Charles S. Peirce's Theory of Information:
A Theory of the Growth of Symbols and of Knowledge

Winfried Nöth[1]

Charles S. Peirce had a theory of information largely ignored by contemporary information theorists. This paper gives an outline of this theory and confronts it with information theories since 1949, Shannon and Weaver's syntactic theory of information, Carnap and Bar-Hillel's logico-semantic theory, and Dretske's cognitive-pragmatic theory of information. In contrast to these more recent theories, Peirce's theory of information is not based on a calculus of probabilities but on one of logical quantities. Furthermore, it does not only study information as growth of knowledge from actual texts or utterances but also as knowledge accumulated in symbols in the course of their history. Peirce takes all three dimensions of semiotics into account without reducing information to any of them: syntax, since it calculates information from the combination of subject and predicate terms of propositions; semantics, since it studies the denotation and signification of symbols; and pragmatics insofar as it studies processes of knowledge acquisition. The specifically semiotic aspect of Peirce's information theory consists in its study of the different effects of icons, indices, and symbols on the growth of words, ideas, and knowledge.

Information does not seem to be a key concept in Peirce's semiotic terminology. Semiotics, as Peirce conceives it, is not the study of *information processing* but the study of *semioses*, that is, of processes in which signs represent objects and create interpretants. Not *information*, but *sign*, *representation*, *mediation*, or *interpretation* are the key terms in the study of such processes (see Nöth, 2011a).

Nevertheless, Peirce had much more to say about how signs convey information than is usually acknowledged in contemporary information sciences (see Johansen, 1993, pp. 145-151; Liszka, 1996, pp. 28-31; De Tienne, 2005). In fact, Peirce himself once referred to his ideas on the topic as his "theory of information" (CP 5.288n1, 1868). After having founded it on principles of logic between 1865 and 1867 (W1:2), Peirce went on to elaborate it to a fully semiotic theory of information after 1893. In contrast to the major paradigms of contemporary theories, Peirce's information theory does not conceive of information in terms of probabilities of the occurrence of signals, words, or sentences in actual utterances. Instead of probabilities, it calculates the logical quantities of extension and intension of symbols. Furthermore, it does not only calculate the value of the actual information conveyed through new informative propositions but also information as it has accumulated through the implications that symbols acquire in the course of their history. It is, hence, both a theory of knowledge acquisition and a theory of the growth of symbols.

1. Pontifícia Universidade Católica de São Paulo, Programa de Pós-Graduação em Tecnologias da Inteligência e Design Digital (TIDD), Rua Caio Prado, 102 - Consolação, São Paulo – SP, CEP 01303-000 Brazil.
E-mail: noeth@uni-kassel.de

1. Contemporary Paradigms of Information Theory

Since the mid-20th century, information theory has largely ignored Peirce's contributions to its field of research. For a better assessment of the relevance of Peirce's theory of information, it may therefore be useful to begin with a brief survey of the major paradigms of the classics of information theory. Cherry (1957) and Nauta (1972) classify the mid-century trends of information theory since 1949 into syntactic, semantic, and pragmatic theories. What they have in common is that they calculate information in terms of probability. A strictly syntactic theory calculates information according to the probabilities of the occurrence of signs in their respective context. A semantic theory calculates it as the amount of content conveyed by a message. A pragmatic theory studies how the sender's message influences and increases the receiver's knowledge.

The protagonists of the syntactic paradigm of information theory are Shannon and Weaver (1949). Irrespective of meaning, the authors measure the information value of a signal according to its probability in a given context. Signals which are rare in a given context have a high information value. The higher the predictability of the occurrence of a signal in a given context, the lower its information value.

Bar-Hillel and Carnap (1953) have proposed an influential semantic theory of information based on probabilistic assumptions. The authors postulate a formal language consisting of all sentences which are true in a given possible universe (see Bar-Hillel, 1964, p. 224) and determine the information values of actual sentences according to the probability of occurrence according to this knowledge base. The information value of an actual sentence is then measured from the number of sentences excluded from this omniscient knowledge base, which is calculated in relation to the reciprocal value of its frequency of occurrence according to the universal knowledge base of true sentences.[2] Sentences which are necessarily true and hence logically fully predictable convey no information. Sentences which are false and other logically unpredictable and improbable sentences count as highly informative. The more a sentence is incompatible with the sentences formulated in the omniscient knowledge base of atomic statements, the more it is informative. In this definition, information does not correspond to the way it is understood in ordinary language. Although tautologies and analytic statements are indeed ordinarily

---

2. An anonymous reader of this paper adds: "Actually, Carnap and Bar-Hillel proposed two theories (definitions), cont and inf, both based on the inverse proportion of the sentences in the supposed information to the total number of possible sentences. It goes this way: For 'technical reasons' they calculate the states ruled out as a number of *state descriptions*. A state description is a conjunction of atomic statements assigning each primitive monadic predicate or its negation (but never both) to each individual constant of the language. The information content of a statement is thus relative to a language. Evidence, in the form of *observation statements*, contains information in virtue of the class of state descriptions the evidence rules out. (They assumed that observation statements can be connected to experience unambiguously.) Information content, then, is inversely related to probability, as intuition would suggest. They have two measures, which are not compatible (give different values), one is the inverse of the probability (actually the expected frequency), and the other is the typical Shannon logarithmic measure). In both cases the values are relative to a descriptive language."

considered as uninformative, contradictions are not. They may be rare and even surprise, but their interpreters do not become more informed by hearing them.

Within the pragmatic paradigm of information theory, several respects in which messages may be relevant to their interpreters have been studied, such as the degree of interest which a message may arouse, the degree of its credibility (see Nauta, 1972), or the degree to which interpreters find their knowledge confirmed or how they acquire new knowledge from a message (Weizsäcker, 1984). The currently most influential pragmatic trend, which adopts again probabilistic methods, can be found in cognitive philosophy (Hanson, 1990). In *Knowledge and the Flow of Information*, Dretske (1981, see also 2008) defines information in terms of knowledge. Gibberish, for example, is both meaningless and uninformative, but to have meaning is not a sufficient criterion of informativity. An informative message must convey new and comprehensive knowledge. True statements in a foreign language are meaningful, but they fail to convey information to one who does not understand its. A meaningful message may also fail to convey information because its interpreter is already familiar with its contents. While all intelligible messages are meaningful, only those that convey new knowledge are informative.

Dretske and others (see Florido, 2005) also postulate truth as a necessary criterion of information. Meaningful, intelligible, novel, but false messages cannot be informative. So-called "*false* information and *mis*-information are not kinds of information" at all says Dretske (1981, p. 44). He argues: "When I say, 'I have a toothache,' what I say *means* that I have a toothache whether what I say is true or false. But when false, it fails to carry the information that I have a toothache because it is incapable of yielding the knowledge that I have a toothache" (Dretske, p. 45). Information as that from which we can acquire new knowledge is also a prerequisite of learning since "what information a signal carries is what we can learn from it" (Dretske, p. 45).

Dretske furthermore postulates the *relative quantifiability* of information. Although the informative content of a proposition cannot be measured in itself, it is possible to determine which of two propositions conveys more and which conveys less information about a state of affairs: "For example, if I tell you that Denny lives on Adams Street in Madison, Wisconsin, I give you *more information* than if I tell you, simply, that he lives in Madison, Wisconsin" (Dretske, 1981, p. 54). What Dretske illustrates here is the logical insight that the increase of the number of predicates attributed to a subject in a proposition also increases the amount of information (and meaning) conveyed by it. Dretske ignores that his method of quantifying propositional meaning is an essential element of Peirce's early theory of information.

Whereas the criteria of meaningfulness, truth, and relative quantifiability are semantic criteria, the criterion of novelty is a pragmatic criterion. Whether a message is informative or not depends exclusively on the recipient's state of knowledge, according to Dretske. The author calls this premise the "*relativization* of meaning" and defines it as follows: "*How much* information a signal contains, and hence *what* information it carries, depends on what the potential receiver already knows"

(Dretske, 1981, p. 79; emphasis in original). To an omniscient hearer nothing can be informative, whereas everything is informative to the newborn child. Information is thus that which actually conveys new knowledge to a particular interpreter. Peirce calls information conveyed in this form *actual information*. In contrast to Dretske, he distinguishes between actual and several other types of information.

2. Logical Foundations of Peirce's Theory of Information

Peirce's early information theory is based on elements of logic. It defines the information conveyed by a symbol as a value calculated from the quantities of its extension and intension. Insofar as extension and intension are semantic concepts, it seems to be a semantic theory of information, but Peirce's theory of information was a pragmatic theory at its roots. It even attributed no information value whatsoever to mere verbal meaning but always conceived of information in terms of knowledge growing with the interpretation of symbols.

2.1 Extension (Denotation), Intension (Comprehension)

For a better understanding of Peirce's early theory of information, a few basic concepts of traditional logic need to be introduced, since Peirce elaborates his theory of information from these concepts. The first concepts are term and proposition. A *term* has typically the grammatical form of a noun or an adjective phrase. It denotes a (general) class of real or imaginary objects. As signs, whose denotation is general, referring to classes of objects, terms are *symbols*.

Terms serve to form propositions. A *proposition* expresses a relation between two terms, of which the first is the subject and the second is the predicate (term), for example: *Dogs are mammals*. The subject is what the proposition is about. The predicate, in Peirce's early logic, ascribes attributes, characters, or predicates to the class denoted by the subject term (here: "are mammals"). In Peirce's words: "What is a "term," or "class-name," supposed to be? It is something which signifies … certain characters, and thereby denotes whatever possesses those characters" (CP 2.341, ca. 1895).

In accordance with traditional logic, Peirce distinguishes between the denotation, extension, or breadth and the comprehension, connotation, intension, or depth of terms. The traditional terminology is heterogeneous, and Peirce examines carefully the advantages and disadvantages of the various terminological alternatives (W2:70-86). Between 1865 and 1867 (W1-2), he uses the dichotomies of *extension* vs. *intension*, *denotation* vs. *comprehension*, and especially *breadth* vs. *depth* alternatively. In his later writings, Peirce adopts the dichotomy of denotation vs. *signification* (e.g., EP2:304, 1904), which is still in use in modern semantics and language philosophy.

Broadly, these dichotomies correspond to the distinction between world or encyclopedic knowledge and verbal, dictionary, or lexical knowledge in modern cognitive semantics. The extension of a term consists of the objects denoted by it. Its

intension consists of the characteristics ascribed to it in the form of predicates. In modern linguistics, the intensions of words are described in the form of semantic features, whereas their extension is studied in a reference semantic framework. For Peirce, however, extension and intension cannot be separated from each other since the extension or denotation of a symbol "is created by its connotation" (W1:287), that is, through the predicates attributed to a subject term. We can only determine the referent (denotatum or extension) of a word if we know its meaning (intension or connotation) and vice versa: we must know the referent if we want to specify its semantic features (cf. Liszka, 1996, p. 124).

Peirce explains that the terms *breadth* (for *extension*) and *depth* (for *intension*) are common usage: "'Wide' learning is, in ordinary parlance, learning of many things; 'deep' learning, much knowledge of some things" (W2:74). The breadth of a term is the set of "real things" of which it can be predicated (CP 2.407, 1867), whereas its depth consists of the set of predicates attributable to it, that is, of the semantic attributes of whatever the term denotes (see W1:459; W2:455-471, 1866-67; Kappner, 2004, p. 132; De Tienne, 2005, p. 153).

Symbols have both extension, since they denote classes of objects, and they have intension, since the objects they denote must have certain characters in common. There are even reasons to argue that all signs, that is, symbols, indices, and icons, have both extension and intension, according to Peirce (Liszka, 1996, pp. 123-124; Nöth, 2011b). With this assumption, Peirce differs from logicians who argue that proper names (*indices* for Peirce) have only extension (reference) and no intension (sense), whereas fictional names, such as *unicorn*, and signs of mere qualities (icons) have no extension but only intension.

2.2 The Quantification of Extension and Intension

Two other key terms of traditional logic are important because Peirce derives his quantification of information from them: logical quantity and quality. *Quantity* is a measure of the extension of a symbol. It refers to the fact that different symbols "may denote more or fewer possible things" (W1:187). The extension of the symbol *mammals* is larger than the one of *dogs* since the former is applicable to more animals than the latter.

Quality is a matter of the intension of a symbol. Despite its name, quality is also quantifiable. The number of characters (or "semantic features") attributed to a term is a logical quantity. A symbol "may imply more or less as to the quality of these things" (W1:187). One of Peirce's examples: "If *horse* be divided into *black horse* and *non-black horse*, *black horse* has more intension" [than *horse*] (W1:272). In terms of semantic feature analysis, the expression *black horse* has an additional semantic feature in comparison with the word *horse*, whose meaning is less specific since it says nothing about color. Notice that this calculus is one of syntagmatic, not of lexical semantics. It is only a matter of semantic syntax. From the perspective of lexical semantics, the word *horse* has evidently no color specifying semantic feature.

That the quality of a term is quantifiable is also apparent in the historical terminology of logic. As Peirce points out, the terms used by many early Kantians for extension and intension were "*external* and *internal quantity*" (W2:72). Intension is hence a quality but also a quantity, not an external, but an internal quantity.

While the intension of a symbol increases with the number of characteristics attributed to it, its extension increases with the number of things to which the symbol is applicable. Between both quantities, there is thus a relation of *inverse proportionality* first discovered by Kant (cf. W2:84, 1867): any addition to the breadth (extension) of a term diminishes its depth (intension; W1:467, 1866), or: "The greater the extension, the less the comprehension" or intension of a symbol (W1:465).

A symbol that denotes more objects has fewer characteristics that a symbol that denotes less objects of the same class. The broader its extension, the fewer the attributes which characterize its intension, and vice versa. There is practically no limit to the characteristics attributable to a single object. The denotation of the symbol *dog* is the class of all dogs so that only those few features can be attributed to this symbol that characterize all dogs, for example, not any specific feature of size, color, and race. In addition to those relatively few characteristics valid for all dogs, Colin's dog Pym has a large number of other very specific features: it is brown, has short legs, is three years old, ate too much yesterday, belongs to the race of poodles, lives in Manchester, etc. etc.

2.3 Essential, Informed, and Substantial Breadth and Depth

Peirce distinguishes three kinds of depth and breath of symbols (W2:79-86; CP 2.391-430), essential, informed, and substantial depth and breadth. The three spheres of meaning and reference characterize a semantic space in which knowledge conveyed by symbols emerges as informed depth and breadth in a continuum between two imaginary extremes determining the limits of the knowable, which lie in the semantic spheres of essential and substantial breadth and depth.

The *essential depth* of a term contains all "really conceivable qualities predicated of it in its definition" (CP 2.410), whereas its *essential breadth* refers to all "those real things of which, according to its very meaning, a term is predicable" (CP 2.412). Within the semantic spectrum from essential depth to essential breadth, it is possible to reach two limit states of knowledge "in which no fact would be known, but only the meaning of terms" and vice versa (CP 2.409). For example, the term *being* has essential breadth "inasmuch as it means that which can be predicated of whatever you please," but it has no essential depth since no number of essential objects can be enumerated to which the word refers (CP 2.412). The term *nothing*, by contrast, has a maximum of essential depth "insofar as we are at liberty to predicate [of this term] whatever we please," but it has no essential breadth since no attributes whatsoever can be ascribed to the term *nothing* (CP 2.412). Thus, the terms *being* and *nothing* are vague and uninformative for opposite reasons, lack or essential depth and lack of essential breadth, respectively.

Peirce's definition of substantial breath and depth must be understood in terms of the metaphysical concepts of substance and form (see below, section 6.). Substances are enduring but still undifferentiated entities, typically expressed in the subject term of a proposition not modified by a predicate: "If we say 'The stove is black,' the stove is the *substance*, from which its blackness has not been differentiated, and the *is*, while it leaves the substance just as it was seen, explains its confusedness, by the application to it of blackness as a predicate. … Substance is inapplicable to a predicate" (CP 1.548). *Form*—a term associated with the term *idea*—has to do with differentiated qualities and is therefore more typical of predicate terms: "its being is a being of the predicate" (EP2:544, 1906). Form gives structure to cognition and conveys meaning (see Nöth, 2002). *Substantial breadth* refers then to "the aggregate of real substances" predicable of a term, whereas *substantial depth* means "the real concrete form" of whatever a term is predicable (CP 2.414).

The dichotomy can be illustrated by the distinction between *general terms*, which are applicable to all objects of a class, vs. *particular terms*, which apply only to some, few, many, or most objects. In the logic of arguments, the distinction between general and particular terms reappears in the one between distributed and undistributed terms. A general term, such as *all cats*, has no substantial depth because "only by abstraction" (CP 2.415) and not by their real qualities, which differ from cat to cat, can all cats be said to have (substantial) characters in common. But general terms have substantial breadth since they denote real cats. A particular term, such as *some cats*, has substantial depth "inasmuch as each of the things, one or other of which is predicated of them, has a concrete form," (CP 2.415) but it has no substantial breadth since it is vague, not being exclusively applicable to any specific group of cats. The lack of either substantial depth or substantial breadth constitutes a lack of informativity.

Peirce's notion of essential in this context characterizes an aspect of information opposed to the actual information created by a new proposition. It circumscribes a kind of meaning which cannot be *relativized* in Dretske's sense, but it is not meant in a normative sense either, which would neglect the reality of semantic change. Peirce's definition of the essential depth a symbol as the "really conceivable qualities predicated of it in its definition" (CP 2.410) and of its essential breadth as "those real things of which, according to its very meaning, a term is predicable" (CP 2.412) anticipates his later theory of the final interpretant as "the effect the Sign *would* produce upon any mind upon which the circumstances should permit it to work out its full effect" (SS:110, 1909) or "the one Interpretative result to which every Interpreter is destined to come if the Sign is sufficiently considered" (SS:111).

Other types of information which may be derived from Peirce's theory of the interpretant are the ones of the essential, the actual, and the intended information (MS 854,1911; Marty, 1997). The notion of essential information extends Peirce's early concept of the essential depth of the symbol (see above). Actual information is the one an interpreter actually derives from the sign, and intended information refers to the information the sign "was intended specially to excite—perhaps only a part of

the essential characters perhaps others not essential and which the word now excites" (MS 854, 1911). Peirce discusses the actual information of a sign also as its *dynamical interpretant*, the "direct effect actually produced by a Sign upon an Interpreter of it" (SS:110, 1909), whereas the intended information of a sign corresponds to the immediate interpretant, which is the "effect that the Sign is calculated to produce, or naturally might be expected to produce" (SS:110).

3. Elements and Dimensions of Peirce's Theory of Information

Peirce derives elements of his theory of information from the logic of terms and their combination to propositions. Not restricted to the study of lexical meanings or definitions, he has a pragmatic theory which conceives of information as interpreted knowledge.

3.1 Information, Meaning, Verbal Knowledge, and the Absence of Information in Analytic Statements

Information is localized between "two imaginary extremes" characterized by the states of essential and the substantial breadth and depth, respectively. The first is the one of a "state in which no fact would be known, but only the meaning of terms" and, the second is a state in which we would have an absolute knowledge of all things, "so that the things we should know would be the very substances themselves, and the qualities we should know would be the very concrete forms themselves" (CP 2.409).

Between these two extremes lies the semantic space of informed breadth and depth, in which information can grow as new but always incomplete knowledge about symbols. The informed breadth of a symbol consists of "all the real things of which it is predicable" in a knowledge state in which "all the information at hand must be taken into account" (CP 2.407). Its informed depth consists of "all the real characters … which can be predicted of it … in a supposed state of information" (CP 2.407). *Information* is thus a third logical quantity between depth and breadth. Peirce calls it the "implication" of a symbol (W1:465). The word *man* has no more than one meaning, but it has many biological, religious, political and other implications which go beyond the mere lexical definition of the word (W1:465-466). In this sense, informational implication takes into account all available knowledge and not only the defining characters from which lexical definitions are made up.

Thus, Peirce does not define *implication* in the sense of structural semantics, where the semantic implications of words have the form of semantic features, which are fragments of definitions, for example, the features of *human*, *female*, and *adult*, as features of woman. Definitions are not informative since nothing new can be learned from them. They are not ampliative (see section 3.4; see also De Tienne, 2005, p. 160). Instead of the implications inherent in the meaning of word, Peirce means implications in the sense of all available biological, psychological, sociological, and cultural knowledge, in this case, about adult females. Since the sum total of this knowledge changes in time, the information conveyed by a word cannot be derived

from a knowledge base of unchangingly true sentences. Peirce calls the lexical knowledge of words *verbal knowledge* and specifies that verbal knowledge does not convey information: "I do not call the knowledge that a person known to be a woman is an adult, nor the knowledge that a corpse is not a woman, by the name 'information,' because the word 'woman' *means* a living adult human being having female sexuality. Knowledge that is not informational may be termed 'verbal'" (MS 664:20, 1910; see also Johansen, 1993, p. 147).

Verbal knowledge in this sense is not informative but redundant because knowledge of the lexical meaning of a word is a prerequisite for understanding and using the word and because it is only knowledge of the system of signs. Nothing new can be learned from knowing words as words because knowledge is knowledge of real things. Peirce underlines this insight in a letter to William James of 1909: "Acquaintance with the system of signs … is the prerequisite for getting any idea signified by the Sign" (CP 8.179 or EP2:494). Information grows in propositions, arguments, discourse, and in the experience of real facts and things.

3.2 Information as the Interpretant of a Symbol: The Growth of Symbols Through Information

Above (section 2.3), we saw how Peirce's theory of information anticipates elements of his later theory of the interpretant. Knowledge grows through interpretation, or as Peirce puts it: in their interpretants, signs grow in information (CP 3.608, 1908). Information thus pertains to the interpretant of a sign. It is created in a process in which a sign is interpreted in a new and more informative sign, the latter being the interpretant of the former. Not all interpretants convey information since interpretants can be mere feelings or reactions (see Nöth, 2011a). Instead, information is that kind of interpretant in which symbols are translated into new and more developed symbols. This is why information is the quantitative aspect of a symbol. In metaphors of biological growth, Peirce describes how terms grow in interpretants which are more informative:

> The process of getting an equivalent for a term is an identification of two terms previously diverse. It is, in fact, the process of nutrition of terms by which they get all their life and vigor and by which they put forth an energy almost creative—since it has the effect of reducing the chaos of ignorance to the cosmos of science. Each of these equivalents is the explication of what there is wrapt up in the primary—they are the surrogates, the interpreters of the original terms. They are new bodies animated by the same soul. I call them the *interpretants* of the term. And the quality of these *interpretants*, I term the *information* or *implication* of the term. (W2:465)

If symbols can create new information and information can only be conveyed in the form of symbols, we are faced with an autopoietic process which Peirce illustrated as follows: "Perhaps the most marvellous faculty of humanity is one which it possesses in common with all animals and in one sense with all plants, I mean that of procreation. … If I write 'Let *Kax* denote a gas furnace', this sentence is a symbol which is creating another within itself" (W1:497 or CP 7.590).

3.3 Information as Knowledge Produced by a Message and as a State of Knowledge
Peirce defines information from two complementary perspectives. On the one hand, information is the product of a message in which the combination of a subject term with a predicate term conveys new knowledge by increasing the quantities of extension or intension of a symbol. On the other hand, information describes a state of knowledge, which interpreters have reached before they interpret an actual message. Both states of knowledge characterize different ways of knowledge acquisition and different types of information. The information learned from an actual message is new information, produced by this very actual message. When Peirce writes "If you inform me of any truth, and I know it already, there is no information" (MS 463:13, 1903), he refers to this kind of actual information. The information state characterizing a knowledge state before a new message increases it is, so to speak, old knowledge acquired through previous learning. The distinction gives a useful foundation to what Dretske defines as the relativization of meaning, the insight that nothing is informative to the omniscient interpreter, whereas everything is informative to the newborn child (see section 1.). The information state of the former is unlimited, whereas the information state of the latter is zero.

Actual information extends the knowledge horizon of the interpreter. The new state of knowledge contrasts with the old one since "nothing can appear as definitely new without being contrasted with a background of the old" (CP 7.188, ca. 1901). This is what actual information has in common with learning. The progress from old to new information is also a characteristic of reasoning in general; it explains why we can learn through logical inferences, for: "Every reasoning connects something that has just been learned with knowledge already acquired so that we thereby learn what has been unknown" (CP 7.536, ca. 1899).

Information states as previously acquired states of knowledge are never static but change with every moment in which new information is communicated. This dynamic aspect of Peirce's concept of information distinguishes it from the knowledge horizon of Carnap' and Bar-Hillel's static repertoire of true statements. Knowledge grows and since it does so, we have more or less knowledge at any given point in time. This makes information a quantity. Information is the measure of how much a symbol "involves more or less real knowledge" (W1:187).

Communication presupposes both sameness and differences between the information states of speakers and hearers. On the one hand, for a message to be informative the knowledge state of an utterer should be different from the one of the interpreter. On the other, communicators must have a general common knowledge horizon, and the message must be related to some real experience of both. Peirce writes: "If there be anything that conveys information and yet has absolutely no relation nor reference to anything with which the person to whom it conveys the information has, when he comprehends that information, the slightest acquaintance, direct or indirect—and a very strange sort of information that would be—the vehicle of that sort of information is not, in this volume, called a Sign" (CP 2.231, 1910). Information as knowledge produced by an actual message and information as a state

of acquired knowledge are thus complementary insofar as the latter grows from the former, not only in communication but also in thought, which Peirce describes as fundamentally dialogic, too.

3.4 Analytic and Synthetic Statements, Explicative and Ampliative Reasoning
The above example of the lexical meaning of the word *woman* serves to illustrate the insight that analytic statements pertain to merely verbal knowledge and are therefore uninformative. Analytic statements, such as "Women are female adults" or "Fathers are male parents," convey no information because their predicates only explicate what is already by its definition logically implied in their subject terms. For a proposition to convey information, it needs to be a synthetic statement, which denotes an object and attributes a predicate to it which is not yet inherent in the definition of the subject term.

However, the traditional opposition between analytic and synthetic statements is only valid against the background of a state of knowledge which needs to be specified and it may lose its validity when different knowledge states are assumed or when these states change (see also Johansen, 1993, p. 159). Statements are only truly analytic and convey merely redundant verbal knowledge, devoid of information, when a knowledge state is assumed which includes the full knowledge of the essential depth and breadth of the terms contained in the proposition. The same proposition may be informative to interpreters only incompletely familiar with the definiendum. The definitions "Capybaras are rodents" or "Whales are mammals" are synthetic statements to interpreters with insufficient knowledge of these species of animals, but analytic statements to the zoologist.

Peirce generalizes the traditional distinction between analytical and synthetic statements in his distinction between *explicative* and *ampliative* propositions (W1:458). A proposition whose predicate term merely explicates the implication contained in its subject term conveys no new information. To convey information, a proposition must be ampliative: what the predicate term signifies must not yet be denoted by the subject term. Analytical statements are thus another point zero of informativity. The more a proposition is synthetic the more it is informative. Furthermore, since analytical statements are necessarily meaningful and true without being informative, Peirce's theory is in agreement with Dretske's theory of information, which equally postulates that meaningfulness and truth are no sufficient criteria of informativity.

4. Information Growth Through Terms, Propositions, and Arguments

How information grows can best be illustrated by information created through propositions and arguments, which serve to increase a given state of knowledge through an actual message. Stjernfelt (2011, p. 47) even argues that only propositions (dicents) can convey information. Terms, however, do have information, although in a different sense. Whenever our information concerning the meaning of a term (rheme)

changes or increases we have more information about its meaning than before. To say that a word (term or rheme) has information means that it has accumulated meanings in the course of time. Peirce's calculus of information of the 1860s discussed in this section is based on the logic of terms outlined above. In a footnote from 1893, he acknowledges that this first method of calculating information on the basis of terms had been too restricted:

> I had not remarked that the whole doctrine of breadth and depth was equally applicable to *propositions* and to *arguments*. The breadth of a proposition is the aggregate of possible states of things in which it is true; the breadth of an argument is the aggregate of possible cases to which it applies. The depth of a proposition is the total of fact which it asserts of the state of things to which it is applied; the depth of an argument is the importance of the conclusions which it draws. In fact, every proposition and every argument can be regarded as a term. (CP 2.407n)

If every proposition and argument can be regarded as a term, the difference between terms and propositions cannot be as fundamental as authors postulate who argue that only propositions can convey information. The reason why terms (*rhemes*) are semantically similar to propositions (*dicents*) is that rhematic symbols also have breadth and depth. The two are combined in their lexical and encyclopedic definitions as well as in the discourse universe in which they occur. In isolation, mere words are only fragments of the propositions and arguments in which they denote or signify. Denotation always presupposes signification and signification is not possible without denotation.

4.1 How Information is Created by Propositions: The Law of Information
A proposition is best suitable to illustrate the semantic growth of information since the increase of depth and breadth can here be exemplified by the semantic syntax of its subject with its predicate. In 1905, Peirce circumscribes this growth as follows:

> An ordinary Proposition ingeniously contrives to convey novel information through Signs whose significance depends entirely on the interpreter's familiarity with them; and this it does by means of a 'Predicate,' *i.e.*, a term explicitly indefinite in breadth, and defining its breadth by means of 'Subjects,' or terms whose breadths are somewhat definite, but whose informative depth (i.e., all the depth except an essential superficies) is indefinite, while conversely the depth of the Subjects is in a measure defined by the Predicate. (CP 4.543, 1905)

In the course of the interpretation of a proposition, we find that the combination of a subject with a predicate term changes the extension and the intension of the symbol, creating new information: "No proposition … leave[s] its terms as it finds them," says Peirce (W1:277). Propositions are thus a source of the growth of symbols and of the acquisition of new knowledge. Peirce gives the example of the proposition "No Britons are slaves." Here, the combination of the subject term, *Britons*, with the predicate term, *slaves*, has the effect of modifying both the extension and the intension of the former since it makes "non-slave to be an additional mark of Britons and also exclude[s] slaves from those objects which are Britons" (W1:277). Hence, the

intension of the symbol *Britons* is deepened because of the addition of *non-slaves* to the set of its attributes. At the same time, this symbol is narrowed in extension since the class of *slaves* is now excluded from the class *Britons*. This is why no proposition leaves its terms as it finds them and any new predicate attributed to a subject term increases the intension and reduces the extension of the latter.

Thus, with each new proposition, the extension of the subject term and the intension of the predicate term grow in information and convey new knowledge. The kind of growth differs according to the type of proposition. Propositions can focus on extension or intension only. There are extensive and intensive propositions: "An extensive proposition is defined to be one which states the relation between the extension of two terms. An intensive proposition is one which states the relation between the intension or comprehension of two terms" (W1:272).

In each synthetic statement, the predicate term thus conveys new information about the subject term in a process in which the intension of the one modifies the extension of the other. The knowledge concerning the extension of a subject term thus becomes modified through the intension of the predicate term of a proposition. "The proper office of the comprehension is [hence] to determine the extension of the term," so that "the information of a term is the measure of its superfluous comprehension" (W1:467). Terms have no superfluous meanings in their lexical definitions, which only formulate the minimum of meaning necessary for its interpretation. Instead of lexical meaning, superfluous meanings are elements of additional world knowledge. This is why information is "that amount of comprehension a symbol has over and above what limits its extension" (W1:287). As Johansen (1993, p. 148) puts it, information "is the set of characters which can be predicated of a symbol minus the characters contained in its verbal definition."

Since new contexts modify the extension and intension of a symbol and since this modification may be more or less significant, information can be measured quantitatively, although not with mathematical precision. As a measure of the quantity of information conveyed by a symbol, Peirce sets up the following formula according to which information is the product of the quantities of its extension and intension (comprehension):

$$\text{Extension} \times \text{Comprehension} = \text{Information},$$

which "crudely expresses the fact that the greater the extension the less the comprehension" (W1:465). This formula is an extension of the rule of the inverse relationship between extension and intension of symbols exemplified above with the sentence "No Britons are slaves," which showed that the diminution of the extension of one and the same term goes parallel with an increase of its intension so that the product of the two quantities remains constant. Peirce gives another example, namely that of the modification of the extension and intension that takes place when the noun *colour* is extended by adjectives, which have the logical status of predicate terms added to the noun as the subject term:

> Add to the comprehension of this term, that of *red*. *Red colour* has considerably less extension than *colour*; add to this the comprehension of *dark*; dark red colour has still less extension. Add to this the comprehension of *non-blue* – *non-blue dark red colour* has the same extension as *dark red colour*, so that the *non-blue* here … does none of the proper business of connotation, that of diminishing the extension at all. (W1:467)

Thus, only the addition of the predicates *red* and *dark* to the subject term is informative, whereas the addition *non-blue* is uninformative.

At this point, we see that Peirce is not talking about lexical but about discourse semantics, since the contextual modification of the general term *color* does not lead to a change of the lexical meaning of this word. The values of extension and intension, in this example, are only created by the semantic syntax of this particular expression, which does not characterize the meaning of *color* in general. The case was different in the example of "No Britons are slaves" since the subject term has a general meaning here so that the proposition conveys information about all Britons, which extends our encyclopedic knowledge about the people to which the term applies.

However, the formula "Extension ✗ Comprehension = Information" is not always applicable. The information conveyed by a proposition only remains constant within one and the same state of information, but the rule is not applicable when the state of information changes (see Johansen, 1993, p. 148), that is, when we acquire new knowledge from collateral experience or knowledge acquired from other propositions comes into play. In that case, the informational product increases with the increase of the new information and there is an increase of information with the "increase of either Extension or comprehension without any diminution of the other of these quantities" (W1:465).

4.2 How Arguments Convey Information

Arguments, too, convey a specific quantity of information expressed in conclusions derived from premises. Explicative inferences convey no information; only ampliative inferences do (see section 3.4). Deductive inference, which is an analytic mode of reasoning, is explicative and therefore conveys no (new) information. In a deductive syllogism, there is an increase of breadth in the major premise and an increase of depth in the minor premise, but the conclusion does not add anything to the information already contained in the premises (CP 2.243; see also CP 5.279).

Inductive and abductive (hypothetic) inferences, which are synthetic modes of reasoning, are ampliative; they alone are methods of discovery, which convey new information (see Levi, 1977, pp. 37-39). By generalizing the attributes of selected objects and attributing them to a larger set of objects, inductive conclusions inform by increasing the depth of their subject terms. By generalizing attributes previously only attributed to some other individuals and thus increasing the breadth of predicate terms, abductive conclusions enlarge the depth of subject terms denoting new individuals (see De Tienne, 2005, pp. 154). This is how information grows in cognitive processes: "At any moment we are in possession of certain information, that is, of cognitions which have been logically derived by induction and hypothesis from previous

cognitions which are less general, less distinct, and of which we have a less lively consciousness" (CP 5.311, 1868).

4.3 The Growth of Information in Terms (Rhematic Symbols): Deriving vs. Conveying Information

In contrast to Dretske and others (see also Floridi, 2005), who argue that only propositions can convey information (provided they are true), Peirce also attributes information to terms and, hence, to mere words. Not only dicentic and argumentative symbols (propositions and arguments) are informative but also rhematic symbols such as mere words. In 1865, Peirce writes: "A symbol not only may have information but it must have it. For every symbol must have denotation that is must imply the existence of some thing to which it is applicable" (W1:287), and in 1866, identifying information with the interpretant of a symbol, he affirms: "Since it is of the very essence of a symbol that it should stand *to* something, every symbol—every word and every *conception* – must have an interpretant—or what is the same thing, must have information or implication" (W1:467).

If only true sentences can convey information, this conclusion must surprise since individual words can neither be true nor false; only propositions can. This may be the reason why Peirce, in a reconsideration of his theory of information in 1903, modalizes his thesis that rhematic symbols have information by adding a "perhaps": "A Rheme is a Sign which, for its Interpretant, is a Sign of qualitative Possibility, that is, is understood as representing such and such a kind of possible Object. Any Rheme, perhaps, will afford some information; but it is not interpreted as doing so" (CP 2.250). The difference which Peirce makes here between offering (affording) and conveying information becomes still clearer in another distinction which he draws in the same year, the one between information which is derived from and information which is conveyed by symbols. Only dicents (and arguments) can *convey* information; only they are "the kind of sign that *conveys* information, in contradistinction to a sign from which information may be derived" (CP 2.309, 1903). Rhematic symbols do not convey and are not interpreted as conveying information, but they afford the information which can be derived through knowledge accumulated in them and whatever they imply if this knowledge is taken into consideration.

This also explains why information is "the sum of synthetical propositions in which the symbol is subject or predicate" (W2:59,83). In this definition, too, *symbol* refers to a term (rheme), and not to a proposition. The sum of synthetical propositions in which a symbol may be used is the knowledge accumulated in it in the course of the history of the language to which it belongs and in the universe of discourse in which they occur.

In sum, if words have information, they have so in a different sense than that in which propositions and arguments have. It is not information produced by an actual symbol but acquired information. Peirce's theory is that rhematic symbols acquire information as they come to mean more than they did before. In the course of the

growth of information in this process, words do not act autonomously without the agency of humans who use them, but the human sign users do not either, for:

> Man makes the word, and the word means nothing which the man has not made it mean, and that only to some man. But since man can think only by means of words or other external symbols, these might turn round and say: "You mean nothing which we have not taught you, and then only so far as you address some word as the interpretant of your thought." In fact, therefore, men and words reciprocally educate each other; *each increase of a man's information involves and is involved by, a corresponding increase of a word's information*. (CP 5.313, 1868, italics added)

5. Peirce's Later Extended Theory of Information

One of the major advances in Peirce's later theory of information consists in its extended applicability to signs in general, not only to verbal symbols. Now, Peirce's distinctions between the sign considered in relation to its object (as icon, index, or symbol) and to its interpretant (as rheme, dicent, or argument) become relevant to his study of information. In the framework of his more developed semiotics, his early logic of the traditional term-proposition-argument trichotomy is reinterpreted in his more general trichotomy of rhematic, dicentic, and argumentative signs already introduced above, and his early logic of terms and their breadth and depth is reconsidered from the perspective of the icon-index-symbol trichotomy. This broader framework of a more fully developed semiotics raises the question whether only symbols can offer or convey information or whether indices and icons can do so too. As so often, Peirce's answer is more differentiated than a mere yes or no. If pure icons and genuine indices are considered, the answer is no, but insofar as symbols contain icons and indices, these signs contribute to their informativity. Not only may information be derived from them but they are also even necessary for any sign to be informative.

5.1 Why Pure Icons and Genuine Indices Do Not Convey Information, Although Information May Be Derived From Them

There are several reasons why pure icons cannot convey information. One is that pure icons are rhemes from which information can only be derived (see section 4.3). Another reason is that they are inherently vague, representing nothing but mere possibilities (see Nöth, 2002). Peirce underlines this incapacity of icons to be informative repeatedly. In 1896, he writes: "The idea embodied by an icon … cannot of itself convey any information, being applicable to everything or to nothing" (CP 3.433), and in 1904, specifying that his topic is the pure icon, he writes:

> A pure icon is independent of any purpose. It serves as a sign solely and simply by exhibiting the quality it serves to signify. The relation to its object is a degenerate relation. It asserts nothing. If it conveys information, it is only in the sense in which the object that it is used to represent may be said to convey information. An *icon* can only be a fragment of a completer sign. (EP2:306)

What he says about pure icons, that is, signs which merely have the quality of whatever they represent, Peirce also extends to pictures, which he sometimes calls hypoicons in contrast to pure icons:

> But pictures alone,—pure likenesses,—can never convey the slightest information. [… The figure of a wheel …] leaves the spectator uncertain whether it is a copy of something actually existing or a mere play of fancy. The same thing is true of general language and of all *symbols*. No combination of words (excluding proper nouns, and in the absence of gestures or other indicative concomitants of speech) can ever convey the slightest information. (EP2:7, 1893)

Notice that Peirce here also extends his argument of the lack of information of rhemes to symbols. He does so because he is speaking about the role of symbols in actual communication. As long as they remain general they cannot increase the information state of an actual interpreter. This is not the sense in which symbolic rhemes do have information discussed above (section 4.3).

For different reasons, genuine *rhematic indices* also lack information. These signs can only show their object without informing about it. Peirce describes this particular incapacity of rhematic indices to inform as follows: "The index asserts nothing; it only says 'There!' It takes hold of our eyes, as it were, and forcibly directs them to a particular object, and there it stops" (CP 3.361).

However, although pure icons and genuine indices are uninformative, icons in their various combinations with indices and symbols, especially in diagrams, contribute to information since information may be derived from them. This is why Peirce, elsewhere, modalizes his affirmation concerning the lack of information in icons by saying that "there *ought … to be* no informational signs among Icons" (CP 2.314, 1903; italics added). Despite their vagueness, icons do not only contribute to information, they are even highly efficient in doing so: "We find that, in fact, Icons may be of the greatest service in obtaining information—in geometry, for example" (CP 2.314, 1903). The inherent vagueness of icons is mainly compensated by their combination with indices which establish the link between the purely imaginary of the icon and the reality indicated by the index. Only in combination with an icon can an index become informative. As De Tienne (2003, p. 49) puts it: "An index without an icon is blind, a symbol without an index is empty. Pure indexes and pure symbols do not occur, except within the abstract classification of semiotic theory, where their isolation is of course most convenient."

5.2 The Indexicality of Denotation and the Iconicity of Signification

In 1865, Peirce uses the dichotomies of *comprehension*, *meaning*, or *intension* vs. *denotation* and *extension* to characterize symbols in contrast to icons (in the terminology of his early writings: *copies*) and indices (called *signs* at the time) and to explain why only symbols can serve as logical terms:

> A term has comprehension in virtue of having a meaning and has extension in virtue of being applicable to objects. The meaning of a term is called its *connotation*; its applicability to things its

denotation. Every symbol *denotes* by *connoting*. A representation which *denotes* without *connoting* is a mere *sign* [i.e., *index*]. If it *connotes* without thereby *denoting*, it is a mere *copy* [i.e., *icon*]. (W1:272)

In his later semiotics, Peirce reinterprets propositions as symbolic dicents incorporating an index and an icon. The icon assumes the role of signification (depth). The predicate of a proposition is reinterpreted as an icon (see Ransdell, 2005). The role of the index is the one of denotation (breadth). The subject of a proposition involves an index whose purpose it is to link the symbol to the reality denoted by it. The icon, by contrast, evokes the images of qualities and characteristics of the object and thus assures that the sign has signification: "A proposition consists of two parts, the *predicate* which excites something like an image or dream in the mind of the interpreter, and the subject, or subjects, each of which serves to identify something which the predicate represents" (MS 280:32, c.1905).

Only together can icons, indices, and symbols become informative. Any proposition is a dicent from the point of view of its interpretant and a symbol as to its object relation, but the dicentic symbol includes an index in its subject and an icon in its predicate. For example, in order to understand the proposition "The leaves are green," the interpreter needs to relate the symbolic rheme *leaf* indexically to its denotatum, i.e., some real foliage, and combine it with an icon, a mental image of the color green. This is how information is reinterpreted in the framework of a new semiotic syntax (see Kappner, 2004, pp. 215-219).

The interaction of iconicity and indexicality in an informative dicent is a pervasive topic of Peirce's theory of information. In a manuscript of 1902, Peirce describes how it gives rise to information:

> Every proposition is capable of expression either by means of a photograph, or composite photograph … together with some *sign* which shall show the connection of these images with the object of some index, or sign or experience forcing the attention, or bringing some information, or indicating some possible source of information; or else by means of some analogous icon appealing to other senses than that of sight, together with analogous forceful indications, and a sign connecting the icon with those indices. (MS 599:9; Johansen, 1993, p. 231)

The requirement of the object's indexical anchorage in the hearer's world of actual experience applies to facts in time and space. Vague and merely iconic signs can only fail to be informative. Without an index, no iconic representation can represent facts and reality since "the real world cannot be distinguished from a fictitious world by any description" (CP 2.337, 1903). Peirce illustrates the requirement of indexicality for informativity by the following example:

> Two men, *A* and *B*, meet in a country road, when the following conversation ensues:
> B. The owner of that house is the richest man in these parts.
> A. What house?
> B. Why do you not see a house to your right about seven kilometres distant, on a hill?
> A. Yes, I think I can descry it.
> B. Very well; that is the house.

> Thus, *A* has acquired information. But if he walks to a distant village and says "the owner of a house is the richest man in those parts," the remark will refer to nothing, unless he explains the interlocutor how to proceed from where he is in order to find that district and that house. Without that, he does not indicate what he is talking about. To identify an object, we generally state its place at a stated time; and in every case must show how an experience of it can be connected with the previous experience of the hearer. (EP2:7, 1893)

Here, we are faced with the scenario of an actual interpreter increasing his state of information through information obtained from an utterer. The dialogue shows that whatever the utterer says remains vague and uninformative to the interpreter as long as indexical signs are missing, which allow the identification of the objects denoted by the utterer's discourse. The information which B's utterance "actually does excite" in the interpreter A pertains to the *actual interpretant* of the sign (MS 854:2-3, 1911; Johansen, 1993, p. 146). It corresponds to the information intended by speaker B. The *intended information* of the symbol uttered by B, in turn, differs in its meaning from the meaning inherent in its essential breadth and depth (see section 2.3) insofar as the implications this symbol seeks to excite are "perhaps only a part of the essential characters perhaps others not essential and which the word now excites" (MS 854:2-3, 1911).

However, as we have seen above (section 4.3), information is not always necessarily conveyed from a speaker to a hearer, according to Peirce's information theory. The sign itself conveys its own information, which it has independently of the speaker's intentions (see Nöth, 2009). Whereas the knowledge *conveyed* by the sign must be *interpreted* by some interpreter for the process of semiosis to be completed, an actual interpretation is not required for the sign to *have* information. It is active even if it is not interpreted through an "effort" to convey its message, which may fail. This is what Peirce means when he writes: "An ordinary Proposition ingeniously *contrives to convey novel information* through Signs whose significance depends entirely on the interpreter's familiarity with them" (CP 4.534, 1905; italics added).

In cognitive respects, too, the interpreter of the sign is not the only agent who produces information. It is true that a state of information is a state of knowledge of an interpreter, but, as Peirce also points out, "all our knowledge comes to us by observation" (CP 1.238, 1902); and since observation is observation of reality and "the real is that whose characters are independent of what anybody may think them to be" (CP 5.405, 1877), the information conveyed to the interpreter is also determined by the object of the sign, and hence a sphere of reality independent of the semiotic agency of the interpreting subject.

5.3 Information Offered by Pictures, Natural, and Other Nonverbal Signs

Peirce's ten main classes of sign (CP 2.254, 1903; 8.341, 1904) can be consulted for answers to the question whether only verbal symbols or also other signs can have information. As seen above, rhemes are signs which cannot convey but only offer information, whereas dicents and arguments have the full potential of conveying information (see section 4.3). Now, six of Peirce's ten main sign classes are rhematic

signs and do hence only qualify for affording, not for conveying information through their implications. Among the four remaining sign classes, there are two which consist of symbols, the ones which Peirce had previously discussed as (verbal) propositions and arguments, the classes nine (*dicent symbol*) and ten (*argument*). The two remaining nonsymbolic dicentic signs among are indexical ones, *dicent* (*indexical*) *sinsigns* and *dicent indexical legisigns*. As dicents, they belong to the class of signs which have the potential of conveying information. Does this mean that indices may convey information, too?

The prototypical example of a *dicent indexical sinsign* conveying information is a weathercock indicating the wind direction. Being a sign caused by forces of nature it is not a symbol but an index, and being singular, it is a sinsign. Peirce describes how this sign conveys information as follows:

> A Dicent Sinsign [e.g., a weathercock] is any object of direct experience, in so far as it is a sign, and, as such, affords information concerning its Object. This it can only do by being really affected by its Object; so that it is necessarily an Index. The only information it can afford is of actual fact. Such a Sign must involve an Iconic Sinsign to embody the information and a Rhematic Indexical Sinsign to indicate the Object to which the information refers. But the mode of combination, or Syntax, of these two must also be significant. (CP 2. 257, 1903)

Here, Peirce says explicitly that to convey information, a sign does not need to be a symbol, which extends Peirce's early theory of information, which was restricted to symbols.

A second example of an informative dicent indexical sinsigns is a photograph. It is an informative dicent since it is "known to be the effect of the radiations from the object renders it an index and highly informative" (CP 2.265, 1903). Peirce interprets the capacity of photographs to convey information as follows: "The mere print does not, in itself, convey any information. But the fact, that it is virtually a section of rays projected from an object otherwise known, renders it a Dicisign" (CP 2.320, 1903).

Portraits (whether photographic or not) with a legend are a third example of informative dicent indexical sinsigns incorporating iconic components. Peirce gives the example of "a portrait of Leopardi with Leopardi written below it" which "conveys its information to a person who knows who Leopardi was, and to anybody else" to whom "it only says 'something called Leopardi looked like this'" (CP 8.183, 1909; for further examples see Stjernfelt, 2011).

Dicent indexical sinsigns usually incorporate diagrams. As icons, diagrams cannot convey information on their own because without an index, they remain unconnected with any real objects which they could denote, and to be informative without having denotation would be against the law of information (section 4.1). However, as part an indexical dicent, a diagram indeed contributes to the information which the dicent conveys. Maps are a case in point, even when they do not incorporate verbal symbols, which most maps do. A map conveys its information by means of cartographic indices, which orient map readers in the territory represented by the map. From the diagrammatic form of the map, the map reader derives information by observing how

the cartographic configurations are related among themselves (without reference to anything else).

Peirce describes this process as follows: "The geometer draws a diagram …, and by means of observation of that diagram he is able to synthesize and show relations between elements which before seemed to have no necessary connection" (CP 1.383, 1890; see Nöth, in press). This potential for deriving information from icons explains why it is the "great distinguishing property of the icon … that by the direct observation of it other truths concerning its object can be discovered than those which suffice to determine its construction" (CP 2.279, ca. 1895). The potential of diagrams to convey information is by no means restricted to map reading. It extends to all kind of structures and arrangements, even to the syllogism, whose arrangement in the form of two premises followed by a conclusion constitutes a mental diagram. This is why even deductive reasoning, although it does not convey new information (see 4.2), does imply information, which may be derived from its syllogistic form of two premises followed by a conclusion: "All deductive reasoning, even simple syllogism, involves … constructing an icon or diagram the relations of whose parts shall present a complete analogy with those of the parts of the object of reasoning … and of observing the result so as to discover unnoticed and hidden relations among the part" (CP 3.363, 1885).

The second class of nonsymbolic dicent signs able to convey information, the *dicent indexical legisign*, differs from the dicent indexical sinsigns only insofar as it comprises indexical signs which function as laws:

> A Dicent Indexical Legisign [e.g., a street cry] is any general type or law, however established, which requires each instance of it to be really affected by its Object in such a manner as to furnish definite information concerning that Object. It must involve an Iconic Legisign to signify the information and a Rhematic Indexical Legisign to denote the subject of that information. Each Replica of it will be a Dicent Sinsign of a peculiar kind. (CP 2.260, 1903)

Traffic signs and commands are further examples of dicent indexical legisigns. Among this class of informative signs are also deictic utterances such as the answer "It is Farragut" given in reply to the question "Whose statue is this?" (CP 2.265, 1903).

5.4 True and Other Kinds of Information
In his early logical approach to information, Peirce associates information with truth, for example, when he defines the informed breadth of a proposition as "the aggregate of possible states of things in which it is true" (CP 2.407n1) or the informed depth of a term as "all the real characters … which can be predicated of it (with logical truth, on the whole)" (CP 2.408, 1867). Notice, however, the modification of the criterion of truth by the adverbial "on the whole," as early as 1867. In 1906, Peirce explicitly abandons this criterion, when he suggests that information may also be false: "Besides the logical depth and breadth, I have proposed (in 1867) the terms *information* and

area to denote the total fact (true or false) that in a given state of knowledge a sign embodies" (EP2:305, 1904).

Peirce has thus a broader concept of information than most contemporary theoreticians of information, who postulate that statements are only informative if their meaning corresponds to real facts, but he also has a broader conception of truth. For Peirce, all propositions with denotation and signification convey information, not only the true ones. The information conveyed by a symbol may be "certain or doubtful" (W2:87), fictive or real, true or false. The fictive is informative as long as its factual reality is not impossible, for "the Possible, in its primary meaning, is that which may be true for aught we know, that whose falsity we do not know" (CP 3.374, 1885).

Peirce's pragmatic concept of truth is broader than the semantic correspondence theory of truth. The true is not necessarily the correspondence of statements with the facts they denote. Truth may even "be in some sense a creation of the mind," although "once created, it must be in a measure independent of thought" (MS 463:9-10, 1903). It includes the possible and informative as long as its falsity remains unknown, for "that is possible which, in a certain state of information, is not known to be false" (CP 3.442, 1896). The untrue is informative since it conveys information about its lack of reality: "The cognitions which … reach us … are of two kinds, the true and the untrue, or cognitions whose objects are real and those whose objects are unreal. And what do we mean by the real? … The real, then, is that which, sooner or later, information and reasoning would finally result in, and which is therefore independent of the vagaries of me and you" (CP 5.311, 1868).

This does not mean that information can be derived from all symbols. For example, no information can be derived from symbols lacking either denotation or connotation. In fact, combinations of symbols which are incomplete in either way are not even true symbols but only pseudo-symbols. As examples of such pseudo-symbols unable to convey information, Peirce discusses noun phrases which combine words without any semantic features in common:

> There are certain pseudo-symbols which are formed by combinations of symbols …, which lack either denotation or connotation. Thus, *cats and stoves* is a symbol wanting connotation because it does not purport to relate to any definite quality. *Tailed men* wants denotation; for though it implies that there are men and that there are tailed things, it does not deny that these classes are mutually exclusive. All such terms are totally wanting in *information*. (W1:288)

Informative signs do not only convey information about what was true in the past or what is presently true but also what will be true in the future, for "[a]n icon has such being as belongs to past experience. It exists only as an image in the mind. An index has the being of present experience. The being of a symbol consists in the real fact that something surely will be experienced if certain conditions be satisfied" (CP 4.447, ca. 1903). The relevance of this insight to the theory of information consists in the definition of information as new knowledge for, as Peirce points out, knowledge is not only knowledge about the past but also about the future: "Knowledge which should

have no possible bearing upon any future experience—bring no expectation whatever—would be information concerning a dream" (CP 5.542, 1902).

6. Information as In-formation: Metaphysical Matters

In a note of 1893, Peirce distinguishes three concepts of information (CP 2.418n; cf. Debrock, 1996, p. 79). The first is the "ordinary use of this word," which Peirce circumscribes as "testimony given privately." Although Peirce adds that his own use of the terms "departs widely" from this meaning of the word, his pragmatic definition of information as new knowledge conveyed through symbols is quite compatible with the ordinary contemporary sense of the word. The second is the logical concept of information "as a measure of predication," a formulation with which Peirce summarizes his own theory of information as a product of extension and intension in synthetic propositions. The third is from "metaphysics, [where] information is the connection of form and matter" (CP 2.418n). Contemporary information sciences are far remote from metaphysical positions, but Peirce warns against the neglect of metaphysics with the argument that "those who neglect philosophy have metaphysical theories as much as others—only they [have] rude, false, and wordy theories" (W1: 490; CP 7.579).

To understand Peirce's metaphysical premise that "information is the connection of form and matter" (see above, section 2.3), a brief look at the ancient dichotomy of form and matter is prerequisite. Peirce defines the two terms in 1902 (CP 6.553-563), pointing out that the Latin word *materia* has its metaphysical root in the ancient Greek term *hylé*, which, in turn, is closely associated to *sōma* (corpus, body) and *hypokeimenon*, whose Latin counterpart is *subjectum*. L. *forma*, by contrast, translates both Gr. *morphé* and *eidos*, which are "pretty nearly synonyms" (W2:544) of *ideia* (among others). Metaphysically, form manifests itself in the characters that distinguish a thing from other things. Peirce says therefore that the "being [of form] is a being of the predicate" (W2:544, 1906).

If matter is thus associated with subjects and form with predicates, Peirce's thesis that information combines form with matter can be read as a metaphysical underpinning of his theory that information results from the synthesis of a subject with a predicate term in a proposition. The ancient association of matter with *corpus* and *body*, on the one hand, and form with *idea*, on the other, corroborates this assumption since, according to Peirce's early definitions, subject terms represent things or objects, whereas a predicate term attributes characters or qualities to the subject term.

In this context, De Tienne sees the following parallels between Peirce's early conception of subject and predicate terms and the ancient dichotomy of matter vs. form:

> Any synthetic proposition of consequence must have matter to matter at all, and form to mean anything. … [It] must minimally consist of, first, some component that represents … some individual thing(s) that the proposition is itself singling out …, the subject-matter of the proposition, or its "subject" …. Second, any proposition needs to reveal some character, relational property, or

form, that is somehow connected to the subject; whether we call it quality, attribute, modifier, relative, or otherwise, such a character must really belong to the subject in order to be predicated of it. (De Tienne, 2005, pp. 153-154)

If matter and form are thus metaphysically present in each proposition, it becomes better understandable why information is in-formation in the sense of giving a form. The notion of form, thus defined, can also elucidate Peirce's somewhat enigmatic thesis that "a Sign may be defined as a Medium for the communication of a Form" (EP2:544, 1906). The form, which "is communicated from the Object through the Sign to the Interpretant" (EP2:544), is first embodied in the object of the sign as the object's potential to create the same effect of signification which the sign creates when it represents the object. Form is embodied representatively in the symbol insofar as the Form communicated by the object of the Sign "produces upon the interpretant an effect similar to that which the Object itself would under favorable circumstances" (EP2:544; see also W1:172, 1865).

References

Bar-Hillel, Y. (1964). *Language and information*. Reading, MA: Addison-Wesley.
Bar-Hillel, Y., & Carnap, R. (1953). Semantic information. In W. Jackson (Ed.), *Communication theory* (pp. 503-512). London: Butterworth.
Cherry, C. (1970). *On human communication* (2nd ed.). Cambridge, MA: The MIT Press. (1st ed., 1957)
Debrock, G. (1996). Information and the metaphysical status of the sign. In V. M. Colapietro & T. M. Olshewsky (Eds.), *Peirce's doctrine of signs: theory, applications, and connections* (pp. 79-89). Berlin: Mouton de Gruyter.
De Tienne, A. (2003). Learning *qua* semiosis. *S.E.E.D. Journal – Semiotics, Evolution, Energy, and Development, 3*, 37-53. (Retrieved May 9, 2012 from http://www.library.utoronto.ca/see/SEED/Vol3-3/De_Tienne.htm)
De Tienne, A. (2005). Information in formation: A Peircean approach. *Cognitio, 6* (2), 149-156. (Also online as: Peirce's logic of information. *Seminario del Grupo de Estudios Peirceanos*, Universidad de Navarra 28-09-2006. Retrieved May 9, 2012 from www.unav.es/gep/SeminariodeTienne.html.)
Dretske, F. I. (1981). *Knowledge and the flow of information*. Cambridge, MA: The MIT Press.
Dretske, F. I. (2008). The metaphysics of information. In A. Pichler & H. Hrachovec (Eds.), *Wittgenstein and the philosophy of information: Proceedings of the 30th International Ludwig Wittgenstein-Symposium in Kirchberg, 2007* (pp. 273-284). Frankfurt: Ontos.
Floridi, L. (2005). Is semantic information meaningful data? *Philosophy and Phenomenological Research, 70* (2), 351-368.
Hanson, P. P., (Ed.) (1990). *Information, language, and cognition*. Vancouver: University of British Columbia Press.
Israel, D., & Perry, J. (1990). What is information? In P. P. Hanson (Ed.), *Information, language and cognition* (pp. 1-19). Vancouver: University of British Columbia Press.
Johansen, J. D. (1993). *Dialogic semiosis*. Bloomington, IN: Indiana University Press.
Kappner, S. (2004). *Intensionalität aus semiotischer Sicht: Peirceanische Perspektiven*. Berlin: de Gruyter.
Levi, I. (1997). Inference and logic according to Peirce. In J. Brunning & P. Forster (Eds.), *The rule of reason: The philosophy of Charles Sanders Peirce* (pp. 34-56). Toronto: Toronto University Press.
Liszka, J. J. (1996). *A general introduction to the semeiotic of Charles S. Peirce*. Bloomington, IN: Indiana University Press.
Marty, R. (1997). *76 definitions of the sign by C. S. Peirce collected and analyzed by Robert Marty*. Retrieved May 21, 2012 from http://www.cspeirce.com/menu/library/rsources/76defs/76defs.htm
Nauta, D., Jr. (1972). *The meaning of information*. The Hague: Mouton.
Nöth, W. (2002). Semiotic form and the semantic paradox of the abstract sign. *Visio, 6* (4), 153-163.
Nöth, W. (2009). On the instrumentality and semiotic agency of signs, tools, and intelligent machines. *Cybernetics & Human Knowing, 16* (3-4), 11-36.
Nöth, W. (2011a). From representation to thirdness and representamen to medium: Evolution of Peircean key terms and topics. *Transactions of the Charles S. Peirce Society, 47* (4), 445-481.
Nöth, W. (2011b). Representation and reference according to Peirce. *International Journal of Signs and Semiotic Systems, 1* (2), 28-39.
Nöth, W. (in press). Medieval maps: Hybrid ideographic and geographic sign systems. In I. Baumgärtner & M. Stercken (Eds.), *Herrschaft verorten: Politische Kartographie des Mittelalters und der Frühen Neuzeit*. Zürich: Chronos.

Peirce, C. S. (1931-58). *Collected papers* (Vols. 1-6, C. Hartshorne & P. Weiss, Eds.; Vols. 7-8, A. W. Burks, Ed.). Cambridge, MA: Harvard University Press (cited as CP Vol.Paragraph).

Peirce, C. S. (1977). *Semiotic and significs: The correspondence between Charles S. Peirce and Victoria Lady Welby*, ed. C. S. Hardwick. Bloomington, IN: Indiana University Press (cited as SS).

Peirce, C. S. (1979). *The Charles S. Peirce papers* (30 reels, 3rd microfilm edition). Cambridge, MA: The Houghton Library, Harvard University, Microreproduction Service (cited as MS).

Peirce, C. S. (1982). *Writings of Charles S. Peirce, