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What is information? A multidimensional concern

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Abstract: *Looking for an answer to the posed question, we will first go through a brief historical enquiry aiming at exploring the development of the uses given to the Latin word "information" from its Greek roots until its scientific formalisation in hands of the Mathematical Theory of Communication. Secondly and starting from the conceptual limitations of Shannon's theory, we will put forward the most important theoretical demands claimed by many scientific and technical fields, directly concerned with the usage of information concepts. Such claims eventually entail an open critic to Shannon's definition with different degrees of radicality, proposing a perspective change in which the different uses and disciplinary interests might be better represented. In order to foster an interdisciplinary approach aiming at gathering together the competing views of information and at bridging their theoretical and practical interests, a sketched glossary of concepts concerning information is proposed as an interdisciplinary tool.*

The evolution from the industrial society to the "information era" is a crucial juncture of our times and a usual concern in classrooms, offices and streets. However, the very concept of "information" puts forward deep and challenging questions. Just one binary digit may tell us if the universe is about to collapse, thus being very informative, and all millions of terabits on the web (measured in a Shannon's sense) may also be generated by the whim of electrons in a rheostat, therefore being uninformative.

The *Mathematical Theory of Communication* (MTC) makes it possible to measure the capacity of channels and to understand information in its syntactical aspects, as a physical magnitude. Information is measured on average and messages come from combinations of objects selected from a predetermined set. However, the informational content of typical human messages seems to have semantic properties of its own (not on average) that are not apprehensible in bits. This fast incursion in the forest of problems and theories of information try to search an answer to:

Which are the difficulties both theoretical and technical, both conceptual and technological that might be encountered in defining a useful unified information concept, valid for cables and organisms, for antennas and societies, for robots and mental states?

1. Concept Lability

The current controversy regarding "what we call information" reflects both its etymological sense, i.e. that of "forming" (whether in a *corporal* or *intangible* manner), and the most popular of its meanings (the one that can be found in the street or in the first lines

of the dictionary). Such common use approximately refers to "the act or fact of informing", or, in other words, "to find out about something". Moreover, the course of what–has–been–called "information" through-out history shows: on the one hand, the persistence of the most remote roots; on the other hand, the constant tension to reflect in the meaning itself the uses and interests posed by everyday life. No matter whether this is ordinary life or the one carried on within a specialised group, for instance, devoted to a specific field of scientific research. This means that through *metonymies* and *metaphors* the term has gradually adapted itself, as far as possible, to various and collective uses and interests. However for some sixty years, the scientific use of the information notion has categorised the term to a large extent, making its sense much more precise but also unrulier, which has created further tension when striving for making certain points of view clearer.[1] This tension is especially obvious between theories that because of a limited universe of reference could be axiomatised (becoming indeed mathematical theories) and those others that in order to not diminish the regarded reality have adopted open models, whose formalisation has not been mathematized, or its mathematical form has resulted of impractical complexity.

Briefly, when it comes to illustrate the different approaches to the term "*information*", it has to be focused in two main directions: On the one hand, toward its very remote roots – including the different meanings it has acquired until the present day–; on the other hand, toward the plurality of meanings given by different scientific communities and other socio-cultural groups of varied nature.

2. Historical Roots (from ancient times to nowadays)[2]

2.1. Antiquity (Greek and Latin roots)

As mentioned above, the Latin term *informatio* (disseminated in different degrees to other European languages, obviously including the Romance ones) derives from the verb *informare*. Primarily meaning "to form", it was used both in a *tangible* sense (*corporaliter*), i.e. the effect on something material, and in an *intangible* or spiritual sense, i.e. linked to moral and pedagogical uses.[3] In its tangible meaning, the use of the term "*informatio*" refers to both artisan (or technical) contexts, as it can be found in Virgil (Vergili 1900, b. VIII, v. 264, 426, 447), and biological contexts, e.g. in Varro (Gellius 2006).[4]

In both meanings, but more especially in the tangible one, the Latin concept grasped a Greek-rooted ontology and epistemology – consequence of the Greek influence on Roman culture–, which entailed the recurrent translation of Greek concepts into Latin, such as *eidos*, *idea*, *morphe* or *typos…* with a long intellectual tradition. This can be found in both Latin and Christian authors, as Cicero, Augustine of Hippo, Aquinas or generally in medieval scholasticism –whose concern was mainly inmersed in intellectual frames and devoted to pedagogical, moral and biological issues–. In this tradition, we eventually find restrictive uses to tangible or intangible senses; swinging from a high development level to a more common sense. In the case of Augustine and Aquinas –who will greatly influence the future meaning of the concept–

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[1] Despite the accuracy of Shannon's mathematical approach, its corresponding concept has also been branded as dark and distant from its usual meaning (Segal 2003; Capurro & Hjørland 2003; Floridi 2005).

[2] Although a deeply inquiry is desirable to grasp the actual dynamics of the "information" senses throughout history, we just pursue here to sketch the most significant changes in a summarized account. Detailed studies can be found in the given references throughout this section.

[3] A thorough inquiry of the historical uses of the Latin term and its derivatives can be found in Capurro (1978), who also offers a briefer but sharp account in a co-authored work (Capurro & Hjørland 2003).

[4] In a sense that can be considered as "partially rescued" in the context of the biological morphogenesis from the late 18th century with authors, such as Oken and Saint-Hillaire (Mason 1962, p. 376ff).

we find a very refined use in both an epistemological and ontological sense.[5]

In sum, the plurality of meanings that foreshadows the current conflict regarding information can already be observed in antiquity as a whole. However, these meanings were loaded with an ontology that will gradually disappear due to the emergence and course of modernity, as Peters argued (1988). These changes are fundamental in order to understand the formalisation of the information concept by the mathematical theory of information in the 20th century.

2.2.   The rise of Modernity

With the advent of Modernity, the old, ordered and structured *cosmos* gives way to a world of corpuscular movements, where *consciousness* take account of its dynamics. The antique world was structured according to supra-sensory and eternal forms enabling the intellectual apprehension of such cosmos. However, the new "picture" of the modern world comes from fragmentary, fluctuant and even hazardous units of feeling that has to be arranged by consciousness itself. Thus "under the tutelage of empiricism, information gradually moves from *structure* to *matter*, from *form* to *substance* and from *intellectual* order to *sensory impulses*" (Peters 1988, p.13).

Reasonably, the Greek *hylemorphism,* embraced by medieval scholasticism in both ontological and epistemic senses, should gradually disappear in the course of this radical transformation. In this trend, the meaning of "giving form" will be now consigned to a domain, regarded as more consistent, namely *consciousness*[6]. Thus former *objec-*

tivity and consistency of "form" is followed by a radical dependence on the subject that fundamentally *subjectivised* such form. Likewise, the *atomisation* of the external world is now associated with the atomisation at the level of ideas, whose interrelation with the world becomes problematic because of substantial restrictions on sensitive mechanisms. Through these means and according to empiricist epistemology, consciousness can *obtain information* about the world. Briefly, in an ontological level, form and structural unit lose importance while both world and consciousness become *analytical,* i.e. devisable into more elemental parts. Furthermore, in a epistemic level, truth becomes also analytical.

2.3.   The rise of contemporary science, the context of the Mathematical Theory of Communication

The crisis in the cosmology of the Enlightenment across the 19th century, entailing the superseding of mechanicism in natural sciences (especially in physics and biology), leads to a partial shift of analyticity through a more structured conception of reality. This process creates a significant tension with previous ontology and epistemology continued until the present day. In fact, the theory of *relativity*, and those of *quantum mechanics*, *statistical physics* and *evolutionary biology* are strictly incompatible with the assumptions of a cosmos of corpuscular interactions and analytical consciousness. Nevertheless, in the gap dividing both poles, and, especially in the development of the information concept –that will be poured into Shannon's theory, as Segal shows (2003)–, an odd and also surreptitious translation takes place from rationalist and empiricist epistemology into the contemporary one. This –so to speak- underground flow befell in thermodynamics –especially within the works of Marjan von Smoluchowsky (1912), Leo Szilard (1929) and Gilbert N. Lewis (1930)–, in quantum mechanics (Von Neuman 1932) and statistics (Fisher 1935). This process is paradigmatically illustrated in the theoretical role played by *Maxwell's demon*, whose perception allows him to "get informed", with the

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[5] According to Capurro & Hjørland (2003, p. 355), the 20th century gives rise to the "renaissance of the ontological dimension of the Greek roots of *informatio* beyond a restrictive humanistic view". However, an underground continuity of the old ontology into the modern one might be argued, for instance, in terms of a gradual transformation of the classical "chain of being" into the modern theory of biological evolution (Bowler 1992, pp. 155-192).

[6] The Enlightenment might be indeed considered – from a modern point of view – as a vast effort of forming consciousnesses or even of transmitting between them those correct forms created from "clear and different ideas".

purpose of achieving an order that cannot be explained without his intervention.[7]

According to a subsequent quantitative adjustment, entropy and information become at the same level. Hence, information rescues a classical *reversibility* that was questioned by the new worldview[8]. However at the same time, a new model of knowledge and even of cosmos –compatible with each other- are forged, in which the information that can be extracted from this 'cosmos' and its unavoidable uncertainty become key issues of the worldview itself.

Thus, two contradictory movements occur at the crystallization of the information concept:

- The analytical and mechanistic ideal of rationalism is taken as a model of the measurability of information, including the informative process itself[9].
- The uncertainty itself, i.e. limiting oneself to the purely observable as a criterion of reality, becomes the corner-stone of the idea and measurement of information.

It is especially paradoxical that this confusion occurred, as previously mentioned, from the matrix of statistical physics, since its worldview is beyond the first of the referred movements (Segal 2003, 15-65). However, as stated by Danchin (Segal 2003, ix-x), this cannot be understood without the development of telecommunication engineering in the post-war context[10] as well as the rationalisation of economic exchanges, whose models of rationality were purely classical and –to a large extent– direct heirs of 19th century positivism.

Thus, it can be said that the imperatives of technological development –both in communication and in computing–, and even the prestige of its brilliant career, gave rise to a theoretical eclipse that –as in other fields– was argued in terms of *technocracy*[11] by Frankfurt School and, especially, by Habermas (1970). From this narrow technical and economic viewpoint, we might enumerate the most relevant information issues for the Mathematical Theory of Communication (MTC) as follows:

a) How shall information optimally be compressed, *i.e.* coded by a minimum quantity of resources?
b) How shall the maximum amount of information be transmitted for a given set of resources;
c) How information amount shall be accounted, so that we can predict the necessary resources and, therefore, the costs.

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[7] An excellent inquiry in the forging of the physical notion of information throughout the work of their authors can be found in the mentioned book of Segal (2003, 16-32).

[8] The contradictory reduction of entropy entailed by the intervention of Maxwell's demon, leaving the system more ordered than before (in a flagrant violation of the second law of thermodynamics, which could be for instance used to obtain energy), is compensated with the contribution of information by the demon itself according to its enquiries (up to the point in which the demon is not able to obtain new information as to increase the order of the system). According to Bidón-Chanal (1971), this exorcism of the demon represents a combination of two different notions of information: as *acquisition of knowledge* –implying an intrinsic increase of entropy–, and an Aristotelian notion as *order*. According to this combination knowledge is able to reconstruct order. Hence, deterministic reversibility results by assuming the exact adjustment of both quantities. Yet, if an additional restriction is considered regarding a limit in the acquisition of knowledge, the process will be irreversible and, therefore, more coherent with contemporary physical assumptions.

[9] The author (Díaz 2007, 2009) refers to the Lockean root of Shannon's model of communication, highlighting its deficiency with regard to the pragmatic point of view. If this is the case –and according to the persistence pointed out by Floridi of Shannon's communication model in the alternatives to his theory of information– this will be an important conceptual burden that should be overcome (Floridi 2005).

[10] Shannon himself worked in this field, as previously done by Nyquist and Hartley, whose contributions were essential for Shannon's theory, as pointed out by himself (Shannon 1948).

[11] According to Danchin (*see* SEGAL, *op. cit.*), "the development of these theories [of information –in physics, statistics and telecommunications engineering-] occurs in a world strongly influenced by an ideology of degradation. Hence, assimilating entropy and disorder, and placing information in this context is not obviously innocent". On the other hand, as pointed out by several authors, the inherent confusion to put information and entropy on the same level was the main argument given by von Neumann to Shannon recommending its use (Floridi 2005).

Nevertheless, beyond MTC formalisations, the reality depicted by evolutionist biology and quantum mechanics involved a world of interrelations absolutely irreducible to classical mechanicism. Hence not surprisingly, due to the centrality of information in these new sciences, they encountered significant tensions by adopting the notion of information coined by the MTC. Moreover, the tensions that came up into social sciences were also very significant, after an initial euphoria of having this new mathematical tool on hand. In these disciplines, the semantic and pragmatic dimensions of information (supported by the linguistic use) are essential to explain the problems under study; but they are alien to the MTC, as stated by Shannon repeatedly (1948, 1949). Thus, in the context of these controversies, the concept of information has intended to limit itself to the uses and interests of each theoretical field, sometimes with the intention of completing the MTC, sometimes openly contradicting some of its points (especially, as general theory of information); at other times with the aim of superseding it.

3. Current points of view on information

As generally highlighted, since the MTC focuses its efforts on the quantitative determination of information, it makes the quality indistinguishable. It refers exclusively to the *syntactical* aspects of *information* (Floridi 2005a-c, Segal 2003, Capurro 2005), even though it is difficult for information to be exclusively linked to this aspect, whatever sense of information is used (unless it were restricted to the MTC quantification, therefore just referred to the uncertainty values of the signals used in the communicative process). A qualitative approach shows the importance of both its *semantic* dimension (whereby the signals or symbols considered by the MTC are necessarily referred to something) and its *pragmatic* one (whereby information is the foundation for action, whether by intentional actors, living beings or automatic systems). This does not simply mean broadening the attributes or details of the reference, but also an important negative limitation driving to

exclude what could not be discriminated at a merely syntactical level.[12]

As pointed out by Machlup and Mansfield (1983), this negative nature can be illustrated by considering the requirements that human contexts normally impose on the legitimate meaning of information, i.e. need for truth, value, innovation, surprise or reduction of uncertainty. This would classify as non-informative those messages that, even complying with all syntactic requirements, were false, incorrect, useless, redundant, expected or promoters of uncertainty. To this regard, the MTC could not say much; neither could any other just syntactical approach. Therefore, the multi-dimensionality of information has to be accounted.

