or selectivity. They'd observed."[72]

When distinguishing between internal and external domains we are not presenting them as independent entities, but as related and co-dependent ones[73]. The process of knowing includes a cognitive (*knowing*) subject and "gnoseological (known) object. In this process, the knowing subject apprehend the known object, or tries to apprehend the to-be-known object. Consequently, from a phenomenological perspective ***to know is to apprehend***, the act by means of which a subject apprehend an object. From a phenomenological/informational perspective to know is to apprehend forms, i.e. to interiorize external forms (to get informed via perception, to transform objective forms into subjective ones) and to infer additional, and more structured, forms by means of cognitive processes, which might combine the just apprehended forms with previously apprehended ones. Information mediates between the cognitive/knowing subject and the apprehended/known object, via transforming objective forms (data) into subjective forms, which are generated by the combination of the recently apprehended forms, what was apprehended in previous perceptions and previously inferred knowledge, and influenced by associated conative and affective contents. Hence, apprehension via informing processes is what conceptually mediate and relate the knower with the known (data, given objective forms). Consequently, a phenomenological perspective of the knowing process seems to harmonize with the etymological meaning of data and information.

Other authors associate 'information' with conative (volitional) processes, additional to associating it with cognitive (thinking) processes. Kochen, for example, defined information as "*decision-relevant data*"[74], which, 1) from the phenomenological perspective is associated to conative processes[75] and 2) 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

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[72] Boden, op. cit. p. 300. Margaret Boden seems to be referencing the following article J. S. Bruner and C. C. Goodman, 1947, "Value and Need as Organizing Factors in Perception," *Journal of Abnormal and Social Psychology*, 42, pp. 33-34

[73] We would like to emphasize, again, internal/external dichotomy is not meant in a spatial-physical context but in a conceptual one, as related to the knowing subject and/or process.

[74] 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.

[75] The three main components of conative phenomenology [are] decision, action, and consent." Uriah Kriegel, 2012, "Understanding Conative Phenomenology: Lessons from Ricoeur." Forthcoming in *Phenomenology and the Cognitive Sciences*. (special issue on "Phenomenal Intentionality Past and Present")

of 'decision' and "relevant decision." *Decisions are always subjective, and relevancy is always related to a deciding 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 in-formation '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 in-formation 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*."[76] 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."[77] 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.***"[78] Taking the context of this paper, we can affirm that computers might process data, but information is processed by the computer's user, the individual, the person, the subject, whose objective(s) and cognition create questions that, in turn, create willingness (via conation) to get some specific data which are supposed to generate the information required for answering the associated question(s). 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?' "[79] Conative and cognitive processes are explicitly involved in transforming the data in information, and affective processes are implicitly involved because the reasoning we presented above. Consequently, all three mental processes are required to transform objective/external data into subjective/internal information. From Floridi's intellectual perspective it can also be concluded that data and information 1) are two sides of the same coin and 2) co-determine or co-influence each other via mental processes, including cognitive ones (cybernetic loop on the left of Figure 4)

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[76] 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.
[77] L. Floridi, 1999, *Philosophy and Computing, An Introduction*; London: Routledge, Taylor and Francis Group; p. 106.
[78] Ibid. Emphasis added.
[79] Ibid.

As a way of doing an additional step in our attempt to pinpoint the nature of information and data, as well as in contrasting both concepts, it is good to try to integrate our 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 "what is given" or "to be given" and the characteristic that makes it specific (a species in such a genre) is that it should make a difference. This difference depends on the conative/cognitive content of the subject receiving the data and transforming it into information.
- 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[80]) 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[81]) 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'." [82] 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." [83]

Balsun-Stanton and Bunker[84], 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. *We propose to examine the nature of 'data' as related to 'information' by means of the cognitive/conative processes required to*

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[80] We will explain below what is related to mental objects

[81] Capurro and B. Hjørland, 2003,

[82] 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

[83] Ibid.

[84] 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, 3010 at www.ballsun.com/amcis2009Ballsun-StantonBunker.pdf

*transform data into information.* In this essay we are trying to give a very initial step in this direction, by means of 1) relating attempting an initial proposed definition of data (its genre and the characteristic that differentiates it from other species included in the same genre), and 2) relating it, directly or indirectly, to information and the knowledge in the context of cognition, conation, and affect. The first means is achieved via ***conceptual analysis***, the second via the constructing a ***systemic-cybernetic synthesis*** of the context required for a more adequate, adaptable, and comprehensive meaning of the term/concept of 'datum' or 'data'. Here 'analysis' and 'synthesis' are meant to complement each other in describing the notion of 'data' and how it relates to information, knowledge, and cognition.

Brian Petheram discusses the close relationships between Information Systems modeling and the Philosophy of Information, claiming that "by focusing on modeling as a key process of information systems development, … the deployment of something akin to a 'philosophy' is inevitable." [85] Consequently, in the context of his paper, we propose that Information Systems Development would be enriched and probably made more effective, not just referring to Petheram's article, but also the cognitive/conative contents of the modeler, analysts, designers, users, etc. of the systems being developed. Balsun-Stanton and Bunker affirm that 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."[86] We suggest, as a working hypothesis, that 1) a Philosophy of Data (PoD) would certainly be an intellectual support for the Philosophy of Information, and vice versa, and 2) to include in Philosophy of Data (PoD) the associated *Philosophy of the Mind, conceived as non-linear relationships among cognitive, conative, and affective processes*. Any further clarification regarding the notion of data would certainly help in the clarification of the notion of information (and knowledge) and vice versa.

As we indicated above, the intellectual perspective of what is being examined and proposed in this paper is a phenomenological. Hence, our objective is to try to describe the phenomena involved as they appear and, accordingly we pre-concluded above that "to know is to apprehend." Knowledge is apprehension. For example, empirical knowledge is the apprehension of empirical objects and rational knowledge is the apprehension of rational objects. But this does not mean that all apprehension is knowledge. Information, for example, is apprehension of objective/external *forms* via sense data perception which are transformed into in-formation by means of combining sense-data with previously stored perceptions and information as well as previously stored and inferred knowledge. Consequently, knowledge is an apprehension, based on data and stored information and previous knowledge, by means of mental processes, including ***cognitive inferences***. *Information might due to* ***partially*** *cognitive processes (because conative and affective processes might also be involved) but knowledge seems to be produced by just, or mostly, by cognitive processes or inferences*. Two different kinds of apprehensions seem to be involved in information and knowledge apprehension. The first is a more immediate one

[85] 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.
[86] B. Ballsun-Stanton and D. Bunker, 2009, op. cit.

and the second require the mediation of cognitive processes that usually require more, much more, time than perception. This time is required for the construction of more complex (and potentially more abstract) structures. Consequently, we might venture suggesting that perceiving is an ***immediate*** apprehension, while knowing is a ***mediate*** one, where thought processes mediate between perception and knowledge. Another difference between apprehending via perceiving and via knowing is the restrictive level in each case. Knowing processes usually have more, much more, restrictions than perceiving. Knowledge processes are usually restricted by implicit and explicit rules (e.g. different kind of logic, scientific methods, previous acquired knowledge generated by others, socially elaborated conceptual constructs accepted by consensus as for example in disciplinary knowledge, etc.). *Consequently, perception/information and cognition/knowledge are both apprehensions but while the first is an immediate and less restricted one, the second is mediated by thought processes* which should flow with more restrictions. These restrictions depend on cultures, languages, believes, epistemological values, disciplinary methods and rules, etc.

Here, we need to make a short note regarding the meaning of 'information/perception' and "cognition/knowledge" in the context of "Artificial Perception" and "Artificial Cognition" or "Cognitive Technologies". In these contexts the meaning of 'perception' and 'cognition' is related to a ***sub-set*** of the senses included in the general meaning of each term/concept. This is what the adjective 'artificial' is supposed to convey. Artificial and natural perception/cognition are two conceptual species of a common genre. They have ***common*** features, but also ***non-common*** ones. This observation does not seem to be always present and clear.

Caulfield and Johnson, affirm that "perception has both unconscious and conscious aspects."[87] Artificial perception hardly can include the unconscious aspect of natural perception, but it might contain some (not necessarily all) the conscious aspects. What is called 'artificial perception' captures the conscious aspect, at best. So, it is an artificial semi-, quasi-, or pseudo-perception, as related to 'perception' as understood in a natural context. This is because the unconscious aspect is, by definition, not included in what is called "artificial perception." Conative and affect aspects are also excluded, unless we are talking about the conative/affect aspects of the designer/programmer. But is such a case, what we would be talking about is artificial perception based on knowledge we have regarding what is natural perception. Consequently, artificial perception is a combination of artificial sensors which produce data to be transformed via Electronic Data Processing (EDP), into data to be used by other EDP systems and/or (potentially) by natural cognition. In such a case, we will be talking about hybrid (artificial/natural) perception. Something similar happens when we refer to artificial knowledge generation (e.g. inference engines), knowledge-base, expert-systems, etc. What we can artificially construct is inference aspect (inference engines) of mental processes supported by external representations of natural knowledge by means of what is called Knowledge Engineering (extracting and human knowledge) and making external representations of this knowledge in machine readable knowledge-bases. The knowledge extracted from a human being is incomplete, in the best case, and distorted or wrong in the worst case. Furthermore, the means chosen to represent it in a machine readable form might introduce entropy and distortions

[87] H. J. Caulfield and J. L. Johnson, 1999, "Artificial Perception and Consciousness," plenary presentation at the Sixth International Conference on Education and Training in Optics and Photonics, pp. 112117, J. Javier Sánchez-MondragOn, Editor, SPIE Vol. 3831 (2000). Accessed on January 27 at http://spie.org/etop/1999/112_1.pdf

depending on the different alternative usually present for the physical representation of the extracted knowledge. Does, then, the word/concept of 'knowledge' has the same meaning when used in the context of a human being, a book (human being readable representation), or an artificial expert system (machine readable representation)? The answer is evidently a negative one. In the case of cognitive/knowing processes, the differences are even more significant, because the reciprocal relationships and co-influences between human cognition and his/her conative and affect mental ingredients are not present in artificial cognition or cognitive technologies. Consequently the word/concept/notion of 'knowledge' has different meanings in human and in artificial cognition. This is evident but, for some reason, is not always taken into account in the literature. On the contrary, sometimes both kind of meaning are implicitly or explicitly identifies.

## A Systemic Perspective of the Notions of 'Subject' and 'Object'[88]

We indicated above that 'data' and 'information' are two sides of the same coin, the 'objective' and the 'subjective' sides, respectively. Analogously, we might think that 'information' and 'knowledge' are also two sides of the same coin: the 'subjective' and the 'objective' side respectively. Accordingly, the 'given object' is transformed into the 'generated object' via cognition, in the context of its relationships with conation and affect.

*Implicit* knowledge is associated with the object known by the experiencing subject (cognition) and/or or by his/her objectives (conation). *Explicit* knowledge is also representable or represented via external symbols and, consequently, with the potential to be communicated to other subjects. In this contest, the term object might generate equivocalness because it might mean 1) object qua object, 2) the known object, i.e. the mental (cognitive) representation of the object, or 3) the extra-mental (physical) representation of the known object in order to communicate the apprehended knowledge. Consequently, we have at least three meaning of object: as object of knowledge, as cognitive representation of the known object, and symbolic meta-representation of the known object in its process of its potential communication. Additional meanings are: the meta-meta-representation generated as cognitive representation in recipient subject in a communicational process. Meta-meta-representations are not necessarily the same in different subjects, or in different situations of the same subject. Consequently, ***object-as-object might generate a diversity of objects-as-representations of the known, or knowable, object-as-object.*** The same object-as-object can generate different objects-as-representations in different intellectual disciplines and in different rigor contexts. Hence, it should not be surprising to observe difficulties that emerge in inter-disciplinary or inter-cultural communication. This kind of situations is among the essential reasons why we advocate epistemological and scientific pluralism, especially when dealing with a general conception of knowledge and cognition.

[88] 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 Bolivar, Caracas, Venezuela; chapter 12, pp. 389-415; and some texts are adaptations from others included in a non published work in progress: N. Callaos, 20011, *Expansion of Science*, and in Callaos and Callaos, 2011, Op. Cit.

Since object-subject relationships are essential to understanding and/or comprehending the relationships among data, information, and knowledge, let us provide more details with regards to these relationships, especially in the way they are being used in this paper along with the associated concepts and conceptions.

Edgar Morin affirms clearly and emphatically that "Subject and object are *indissociabl*e…Our path is cleared on one side by micro-physics where subject and objects become *relation*…and in the other by *cybernetics* [especially Second Order Cybernetics] and the concept of self-organization."[89]

Elsewhere[90] 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. Let us make a short digression, in the next paragraph, in order to provide background and context to following ones. What we will propose in the following paragraphs is one of the results of action-research oriented to a dynamic design of an adequate methodology for information systems development that ended up in a General System Methodology proposal. this methodology is cause and effect of making explicitly planned interactions 1) between cognitive and conative processes, in the context of an incrementally-evolutionary methodology based on incremental planning and the framework of decision under uncertainty; and 2) explicit planned interactions with the affect via a prototyping methodology with which we tried to anticipate the potential affective impacts of the system being developed with its future users. Potential relationships of group (social) cognition, conation, and affect were also addressed in managing the people who were developing the system. This paper is not the place to provide details regarding this issue,[91] but it is good to take a short detour in the next paragraph in order to make a very short description of the research context of the next paragraph.

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[92] methodology, as opposed to the idea that "knowledge is *absolute*" in what was then the current methodology.[93] 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[94] (when we described some of the results achieved after following our 1976 suggestion); as well as for the nature of information (along with 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 knowledge apprehended was mostly a methodological one. Consequently, its true value was associated with methodological effectiveness. The epistemological context was related to a pragmatic-teleological perspective. The diversity of the systems studied, analyzed, designed and/or

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[89] E. Morin, 2008, *On Complexity*, (translated by Robin Postel); Cresskill, New Jersey: Hampton Press, Inc.
[90] N. Callaos, 1995, op. .it.
[91] Ibid.
[92] OR/MS is an acronym used to refer to the related scientific fields of operations Research and Managements Science.
[93] 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
[94] N. Callaos, 1995. op. cit.

implemented allowed us to make some general formulations in the context of a Systemic General Systems Methodology.[95] 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 notion of truth, we proposed a *plural epistemology* where—as we briefly suggested above—true knowledge 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 knowledge apprehension based on a pragmatic-teleological epistemology.

Figure 5 schematizes what we presented with details in our developed (and still developing) *Systemic Systems Methodology*.[96] As we suggested elsewhere, the generality of the proposed systems methodology paved the way for cognitive/thinking methodology which can support the conception of a Methodological Theory as well as a Theoretical Methodology.[97] We suggest here that this General Systems Methodology might be applied, or provide the support for analogical thinking, in the conception of the methodology with which data is transformed into information and then into knowledge through cognitive processes propelled and influenced by conation and affect.

The intention of the subject to know a selected object is consequence of conative processes of him/her. This intention, based on the subject objective(s), determine the data-object to be addressed and, consequently, the information to be apprehended via perception. The perceived information might 1) modify the ***intention*** of the subject selecting, via ***conative*** processes, other data-object to be addressed, and/or 2) to ***know***, to reflect, to process the apprehended information, etc. via ***cognitive*** processes. Metaphorically speaking, we might say conative/affective processes are the ***propulsion*** of our thinking, while cognition is what ***directs*** it. Propulsion and directions are both necessary in the production of knowledge. Co-regulative and co-amplificatory cybernetic loops support knowledge generation, communication, and management.

In figure 5 we contrasted 'in-formation' and 'ex-formation'[98] in order to refer to: 1) the 'forms' originating from the object and are **in**stilled **into** the subject, i.e. 'in-formation', and 2) the

[95] Ibid.
[96] Ibid. p. 395
[97] N. Callaos and B. Callaos, 1995, "Toward a practical methodological theory," IEEE International Conference on Systems, Man and Cybernetics, Intelligent Systems for the 21st Century, 22-25 Oct 1995, Vol. 1, pp. 597-602
[98] 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

'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 **ex**ternal environments, or to **ex**press, **ex**teriorize them via **ex**ternal objects or to other subjects. The subject may exteriorize his/her mental form, by means of cognitive/conative/affective processes, via: 1) communicational signals, or verbal action; 2) technological action processes ending in technological innovations, products, or systems; 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 in 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).

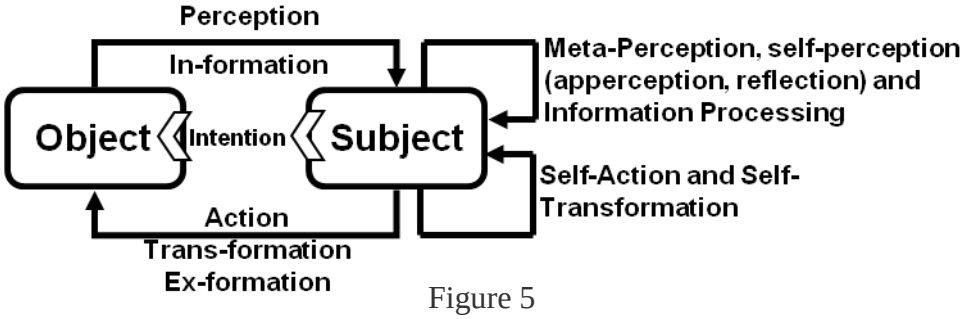


Figure 5

Although some authors refer to 'subjective' and 'objective' in the modern sense of these terms when they relate them to information, by no means are we using, in this paper, '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, what contain cognitive, conative, and affective processes.

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, as Jaquette did "between thinkers and what they think about [between knowers and knowns or knowlables]. The distinction is not an *exclusionary* one, since subjects 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 [or knowers], there may yet be mind-independent

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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 6th, 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 6th, 2011 at http://www.heise.de/tp/artikel/2/2108/1.html)

things that are neither subjects nor objects…The dichotomy is *an inter-implicative distinction* between thinkers [knowers] and what they think [know] about, in which each presupposes the other. If there are no subjects, then neither are there objects in the true sense; and conversely"[99]

Figure 6 visualizes the general meaning of 'object' and 'subject', we above referred to, where *the distinction made is not exclusionary, where the subject can also be its own object in a reflexive self conscientious thought or self-knowing cognitive process. In such a case a subject takes the subject as its intended object*, i.e., the knower as among the knowing objects, the observer as among the objects observed, according to hat is suggested by Second Order Cybernetics.

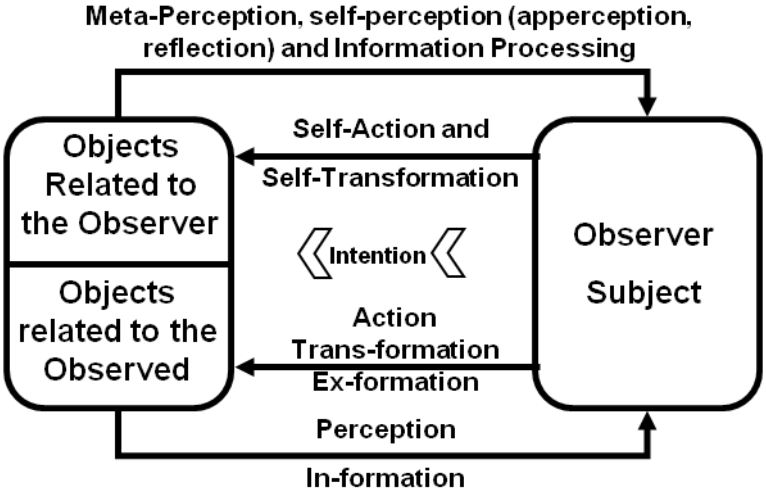


Figure 6

Accordingly then, 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-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."[100] Radical Constructionists make similar affirmations for similar reasons. On the other hand, realists "hold that what idealists say of objects is indeed largely true of subject-objects; but flagrantly untrue of object-objects."[101] 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.

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[99] D. Jaquette, 1995, "Subject-Object Dichotomy;" *The Cambridge Dictionary of Philosophy*; Robert Audi (Ed.); Cambridge: Cambridge University Press; pp. 885-6 (Italics added)

[100] Johnston Estep Walter, 1915, *Subject and Object*, West Newton, PA., Johnston and Penney; p. 75.

[101] Ibid., p. 81

Geometrical forms (e.g. triangles) and mathematical forms or equations (e.g. Shannon's mathematical definition of 'Information') are examples of *subject-objects* that in-form us as soon as they are apprehended (known) 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 (known) and interiorized become in-formation; which, to be communicated, should be expressed in physical forms (signals) via ex-formation. Consequently, knowledge (or at least some species of it) can be internally or externally represented, or meta-represented, via information. But, knowledge can also be produced by (natural or artificial) information processing. Consequently, information and knowledge seems to have non-linear relationships. But, before providing more details on this suggested proposition let us continue with the distinction/relation between 'subject' and 'object'.

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."[102]

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, or cognized; i.e. what is perceived as the external world. ***The observer (the knower) is part of the observed (the known) and the observed (the known) is part of the observer (the knower).*** Internal forms are part of what we perceive as external forms, and vice versa. Information is part of ex-formation, and vice-versa. Fuzzy sets and/or fuzzy logics might provide the intellectual support for this systemic-cybernetic perspective. We might say that similarly to the Yin and Yang, the Observer and Observed, the knower and the known, the cognizant and what is being cognized, 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[103]) different concepts but they always exist together.

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[102] Ibid., p. 84

[103] 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

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 5, 6, 7, and 8. 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. He/she does that by means systemic-cybernetic integration of his/her cognition, conation, and affect (Figure 2a). 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* (identified with the support of conation and affect) and cognitive *means* (including previously acquired internal forms: concepts, notions, perceptions, mental constructions, etc, as well as cognitive skills). The objects, as perceived and conceived (cognized) 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.

As a consequence of a systemic perspective (as the one described above and schematized in figures 5 and 6) 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 7 and 8; which schematize what we have been describing above.

**Is Knowledge, then, some Kind of Information?**

The answer depends on what we understand by 'Knowledge' (with capital letter) or the sense with which we are using the term 'knowledge' in the context of the diversity of senses contained in its meaning. As it is easily realized, the term 'know' is used in many senses. We will review below the main senses in which the word 'know' has been used.

Meanwhile, let us suggest that Knowledge is some kind of information, but not all information is knowledge. Knowledge can be cognized, conceived, as an in-meta-formation (or ex-meta-formation)[104] with some properties and/or related to some issues like truth, belief, validity, supported by a specific methodology, based on some specific disciplinary concepts, etc.

Since we are suggesting that knowledge is some kind of a meta-form (in meta-form when is internally apprehended and ex- meta-form when it is expressed through language or physical symbols), it might be useful to think and provide some details regarding the notion of 'form.'[105] This conception of 'knowledge' is in agreement with the meaning of the term in Cognitive

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surface. This metaphor has been related to Aristotle but we could not verify it in the Aristotelian writings we were able to read.

[104] Notice that we are not suggesting that knowledge is some kind of meta-information, but some kind of meta-form that can be internally apprehended (in-meta-formation) or externally expressed (ex-meta-formation)

[105] What follows regarding the notion of 'form' is an adaptation of a section we included in another paper (Callaos and Callaos, 2011, Toward a Systemic Notion of Information: Practical Consequences. A shorter version can be found at http://inform.nu/Articles/Vol5/v5n1p001-011.pdf ). In this adaptation we are taking into account the context as well as the objective of this paper, which are not the same of the paper from which is being extracted and adapted.

Psychology. Lee, et. al. affirm that "Cognitive Psychologists … assume that knowledge exists in the form of interrelationships among the elements and knowledge organization can best be captured with the representation of its structure."[106] If these elements are forms (or in-formational elements then their ***interrelationships*** is a system for their forms (informational elements), i.e. a form of forms, a meta-form; and the ***structure*** which represent these relationships among the informational elements is also a meta-form, i.e. a form of forms (or informational elements). Let us now provide more details regarding the meaning of the word 'form' in order to enhance the rational supporting our suggestion related to conceiving knowledge as meta-form, or meta-meta-…-meta forms, represented in the mind (in-meta-forms, not to be confused with meta-information which have a different meaning to the one we are suggesting her, as in meta-data related information) or via physical signs external to the mind (ex-meta-forms, not to be confused with we might call meta-ex-formation which might mean the physical means or form used to deliver ex-formation, i.e. to exteriorize an information)

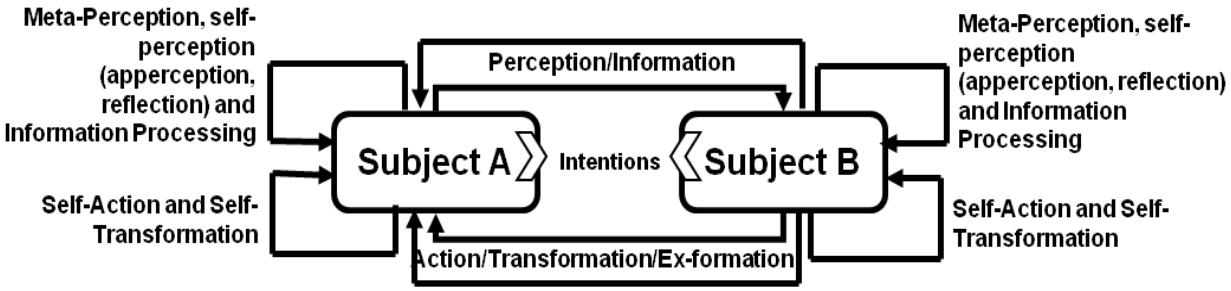


Figure 5

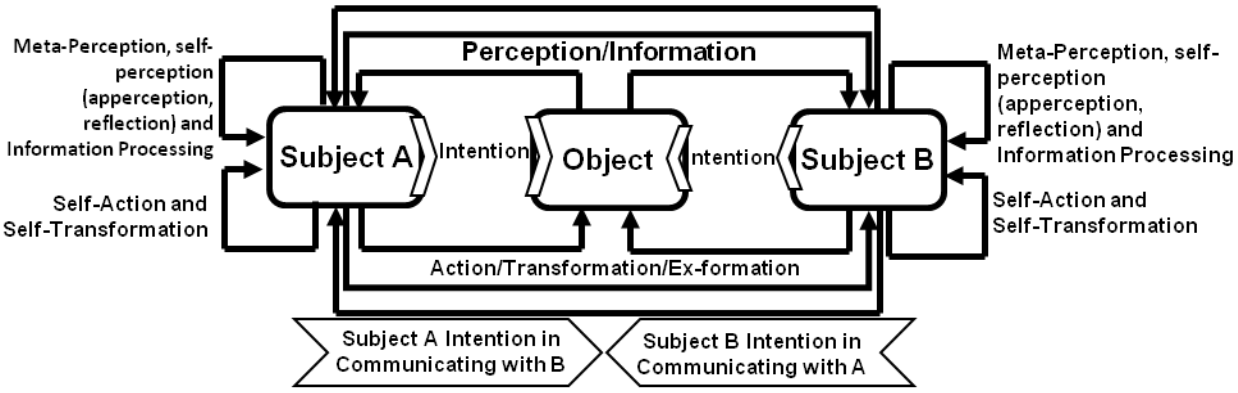


Figure 6

[106] S. Lee, K. S. Choi, I. S. Choe, *Representation of Tacit Knowledge in Organizations*, which can be retrieved at http://apollon1.alba.edu.gr/OKLC2002/Proceedings/pdf_files/ID121.pdf (Accessed on March 2, 2013). Archived in WebCitation at http://www.webcitation.org/6EpoPmJtx

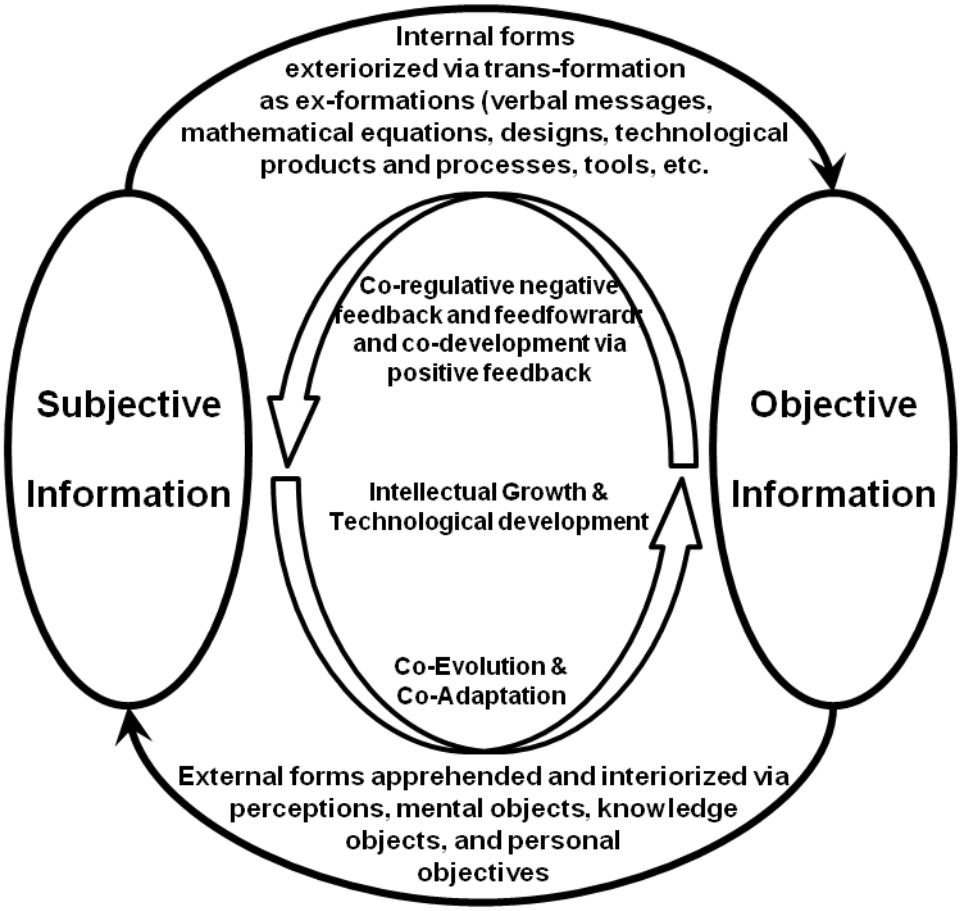


Figure 7

The term 'form' (which etymologically signifies: "shape, mold") means "the shape and structure of something as distinguished from its material."[107] The 'mold' metaphor might be a useful one to understand an important aspect of the notion of 'form.' Water in a cup takes the shape of the cup but cup and water are completely different things. Furthermore, any other liquid in the cup takes also the shape of the cup. So, water and milk take the same shape of the cup but are different kind of liquid and different to the solid material of the cup. The shape of a tree impressed in our mind is different to tree and to our mind. Accordingly, in the context of what we are suggesting in this paper, 'meta-form' might be metaphorically conceived as a meta-shape, meta-mold, a shape that might contain different shapes. The concept or the idea of a tree may represent different kinds of trees. A genre might be conceived as a meta-form which contain (or may contain) different forms, or species. A genre might also be conceived as an 'intellectual meta-mold' because of its capacity of different kind of 'intellectual molds.' The genre 'animal' might be conceived as a meta-form that includes different species (primates, insects, birds, etc.) which are *related* by common and un-common features. A meta-form is a 'form of form' and it

[107] Merriam-Webster, 1999,

might be conceived as a 'set of related or relatable forms'. The actual or potential relations among the constitutive forms represent a meta-form.

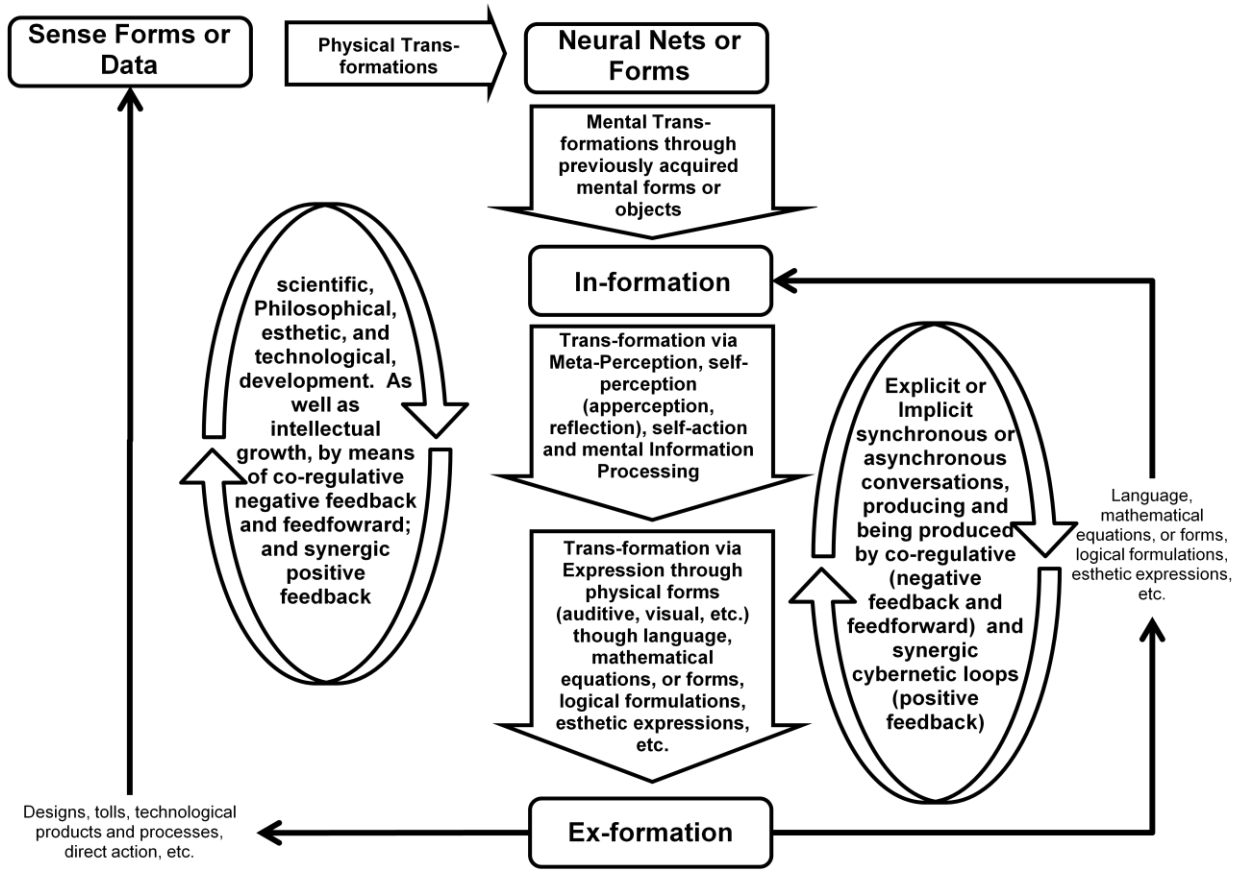


Figure 8

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.[108] These senses of the term 'form' agree with what we suggested above, which was based on the metaphor of 'mold' or 'shape'. The opposition noticed by Cicero between notions of 'form' and 'content' is an important one, as we noticed above. ***Form is different to content and container***. Different contents may take the same shape/form of the same container, and the same content might take different forms in containers with different containers. By analogical thinking we can suggest that, for similar reasons, the same data may produce different in-formation (perceptions) in different subjects (containers) and the same in-formation may produce different kinds of knowledge (meta-form, 'form of forms', related or relatable set of forms) or no knowledge at all in different subjects with different kind of previous knowledge, beliefs, convictions, cultures (including disciplinary and corporative cultures) prejudices (including disciplinary and academic ones), stereotypes, etc. It is important to emphasize here that the linear thinking with which we

[108] 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.

presented the above suggestion is immersed in a systemic-cybernetic process in which container and content shape each other. The water shapes and it is shaped by the river and the resulting shape is a dynamically variable one especially at the beginning of this non-linear process. Analogously, external and internal realities shape each other and the forms (information) and meta-forms (knowledge) that interface them is, as a consequence, changing in a dynamic process. In this context, to in-form might be thought as to 'mold' or 're-mold' the mind by means of 'combining' external and internal forms. To know would be to apprehend content via meta-forms, i.e. a set or related or relatable forms (theories, methodologies, etc) and/or 'form of forms' as it is the case of concepts, genres, ideas, images, analogies, metaphors, etc. In this context, ex-forming, or ex-meta-forming might be conceived as 'molding' external means in order to express our internal thoughts (cognition), emotions, or feelings (affect) according to our objective or intention (conation), and to contribute to information acquiring and/or knowledge apprehension of other minds.

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 'ειδοζ'(*eidos*) has been translated to Latin as '*idea*' or '*formā*', i.e. 'idea' and 'form' were taken as synonyms in order to translate *eidos*. In this context, "in-formation" would mean "in-idea" or 'in-ideation'. Knowledge, in the sense of meta-form, would mean a "set of related or relatable ideas" or a general idea with the potential of generating more specific ideas, a theory that might generate several applications, a concept that might be analyzed in several related sub-concepts, etc.

Ferrater-Mora distinguishes three basic senses of the term 'form': the philosophical, the logical and the methodological.[109] 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" (ειδοζ, *eidos*) 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 external *morfé* and the internal *eidos,*[110] the external figure and the internal form. The external *morfé* is transformed in information (internal reality) via perception and/or *eidos* via abstracting its essence, its meta-form, by means of reflection, inference, etc. generated by cognitive processes.

The pair external *morfé*/internal *eidos* seems to be analogous (but not equivalent) to the pair data/information-knowledge, where information-knowledge are 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 "forms" (hence the name of Formal Logic) and "variables" represent what is changeable.

[109] Ferrater-Mora, op. cit. Vol. I, p. 716
[110] Ferrater-Mora, op. cit., Vol. I, p. 658

Consequently, *in Formal Logic, "form" represents what is permanent, unchangeable, in contrast to what is variable, non-permanent, and changeable.* A given, specific Logic (e.g. Syllogistic Logic, Predicate Logic, etc) might be conceived as a meta-form. Syllogistic Logic, for example, provides several forms of thinking, and these forms are related. Consequently, Syllogistic Logic might be conceived as a meta-form (a form of forms) that might generate different kinds of knowledge when applied to different context, i.e. when the meta-container is combined with different kind of contents. A logical system is a knowledge generator because of its potentiality of providing meta-forms for different informational contents.

In its methodological sense, the term 'form' has been used to represent a 'way', a 'method' of knowing. Cassirer[111], 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. 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 it is the case of the pragmatic-teleological approaches to Engineering Philosophy, Systems Engineering, System Sciences, etc.; '*f*orm' and '*telo*s' 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 to reinterpret 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 terms of 'in-formation' and 'knowledge.' 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' and 'knowledge.' 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. Plato's "Forms are ideal 'patterns', unchanging, timeless, and perfect."[112] 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."[113] 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

[111] referenced by Ferrater-Mora, op. cit., Vol. I, p. 658
[112] R. Audi, (General Editor), 1999, *The Cambridge Dictionary of Philosophy*; Second Edition, Cambridge: University Press; p.315.
[113] Ibid., p. 710

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. According, a platonic perspective of our suggestion above, 'knowledge' might be conceived as 'mental meta-forms, meta-ordering, meta-patterns.'

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."[114] Consequently, Plato's Theory of Forms is relevant in this essay because 1) we are trying to find the *meaning* of 'information' and 'in-meta-information'; and 2) because the notion of "*form*" is an essential ingredient of these meanings. 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."[115] 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'."[116] 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 everyday, scientific, technological and philosophical languages) predates posterior senses, definitions, and uses of the term.

When we affirm "a cat is an animal", we are ***relating*** two forms: the form of 'cat-ness' and the form of 'animal-ness' by means of the verb "is". Consequently, the affirmation, "a cat is an animal" is a meta-form constructed by three forms and, consequently, is an expression of our knowledge regarding the genre of a cat. When we say "this is a cat" we are ***relating*** our perception (perceived form, in-formation) of an individual animal to the form of cati-ness, i.e. to a previously acquired form, or in-formation. Consequently, to affirm "this is a cat" is to generate

[114] B. Russell, 1945, *The History of Western Philosophy*, New York: A Touchstone Book, Simon & Shuster; p. 121 (italics added)
[115] Ibid.
[116] Ibid.

a meta-form containing two in-forms related by another in-form. The apprehension of forms and the process of relating then are cognitive processes that allow us to get information (perception) and to relate different forms into a meta-form, i.e. knowledge which might be transmitted, or externally expressed, via physical forms (e.g. language, physical symbols, physical images, etc.)

If we continue paraphrasing Russell, via analogical thinking and plausible thinking, we might say *if the word "knowledge" means anything, it means something which is not this or that knowledge, this or that definition of knowledge, but some kind of universal knowledge-ness or knowing-ness*; which is not born when a particular knowledge, or definition of knowledge, is born, and it does not die when it dies. The property of knowledge-ness has no position in space and time; it may be thought as 'eternal.' A similar hypothetical suggestion might be done with the term of 'cognition.'

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 "$H=-K\ \Sigma_i\ p_i\ \log p_i$ is information" is useful or true[117], 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. Many confusions, contradictions, and non-senses has been generated with careless interpretation of the way in which Shannon's mathematical definition information whose objective was mainly to have some measure technologically useful in physical signals communication engineering.[118] After making this short but (in our opinion) much important digression, let us now continue with the main issue of this section.

Since we showed and suggested above, both notions 'information' and 'knowledge' are based on the notion of 'form' and since cognition and cognitive processes are also based on 'neural forms' or 'neural networks', it might be intellectually useful to continue examining the notion of 'form' analyzing and relating it to the context and purpose sought in this paper. Consequently, let us 1) briefly examine how the notion of 'form' has been conceived, and reflected upon, by representative thinkers, and 2) to interpret and relate their respective ideas under the light of the conceptual perspective we are proposing here.

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[117] We are referring to the very known mathematical definition of 'information' that Claude Shannon provided, where $p_i$ is the probability of using signal i in the context of a set of possible signals being transmitted, and K is a constant. Shannon's mathematical definition of 'information' allowed him to formulate a Theory of Communication (wrongly named by other authors Information Theory); which generated significant technological advancement in the area of communication engineering. Details regarding many misunderstanding and abuses of this definition by other authors has been explained and referenced with details in Callaos and Callaos, 2011, Toward a Systemic Notion of Information: Practical Consequences. A shorter version can be found at http://inform.nu/Articles/Vol5/v5n1p001-011.pdf

[118] Details and references with regards to the confusions, contradictions, and no-senses generated by wrong interpretations that violate the most basic rules of logic have been comprehensively examined by Callaos and Callaos in the paper referenced in the above note.

Aristotle expanded the meaning of 'form' to include the objective reality 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. He 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 important in the context of this paper because it refers to forms and meta-forms (information and knowledge) both apprehended and generated. His conception includes descriptive information and propositional knowledge as well as action oriented ones. It includes the 'know that' and the 'know how.' We will below refer to this distinction with more details.

Furthermore, Aristotle's 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, and because it relate and integrate 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, knowledge and cognition*; which is among our main aims in this essay.

Actually, in human communication, the production of information and knowledge 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, a knowledge to be communicated (formal cause); 3) physical means to be used in order to transmit the idea (material cause); and 4) the human potential required for the required internal cognitive processes and the exteriorization of the idea and the physical/mental energy required to transmit it between two subjects (efficient cause).

The Scholastic controversy[119] 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 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? Is the Scholastic controversy (with regards the separation of matter and form) back in the context of separating a mathematical form of 'information' and making it independent of any kind of the matter supporting it? To answer this kind of questions is not just an intellectual/conceptual/theoretical issue. It might have an

[119] Ferrater-Mora, op. Cit., p. 718.

important pragmatic, managerial, and economic impact, as we have shown happening in the area of information systems development.[120]

Another Scholastic controversy regarding the *unity* or the *plurality* of the form (in metaphysical and theological contexts) is also interesting and suggestive, via analogical thinking. Aquina, for example, conceived the Unicity of Form, while John Peckham (Archbishop of Canterbury in the years 1279–1292) affirmed the plurality of forms. By analogical thinking, it is 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."[121] Then, Lloyd adds "Energy and information are by nature (no pun intended) intertwined."[122] Hence, energy and information cannot be separated. Is there any similarity with Aquinas's doctrine of the inseparability of matter and form? Is there any similarity with his conception regarding of the Unicity of 'Form'? If we refer to a unique mathematical form for defining 'information' (e.g. Shannon's definition), is there any analogy with Aquinas's doctrine of the "Unicity of Form? Are we talking about a unique mathematical form of defining in-formation? Are we referring to 'information' unicity, or universal unity? Are we back to some kind of scholastic controversy but under the light of new scientific concepts and theories? Similar analogical reasoning might be made with regards to 'knowledge', especially if we conceive it as a 'meta-form.' Is there one 'Knowledge' (with capital letter), just one kind of Knowledge, just one definition of Knowledge? Are there many kinds of knowledge? From a constructivist perspective, knowledge is personal and/or social constructions (in plural) which depend on the objectives of who is or are making the constructions and on the context in which is being done (actual and past perceptions, memory, previous knowledge, believes, genetic instincts, culture, the kind of cognitive processes being applied, the respective conation, the associated affect or feeling, etc.)

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.[123] "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."[124] Consequently, Bacon conceives "forms" as "laws of nature", "the

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[120] Callaos and Callaos, op. cit.
[121] Seth Lloyd, 2007, *Programming the universe*; New York: Vintage Books; A Division of Random House, Inc; p. 40 (Lloyd's italics)
[122] Lloyd, p.44
[123] Ferrater-Mora, op. cit., p. 718
[124] *Stanford Encyclopedia of Philosophy*; 2003 "Francis Bacon", (First published Mon Dec 29, 2003), accessed on September 18th, 2010 at http://plato.stanford.edu/entries/francis-bacon/

last step for the human mind when investigating nature". Combining the Bacon conception with what we have been suggesting here (based on previous conceptions of this notion and on our idea of knowledge as a meta-form), we might affirm that, through a Baconian perspective, 'information' can be interpreted as ***inductive inferences we make from our observations, or sense data***, from which we might continue making more general inductive inferences, which may generate meta-forms, or knowledge. At the peak of this inferential process we arrive to the general law of nature (the most general principles), which are at the summit of Bacon's pyramid of knowledge (meta-meta-…meta-forms). We communicate these "inductive inferences" by means of 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 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? As we said above, we tied elsewhere[125] 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."[126] Hence, from a Kantian perspective, forms are associated with conceptions, concepts, conceptual structures, and categories.[127] Combining the meaning we have been identifying and describing in this paper a Kantian perspective of 'form' we might suggest that information and knowledge are associated with 1) conceptions, which, as such, are formed by a human cognition to order sensations (sense-data); or with 2) conceptual categories (meta-forms), 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 (perception) and meta-formation (knowledge) are associated, in different phases, 1) with a priori and a posteriori concepts, and orders; and 2) with conceiving and ordering.***

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[125] Callaos and Callaos, op. cit.

[126] W. L. Reese, 1996, *Dictionary of Philosophy and Religion*, New York: Humanity Books; Expanded edition; p.235.

[127] "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 19th, 2010 at http://plato.stanford.edu/entries/categories/

*One of the basic reasons why human beings communicate with each other is to get in-formed and to in-form others, to know and to share knowledge, i.e. to get external forms into their minds (or brains, via neural nets), process them in a meta-formation (knowing via cognition) and to contribute to, or influence, external processes by means of which other human beings get in-formation and knowledge into their minds or brains.*[128] To achieve this 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, to get knowledge (meta-forms) and to share it, is the* ***end,*** *and communications systems are* ***means***. Different means are (or might be) 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 in-formational and in-meta-formational 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 ok not to clearly distinguish knowing with the cognitive processes supporting it_ 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?

"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?* To take care in not making these kind con confusions with the term 'information,' is a necessary condition in not making similar kind of confusion with the term 'knowledge' and cognition.'

**Scientific and Engineering Knowledge**

The words 'knowledge' and 'to know' has been used in several senses and many theories of knowledge has been described and proposed since ancient times. Our objective in this section is to *differentiate and relate* two kinds of knowledge relevant to the purpose of this essay, i.e. 'scientific knowledge' and 'engineering knowledge.' This would provide us with adequate support to also differentiate and relate '*Cognitive Science'* and '*Cognitive Engineering and*

[128] Based on the meaning suggested here, we might pre-hypothetically think that two persons communicate with each other by means of interactive *in-forming* and *ex-forming* processes, as well as of in-meta-forming and ex-meta-forming (knowing, cognizing) ones.

*Technologies*.' But, before making attempting this differentiation, let us present, in a very brief way, the different ways in which the terms 'knowledge' and 'to know' has been *used*. Alan White affirms that "philosophers commonly approach the world, not directly, but via people's statements about the world."[129] We will adopt this way, which White initiate his book titled "*The Nature of Knowledge*, (though not with the intellectual profoundness with which he continues his book) in order to provide a ***general context*** and ***sketchy reference*** to what will follow in this section. The uses schematized in table 1[130] are associated when the use of the term 'know' is associated with its 'object.' There are other ways of using the word "know" but without referencing the object of knowledge, e.g. when the word 'know' is *preceded* by an interrogative. Examples are the following, when we ask: When did you know that? How did you design it? What is said in this text? Where did you hide it? Why are you doing so? In these examples the object is not known but it is enquired about, the word 'know' "does not indicate the object of knowledge, the thing known, but something about the circumstances in which it is known." Consequently, classification of the uses of the word 'know' shown in table 1 is made in the context of, and limited to, the "*objects of knowledge*".

| **Types of Uses** | **When the word 'know' is followed by** | **Examples** |
|---|---|---|
| 1 | *An interrogative* (e.g. what, who, how, where, when, which, why) and followed by a verb in the *indicative*. | I know who did it. I know what is said in this text. I know how it was designed. I know where the assassin is hiding. I know when the project finished. I know why this task is being done. |
| 2 | *An interrogative* (e.g. what, who, how, where, when, which, why) and followed by a verb in the *infinitive.* | I know whom to ask. I know what to say in these circumstances. I know where to hide this book. I know when to finish this discussion. I know why to exercise. |
| 3 | The relative 'what' | I know what I am being told. I know what I am doing. |
| 4 | A noun or a noun-phrase, where the noun-phrase is a variation of an interrogative | I know the color. I know the size of this shirt. I know the volume of this container. |
| 5 | A noun or a noun-phrase, where the noun indicate something we can learn, calculate, recite, repeat | I know Spanish. He knows the chemical table. She knows the Bible. |
| 6 | A noun or a noun-phrase, where it indicates person, place, condition, or thing with which one acquires knowledge by acquaintance, or direct experience. | I know my parent's home. I know my professor in Spanish. She knows her neighbor, he knows poverty. He knows the president. |
| 7 | An infinitive clause | I know this computer to be faulty. I know this man to be honest. I know this statement to be true. |
| 8 | A that-nominalization | I know that I failed the exam. I know that she is married. I know that $E = mc^2$. |

Table 1

White affirms, after a detailed analysis, that the types of uses of the word 'know' (sketched in table 1 are linguistic variations that "can be reduced to three broad conceptual classes, namely, (a) *'know' followed by interrogative*, whether explicitly, as in [kind of use 1, 2, and 3]…or

[129] A. R. White, 1982, *The Nature of Knowledge*, Totowa, New Jersey: Rowman and Littlefield, p. 1

[130] Table 1 is a very superficial sketch of the deep analysis made by White, in the second chapter entitled "Objects of Knowledge," op. cit., pp. 9-43.

implicitly as in [use types 4 and 5]…; (b) *knowing that* [use kinds 7 and 8]…; *knowing by acquaintance* [use type 6]."[131] White proposes to reduce his first conceptual class ('know' followed, explicitly or implicitly, by interrogative) to the second one ('knowing that'). With regards to this issue he affirms that "the first two classes can be shown to be basically the same, namely 'knowing that.' They differ only in that the first ***states*** what is to which one knows the answer, while the second ***states*** the answer which one knows."[132] From our intellectual perspective (to be shown with more details below), this difference is a qualitative one, and we should not reduce it to different kinds of ***statements***. They can also be referring to having knowledge regarding 'what-it-is-given,' or 'what-it-is' ('know that'), as contrasted to 'what-it-is-not-given-yet' or 'what-might-be'. The logic of knowing in these conceptual classes is not the same one. Even the products are not necessarily the same: in one case it might be some aerodynamic laws or theories and in the other might be an airplane. Consequently, although they might be the same from a statement perspective (as White proposed) they are not the same from the perspective of the logic, or the kind of reasoning, supporting them, and they are not the same from the kind of products they might generate, even in both cases 'statements' are, or might be, produced. Consequently, in the context of the purpose of this essay, we will not reduce these to conceptual classes of knowledge. On the contrary, we will contrast them as polar opposites which might reciprocally co-regulate and co-enhance each other in cybernetic loops. Below we will analyze with more details what we synthetically resumed in the last phrase.[133]

McCarthy[134] affirms that one characterization of the distinction between Science and Engineering "is that science aims to build theories that are **true**, while engineering aims to make things that **work**. The disciplines have different aims – models or theories for science, artifacts or processes for engineers... Science aims to **understand** the world, whereas engineering aims to **change** it." Davis asserts that "Technology bakes our bread; science only help us to understand how…technology is not merely applied science."[135]

Science and Engineering, although complementing each other, have different purposes and do not use or produce exactly the same kind of knowledge. The logic of Science is the logic of the "**what-is**"; the logic of Engineering is the logic of "**what-might-be**", the logic of "**what-is-possible**". Science is oriented and determined for "what-already-exists"; Engineering is oriented by purposes and objectives toward "what-is-not-existent-yet". Truth is the purpose of Science; to produce useful things and to generate human benefit is the purpose of Engineering. In science, truth is an **end**; in Engineering truth is a **mean** for generating human benefit and usefulness. Science is, for many scientists and philosophers (especially Aristotelians and Thomists or Neo-Thomists), an **end in itself**; but engineering activities are a **means** for the production of useful things and the generation of human benefit. Scientific knowledge is a necessary input for how it

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[131] White, op. cit. p. 10 (Italics added)
[132] Ibid. (emphasis and italics added)
[133] This will be done by adapting a text we extracted from another essay (N. Callaos, 2011, *The essence of Engineering and Meta-engineering*) which is posted at http://www.iiis.org/nagib-callaos/engineering-and-meta-engineering/engineering-and-metaengineering.pdf
[134] N. McCarthy, 2006, "Philosophy in the Making", *Ingenia*, issue 26, March, 2006; pp. 47-51; p. 48; (emphasis added)
[135] M. Davis, 1998, Thinking Like *an Engineer: Studies in the Ethics of a Profession*; Oxford University Press; p.7; (emphasis added)

is usually defined Engineering as a profession in modern times, but it is a desirable input for the general notion of Engineering. Using the conceptual classes suggested by white, and described above, Science is supported and oriented by 'know that' and Engineering is supported and oriented by 'know followed by an interrogative' and by 'knowing by acquaintance.'

"Science and engineering depend on each other – and upon business process skills – for the successful conversion of knowledge and experience into something **useful**. They need therefore to work more closely together."[136] In technological innovations Science, Engineering and business processes and skills combine synergistically in order to transform scientific knowledge into products or services useful to society, or into technological innovations. This is one of the reasons why there is an increasing awareness about the high desirability of including **entrepreneurship** skills and motivation in the (academic and/or corporate) preparation of engineers.

In any case, Science and Engineering need each other for their own existence. Both kinds of knowledge and cognitive processes need to complement each other in a systemic-cybernetic whole. "For a start, -- McCarthy writes -- engineering is central to theoretical science's search for knowledge. The most fundamental physical theories are supported by experimental data which would not be attainable without engineering. The particle accelerators built to reveal the fundamental building blocks of nature would not be possible without impressive feats of engineering. It takes something like the satellite Gravity Probe B, a product of engineering rather than of 'pure' science, to test our understanding of the structure of time and space and the nature of gravity."[137] "It is the engineering process which is converting the 'new knowledge' of science and engineering into new computer software and hardware, mobile telephones that can link to the internet, digital television, medical implants, new drugs, pharmaceuticals, machines which can learn, etc."[138] Artificial cognition (achieved by means of cognitive engineering and technologies) supports and it is supported by natural cognition and cognitive science. "The engineering process converts scientific, engineering and other kind of knowledge and experience into something **useful**, so although science and engineering are intertwined, **engineering is not a subset of science**."[139] Engineering logic and cognition processes are qualitatively different and frequently oppose each other in a synergic polarity.

As we noticed above, scientific knowledge is a "know-that", a knowledge about facts, supported by the logic of the "what-is". This is why this kind of knowledge is also called **descriptive**, **declarative** or **propositional** knowledge. Engineering is nurtured by this kind of knowledge but it also needs **prescriptive**, **procedural** and **non-propositional** knowledge. Consequently, Science and Engineering could be seen (as we suggested above) as opposites, **polar opposites**, requiring (not contradicting) each other. In this way, the generated dialectical relationships between Science and Engineering remove any hierarchical relation between them. Science is no more intellectually "superior" to Engineering; and Engineering is no more pragmatically or

[136] R. Malpas, 2000, *The Universe of Engineering: A UK Perspective*, Royal Academy of Engineering, June 2000; p. 8
[137] McCarthy, op. cit., p. 48
[138] Malpas, op. cit., p.10
[139] Ibid. p. 11

praxeologically "superior" to Science. Even so, McCarthy[140] suggests that Engineering may provide the certainty that Science is lacking. But, before quoting McCarthy, with regards to this issue, let us first provide a brief background on it.

Science history proves that scientific theories have always, up to the present, been rejected by new theories. Supported on this fact, Popper based his Philosophy of Science and respective epistemology on what has been called the "falsifiable truth", according to which a preposition is scientific as long as it could be falsified in the future; i.e., scientific truth is a falsifiable one. Jarvie affirms that "Popper's 'falsificationism' reverses the usual view that accumulated experience leads to scientific hypothesis; rather, freely conjectured hypothesis precede, and are tested against experience…He considers knowledge in the traditional sense of **certainty**, or in the modern sense of **justified true belief** , to be **unobtainable**."[141] Popper rational significantly contributed to what has been named "Pessimistic induction or Meta-Induction."[142]

Pierre Maurice Marie Duhem[143], a *French physicist, mathematician and philosopher of Science*, and Quine[144] (1951), one of the *most influential logician and philosopher*, put, according to Lipton, "severe strain on the idea that science reveals the truth."[145] "The argument against scientific truth — Lipton continues — is the pessimistic induction, and the evidence it appeals to is from the history of science…That evidence strongly suggests that scientific theories have a sell-by date. **The history of science is a graveyard of theories that were empirically successful for a time**, but are now known to be false, and of theoretical entities— the crystalline spheres, phlogiston, caloric, the ether and their ilk—that we now know do not exist. Science does not have a good track record for truth, and this provides the basis for a simple empirical generalization. Put crudely, all past theories have turned out to be false, therefore it is probable that all present and future theories will be false as well. That is the pessimistic induction."[146]

In face of this uncertainty with regards to scientific truth, McCarthy proposes engineering processes and products as an alternative for achieving certainty. With this regards she affirms that

> if "the philosopher focuses not just on a few cases in theoretical science, but instead turns his attention to applied science and engineering, he might reach quite different conclusions about the progress [and the certainty] of knowledge. For, although there are revolutions in engineering, the products of **engineering knowledge are not going to be overturned in the way that some scientific theories have been**. Phlogiston theory was plain wrong, and explanations in terms of phlogiston have never worked. But **technologies that become obsolete do so because they are improved upon, or become redundant, and not**

[140] McCarthy, op. cit.
[141] I. C. Jarvie, I. C., 1998, "Popper Karl Raimund," in in *Routledge Encyclopedia of Philosophy* (E. Craig, General Editor); London and New York: Routledge; vol. 7; pp.533-540, p. 533; emphasis added
[142] P. Lipton, P., 2005, "The Medawar Lecture 2004: The truth about science," *Philosophical Transactions of the Royal Society B.*, 360, pp. 1259-1269; also available at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1569498/
[143] P. Duhem, 1914, *The aim and structure of physical theory.* [Reprinted by Princeton University Press 1954]
[144] W. V. O. Quine, 1951, "Two dogmas of empiricism." *Philosophical Review*, 60, 20–43.
[145] Lipton, op. cit. p. 1265.
[146] Ibid. (emphasis added0

> **because they have never really worked in the first place**. So, while the philosopher might argue that any scientific theory might come to be rejected, he cannot claim that we might one day wake up to find that the bridges that have been constructed according to older engineering methods have all collapsed, or that all methods of transport have ground to a halt because the underpinning knowledge was defective. This shows that **knowledge of what works, the 'know-how' that engineering provides, is secure knowledge**. Engineering knowledge is also genuinely cumulative – improved all the time by building on, and not re-writing, what went before. Hence, if philosophers look at engineering practice as well as scientific theory when they consider progress, they may not be led into scepticism. In this way, a philosophy of engineering might prove enlightening to the pessimistic philosopher!"[147]

This evident McCarthy's intellectual perspective, provide us with another dimension in which Science and Engineering are qualitatively different and even opposite: the ever present uncertainty regarding the trueness of scientific results versus the certainty regarding the engineering products. *Progress makes engineering products obsoletes, not false, while it makes make scientific products false*.

So, as we might conclude, scientific and engineering activities are related to each other and integrated in a more comprehensive whole, in which 1) Science provides the "***know-that***", the propositional knowledge that engineering activities and thinking need as one of its inputs, and 2) the processes and technologies produced by Engineering provide the ***know how***[148] support scientific activities and instruments. According to this perspective, scientific and engineering activities might be related through (positive and negative) feedback and feedforward loops, in order to generate mutual synergies where the whole would be greater than the sum of its parts.

Empirical propositional knowledge is seen as objective, public knowledge of what is perceived as the external world. It represents abstract, formal, logical and mathematical descriptions of causal and interactional relationships among concepts, constructs and events associated with the external world. Heron affirms that "the outcome of research is stated in propositions which claim to be assertions of facts or truths"[149] Propositional knowledge might be generated by different research paradigms (positivistic, empiric-analytic, interpretative, critical, etc,) and is usually **represented in papers and books** which support its potential communicational processes. Engineering knowledge is also **represented but via artifacts, tools and technologies**. The purpose **Reverse Engineering** is to "read", to unveil the knowledge embedded in the artifact,

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[147] McCarthy, op. cit., p. 48; emphasis added

[148] We will use the term 'know how' with the meaning of 'know follows by interrogative' (how, where, when, etc.) and 'knowledge by acquaintance'. In ***effective*** engineering activities, it is Inherent, or implicit, to its 'know how' the know where, know when, know what, know which, etc. and the 'knowledge acquaintance' provided by experience and by what is called as' implicit knowledge' (to be described below)

[149] J. Heron, 1981, "Philosophical bases for a New Paradigm." In *Human Enquiry: a Sourcebook of New Paradigm research* (P. Reason and J. Roan, eds.); Chichester: Wiley; pp.19-35; p. 27;

tool, or technology which is the object of the respective reverse Engineering process. Concepts and terms related to propositional knowledge are: descriptive knowledge (where facts are "passively" observed, represented and stated in verbal and/or mathematical terms); discursive language (rational knowledge; a mode of generating and organizing knowledge that is rooted in language and mediated by reasoning); and declarative knowledge (understanding and awareness of factual information about the world.). Terms related to engineering knowledge (which combines propositional and non-propositional knowledge) are patents, technological innovations, inventions, designs, projects, drafts, artifacts, system analysis, design, implementation and deployments, systems documentation, manuals, etc.

What Schön affirms with regards to professions in general is completely applicable to the engineering profession. He emphasizes that there is an intensified concern with regards to the increasing gap between the propositional knowledge being taught in professional schools and practical knowledge along with the "actual competencies required of practitioners in the field."[150] Schön indicates that to deal with the crisis created by this growing gap it is necessary to recognize that outstanding, effective and excellent professionals do not have necessarily more propositional knowledge, but 'wisdom', 'talent', 'intuition' and 'artistry'. Non-propositional knowledge, including *technê*, procedural,[151] prescriptive[152], practical,[153] tacit and personal[154] (Polanyi, 1962; 1967) knowledge, is required for effective professional practice. Propositional and non-propositional knowledge do not contradict each other. On the contrary, an effective professional practice depends on their integration. The testimony of effective practitioners (from different professions with a wide range on disciplines) is a serious evidence of it. In the context of Engineering, *propositional and non-propositional knowledge are certainly polar opposites, requiring each other, and systemically relating to each other in a whole which is larger than the sum of its parts.*

***An adequate integration of different non-propositional and propositional knowledge is a necessary condition for an effective practice of the engineering profession, which provides the required technological support for scientific activities and help in their societal integration.***

Science and Engineering oppose each other in other aspects, but always synergistically, in polar opposition, and not contradicting each other. Scientific thinking, especially in the empirical sciences, for example, mainly (but no uniquely) proceeds from **the concrete to the general**, from concrete observations to the formulation of general hypothesis and general laws. Engineering thinking proceeds mainly (but not uniquely) **from the general to the concrete**, from scientific abstractions to concrete designs, artifacts, tools and technologies. In this sense, scientific results are mainly produced by **abstract thinking**, while Engineering products and

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[150] D. A. Schön, 1987, *Educating the Reflective Practitioner*; San Francisco: Jossey-Bass.
[151] J. B. Biggs, R. and Telfer, 1987, *The Process of Learning*; Sydney: Prentice-Hall.
[152] R. E. McGinn, 1978, "What is technology?" *Research in Philosophy and Technology, 1*,179-197. C. Mitcham, C.,1978, "Types of technology," *Research in philosophy and technology, I*, 229-294. J. Perrin, J., 1990, "The inseparability of technology and work organization," *History and Technology, 7*(1), 1-13
[153] Heron, Op. Cit. and P. Benner, 1984, *From Novice to Expert: Excellence and Power in Clinical Nursing practice*; London: Addison-Wesley
[154] M. Polanyi, 1962, *Personal Knowledge: Towards a Post-Critical Philosophy*; Chicago: The University of Chicago Press.

services also require **concrete reasoning** in order to concretize, to make real, the designed product or service. Another way to present this kind of opposition between scientific and engineering thinking or reasoning is to notice that while scientific activities are essentially oriented to the **necessary**, engineering is oriented to the **contingent**. Steven Goldman presents this opposition in an article's abstract which, in our opinion, is insuperable in its combination of density and clarity. "Engineering problem solving – affirms Goldman in his article's abstract -- employs a **contingency** based form of reasoning that stands in sharp contrast to the **necessity** based model of rationality that has dominated Western philosophy since Plato and that underlies modern science. The concept 'necessity' is cognate with the concepts **'certainty', 'universality', 'abstractness' and 'theory'**. Engineering by contrast is characterised by **wilfulness, particularity, probability, concreteness and practice**. The identification of rationality with necessity has impoverished our ability to apply reason effectively to action. This article locates the contingency based reasoning of engineering in a philosophical tradition extending from pre-Socratic philosophers to American pragmatism, and suggests how a contingency based philosophy of engineering might enable more effective technological action."[155]

***An adequate integration of "certainty, universality, abstractness and theory" with "wilfulness, particularity, probability, concreteness and practice" is highly desirable -- if not necessary – for both: scientific advancement and engineering increasing capacity in generating goods and services with a continuously growing efficacy.***[156]

Figure 9 shows the fundamental synergic relationships between Science and Engineering through mutual positive feedback loops. Regulative feedback loops may also exist via negative feedback and feed-forward loops. Figure 10 combines the basic features visualized in figure 9 and figure 2b, described above.

## Tacit or Personal Knowledge: Necessary Condition

Engineering professionals need propositional (scientific) knowledge ('know that') related to the domain area where they want to generate required "non-existent-yet" useful products, and – using Norman's term – '***future objects***'[157]. But, as we indicated above, to do so they also need, as a **necessary condition**, **non-propositional** knowledge ( 'know how,' know where,' know when,' 'know which,' 'know who,' etc., and 'knowledge by acquaintance or experience'). They need different forms of non-propositional knowledge, including what Polanyi[158] identified as **tacit** or **personal** knowledge, which is acquired by experience or acquaintance.

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[155] S. L. Goldman, S. L., 2004, "Why we need a philosophy of engineering: a work in progress," Interdisciplinary Science Reviews, Volume 29, Number 2, June 2004 , pp. 163-176; p. 163; emphasis added; available at http://www.ingentaconnect.com/content/maney/isr/2004/00000029/00000002/art00007 (Accessed on March 2, 2013)

[156] We are using the term 'efficacy' in the sense of an adequate blending of 'efficiency' and 'effectiveness.'

[157] D. A. Norman, D. A., 2007, *The Design of Future Things*; Basic Books.

[158] Polanyi, M., 1962, *Personal Knowledge: Towards a Post-Critical Philosophy*; Chicago: The University of Chicago Press. And Polanyi, M., 1967, *The tacit dimension*. New York: Doubleday Anchor.

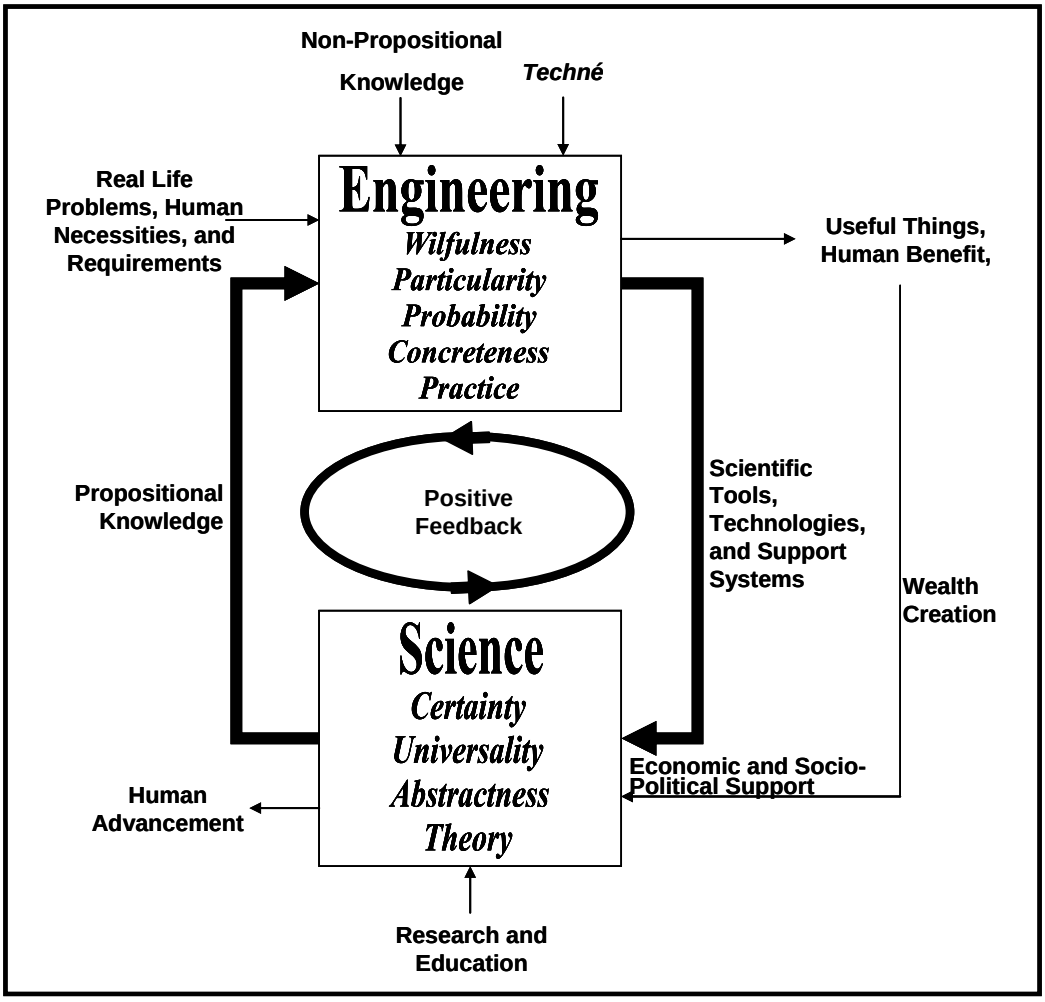


Figure 9

***Tacit knowledge is implicit***, and is related to the outcome of individual skills, practice and experience.[159] Tacit knowledge cannot be easily made explicit or represented formally. Visual representations like pictures, diagrams, and descriptions, help to exteriorize tacit knowledge, but it is largely embedded in experience as personal knowledge and it results from individual practice and experience.

Tacit knowledge cannot usually be transmitted verbally, through oral or written form. It is subjective, personal knowledge. It is usually not mediated by reasoning or logic; it is immediate knowledge. Tacit knowledge is usually learned by **working side by side with an expert**. Perrin affirms that operational knowledge usually "remains tacit because it cannot be articulated fast enough, and because it is impossible to articulate all that is necessary to a successful

[159] Polanyi, M., 1967, *The tacit dimension*. New York: Doubleday Anchor.

performance and also because exhaustive attention to details produces an incoherent message."[160]

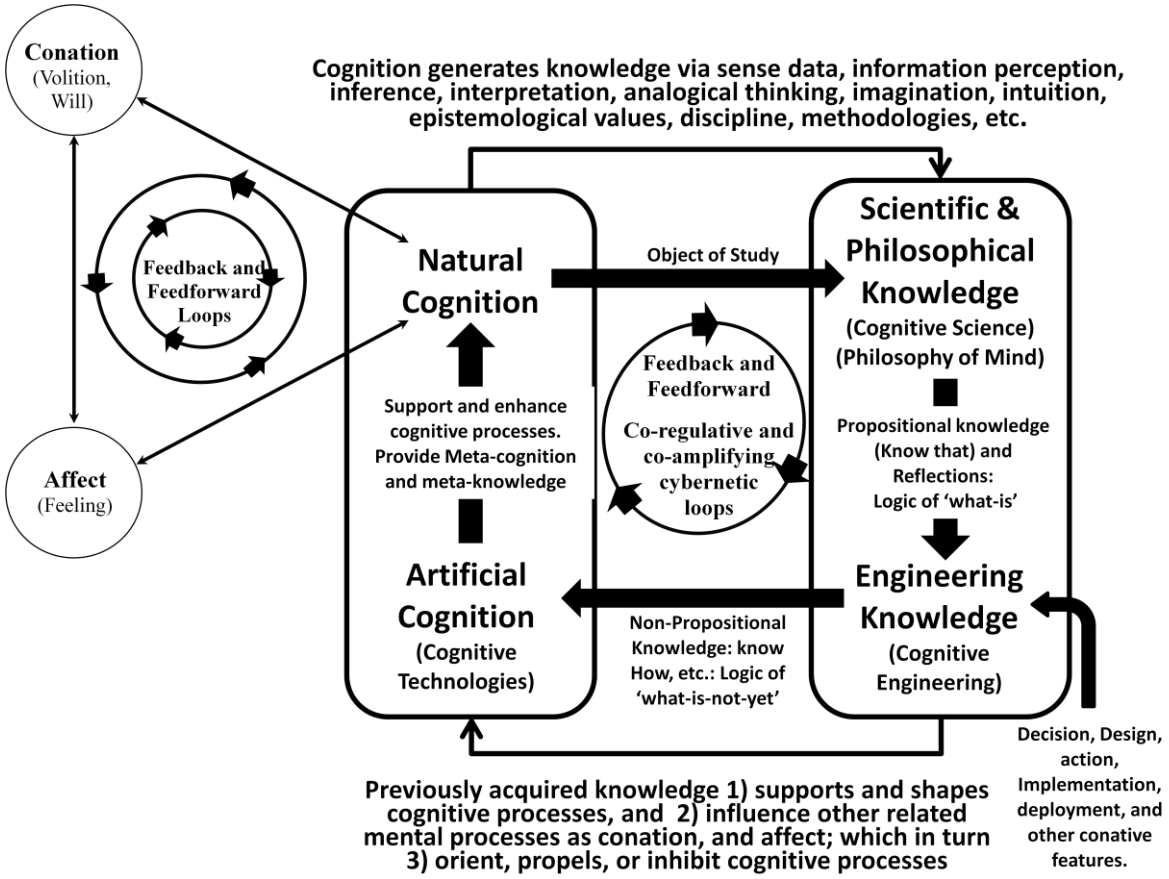


Figure 10

Polanyi a chemist and a philosopher, showed that all human actions, including those of scientists when making scientific research, involves, in some degree, some form of ***tacit*** knowledge.[161] Tacit knowledge is embedded in engineering activities more than is usually recognized. Tacit knowledge has not disappeared with the use of more sophisticated and systematic engineering means, which are based to a larger extent on the application of science and propositional knowledge. "On the contrary – affirms Perrin --, new forms of know-how have appeared and all these non-codified techniques play an important role in industrial production and in technical and technological innovation."[162] Explicit and implicit 'know how' are included in engineering practice. Even the so-called high-tech industries, such as telecommunications, electronics, software development, aircraft production, etc. rely intensely on tacit knowledge acquired

[160] Perrin. op. cit., p. 7
[161] Polanyi, ob. cit.
[162] Perrin, op. cit. p. 6

through practice and experience. Considerable technological and industrial innovations are generated through non-explicit methods and techniques.[163]

On the other hand, Holt affirms, "Personal knowledge [in the sense of knowledge by acquaintance] does seem to involve knowledge of at least some propositions. Simply having met someone is not enough to know them (in the personal knowledge sense); you also have to know a few things about them (in the propositional knowledge sense)."[164]

It is evident that engineering activities and thinking require three kinds of knowledge, i.e., personal/tacit (knowledge by acquaintance or by experience), propositional ('know that'), and procedural knowledge (know how, where, what, when, which, who, etc). Intuition is also an ingredient in many engineering practice, because, as Malpas affirmed, "engineering, practiced as a process, is a hugely **creative** activity [especially in its designing phase]."[165] But, Hawley alerts, "Whilst, for an experienced engineer, **intuition** is important [especially in the creative phase], it cannot be solely relied upon."[166]

Since Polanyi proposed his conception and definition of tacit knowledge, several variations emerged regarding the meaning of this term. In the next version of this article, we will provide a brief summary of these new variations regarding the conception of 'tacit knowledge' and on the different methodologies and techniques that have been proposed and used in order to somehow make explicit and represent some of its features, effects, or consequences in order to allow organizational knowledge management. Some of the techniques and methodologies used are Expert Systems, Knowledge Data-Bases, Policy Capturing, Group Support Systems, etc.

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[163] See for example N. Rosenberg, 1982, *Inside the black box: Technology and economics*. Cambridge, UK: Cambridge University Press. W. G. Vincenti, 1984, Technological knowledge without science: The innovation of flush riveting in American airplanes, *Technology and Culture*, *25*(3), pp. 540-576. D. R. Herschbach, 1995, "Technology as Knowledge: Implications for Instruction," *Journal of Technology Education*, Volume 7, Number 1, Fall.

[164] T. Holt, 2006, "Types of Knowledge: Personal Knowledge," available at www.theoryofknowledge.info/propositionalknowledge.html (Accessed on March 2, 2013)

[165] Malpas, op. cit. p. 10

[166] F. Hawley, 2006, *What Is Engineering?* The Royal Academy of Engineering, Philosophy of Engineering, Monday, 27 March 2006; pp. 6-9; p. 6. available at http://www.raeng.org.uk/societygov/philosophyofeng/pdf/Transcript_of_Presentations_on_27_March.pdf (Accessed on March 2, 2013).