Hence from the previously mentioned theoretical coherence or the conceptual extension posed by different approaches, a panoply of alternatives and criticism has arisen since the MTC was formulated. This must be taken into account in order to distinguish "what is being called information" and to envisage "what might be called information", so that the interests at stake were reflected and the mutual understanding were possible.

Aiming to address the different approaches in a systematic way, as well as increasing the perception of relationships between such approaches, a three-fold classification is proposed, as follows:

a) According to the ontological and epistemological categories involved, i.e. with regard to fundamental questions, such as: "Is it something *objective* or *subjective*?", "Does it refer to an *independent* or *dependent* ontological category?", "Does it require an *abstract*, *general* or *human* subjectivity?", "Does it depend on its *truth-value*, *relevance* (social, political or psychological), *meaning* or *interpretation* (in theoretical or cultural contexts)?

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[12] In his analysis of the qualitative nature of information, W. Gitt distinguishes two other levels – the *statistical* and *apobetic* ones (referred to purposes of the actors) – that would be situated below and over the other three mentioned levels respectively (Gitt 1996).

b) According to the considered dimensions of information (syntactical, semantic, pragmatic, etc.).

c) According to the disciplines, from which it is proposed or elaborated.

3.1.   Ontological and epistemological categorisation

The fact of being or not considered as something *objective* is perhaps the main distinction that can be made concerning what is understood by i*nformation*. If it is objective it will be independent from mental states or user's intentions; if it is *subjective* it will depend on the interpretation of a cognitive or intentional agent.[13] Between both poles, an intermediate approach could be adopted, according to which it is not necessary to consider information as something having its own entity or something belonging to subjectivity, but rather in terms of a *relationship.* This may enable an action to be executed, an order to be obeyed, an structure to be established or simply allows a behaviour, adaptation or an interpretation (even though it could be referred to any type of intentionality).

In the most extreme position of objectivist categorisation, information is deemed as a third metaphysical principle, in the sense expressed by the popular Wiener's adage: "Information is information, not matter or energy" (Wiener 1948, p. 132; Günther 1963). This principle is sometimes associated with a teleological description of the universe as it happens in Teilhard de Chardin's "noosphere", to which Stonier refers (1991), or in an openly theological "cosmovision", as in Gitt (1996). Regarding the MTC, it remains unclear if the authors consider information as objective, substantial (as sometimes interpreted) or by the contrary it refers to the uncertainty concerning the identification of the signals being received in the communication process. This second interpretation seems closer to the interest frame, in which the theory was developed (Shannon 1948, 1949).

Figure 1 shows a relevant number of theoretical viewpoints –without attempting to be exhaustive, these models are grouped into theories named under a title that not always corresponds with the one used by the authors, but referred to some key elements of their works and to a relative parallelism of their approaches–. It arranges different information concepts with respect to its greater or lesser subjective nature. On the left, the most objectivist theories are placed; on the right, the most subjectivist ones, and centred, a range of intermediate theories that normally adopt a two-fold approach. This is, e.g., the case of Weizsäcker's dual concept of his *objectivised semantics*, in which information is defined as: 1) what might be understood (even if it is done by an abstract intentionality) and 2) what generates information (Weizsäcker 1974, p. 351).

As a relational concept, information might be dependent:

- on *reception probability or uncertainty* as in MTC.
- on *measurement* processes, as in the general theory of measurement (Neuman 1932, Brillouin 1956, Mähler 1996);
- on the *complexity of a referred object* or process to be done, as in the "Algorithmic Information Theory" (Solomonoff 1964, Kolmogorov 1965, Chaitin 1969, 1982);
- on the *understanding potentials and generating facts* of the mentioned "objectivised semantics" (Weizsäcker 1974) and other related or similar approaches as Lyre's information-theoretic atomismus (1998) or Matsuno's informational diachronism of evolution (1998);
- on the *evolutionary adaptation ability* of self-organizing systems as in the "Unified Theory of Information" (Hofkirchner 1999b);
- on the *releasing features of recipients* as in Karpatschof's activity theory (2007)

As illustrated in fig. 1 (below) this relational character implies sometimes the reference to

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[13] The relevance of this distinction is, for instance, considered by Capurro and Hjorland (2003, p. 396).

a certain kind of subjectivity or intentionality. This is the case of the *Unified Theory of Information* – frequently presented as a mediator of all points of views without falling into reductionism or holism (Fenzl & Hofkirchner, 1997) –, which appeals to a certain degree of

intentionality, not necessarily human, that we call *general*. The complexity may present different degrees depending on the process this theory refers to (i.e. adaptation of systems with a greater or lesser complexity).
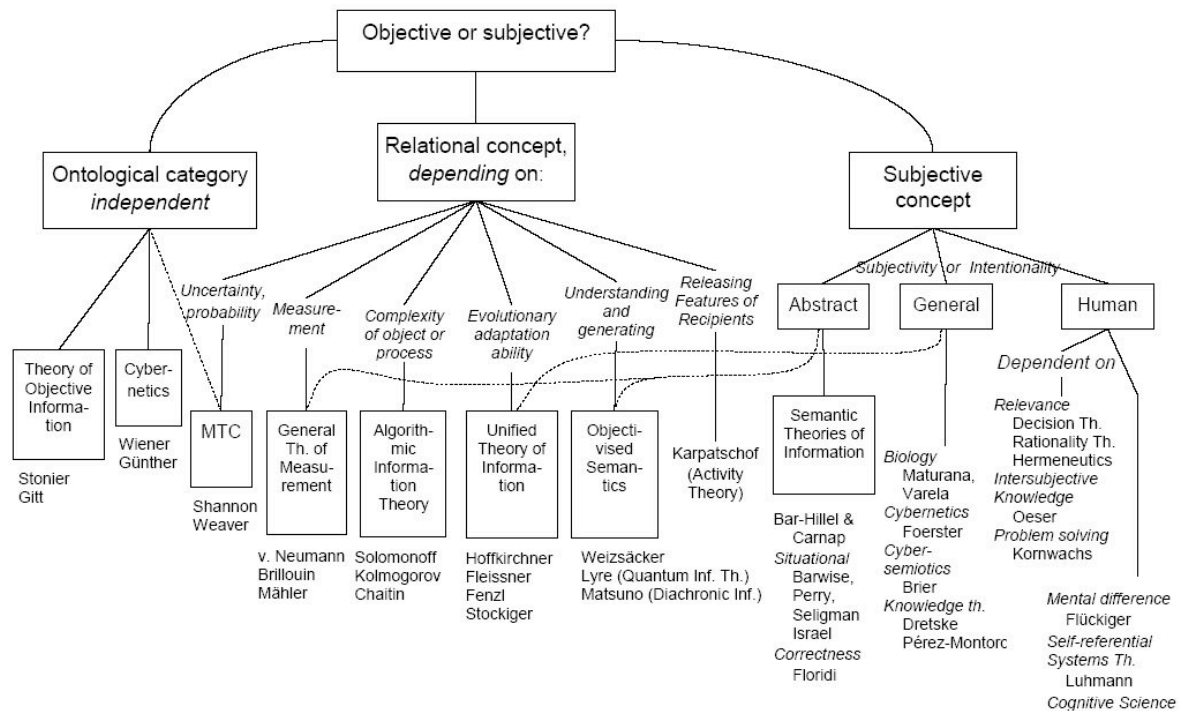

Figure 1. Taxonomy of theories based on information as something objective, relational or subjective.

Nevertheless, trying to give account of all processes and to explain the emergence of more complex auto-organizing systems, this approach also refers to the organisation of physical systems without intentionality

Thus, intentionality belongs to the realm of the most complex systems (normally human or social) aiming to harmonise with diachronic struc-turing and organisation from the most simple elements.[14]

If information is considered from a *subjectivist* point of view, the objective qualities of signals are left apart, focusing on those regarded as relevant by subjects (interpreters). However, this does not mean that information is only interpreted from an anthropocentric point of view (or something just oc-

curring inside minds[15]), but that subjectivity may be referred to an inten-tionality that can be:

a) *Abstract*, or formal, in the sense of a series of general conditions of representation and intellection of reality, as it happens in most of the semantic theories of information (Bar-Hillel & Carnap 1953, Barwise & Perry 1983, Barwise & Seligman 1997, Israel & Perry 1990, Floridi 2004-2005c);

b) *general*, in the case of information as a construct of an observer (whether human or not), who finds differences in its circumstance –as suggested by Maturana and Varela (1980) from a biological approach, or by Heinz von Foerster from a

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[14] avoiding a strictly casual explanation (bottom-up) or its exclusively projectionist counterpart (top-down)

[15] Indeed sometimes, an externalist viewpoint is adopted, reducing the role of intentionality with respect to information as a sort of correlation between facts, signals and behaviour (Drestske 1981).

cybernetic perspective (1981)– (Brier 2008, Dretske 1981, Pérez-Montoro 1997);

c) *human*, in whose case the consideration of language (Wilson 1993), interpretation (Capurro 2008), action (Benthem 2003, 2008, Floridi 2005d), cognitive mechanisms (Flückiger 2005) or social systems (Luhmann 1987) become essential, while the quest for *relevance,* whether social or individual, *veracity* or relationship with *knowledge* turn into articulating aspects (Kornwachs 1996, Oeser 1976, Habermas 1981).

With regard to the epistemic value of each perspective, it is clearly neutral for objectivist conceptions (the value of information lies in itself and it is meaningless to talk about truth) while it can be considered subjectivist or not for those conceptions depending on intentionality, especially if they are linked to knowledge or semantic issues. To some extend when moving from left to right in fig. 1, we go from ontological to epistemological questions. The particular epistemic value will depend on the attention paid to syntactical, semantic and pragmatic aspects.

3.2.   Dimensional approach

The perspective adopted concerning which dimension of information is to be considered, is also a clarifying aspect of the scope and intention of the different information concepts.

As mentioned above, both epistemological and ontological consequences will result from this stance. If just the syntactical level is considered, the question about the truth of the content is meaningless, whereas the way toward the objectification of information is maximally feasible[16]. On the other hand, when pragmatics comes on stage, the question about truth is substituted by others, such as value or utility.

Briefly, the three mentioned dimensions of information could be characterised by means of three major questions[17]: 1) concerning the *syntactical* content, "How is it expressed?"; 2) for the *semantic* content, "What does it represent?" as well as "with which truth value?"; and, 3) for the *pragmatic* content, "What value and utility has it?".

Although in communicative or information-transmission processes, speaking about transmission of semantic contents without expression is clearly meaningless, and such contents are in turn necessary to identify the pragmatic contents, it is still unclear to what extent each question determines the other two. Although the three regarded dimensions are usually considered hierarchically (being the syntactical aspects at the lowest level and the pragmatic one at the highest one), different positions can be taken to this regard due to different reasons: 1) the degree of freedom that each aspect lets the others depends on the adopted point of view, 2) usually some of the mentioned levels are not considered at all, and 3) in some cases the levelism is avoided.

Thus, whereas the MTC is only related to the syntactic dimension –regarding the other two besides the point– some semantic approaches consider the semantic question strongly restricted by Shannon's information – such as in Weaver (Shannon & Weaver 1949) – while others consider a weak restriction allowing a large margin of freedom (Sloman 1978, Floridi 2005c, §4).[18]

In Figure 2 (not trying to be exhaustive once again), it is shown the extent to which each concept answers to the posed questions about the multi-dimensionality of information .[19]

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[16] According to Zoglauer (1996), the naturalisation of the information concept is only possible at the syntactical level, even if it is related to semantic units mentally dependent or to any type of functional information that could be interpreted by a Turing machine.

[17] Within this section, just the syntactic, semantic and pragmatic dimensions will be considered, though some authors refer to others (see note 12, Gitt 1996).

[18] To this respect, it is remarkable that there are good reasons to consider that a simple noise (for example, due to the thermal erratic movement of electrons in a resistor), although maximally pondered by the MTC in terms of entropy or amount of information, does not meet the requirements commonly attributed to information. However, a single bit may tell us if the Ptolemaic universe is or not the case or if war has begun, which might drastically change our worldview or our expectations.

[19] Notice in fig. 2 the syntactical dimension is located both on the left and on the right, in order to represent the

Syntactical *How is it expressed?*	Semantic *What does it represent? Is it true?*	Pragmatic *What value does it have?*	Syntactical *How is it expressed?*

MTC (Shannon, Weaver)   *Logical empiricism* (Bar-Hillel, Carnap)

Theory of purpose-oriented action (Janich)

Algorithmic Information Theory (Solomonoff, Kolmogorof, Chaitin)

Holographic Universe (Bekenstein)   *Cognitive constructivism* (Dretske)

Aesthetic Theory of Information (Bense, Moles)

Quantum Theory of Information and Measurement (Lyre, Mähler…)   *Situational semantics* (Barwise, Perry, Seligman…)

Activity Theory (Karpatschof)

Fuzzy semantics (Zadeh, Pérez-Amat…)

Theory of Self-referential Systems (Luhmann)

Cybersemiotics (Brier)   *Theory of Objective Information* (Stonier, Gitt)

2nd Ord. Cybernetics (Foerster, Maturana…)   *Unified Theory of Information* (Hoffkirchner …)
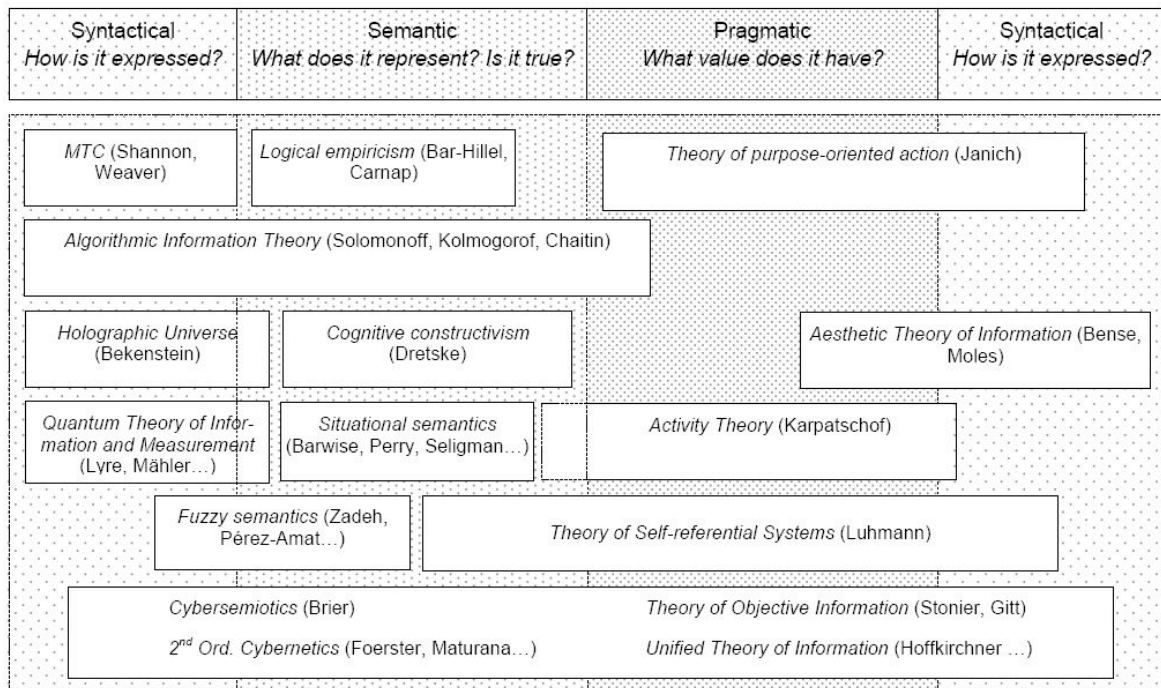
Figure 2. Aspects of qualitative content covered by different information concepts.

Shannon's information as well as the reformulations trying to supersede the inconsistencies with respect to modern physics epistemology are located at the syntactical plane (quantum information theory or information according to the holographic principle). The last-mentioned cases are represented as partially covering semantic aspects, since –contrary to the classical MTC concept– there is a certain degree of indeterminacy in the description of reality by means of data, implying that information is necessarily mediated by theory. However, this consideration rather belongs to an epistemological level concerning the observation and measurement of reality, therefore not referring to what is commonly understood as semantic aspects of information. It is rather an additional limitation at the syntactical level with regard to MTC assumptions.[20] If only semantic questions are to be accounted, there are a significant

number of proposals that, in turn, present important internal differences hardly reconcilable, as they are rooted in atavistically opposed assumptions, such as empiricist, constructivist or rationalist positions. Thus, although the semantic value of a proposition –assumed as informative– it is usually referred to probabilistic computations (inspired by Shannon's quantification model) and the "Inverse Relationship Principle" is followed, linking the increase in information to the decrease in possibilities (Barwise 1997), a different probabilistic approach can be found in each case:

- For Bar-Hillel's and Carnap's *logical empiricism* (1953), the probability space is based on the result of a logical construction of atomic propositions in a formal language;
- in Dretske's *cognitive constructivism*, the probability of the observed state of affairs is accounted (Dretske 1981);
- in *situational semantics*, the probability of the space of states and the consistency from a certain contextual situation

inclusion or exclusion of any of the three dimensions represented without hierarchy.

[20] Such additional limitation can be, for example, illustrated by the fact that Von Neumann's entropy, related to quantum states, is smaller than Shannon's entropy (Neumann 1932).

are accounted (Barwise & Seligman 1997);

- in Zadeh's *fuzzy semantics*, the categories used in the descriptors are associated to elastic constraints and fuzzy quantifiers (Zadeh 1986).

In the *algorithmic information theory,* differing from the combinatory and probabilistic approaches*,* information content is defined in terms of the minimal resources to reproduce (compute) something, whether a mere binary structure, an object or the development of a certain operation (Somolonoff 1964, Kolmogorov 1965, Chaitin 1966, 1982a). Hence, this approach by referring to the expressive resources required to perform something covers both the syntactic and the semantic issues. But considering that certain codes are just aimed at doing something –purpose oriented – the pragmatic questions may also arise[21].

In an expressly pragmatic sense, Janich's theory of information (1998) refers to purpose-oriented human actions searching the possibility of reproducing such actions through artificial anthropomorphic devices articulated by standard interrogative dialogues, qualified by information predicates. Hence, a two-fold attention to pragmatic and syntactical dimensions is found.

In a higher degree of abstraction regarding informative pragmatics, *Karpatschof's activity theory* (2007) reduces the syntactical field to that of qualities of signals with regard to a "release mechanism'", which –so to speak– rules the roost. Thus Karpatschof's approach focuses on the characteristics of this mechanism as a system containing potential and stored energy that can be released in a spe-

cific way, whenever trigged by a signal fulfilling certain conditions[22].

In an integrating perspective of the three considered information dimensions, Luhmann's theory of self-referential systems (1987) considers information as mediating instance between the "meaning offer" (typical of the cultural circumstance) and "understanding". Thus, semantic and pragmatic dimensions are in this case closely related, whereas social systems can be considered as both worlds of meanings or problem-solving worlds. This interrelation of pragmatic and semantic dimensions constitutes in Lyre's Quantum Theory of Information (1998) or Weizsäcker's semantic theory (1974) the condition for the possibility of the objectivisation of semantics, achieving the unification of the three fundamental dimensions of information (Lyre 2002), solving for the syntactical one the already mentioned epistemological defects of the MTC –especially in relation to the certitudes of quantum theory.

In a more hierarchical sense of the three dimensions of information, the *unified theory of information* intends to cover all problems related to information, such as physical-, organic- or social phenomena, by means of the self-organisation paradigm (Hofkirchner 1997, Fenzl & Hofkirchner 1997). In this approach the three referred dimensions are considered as levels: the constitution of the syntactical level is the condition and substratum for the articulation of a semantic level, and this one is, in turn, the condition and substratum for the self-re-creation of a pragmatic level (Hofkirchner 1999a, 1999b). This hierarchy is also shared by Stonier's (1999) and Gitt's objectivised information (1996). Gitt considers two additional levels below and over the other three ones, the statistical level –below the syntactical one– and the apobetic

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[21] Indeed, the complexity limit studied by Chaitin in relation with Gödel's incompleteness theorem and Turing's halting theorem can be interpreted as having a practical scope, since the knowledge background or the used/selected semantic frame limits what can be done and therefore what can be pursued (Chaitin 1982a, 1982b, Lyre 2002, §1.4.2).

In the sense that *algorithmic information theory* also deals with an optimal representation of something, the theory can also be understood as a semantic and syntactical approach. So is considered by LYRE, H. *Informationstheorie*, Wilhelm Fink Verlag (UTB), Munich, 2002.

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[22] One of the benefits of Karpatchof's proposal, concerning a unified approach to information, is the lability of the signals requirements and the characteristics of the release mechanism. For example, if the imposed requirements concerns the satisfaction of certain truth or veracity constrains, the model will be linked to the knowledge problem or, generally, to semantic issues. If the requirements are of aesthetic nature, the model will be linked to the problem of artistic information. Analogously, it could also be adjusted to problems of biological adaptability, social coexistence, etc.

level (or purpose level) –over the pragmatic one.

3.3. Domain approach

Other perspective that allows us to distinguish the scope and interests reflected in the different approaches to information are the scientific and technical disciplines involved in their development. If these approaches come from telecommunications, biology or sociology, "information" will be obviously used in a different sense. The first one intends not to get involved in questions of meaning or relevance (Shannon 1948), the second one usually avoids intentionality, which cannot be left apart in sociology.

Despite this heteronomy, one of the most outstanding characteristics of information theories is perhaps that they have intended to embrace very different points of view, even in those cases with no apparent intention of being exhaustive. Such was the case of the MTC, though mainly developed within the frame of telecommunications and mathematics, its concepts arose (as widely shown by Segal 2003) from thermodynamics and quantum physics, statistics –linked to eugenic projects– and telecommunications, and it was applied to many natural and social sciences.
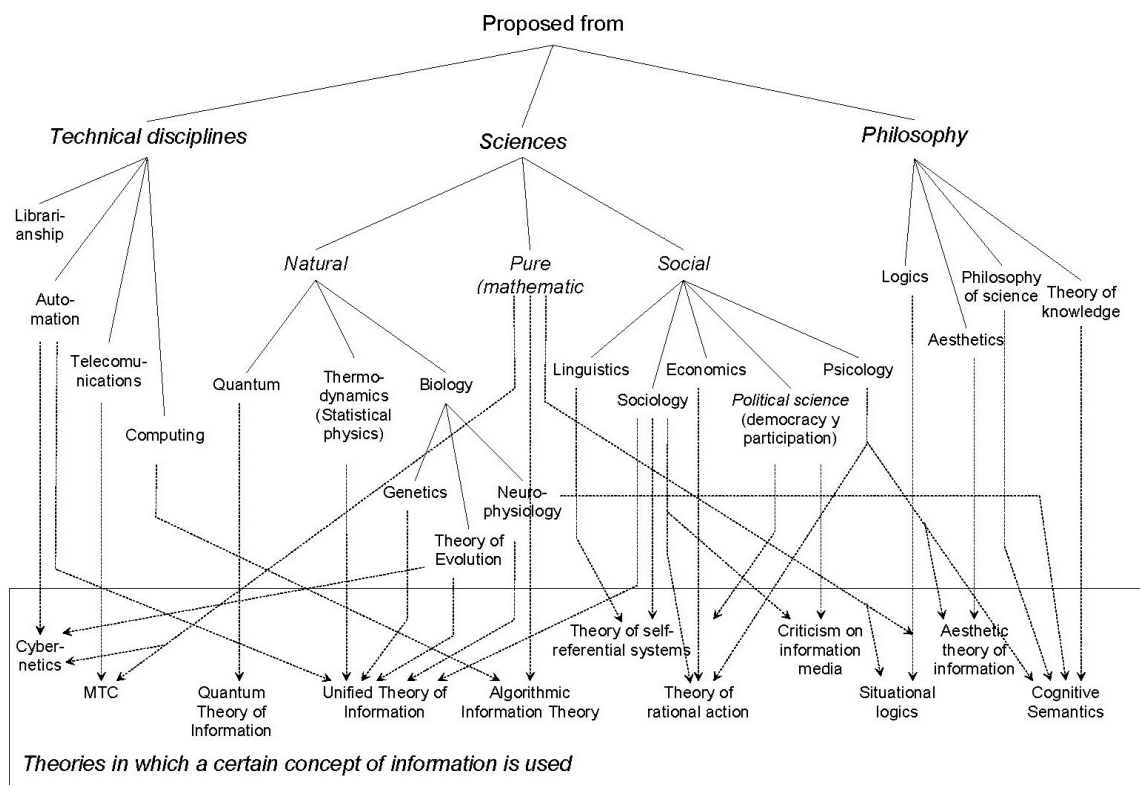

Figure 3. Relationship among theories of information and technical and scientific disciplines.

In any case, this prominent interdisciplinary nature is especially observed in the foundations of classical cybernetics in 1940s constituted from contributions derived from physics, biology, psychology, automation, neurophysiology or psychiatrics. Interrelation that can also be observed in other informational approaches developed in System theory (e.g. the Unified Theory of Information) or also in cognitive sciences.

However, in spite of this background of relationships between scientific and technical specialities, some theories have been developed from not so open contexts. Such is the case of the *Algorithmic Information Theory*, mainly linked to mathematics and computing (especially in its genesis); the *Aesthetic Theory of Information*, linked to the theory of art, mathematics and psychology (Bense 1969, Moles 1972); the theories of rational action or self-referential systems, developed in the field of social sciences –such as the *theory of self-referential systems* or the *criticism on information media*– and, finally, the *semantic theories*, of a more philosophical and logical nature.

Figure 3 shows –not thoroughly again– the relationships between scientific and technical disciplines, taxonomically ordered, as participants in the definition of different information concepts. As it can be observed, on the one hand, the deep interrelation among academic disciplines shows the typical interdisciplinarity of information theories; on the other hand, the fact of having located natural sciences on the left and social or human sciences on the right has the consequence that on the left the most syntactical and objectivist theories prevail, while on the right, the semantic, pragmatic and most subjectivist theories are predominant.

4. Problems of reductibility and agreement

Summarising, some of the posed problems in order to achieve a generalisation of the information concept, so that no point of view is left aside, could be enumerated as:

a) Is there a single notion useful for all disciplines? In other words, might every scientific notion be reduced into a single and fundamental one?

b) Is there any meaning of informational content, being at the same time useful and relevant, able to unify the different approaches to information, including intentional contents and those leaving the question of intentionality aside or avoided?

c) Could a general meaning be accepted and agreed by all disciplines?

d) Would this general –and consequently abstract– meaning of information be useful?

e) What ontological, epistemological and methodological consequences would entail the supposed validity of this type of notion?

f) Can the question of information be disconnected from those of knowledge, communication, reproduction or self-regulation?

As it was previously highlighted, there are some shortcomings in every concept of information with regard to others. For instance:

- the canonical definition of the MTC comes into conflict with the irreversibility of the theory of measurement, which is more consistent with the approach of quantum mechanics;
- merely syntactical approaches avoid irreducible semantic aspects;
- veracity can or cannot be taken into account, as well as contradictions or tautologies;
- relevance might be a major issue or excluded in non-contextualist approaches.

The tension among theoretical positions strongly depends on the problems they tackle. Since any science spins around its own problems, how the others consider them will be essential to achieve a unifying arena. Just to mention some problems that might arise by gathering the information theories considered above: measure, stability, control, adaptative efficiency, maximal capacity of storable data, maximal efficiency of a code, communication, knowledge, context, truthfulness, truth, contradiction, socialization, coexistence, plurality, politic participation, security, identity, creativity, sustainability, etc.

To give an idea of what kind of controversies may appear when trying to generalize the concept of information there is probably nothing better than considering what every one says about these central questions. Sometimes we observe that specialists from different fields speak about the same matter using

different words, while in other cases, the same word is used but it is understood with different meanings.[23] Therefore, in order to achieve a generalization of the information concept it will be of major importance to know: what the others understand about the terms they use to articulate their theories; and which are their particular positions – in every related issues.

As an example of this two-fold approxima tion, we show in the appendix a brief glossary of terms showing in some cases simple defini- tions of theoretical terms, free of controversy either because they are only used in restricted frames (e.g. self-re-creation), or because there is some kind of agreement (e.g. feed- back); and in other cases an open controversy about particular questions (e.g. context, contradiction, knowledge).

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[23] To some extend, this is related to the 20th century controversy about the "indeterminacy of translation", which crosses many different scientific fields (from philology or anthropology to physics or mathematics).

Appendix: Glossary as an interdisciplinary tool

The following glossary has just been developed for a short number of entries as an example of what-it-could-be. The purpose of such a glossary, conceived as an interdisciplinary tool for disambiguation and mutual understanding between different points of view concerning information, is double-faced: 1st) the clarification of the terms used by each point of view and, 2nd) the analysis of the main problems regarding information from each approach. This is the reason why some articles –of restricted use– may be very concise, while others –open to controversy– may exhibit a larger extension.

A.1. Arrangement of entries and symbols

Main voices are highlighted with bold characters, followed by the most common used names for the same concept –or the nearest ones – in French (F), German (G) and Spanish (s). Whenever a voice is used in compound names the simple voice is typed in capital letters before all the compounds ones. Instead of rewriting the simple voice, it is symbolized by the special character ~. Secondary voices are typed in italics within articles of the primary voices. Whenever a voice is highlighted in italics and goes along with the symbol →, it indicates that such voice is further developed in an article of the glossary. In case a particular voice is used in a restricted field or only by a limited number of authors, they will be specified between square brackets.

For abbreviation purpose the following ACRONYMS has been frequently used within the text: **AIT** shortens *Algorithmic Information Theory*; **MTC**, *Mathematical Theory of Communication;* **UTI**, *Unified Theory of Information.*

A

Alphabet (F. *alphabet*, G. *Alphabet,* S. *Alfabeto*; from Latin *alphabētum*, and this from Greek λφα, alfa, and β τα, beta) has been originally used to refer to the writing system whose symbols (letters) are in relative correspondence with *phonemes* of the spoken language, in contrast to those writings in which the correspondence is established with *morphemes* or *syllables*. However, the usage has been extended to refer the set of symbols employed in a communication system. This is the sense normally used in communication theory and particularly in the model of information transmission (especially in its syntactic level, such as in the case of MTC), labelling the finite set of symbols or messages that make up the →*code* which must be known for both the emitter and the receiver.

There are two fundamental features to characterise the alphabet with regard to its *performance in communication efficiency*: 1) its *adequacy to the constraints* of the communication channel (e.g., that the stroke could be continuous or not, or that the spectral content had to be limited to a given range); 2) the *differentiability* of its component symbols. The former because it will just be effective what success in crossing the channel; the latter because depending on it the reception in noisy environments will be better or worse. Indeed, Kotelnikov (1959) proved that the detection error probability is a function of such differences (measured in terms of energy with respect to the noise spectral density).

Concerning alphabets coming from natural languages, they exhibit relevant features regarding an efficacious coding for transmission through artificial channels: 1) the *statistical frequency* of each symbol, and 2) the *statistical dependence* between a symbol and its adjacent ones (i.e., the transmission probability of a symbol *j* when the previous was *i* or a given sequence). The observation –by Alfred Vail– of the first feature in the development of the Morse code played a major role in the success of Morse Telegraph (Oslin 1992) and probably, it also played an important heuristic role in the forging of the concept of information measure, especially in Hartley and Shannon work (Lundheim 2002, Segal 2003). The latter, in his famous "Mathematical Theory of Communication", account for both features in the determination of the entropy (or →*amount of information*) of a source (Shannon 1948).

Amount of semantic information [Bar-Hillel & Carnap] →*content-measure.*

Aspects of **information** (F. *aspects de l'information*, G. *Aspekte der Information,* S. *aspectos de la información*) are also referred as *dimensions*. The designation of syntactic, semantic and pragmatic aspects proceeds from *Peirce's* definition of *sign* according to a triple perspective linking the sign with itself, with the object and with the subject (Peirce 1873). Such triadic relationship is taken by *Morris*, linked to specific studies: syntax, semantics and pragmatics, respectively (Morris 1938).

Autopoiesis (from Greek *αυτο-ποιησις*, 'auto (self)-creation'), neologism introduced in 1971 by the Chilean biologists Humberto *Maturana* and Francisco *Varela* to designate the organisation of living systems in terms of a fundamental dialectic between *structure* and *function* (Maturana & Varela 1980). Although the term emerged in biology, afterwards it came to be used in other sciences as well. Its use by the sociologist Niklas Luhmann is worth pointing out (Luhman 1989). The →*UTI* takes and reproduces the concept in more differentiated categories (→*self-restructuring, self-reproduction* and *self-recreation*).

For Maturana and Varela, *autopoiesis* is a fundamental condition for the existence of living beings in the continuous production of themselves. According to Maturana (*Transformation in coexistence*), "living beings are networks of molecular production in which the produced molecules generate, through their interactions, the same network that creates them". *Autopoietic* systems are those showing a network of processes or operations that characterise them and have the capacity to create or destroy elements of the same system as a response to the disturbances of the medium. Within them, even if the system changes structurally, the network that characterises them would remain invariable during its whole existence, maintaining its identity.

For *Luhmann*, autopoiesis means a new theoretical paradigm, which, if applied to social systems, has a self-referential nature that does not restrict itself to the structural level; they construct themselves the elements constituting them. Thus, whereas in biological systems self-reference corresponds to self-reproduction, in social (or psychic) systems, it is constituted through *meaning* (Sinn), which, in its turn, is produced by the "processing differences" which permit to "select" from the "meaning offer" (*Mitteilung*). According to Luhmann's interpretation, "communication" (*Kommunikation*) melts the difference between "information" (*Information*), "meaning offer" (*Mitteilung*) and "understanding" (*Verstehen*) (in which each part differentiates the other two and leads them towards a unity), whereas *information* just refers to a selection within the "meaning offer" through a connection between differences. Therefore, strictly speaking, there is no transmission of information between emitter and receiver; instead, the former makes a suggestion for the selection of the latter, so that the information for both is different, though in any case constituted through communication processes.

B

Behaviour (F. *comportement,* G. *Verhalten,* S. *comportamiento*) is generally used to refer to the set of responses of animals or humans to exogenous stimuli (from the environment) or endogenous stimuli (from the organism itself). It plays a key role in the →*UTI* as a fundamental feature of the *macro level* (where the pragmatic aspects of information are expressed separately) concerning the way in which the system interacts with its adjacent ones in the network. What *structure* is to the *micro-level* and *state* to the *meso-level, behaviour* is to the *macro-level*, to which the external manifestations of the system (or *outputs*) belong. The eventual differences of these outputs must be based on a change of the state, being this supported by a change in the relationships or elements of the structure (Fenzl & Hofkirchner 1997).

According to UTI, information appears whenever the self-organising processes give rise to a qualitative change in any of the three levels, so that: 1) only a part of the system input (or stimuli) will entail a change in its internal structure; 2) only a part of the structural changes will drive to a change of state and, 3) only a part of the state changes will result in a change of behaviour, through which the sys-

tem will respond to the environmental changes. Depending on the severity of these changes the system will be forced or not to modify its activity, either following its own interest or that of the network to which it belongs. From this point of view, behaviour involves the highest manifestation of information, where the syntactic and semantic aspects are subsidiary, representing the precondition of behaviour.

C

Channel (F. *canal*, G. *Kanal,* S. *canal*). *Communication* ~ deals in the MTC and by extension in many other information and communication theories, with the medium (or set of media) that allow(s) transmitting the signals generated by the transmitter to the receiver. As stated by Shannon: "merely the medium used to transmit the signal from transmitter to receiver. It may be a pair of wires, a coaxial cable, a band of radio frequencies, a beam of light, etc" (Shannon 1948).

To some extend, the objective of the *transmission coding* is to adapt the messages, sent through the information source, to the characteristics of the channel (which has certain limitations and available resources, such as the bandwidth or frequency margin that can be sent). In the analysis, Shannon distinguishes between *channels without noise* (which is nothing but a theoretical abstraction that can approximately correspond to a situation in which the noise is negligible with respect to the received signals) and *channels with noise* (which is the most normal situation and must be especially considered whenever the noise is notably present with respect to the signal).

A fundamental part of Shannon's theory is aimed at finding the limits of the →*information amount* that can be sent to a channel with given resources (Shannon 1948).

Code (F. *code,* G. *Kode,* S. *código*) is a system of signs and rules for converting a piece of information (for instance, a letter, word, or phrase) into another form or representation, not necessarily of the same type. In communication (especially, in telecommunica-

tions) and information processing: **encoding** is the process by which information is converted into symbols (usually belonging to an →*alphabet*) being communicated, stored or processed; whereas **decoding** is the reverse process which reconverts code symbols into information understandable or useful to the receiver.

Notice that from this point of view the code is supposed to be simultaneously known by the sender (or source) and the receiver (or destination), which explains the intercomprehension between them (in case it involves intention) or interoperability (if the information is understood only at a *pragmatic* or *operational level*). Therefore, this point of view deals with a traditional relation to reversibility, which would explain neither the emergence nor the dynamics of code. An improvement of this perspective can be found in Foerster´s criticism at of *first order* →*cybernetics*, which is intended to be improved in *second order cybernetics* as means of explaining self-referential and →*autopoietic* processes (Foerster 1984).

In *semiotics,* as system of signs, a code is a system of correlations or correlation rules between the coding system (system of signifiers or syntactic space or expression space) and a codified system (system of meanings or semantic space or content space). In words of Umberto Eco: the code "associates a vehicle-of-the-sign (or signifier) with some-thing that is called its meaning or sense" (Eco 1973).

CONTENT (F. *contenue*, G. *Gehalt*, S. *contenido*)

Qualitative ~ of information: generally used to distinguish it from a purely quantitative consideration on information. It emphasizes the fact that information can be viewed from different perspectives or →*aspects*. Only when the focus is restricted to one of them, therefore easier to abstract, its quantification becomes more feasible, being consequently one-dimensional. Nevertheless, given the limitations of the syntactic aspect, which refers to a limited set of symbols and rules, and regarding the eminently open character of semantics and pragmatics, it is not surprising that the goal of achieving a quantitative approach of information has succeeded in the syntactic

level but not in the other two (Floridi 2005c, Flückiger 2005, Pérez 1990, Pérez-Amat 2008).

Information ~ [AIT, Chaitin]: $I(x)$ of a binary sequence x is defined as "the size in bits (number of binary digits) of the smallest program for a canonical universal computer U to calculate x" (Chaitin 1982).

It was first introduced in equivalent terms by Solomonoff (1960), who talked about "minimal description" and "amount of information" in a preliminary approach to his Universal Theory of Inductive Inference (1964), which is taken as a first formulation of the *Algorithmic Information Theory* (AIT). Kolmogorov (1965) and Chaitin (1966), who also provide independent early formulations of the AIT, provided equivalent definitions to the size of such "minimal description", which is very well known as **Kolmogorov's complexity** but is also called *algorithmic complexity*, *algorithmic entropy*, *Kolmogorov-Chaitin complexity*, *stochastic complexity* or *program-size complexity*.

An important conclusion of AIT is the incomputability of $I(x)$ or $K(x)$ –in Kolmogorov terminology–, which is close related with Turing's Halting theorem.

Informational ~ [Israel and Perry]. In the *situational semantic* approach of Israel and Perry, where the relationships between the contents of an information system are considered as architectural, the *informational content* of a fact may involve very remote objects from those involved in the particular fact and will "only be *information* when the constraints and connecting facts are actual". (Israel & Perry 1990b).

~-measure [Bar-Hillel & Carnap], cont(), is provided as a first explicatum of the **amount of semantic information** in Bar-Hillel and Carnap's probabilistic approach to semantic information (1953). The content-measure of a sentence is defined as the sum of the measures ascribed to the elements of its content, based on proper measure-functions and state-descriptions referring to possible states of the universe of discourse.

Due to the inadequacy of such explicatum for inductively independent predicates, a second explicatum for the amount of semantic information is suggested, called **measure of information**, inf(), defined as: inf(i) = $\log_2(1/[1\text{-}cont(i)])$.

This probabilistic approach to semantic information was further developed by several authors (Floridi 2005c, Dretske 1981), providing different interpretations for the probability space to which they are referred. For instance, while in Bar-Hillel & Carnap (1953) the probability distribution results from a logical construction of atomic statements in a chosen formal language, in Dretske (1982) the probability refers to the *observed* state of affairs.

Generally, if we denote by P(i) the probability of a instance of semantic information i: 1) the **content-measure** CONT (generalizing Bar-Hillel & Carnap's 1st explicatum and having the drawbacks of not being additive and well condizionated) can be defined as the complement of the priori probability: CONT(i)=1-P(i); and 2) **informativeness**, INF (generalizing Bar-Hillel & Carnap's measure of information): INF(i) = $\log_2(1/[1\text{-}CONT(i)])$ = $-\log_2 P(i)$, which is indeed similar to Shannon's measure.

Context (F. *contexte*, G. *Kontext*, S. *contexto* ; from the Latin verb *contextere*, meaning 'to weave' or 'interlace') in a figurative sense, it refers to both the interlacement of the meanings contained in a text or, generally, in a communication and the circumstance in which this communication occurs (e.g. physical, pragmatic and cultural environment). It allows the clarification of the communicated sense. Although the meaning of 'context' is common in relation to enunciations, the 'context of something' is understood by extension to the structure in which it is situated, and without which it could not be understood, or it could be less intelligible.

A distinction can be made between *situational context* (or non-expressive context) and *expressive context,* relating to the set of syntactically and semantically related expressions, which, at the same time, are articulated through *deixis* and modal indicators in the situational context. In its turn, the *situational context* can be divided into: *general* (related to the communicational situation defined by the

time, place and action within communication frame), *social* and *personal* (defined by the relationship between the communicants, their attitudes, interests and their respective knowledge).

There is significant disparity in the considered role of context between different notions of information: from complete oblivion (in the most objectivised meanings of information, it is entirely contained within the message) to central attention (in those perspectives, for which information only makes sense in social frameworks or in adaptation to the environment, the message is a mere key to release the information contained in the context). Ironically, while in linguistics the consideration of context was brought to the forefront and in physics the classical conception of the outer observer was lost (Lyre 2002, Segal 2003), at the same time the *MTC* was defining information as a typical characteristic of the information source without making reference to its context (Díaz & Al Hadithi 2009). Something similar could be said about the founding of the "cognitive sciences" in the "symposium on information theory" of 1956, which minimized the consideration of cultural and historical contexts in which cognitive processes happen (Miller 2003). Nevertheless, though it might be spoken about epistemological anachronism, it has to be pointed out on the one hand, the then open discussion about hidden variables in quantum theory; on the other hand, the running project on the unification of sciences at Vienna Circle, whereas the so-called historicist turn, underlining the importance of cultural contexts, was still far away (Kuhn 1963).

However in →*cybernetics,* the contextualized character of information has been a basic aspect of its theory from the very beginning. Indeed, information makes sense in this approach as a means to pursue an objective within a given pragmatic situation, thus the generalized context (Wiener 1948). Even so, it is in *second order cybernetics* where the emphasis on context will become larger, as the regulation of the environment itself is part of both the adaptive process and the observation (Foerster 1981).

From the point of view of quantum physics, information is –as stated by Mahler– a "con-

textual concept", intrinsically linked to a "situation". This *situation* is just the dynamic scenario in which a system takes "decisions", giving place to an "information flow". Therefore, in accordance with current physics, it cannot be stated that information is encoded in physical, elementary components, but that it appears after measuring (Mähler 1996).

In the analysis of the semantic aspects of information, a change has also been observed towards a wider consideration of context: from the "ideal receiver" of Bar-Hillel and Carnap (1952), able to assess information in terms of a structure of atomic statements (in an almost formalised language), to the *situational semantics* of Barwise, Perry, Israel… (Barwise & Perry 1983, Barwise & Seligman 1997, Israel & Perry 1990a, 1990b), where information is not longer a property of events but something conveyed by information reports regarding states of affairs in given situations. Hence in situation theory, information is dependent of 'situations' (about the generalised context mentioned above) and consistency restrictions between statements (→*informational content*). Regarding the personal context, Dretske's approach (1982) considers information in relation to a knowledge background, while Floridi bases information not in terms of truth (as Dretske or the situationalists do, involving a certain privileged view beyond all context), but in terms of veracity, entailing the fallibility of the interpreter and the belonging to a temporality and a finite knowledge (Floridi 2005b, 2005c).

Although, as mentioned before, many of the information theories related to cognitive sciences show a reducing trend to minimise the role of context, in other fields of social science, several approaches have arisen highlighting context as an essential element. Therefore, while under the cognitive interpretation: the subject extracts information from the physicochemical properties of sensorial stimuli; in hermeneutics, historical approaches, critical- or Luhmann's sociology: reference and meaning only appear contextualised in cultural worlds.

In *hermeneutics*, understanding is seen as something determined by schemas of pre-understanding regarding the cultural context of the interpreter (Capurro 2008). In *historical*

approximations, information acquires the level of genuine historical phenomena (Brown & Duguin 2000, Borgman 1999), i.e. historicity or temporality becomes an essential feature of information. But to this temporality of information is also arrived by Matsuno or Lyre from strictly physical assumptions (Matsuno 1998, Lyre 1998, 2002). In Luhmann's →*systems theory* (1987), there is not properly a transmission of information, instead the emitter just makes a suggestion for the selection within the "offer of meanings" (Mitteilung), characterising a communication process in a specific, socio-linguistic circumstance. Therefore this social circumstance (context) implies a sort of closure in communication. However, in Habermasian critical sociology, the subject (or receiver), though framed within a given life horizon, has a reflexive faculty (or communicative competence, attained by virtue of being part of a certain social group), which eventually allows him to identify the distortions, asymmetries and censures conditioning any factual communication processes (Habermas 1981). Thus Habermas makes possible to go –so to speak– beyond Luhmann's "meaning offer" (context closure) or to move – by means of willpower – the hermeneutic life horizon.

Contradiction (F. *contradiction*, G. *Widerspruch,* S. *contradicción*). Relationship between an affirmation and a negation having the same subject and predicate. It was traditionally studied under the "law of non-contradiction" and initially formulated and studied by Aristotle as a supreme principle of beings and thinking. It can be formulated as: "the same attribute cannot *at the same time* belong and not belong to the same subject *and in the same respect*." (Aristotle, *Metaph.* B.IV, §3)

It has adopted a twofold interpretation distinguished by either a logical or an ontological sense, even erecting as an ontological principle, i.e. as expression of the constituting structure of reality. However, its fall as unquestionable principle can be found in Hegel's regard of contradiction as a basis of reality's internal movement (though generally the philosopher refers more to opposing realities than contradicting ones) (Hegel 1841). Within the dialectic tradition of Hegelian roots, Adorno judges that there exists a link between the ontological and logical aspects (Adorno 1966). According to such link the "repressive structure of reality" and the coercive character of survival as well are reflected in the logical principle of contradiction (1956). Regarding Adorno's negative dialectics, the possibility of transcending both the law of non-contradiction and the law of identity accounts for the capacity to overcome social contradictions. Generally according to dialectical schools, the consideration of the logical law is just subordinate to the need of overcoming contradictions of reality.

This – so to speak – utilitarian regard (genetic, following Adorno's interpretation) of the law of non-contradiction can also be found in some of the information theories based on *self-referential* systems. For instance, from a *cybernetic* perspective, the logical law of non-contradiction can be considered as being a part of the regulation mechanism under normal conditions, whereas the overcoming of such law corresponds to the need of re-adapting the mentioned regulation to changing circumstances (s. *positive* and *negative* →*feedback*).

Although the law of non-contradiction might be easily refuted in its most brief expression (removing the italic text in the above formulation, without which it might be exposed to a large number of paradoxes), it must be pointed out that the remark of "*at the same time and under the same respect*" makes it less vulnerable. This remark also introduces a necessary *contextualization* of the statements (to which we have referred to in the →*context* article) for a correct analysis of the consistency of the semantic content of information, such as the approaches of Bar-Hillel and Carnap (1953), Dretske (1981) and Situation Theory (Barwise 1997) propose – though only the last ones consider context as a key issue.

In any case, the claim to consistency in what is considered →*informational content* means that contradictions have no place in informational context and, consequently, the probability of receiving self-contradicting information would be zero (according to a naturalistic approach on information, such as the one of Dretske, the ontological version of the law of non-contradiction states that contradictory information cannot emanate from reality,

since reality itself rejects contradiction). Therefore, in case of considering the semantic content of an informative statement as inversely related to its probability –under Barwise's *inverse relationship principle* (1997)–, the following paradox might arise: a contradiction provides a maximum amount of information, which Floridi (2005c) labels as the *Bar-Hillel-Carnap Paradox*. Circumventing this paradox, most of semantic approaches get somehow rid of contradictions.

Nevertheless, if a dialectical point of view is adopted (for instance, in critical theory) contradictions will not be something for turning a deaf ear, but, on the contrary, the possibility of updating the view of reality with fewer contradictions. That is, contradictions might somehow announce –so to speak- a new world, a new Weltanschaung. If it could be achieved, a new state of affairs could be seen, whereas much of what was previously seen would dissolve with the smoke of past errors. For instance, the superseding of classical physics due to accretion of contradictions of different nature –optical, electrical, astronomical, etc– can be regarded as one of these cases (Pointcaré 1904). However, it must be remarked, on the one hand, that rarely the so-called contradictions follow the clause of "*at the same time and in the same respect*", on the other hand, that in normal situations –or what Kuhn (1962) called, concerning research work, "normal science"– the contradictions serve to detect false information, wrong interpretations, etc. Thus the law of non-contradiction becomes an essential tool to receive information in normal situations, as well as for its incorporation into knowledge systems.

CYBERNETICS (F. *cybernétique*, G. *Kybernetik,* E. *cibernética*) comes from the Greek Word *Κυβερνήτης*, meaning the art of steering a ship, used by Plato in the sense of guiding or governing men. Nowadays, it refers to the study of the control and communication of complex systems, whether they are living organisms, machines or organisations, paying special attention to the →*feedback* as the main way of regulation. It is usually considered that it was properly formulated in the work of Norbert *Wiener* (1948), for whom cybernetics is a science that studies control sys-

tems, especially, self-control systems, whether in living organisms or machines, where "this control is the sending of messages that modify the behaviour of the receiving system". In its genesis in the 1940s, with contributions coming from evolutionary biology (von Uexküll), psychology (Anokhin), control systems (Wiener), neurophysiology (McCulloh and Rosenblueth), psychiatry (Ashby), etc, and in its ulterior development as well, it has been an eminently interdisciplinary discipline.

For cyberneticist *Gregory Bateson* (1979), cybernetics is "a branch of mathematics dealing with problems of control, recursiveness, and information", while from a more general point of view for *Stafford Beer* (1959) (considered as father of management cybernetics) it is "the science of effective organisation"

First order ~ or **classical ~** and **second order ~** (F. ~ *de premier et deuxième ordre*, G. ~ *erster und zweiter Ordnung,* S. ~ *de primer y segundo orden*). In 1958, Heinz von Foerster conducted a critical review of the cybernetic theory of Wiener, observing that although this theory had introduced significant changes regarding the previous notions of regulation and control, it did not lead an epistemological break with the traditional understanding of science. Instead, the model in which the observer contemplates the object or the system from outside without influencing it and succeeding in its objective study continued to be applied. Von Foerster believed that cybernetics should overcome this epistemological anachronism, so that the observer would be part of the system, asserting his own goals and his own role within the system. Since then, there is a distinction between *traditional cybernetics* or *first order cybernetics* and *second order cybernetics*, also named *complexity theory*. While fist order cybernetics poses: "What the feedback mechanisms of the system under study are?" and "how are they?" second order cybernetics poses: "How are we able to control, maintain and generate this system through feedback?"

Cybersemiotics [Søren Brier]. By means of connecting Peirce's semiotics (*sign*) with the →*cybernetics of the second order*, Brier defines *cybersemiotics* in terms of a dynamic

and contextually adaptive relationship between a sign, an object and an interpreter (Brier 2008). According to Capurro & Hjørland (2003) it is conceived as a "hermeneutics of the second order that extends the concept of interpretation beyond human knowledge, relating it to all kinds of selective processes".

E

Encoder (E. *codificador,* F. *codificateur*, G. *Kodierer*) is a device for converting data or signals by using a specific code. It is normally used with four clearly differentiated purposes: 1) To remove redundancy or anything that is not going to be perceived by the information receiver or remain beyond the quality goals of the received signal, typically named *source encoder*. 2) To increase redundancy, so that the decoder can eventually detect and correct the errors occurred within the reception of signals or symbols, named *channel encoder*. 3) To make the coded data unreadable, except if the code (*cipher*) is known by repients (specially, what is labelled as *key*), by using *encryptors*. 4) To allow the transmission of data through a channel with certain resources and limitations, corresponding in the MTC communication model to the *transmitter-encoder*, also named *modulator* -especially in telecommunications-.

The **decoder** (F. *decodificateur*, G. *Dekodierer,* S. *decodificador,*) is the device performing the inverse operation of the encoder, whatever the purpose of the code: 1) the *source* decoder tries to restore the eliminated redundancy; 2) the *channel* decoder removes the redundancy that has been introduced by the corresponding encoder, and correct those errors being detected; 3) the *unencryptor* makes the data readable; and 4) the *demodulator* or *receiver-decoder* identifies the symbol transmitted through the channel –normally according to a maximum likelihood criterion– and restate the data into its original form, i.e., as it was before the modulator.

Entropy →*Information Amount.*

Erotetic Analysis [Floridi (2005a, 2005c)] (from Greek ἐρωτάω, 'to ask') refers to the method aimed at determining what the source is communicating by means of proper posed queries. If all of them accept a binary response (yes, no), the number of queries and answers might corresponds to the information given by the source (measured in bits). This interpretation of Shannon's *Amount of →Information,* compatible with his notion of information as recipient's uncertainty, is perhaps the most closely related to the common notion of information as "what allows us to know about something", obviously linked to the fact we are uncertain about what has happened. A reasonable method of remedying this ignorance consists of proper posed questions. Observe that if the uncertainty is reduced to $N = 2^k$ equiprobable states of affairs, with probability $p = 1/N$ (for instance, picking a card out of a deck of 32 cards), the most economic way of knowing what is the case by means of binary answers just needs $\log_2 N = k$ proper questions.

It can also be easily intuited that if some of the possible source states were to be more likely (for instance, the same card is picked half of the times) then the queries might be posed as to require on average less questions and answers. Briefly, it can be observed that Shannon's expression $-\log_2 p$ (for a message) has a certain naturalness or coherence with one of the basic intuitions related to information.

As Floridi points out, an erotetic analysis allows to distinguish data from semantic content, reducing the former to a set of binary answers, and being the latter represented by the corresponding set of queries. In a Carnap's sense, the queries accounts for intension, while the answers do it for the extension. In Frege's terminology queries and answers might be related to sense and reference, respectively.

According to Floridi (2005c), "semantic content is unsaturated information", whereas data works as a key to unlock the information contained in the query". Thus Shannon's entropy, as a characteristic of data, represents the average "amount of details […] to saturate the informee's unsaturated information", which can also be interpreted as a "measurement of the freedom of choice" when it comes to answering (Shannon & Weaver 1949).

G

Gödel's incompleteness theorems: *1st GIT*) Any effectively generated theory capable of expressing elementary arithmetic cannot be both consistent and complete. In particular, for any consistent, effectively generated formal theory that proves certain basic arithmetic truths, there is an arithmetical statement that is true, but not provable in the theory.

2nd GTI) For any formal recursively enumerable (i.e., effectively generated) theory T including basic arithmetical truths and also certain truths about formal provability, T includes a statement of its own consistency if and only if T is inconsistent.

I

INFORMATION

Amount of ~ or **Entropy** (F. *quantité d'information, entropie*, G. *Informations-gehalt, -entropie,* S. *cantidad de información, entropía*) [Shannon] of a discreet information source, characterised by the probability p_j, of sending each of its symbols, *j*, is the statistical average:

$$H = -\sum_j p_j \log_2 p_j \text{ (bits)}$$

being bounded within the limits $0 \le H \le \log_2 N$, where *N* is the number of symbols.

In case the source might adopt various states *i*, being *Pi* the state probability, and $p_i(j)$ the probability of sending symbols *j* when the source is in state *i*, then the *entropy* is defined as the average of the entropies of each state:

$$H = \sum_i P_i H_i = -\sum_{i,j} P_i p_i(j) \log_2 p_i(j) \text{ (bits)}$$

According to Floridi (2005c), the *entropy H* might designate three equivalent quantities in the ideal case of a noiseless channel: 1) "the average amount of information per symbol produced by the informer"; 2) the "average amount of data deficit (Shannon's uncertainty) that the informee has before inspection of the output of the informer"; 3) "informational potentiality".

Since the first two interpretations assume that a defined uncertainty corresponds to each symbol (whether it is in the emission or reception), it implies a certain tactical agreement regarding to the →*alphabet* or the informational game in which the agents are immersed. In both cases, the information can be quantified under the condition that the probability distribution can be specified.

Concerning the third interpretation, entropy might be understood in terms of a physical magnitude related to the amount of disorder in processes or systems conveying energy or information. The larger the entropy, the higher the number of physical states in which the system can be found, consequently, the more information it can refer to, or in other words, the specification of the state in which a certain system is requires more information as its entropy increases. Numerically, this is equivalent to the amount of information or data that has to be given in order to specify the state.

Common or **Mutual ~** of two strings, *I(x : y)* [AIT, Chaitin], is the difference between the sum of the information content of both and their joint information, $I(x : y) \equiv I(x) + I(y) - I(x, y)$ which is symmetric, *i.e.,* $I(x : y) = I(y : x) + O(1)$. Considering the definition of joint information, there are two alternative expressions:

$$I(x : y) = I(x) - I(x \mid y, I(y)) + O(1)$$
$$= I(y) - I(y \mid x, I(x)) + O(1)$$

"The mutual information of two strings is the extent to which it is more economical to calculate them together than to calculate them separately" (Chaitin 1982).

Two strings are said to be algorithmically independent if their mutual information is zero, i.e., I(x , y) is approximately equal to I(x) + I(y).

Conditional or **Relative ~** of a string *x* given the string *y, I(x|y)* [AIT, Chaitin] is the size of the shortest programme for a canonical universal computer *U* to calculate *x* from *y*.

Joint ~ of two strings, I(x, y) [AIT, Chaitin]: is the size of the smallest programme that makes a canonical universal computer *U* to calculate both.

$$I(x , y) = I(x) + I(y|x , I(x)) + O(1)$$
$$\le I(x) + I(y) + O(1)$$

Saturated and **unsaturated ~** [Floridi] →*Erotetic Analysis.*

~ Science (F. *sciences de l'information,* G. *Informationswissenschaften,* S. *ciencias de la información*)*.* Although there are significant regional differences in its use, there exist a tendency to understand it as an interdisciplinary science mainly focused on the analysis, collection, classification, manipulation, storage, retrieval and dissemination of any type of information (Griffith 1980, Khosrow-Pour 2005). It has been commonly associated to more specific domains as →*Library Science* or *informatics* (in Spain –but not in other Spanish-speaking countries– the equivalent Spanish term is used as synonym of *Communication Sciences,* specially in the branch of journalism, though in several cases *Library Science* is included within its faculties).

In a more broaden sense a **Science of Information** has been posed as a "cooperative research concept that includes scientists from all scientific branches", from basic- to applied research, and even integrating stakeholders (Doucette et al. 2007). Considering that a refined concept of information might bridge among matter and energy (physics), life (biology), cognition and consciousness (psychology and neuroscience) and societal systems (sociology), different initiatives have been fostered aiming to achieve an information theoretical approach that could solve major scientific problems bridging apparently irreconcilable disciplines (Lyre 2001; Conrad & Schwarz 1998, Marijuán 1998, Hofkirchner 1999b). Among them, it is worth to mention: the *Foundations of Information Science* initiative, since 1994 (fis.icts.sbg.ac.at) the →*Unified Theory of Information* Research Group, since 2003 (www.uti.at) and the *Science of Information Institute*, since 2006 (www.soii.info).

K

Knowledge (F. *connaissance*, G. *Erkenntniss*, *Wissen,* S. *conocimiento*). From the most points of view regarding information and knowledge, there are close relationships between these two concepts, especially as far as the common use of both terms is concerned. Usually, information occupies a lower position than knowledge, and the former –so to speak- 'nourish' the latter. However, this connection is disregarded in cases of a *radical syntactic* approach, in which the relationship question is avoided just addressing to the technical dimension (as in the *MTC*), or in a *radical pragmatic* approach in which only what-is-being-done is posed, that is, information is considered as a mere instrument of the action and, therefore, the problem of whether the information refers to states of affairs is ignored (be it dealing with a correct apprehension or knowing that *p* is the case).

Although there have been throughout the history of thought countless approaches to knowledge concerning its *definition*, *possibility*, *basis* and *modes*, two fundamental models have prevailed: 1) the *iconic* model, according to which knowledge is an accurate picture (of mental nature) of the object of knowledge, and 2) the *propositional* model, whereby knowledge is a truthful proposition. In the *iconic* model, where perception and apprehension play a key role, the main problems lie in both the specification of the limits between object and subject, and the explanation of non-iconic knowledge (such as logical, mathematical and logical "truths"). However, in the *propositional* model, where scientific statements play an exemplary role, the unavoidable circle of the justification of knowledge becomes problematic (→*Gödel´s incompleteness theorem*). Nevertheless, whatever the model of representation, knowledge is distinguished from a *true opinion,* insofar as only the former knows how to justify itself (though its justification might be partial or problematic).

According to the above, the relationship between information and knowledge must evidently appear in all those informational approaches considering the semantic dimension, usually adopting a more analytic notion with respect to information, and a more synthetic one with respect to knowledge. Furthermore, a closer proximity to the object is used in information concerns, and to the subject in knowledge concerns.

For Dretske "Knowledge is information-produced belief" (Dretske 1981, pp. 91-92) and belief always relates to "a receiver's background knowledge" (pp. 80-81). From a naturalistic perspective, in which there is a casual dependence between the external

conditions of a living being and and its internal states, information for Dretske creates experience (sensorial representations) and originate beliefs (cognitive experiences), which underlie the sedimentation of knowledge.

According to Floridi´s semantic approach (2005b, 2005c), *knowledge* is constituted in terms of justifiable *semantic information*, i.e. information constitutes the elements for further inquiry. At the same time, *information* is the result of a *data* modelling process. But unlike Dretske's naturalistic assumption, this data modelling does not necessarily represent the intrinsic nature of the studied system, or it must not be directly related the system by means of a causal chain, instead, it will depend on the processing of data by knowledge. In turn, data are conceived as the resources and restrictions allowing the construction of information. Therefore, it can be stated that Floridi proposes an architectural relationship between knowledge, information and data, being knowledge on the summit and data on the base. At the same time and as a result of such interrelationship, he replaces Dretske's requirement of *truth* of (which is also subscribed by the situation theory) by a requirement of *truthfulness*, i.e. instead of searching for a correspondence between the statement and what the information is about, the attention is rather paid in the correspondence between what is reported and the informer.

In the →*UTI, knowledge* is constituted by means of interpreting the *data* (or meaning assignment) and is the basis for decision-making, which shapes "practical wisdom" (Hofkirchner 1999a). This approach refers to different levels of information rather than dependency relationships, i.e. information is gradually processed: first, at the syntactic or structural level, then at the semantic or state level, and, finally, at the pragmatic or behavioural level. The information processing is performed by means of interrelationship between adjacent strata and not in terms of a casual progression (as in Dretske's naturalism).

L

Library Science and **Special Librarianship** (F. s*ciences des bibliothèques*, *bibliothéconomie*, G. *Bibliotheks-, Dokumentations-*

wissenschaft, S. *biblioteconomía,* –Amer.– *bibliotecología*). At the beginning of the 20th century, the term 'information' was frequently linked to *Special Librarianship* in the English speaking world. After a period in which this activity had been associated to *Documentation*, in the 1960s it came to converge with what was labelled as →*Information Science* (which in some Latin-American countries has been translated into "Ciencia de la Información", with a sense close to the English usage). According to Capurro and Hjørland (2003), this was motivated by the growing interest in computer applications, the influence of Shannon's theory and the current information processing paradigm in cognitive sciences.

In the academic disciplines concerning librarians and documentalists, two clear trends have been distinguished in Library Science: the *general* approach, –to some extent- aimed at public libraries, emphasising general education and significantly divorced from the knowledge it serves, and the *specialised* approach, aimed at specific subjects. However, although this second approach was relatively dominant until the 1970s, thereafter it lost its dominant position as education tended to become more general and oriented towards psychology, subjective idealism and methodological individualism. But simultaneously, an intermediate approach emerged which could be branded as a neutral specialisation (even formal or abstract), the *domain-analytic approach*, related to hermeneutics, semiotics and social constructivism (Capurro & Hjørland 2003).

According to Griffith's definition (1980), "Information Science is concerned with the generation, collection, organisation, interpretation, storage, retrieval, dissemination, transformation and use of *information*, with particular emphasis on the applications of modern technologies in these areas". The objective of its disciplinary framework is "to create and structure a body of scientific, technological and system knowledge related to information transfer". That is to say, –despite the problematic or contingent link Griffith makes with respect to the used tools– one can say that we are dealing with a science which contains elements that are *theoretical* (except for its

specific application) and *applied* (aimed at services and products).

Regarding the conceptualisation of information that is carried out in this field, it could be said that special focus is put on two opposing meanings: 1) the information as an object in documents and 2) its radical subjectivisation, i.e. information as everything "that can be informative to someone".

N

Negentropy (F. *néguentropie*, G. *Negentropie,* S. *negantropia*) is the negative value of the →*entropy*. Although the concept was first used by Erwin *Schrödinger* in 1943, who stated that "life feeds on negative entropy" (1944), the term "negantropy" was first coined by the French physicist Léon *Brillouin* (1953), who generalised the second law of thermodynamics as: in any transformation of a closed system, the quantity "entropy minus information" must always increase over time or may, at best, remain constant. Moreover, Brillouin's theory of information is considered as a consequence of the negentropy principle, which might be illustrated by the negentropy cicle: negentropy–information–decision– negentropy.

Criticizing the use of this term, Carl Friedrich von Weizsäcker stated: "Information has been correlated with knowledge, entropy with ignorance and consequently information has been labelled as negentropy. But this is a conceptual or verbal lack of clarity" (1985). To overcome such obscurity he distinguished between *potential information* (designated by Shannon's entropy) and *actual information*, which is factual and present. By knowing the macro-state of an object, the potential information is bounded; while the specification of its microstate is actual information (Lyre 2002).

S

Self-re-creation (F. auto-ré-création, G. Selbst-Re-Kreation, S. Auto-re-creación) [UTI (Fleissner & Hofkirchner 1996, Fenzl & Hofkirchner 1997)] is used in the →*Unified Theory of Information* as one of the three basic processes of information systems –the most advanced one. Self-re-creation is a more elaborated type of →*self-reproducing* processes and refers to the capacity of self-organizing systems to create the necessary conditions, not only for their reproduction, but also to create themselves according to the objectives that they have established themselves. In their capacity to change the environment for their own settlement, they show an even bigger capacity to adapt than the systems that are merely biotic (→*self-reproducing*) of which they are part. Thus they involve the most advanced evolutionary stage (or stage of cultural evolution).

They can be classified as *self-determining* insofar as their self-organising capacities offer, under certain circumstances, a set of possibilities, which can be chosen by themselves. Given the fact that such a choice takes the form of a decision adopted under the condition of an irreducible freedom of choice, the pragmatic and semantic levels are separated. Consequently, in the stage of social, self-recreating and self-determining systems, the semiotic relationship spreads in its three levels of sign production, which can be described in terms of the creation of ideas. Such creation happens in three stages: 1st) the perception of signals from outside the system causes the appearance of a sign, which is a modification of the system's structure; 2nd) the interpretation of the perceptions by which the system's state is modified and another sign emerges, meaning something that is given to the system as its object; 3rd) the evaluation of the interpretations that cause another sign to emerge, by means of which the system -as subject- completes its meaning, considering the object as an initial state to reach the end and affects the behaviour of the system so that it can be modified.

The sign, in each of these three levels, is called (in UTI) data, knowledge and wisdom (or practical wisdom), respectively, each one corresponding to the field of the perceptive, cognitive and evaluative capacities, which together make up the characteristics of conscience, which appears in systems. In each stage, a break in the self-organisation occurs, which is a starting point for another one to occur (or not occur) afterwards.

Self-organising systems on the human, social, cultural level are capable of constructing themselves anew, inventing themselves, creating themselves again and again. Erich Jantsch called this capability "re-creative". Thus "re-creative systems" are a branch of autopoietic systems that lead to a new level: (Self-)Re-creation is a refinement of, and further development in, autopoetic self-organisation (self-reproducing).

Self-regulation (or *automatic regulation*) is used in systems theory and →*cybernetics* in the sense of *homeostasis* (→*feedback*), i.e., the capacity of a system to maintain itself in a stable situation. The term "automatic regulation" is mainly found within the field of electronic systems and control engineering.

Self-reproduction (F. autoreproduction, G. Selbstreproduktion, S. Autoreproducción) [UTI (Fleissner & Hofkirchner 1996, Fenzl & Hofkirchner 1997)] is used in the →*Unified Theory of Information* (UTI) as an intermediate process -in evolutionary sense- of information systems. Self-reproduction is a more elaborated type of self-restructuring processes and refers to the capacity of self-organising systems, which do not only change their structure into another one more or less chosen by themselves, but they also insert these modified structures into a wider context: that of helping them to keep their own existence. Here, a functional structure is not a simple pattern any more, but a 'thing' that has meaning, and this 'thing' will be called here a *symbol*, so that the production of *signs* in this evolutionary stage of living systems changes from creating patterns to creating symbols.

The self-reproducing systems are considered an evolutionary stage (called *biotic* or *living*) among the →*self-restructuring* and the →*self-recreating* ones, so that they involve a special case of self-restructuring systems, as well as a more general case than the self-recreating ones.

As far as the evolution of the semiotic relation is concerned, one can observe here a ramification in which the syntactic level is separated from the semantic-pragmatic one, regarding the former just to the sensations of the living systems. These sensations -on the syntactic level- consist of self-organised re-

structurings evoked by the environmental disruptions and limited by the "offer of sensitive mechanisms" in a recursive process of symbolic production. However, on the semantic-pragmatic level, actions are developed according to sensations. Since living systems act according to what such sensations mean in terms of relevance for survival, we could talk about both meaning and action, although in an indissoluble manner. The syntactic difference means -in practice- a difference with regard to the objective of the survival, so that the signs now represent the aptitude of the system towards the environmental conditions (whereas in the self-restructuring systems one talks about reflection, one could talk here about representation).

Self-organising systems on the biotic level are capable of reproducing themselves. Notice that "reproduction" in that context is not the same as to what biologists are used to referring. The notion here includes the narrow biological meaning of reproduction but goes beyond that. It refers to the capability of the system to maintain itself – a meaning that usually comes with the notion in sociological context only. This kind of reproduction can be called after Maturana and Varela "→*autopoiesis*". Therefore living systems can be called "autopoeitic systems". Autopoiesis is a refinement of, and further development in, dissipative self-organisation (self-restructuring).

Self-restructuring (F. autorestructuration, G. Selbst-restrukturierung, S. auto-reestructuración) [UTI (Fleissner & Hofkirchner 1996, Fenzl & Hofkirchner 1997)] is used in the →*Unified Theory of Information* as the lowest capacity of information systems. *Self-restructuring* is the most primitive type of *self-organising* processes, in which the most primitive manifestation of signs also occurs. This type of systems is also called dissipative, because, in thermodynamic terms, they dissipate the entropy as a sub-product of the work carried out during the restructuration, in which, at the same time that the energy degrades, the system manages to get rid of it. This is necessary for the new structure to be considered a creation of a superior order, instead of a degradation of the system. The structuring process leads to a special and/or temporal pattern.

Understood as information processing, the creation of patterns is the rudimentary way of producing signals, being the pattern the distinction carried out by the system in which the three semiotic relations can be found (*sign*): 1st) a syntactic relation can be observed, insofar as the creation of the pattern is a type of recursive process which builds on the previous pattern and chooses one amongst various possible patterns; 2nd) as far as the incoming energy allows the system to change its pattern, the input becomes a signal that makes the new pattern arise, although it does not establish it completely. The state adopted by the system when creating a new pattern can be interpreted as a representation of the input, thus it can be said it is a semantic relationship. 3rd) As long as the new pattern corresponds to the observable behaviour in which the system expresses its activity, the pragmatic relation remains also thematised here.

However, the three semiotic relationships coincide with the pattern and, therefore, they are not differentiated yet. It can be said that the pattern reflects the conditions of its environment, as the pattern depends on it. Such reflection of the environment constitutes a precondition for the appearance of a sphere of influence in which the behaviour of the system launches that of the adjacent ones, so that the appropriate conditions can emerge for the maintenance and improvement of the system, which will be possible in →*self-reproducing* systems.

Unified Theory of Information (UTI).

Although the Anglo-Saxon term was used by Kerns Powers (1956) "to provide a unified mathematical theory for the treatment of the statistical processes by which information is conveyed in communication systems", it is now used in a more ambitious proposal that in contrast with Power it is not limited to the syntactical level. The UTI aims at a theoretical articulation embracing all processes related with the creation, transformation and communication of information, by means of (an allegedly feasible) blending of the concepts of *self-organization* and semiosis (→*self-re-structuring*, →*self-reproduction*, →*self-re-creation*).

The purpose of achieving a comprehensive theory roots its necessity (relatively urgent) in developing a theoretical frame able to rise to the problems appearing in the so called information society. With this goal, an interdisciplinary development is pursued -nourished by notions developed in cybernetics, biology, psicology, sociology or semiotics. In its advancement is worth to mention the direct engagement of: Wolfgang Hofkirchner, Peter Fleissner, Norbert Fenzl, Gottfried Stockiger; and indirectly (by means of suggestions, criticism, etc): Michael Conrad, Pedro Marijuán, Dail Doucette, Søren Brier, Koichiro Matsuno, etc. Although only the former have been involved in the development of the UTI, all of them share the fostering of a →*Science of Information*, having relevant differences in the viability beliefs concerning a unified theory (Capurro et al. 1999, Hofkirchner 2008, Marijuán 2008).

Capurro and Hjørland (2003) critic this approach as having a metaphysical rather than a scientific status insofar as "a view of the whole of reality that is not possible for a finite observer" is assumed.

Figure 4: Main page of Glossarium BITri

A.2. Glosarium BITri: Glossary of concepts, metaphors, theories and problems concerning information

When the previous exemplified glossary was developed in 2008 and included as an appendix of this paper, it was also suggested through an open call addressed to researchers in information studies as an example for a collaborative edition of a glossary authentically interdisciplinary (since diverse specialised domains were to be convened), named "Glosarium BITri -Glossary of concepts, metaphors, theories and problems concerning information" and assumed as a first step of the BITrum project as well as one of its core activities (BITrum 2010). At the beginning of 2010 the first stage of the glossary has been accomplished following a three-step process: First a call for terms, editors and authors, let us gather a team of 42 members for the development of the glossary. Second, an open call for entries was convened aimed at collecting in each voice different viewpoints. Third, the responsible of each voice (editor) should articulate all the given entries in a systematic and non redundant article.

The glossary – conceived as the place where conceptual advancements and results from BITrum research are reflected – can be freely consulted, and is opened to new participations:

http://sites.google.com/site/glosariobitrum/glossary.

References

Adorno, T.W. (1956). *Zur Metakritik der Erkenntnistheorie. Studien über Husserl und die phänomenologischen Antinomien.* Stuttgart: Kohlhammer.

Adorno, T.W. (1966). *Negative Dialectics*, (trans. E. B. Ashton, 1973). New York: Seabury Press.

Alvarado Ballester, R. (2000). *Comunicación, Información, Evolución Biológica*, Madrid: Instituto de España.

Aristotle (350 BC), *Metaphisics* (translated by W. D. Ross). [online] Internet Classics Archive by Daniel C. Stevenson, Web Atomics <http://classics.mit.edu/Aristotle/metaphysics.html> [accessed: 12/12/2009]

Bar-Hillel, Y. & Carnap, R. (1953). Semantic information. *British Journal of Science*, *4*, 147-157.

Barwise, J. & Perry, J. (1983). *Situations and Attitudes*. Cambridge, MA: MIT Press.

Barwise, J. & Seligman, J. (1997). *Information Flows: The Logic of Distributed Systems*. Cambridge, RU: Cambridge University Press.

Barwise, J. (1997). Information and Impossibilities. *Notre Dame J. Formal Logic*, *38*(4), 488-515.

Bateson, G. (1979). *Mind and Nature: A Necessary Unity (Advances in Systems Theory, Complexity, and the Human Sciences)*. New Jersey: Hampton Press.

Beer, S. (1959). *Cybernetics and Management*. London: English Universities Press.

Bekenstein, J. D. (2003). Information in the Holographic Universe. in *Scientific American*, *289(*2), 58-65.

Bense, M. (1969). *Einführung in die informationstheoretische Ästhetik*. Hamburg: Rowohlt.

Benthem, J. van (2003). Logic and the Dynamics of Information. *Minds and Machines, 13*(4), 503–519.

Benthem, J. van (2008). Tell It Like It Is: Information Flow in Logic. *Journal of Peking University (Humanities and Social Science Edition) 1*, 80 – 90.

BITrum (2010). *Reseach project: Interdiciplinary elucidation of the information concept*. BITrum Research Group [online] http://sites.google.com/site/ebitrum/Home [accessed: 10/01/2010]

Borgman, A. (1999). *Holding on to reality. The nature of information at the turn of the millennium*. Chicago: University of Chicago Press.

Bowler, P. J. (1992). *The Fontana history of the environmental sciences*. London: Fontana Press.

Brier, Søren (2008). *Cybersemiotics: why information is not enough.* Toronto: University of Toronto Press.

Brillouin, Leon (1953). The negentropy principle of information. *Journal of Applied Physics*, *24*, 1152-1163.

Brillouin, Leon (1956). *Science and Information Theory*. New York: Academic Press.

Brown, J. S. and Duguin, P. (2000). *The Social Life of Information*. Boston, Mass.: Harvard Business School Press.

Bruner, J. S. (1992). *Acts of Meaning: Four Lectures on Mind and Culture (Jerusalem-Harvard Lectures)*. Harvard University Press.

Calude, C. S. (1995). *Information and randomness: an algorithmic perspective*, Springer.

Capurro, R. (1978). *Information. Ein Beitrag zur etymologischen und ideengeschichtlichen Begründung des Informationsbegriffs*. Munich: Saur.

Capurro, R. (2008). Digital Hermeneutics: An Outline. in: E. Buchanan & C. Hansen (Eds.). *Proceedings. Thinking Critically: Alternative Methods and Perspectives in Library and Information Studies*. (pp. 19-22). CIPR, University of Wisconsin-Milwaukee,

Capurro, R., Fleissner, P., & Hofkirchner, W. (1999). "Is a Unified Theory of Information Feasible? A Trialogue". In W. Hofkirchner (Ed.), *The quest for a unified theory of information* (pp. 9 – 30). Amsterdam: Gordon and Breach. [Online]<http://www.capurro.de/trialog.htm> [Consulted: 10/07/2007]

Capurro, R. & Hjørland, B. (2003). The Concept of Information. *Annual Review of Information Science and Technology*, Ed. B. Cronin, *37*(8), 343-411. [Draft version available online] <http://www.capurro.de/infoconcept.html > [Accessed: 12/11/2009].

Castells, M. (1996-1998). *The Information Age: Economy, Society and Culture*. (3 volumes). Malden, MA: Blackwell.

Chaitin, G. J. (1966). On the length of programs for computing finite binary sequences. *Journal of the Association for Computing Machinery*, *13*, 547-569.

— (1982a). Algorithmic Information Theory. In *Encyclopedia of Statistical Sciences*, Vol. 1, New York: Wiley, 38-41.

— (1982b). Gödel's theorem and information. *International Journal of Theoretical Physics*, *22*, 941-954.

Chmielecki, A. (1998). What is information? *The Paideia Archive, Philosophy and Cognitive Science,* 20th. World Congress of Philosophy, Boston, USA [online] <http://www.bu.edu/wcp/Papers/Cogn/CognChmi.htm> [Accessed: 12/11/2009].

Chomsky, N. (1986). *Knowledge of Language: Its Nature, Origins and Use*. Praeger Paperback.

Conrad, M. & Schwartz, A.W. (Eds.) (1998). Special issue: Foundations of Information Science. The quest for a Unified Theory of Information. *Bio Systems, 46*(1,2)

Díaz Nafría, J. M. (2007). Tecnologías del Ostracismo o de la pseudocomunicación, *Le Monde Diplomatique edición española, 11(135)*, 30.

Díaz Nafría, J. M. & B. Al Hadithi (2009). Are "the semantic aspects" actually "irrelevant to the engineering problem"?, *TripleC, 7(2)*, 300-308.

Doucette, D., Bichler, R., Hofkirchner, W. & Raffl, C. (2007). Toward a New Science of Information. *Data Science Journal*, *6(supplement)*, 198-205.

Dretske, F.I. (1981), *Knowledge and the flow of information*. Cambridge, MA: MIT Press.

Eco, U. (1973). Social Life as Sign System. In D. Robey (Ed.). *Structuralism, an Introduction*. Oxford: Oxford University Press.

Fenzl, N. & Hofkirchner, W. (1997). Information Processing in Evolutionary Systems. An Outline Conceptual Framework for a Unified Information Theory. In F. Schweitzer (Ed.), *Self-Organization of Complex Structures: From Individual to Collective Dynamics (*pp. 59-70).   London: Gordon and Breach.

Fischer, R.A. (1935). *The design of experiments.* Edindurg: Oliver & Boyd.

Fleissner, P., Hofkirchner, W. (1996). Emergent Information. Towards a unified information theory. *BioSystems, 2-3*(38), pp. 243-248.

Floridi, L. (2004). Outline of a theory of strongly semantic information. *Minds and Machines*, *14*(2*)*, 197-221.

— (2005a). Information. In C. Mitcham (Ed.). *Encyclopedia of Science, Technology and Ethics,* Macmillan Reference.

— (2005b). Is Semantic Information Meaningful Data? in *Philosophy and Phenomenological Research*, *70(2)*, 351-370.

— (2005c). Semantic Conceptions of Information. In E. N. Zahlta (Ed.) *Stanford Encyclopedia of Philisophy*. Stanford: *The Metaphysics Research Lab* [online] <http://plato.stanford.edu/entries/information-semantic/> [accessed: 12/11/09]

— (2005d). Consciousness, Agents and the Knowledge Game. *Minds and Machines*, *15*(3-4), 415-444.

Flückiger, F. (2005). Mathematical Foundation of Information Theory. A Set Theoretical Approach. In M. Petitjean (Ed.) *Proceedings of FIS2005, The Third Conference on the Foundations of Information Science*.

Foerster, H. von (1981). *Observing systems*. Seaside, CA: Intersystems Publications.

Gellius, A. (2006) Noctium Atticarum. Chicago: Bill Thayer, Liber III, X, 7 [online] LacusCurtius: Greek and Roman Authors. University of Chicago <http://penelope.uchicago.edu/Thayer/L/Roman/Texts/Gellius/3*.html> [accessed: 10/11/2009]

Gitt, W. (1996), Information, Science and Biology. *Technical Journal*, *10*(2), 181-187.

Green, H. (2000). *Information Theory and Quantum Physics: Physical Foundations for Understanding the Conscious Process*. Berlin: Springer Verlag.

Griffith, B. C. (Ed.) (1980). *Key papers in information science*. New York: Knowledge Industry Publications.

Günther, G. (1963). *Das Bewußtsein der Maschinen. Eine Metaphysik der Kybernetik*. Krefeld/Baden-Baden, Germany: Agis Verlag.

Habermas, J. (1981). *Theorie des kommunikativen Handelns*. Frankfurt a.M.: Suhrkamp.

Habermas, J. (1970). "Technology and Science as Ideology". in *Toward a Rational Society*. J. Shapiro (trans.). Boston: Beacon Press.

Haken, H. (2000). *Information and Self-Organization. A Macroscopic Approach to Complex Systems* (2nd edition). Berlin: Springer Verlag.

Hegel, G.W.F. (1841). *Wissenschaft der Logik. Erster Teil. Die objektive Logik*. Berlin: Henning. [online] Guttenberg Project (Ed. 2004) < http://www.gutenberg.org/etext/6729 > [accessed: 12/12/2009]

Hofkirchner, W. (1997). Evolution of Learning. The Merging of Semiotic and Evolutionary-System Theories. In A. M. Meystel (Ed.). *Proceedings of the 1997 International Conference on Intelligent Systems and Semiotics: A Learning Perspective* (pp. 248-251). Washington: U.S. Government Printing Office.

— (1999a). Towards a Unified Theory of Information. The Merging of Second-Order Cybernetics and Semiotics into a Single and Comprehensive Information Science. In: *15e Congrès International de Cybernétique*, *Namur 1998*, (pp.175-180) Namur.

— (Ed.). (1999b). *The quest for a unified theory of information. Proceedings of the Second International Conference on the Foundations of Information Science*. Amsterdam: Gordon and Breach.

— (2008). How to Achieve a Unified Theory of Information. In J.M. Díaz Nafría, F. Salto Alemany (Eds.). *¿Qué es información?* León, Spain: Universidad de León.

Hofkirchner, W. & Stockinger, G. (2003). Towards a Unified Theory of Information. *404nOtF0und*, *1*(3), N. 24. [Online] <http://cartoon.iguw.tuwien.ac.at/zope/igw/menschen/hofkirchner/papers/InfoConcept/article/article.html> [Consulted: 20/07/2009]

Israel, D. & Perry, J. (1990a), What is information?. In P. Hanson (Ed.), *Information, language and cognition (*pp. 1-19). Vancouver, Canada: University of British Columbia Press.

— (1990b). Information and architecture. In J. Barwise, J. M. Gawron, G. Plotkin, & S. Tutiya (Eds.). *Situation theory and its applications* (pp. 147-160). Stanford, CA: Stanford University-CSLI.

Janich, P. (1998). Informationsbegriff und methodisch-kulturalistische Philosophie. *Ethik und Sozialwissenschaften, 2*, 169-182.

Karpatschof, B. (2007). *Human activity. Contributions to the anthropological sciences from a perspective of activity theory*. Lund, Sweden: InformationR.net [online] <http://informationr.net/ir/12-3/Karpatschof/Karp00.html> [accessed: 12/11/09].

Khosrow-Pour, M. (2005). *Encyclopedia of Information Science and Technology*. Hershey, USA: Idea Group Reference.

Kolmogorov, A. N. (1965). Three approaches to the quantitative definition of 'information'. *Problems of Information Transmission*, *1(1)*, 3-11.

Kornwachs, K. (1996). Pragmatic information and System surface. In K. Kornwachs & K. Jacoby (Eds.) *Information. New questions to a multidisciplinary concept* (pp. 103-118). Berlin: Akademie Verlag.

Kotelnikov, V.A. (1959). *The Theory of Optimum Noise Immunity*. Russia 1956, USA: McGraw Hill.

Kuhn, T.S. (1962). *The Structure of Scientific Revolutions*. Chicago: Univ. of Chicago Press.

Lewis, G.N. (1930). The symmetry of time in Physics. *Science, 71,* 569-576.

Luhmann, N. (1987). *Soziale Systeme*. Frankfurt am Main: Suhrkamp.

— (1989). *Essays on self-reference*. New York, Columbia University Press.

Lundheim, L. (2002). On Shannon and "Shannon's Formula", *Telektronikk* (special issue on "Information theory and its applications") *98*(1), 20-29.

Lyre, H. (1998). *Quantentheorie der Information. Zur Naturphilosophie der Theorie der Ur-Alternativen und einer abstrakten Theorie der Information*. Viena: Springer.

Lyre, H. (2002). *Informationstheorie. Eine philosophisch-naturwissenschftliche Einführung*. Munich: W.Fink Verlag.

MacBride, S. (Dir.) (2003). *Many Voices, One World: Towards a New, More Just, and More Efficient World Information and Communication Order*. Paris: UNESCO. International Commission for the Study of Communication Problems.

Machlup, F. & Mansfield, U. (Eds.) (1983). *The Study of Information. Interdisciplinary Messages*. New York: Wiley.

Mähler, G. (1996). Quantum Information. In K. Kornwachs & K. Jacoby (Eds.). *Information. New questions to a multidisciplinary concept* (pp. 103-118). Berlin: Akademie Verlag.

Marijuan, P. (Ed.) (1998). The FIS (Foundations of Information Science) Initiative: A Presentation. *Cybernetics & Human Knowing, 5*(4)*,* 3-5*.*

— (2008). The advancement of Information Science. Is a new way of thinking necessary?. In J.M. Díaz Nafría & F. Salto Alemany (Eds.). *¿Qué es información?*. León, Spain: University of León.

Mason, S. F. (1962). *A History of the Sciences.* New York: Collier Books.

Mattelart, A. (2006). *Histoire de la société de l'information*. Paris: La Decouverte.

Maturana, H.R. & Varela, F.J. (1980). *Autopoiesis and congnition: the realization of the living.* Dordrecht, Netherlands: Reídle.

Matsuno, K. (1998). Dynamics of time and information in a dynamic time. *Bio Systems, 46*, 57-71.

Miller, G.A. (2003). The cognitive revolution: a historical perspective. *TRENDS in Cognitive Sciences*, *7*(3)*,* 141-144.

Moles, A. (1972). *Théorie de l'information et perception esthétique*. Paris: Denoël.

Morris, C.W. (1938). *Foundations of the theory of signs*. Chicago: International Encyclopaedia of Unified Science.

Neumann, J. Von (1932). *Mathematische Grundlagen der Quantenmechanik.* Berlin: Springer.

Oeser, E. (1976). *Wissenschaft und Information*. Vienna, Austria: Oldenbourg.

Ortega, J. (2002). *What is Knowledge?*. New York: State University of New York Press.

Oslin, G.P. (1992). *The story of telecommunications*. Macon GA (USA): Mercer University Press.

Peirce, C. S. (1873). On the Nature of Signs. *MS 214 (Robin 381): Writings 3*, 66-68. [online] Arisbe: The Peirce Gateway <http://www.cspeirce.com/menu/library/bycsp/logic/ms214.htm > [accessed: 10/10/2009]

Pérez-Amat, R. (2009). Towards a Semantic Theory of Information. *TripleC* (special issue: J.M. Díaz Nafría & F. Salto (eds.) "What is really information? An interdisciplinary approach"), *7*(2), 158-171.

Pérez García, R. (1990). *Información y significado: hacia una teoría semántica de la información*. Madrid: Universidad Complutense.

Pérez-Montoro, M. (2007). *The Phenomenon of Information. A Conceptual Approach to Information Flow.* Lanham, Maryland: Scarecrow Press.

Poincaré, H. (1904). The principles of Mathematical Physics. In P.L.. Williams (Ed., 1968). *Relativity Theory* (pp. 39-49). New York: J. Wile.

Powers, K. (1956). *A Unified Theory of Information*. Cambridge, USA: Massachusetts Institute of Technology.

Rüting, T. (2004). Jakob von Uexküll — theoretical biology, biocybernetics and biosemiotics. *European Communications in Mathematical and Theoretical Biology*, *6*, 11-16.

Schrödinger, E. (1944). *What is life? The physical aspect of the living cell.* Cambridge: Cambridge University Press.

Searle, J. R. (1983). *Intentionality: An Essay in the Philosophy of Mind*. Cambridge, Mass. : Cambridge University Press.

Segal, J. (2003), *Le Zéro et le Un. Histoire de la notion scientifique d'information*. Paris: Syllepse.

Sfez, L. (1993). *Dictionaire critique de la communication*. Paris: Press Universitaire de France.

Shannon, C. E. (1948). A Mathematical Theory of Communication. *The Bell System Technical Journal*, *27*, 379–423, 623–656.

Shannon, C. & Weaver, W. (1949). *The mathematical theory of communication*. Urbana: The University of Illinois Press.

Sklar, B. (2001) *Digital Communications. Fundamentals and Applications*. New Jersey: Prentice Hall.

Sloman, A. (1978). *The Computer Revolution in Philosophy: Philosophy, Science and Models of Mind*. Hassocks, UK: The Harvester Press.

Smoluchowsky, M. von (1912). Experimentell nachweisbare, der üblichen Thermodynamik widersprechende Molekularphänomene. *Annalen der Physik, 33,* 1559-1570.

Solomonoff, R. J. (1960). A Preliminary Report on a General Theory of Inductive Inference. Report V-131, Zator Co., Cambridge, Ma. Feb 4, 1960.

Solomonoff, R. J. (1964). A formal theory of inductive inference. *Inf. Control*, *(7)*, 1-22 (I part), 224-254 (II part).

Stonier, T. (1991). Towards a new theory of information. *Journal of Information Science*, *17* (5), 257-263.

Stonier, T. (1999). The Emerging Global Brain. In W. Hofkirchner (Ed.). *The quest for a unified theory of information. Proceedings of the Second International Conference on the Foundations of Information Science* (pp. 561-578). Amsterdam: Gordon and Breach.

Szilárd, L. (1929). Über die Entropie Verminderung in einem therodynamische System bei Eingriffen intelligemter Wesen. *Zeitschrift für Physik, 53,* 840-856.

UTI (2009) *Unified Theory of Information Research Group Website* (provides access to links, texts, references and projects related to the Unified Theory of Information) [online] <http://www.uti.at/> [accessed: 12/11/2009]

Vergili, M. (1900) *Aeneid* edited by J. B. Greenough. *Aeneid, Ecloges & Georgicon.* Boston: Ginn & Co. [online] <http://www.thelatinlibrary.com/verg.html> [accessed: 12/11/2009]

Vitányi, P. (2006). Meaningful Information. *IEEE Transactions on Information Theory*, *52*(10), 4617-4626.

Weizsäcker, C.F. von. (1974). *Die Einheit der Natur*. Munich: Deutscher Taschenbuch Verlag.

Weizsäcker, C.F. von. (1985). *Aufbau der Physik*. Munich: Hanser.

Wiener, N. (1948). *Cybernetics : Or Control and Communication in the Animal and the Machine.* Cambridge, MA: MIT Press.

Wilson. D. & Sperber, D. (1993). Linguistic form and relevance. *Lingua, 90*, 1–25.

Zadeh, L.A. (1986). Test-Score Semantics and a Basis for a Computational Approach to the Representation of Meaning. *Literacy and Linguistic Computing, 1(1)*, 24-35.

Zoglauer, T.(1996). Can information be naturalized?. In K: Kornwachs & K: Jacoby (Eds.). *Information. New questions to a multidisciplinary concept* (pp.187-207). Berlin: Akademie Verlag.

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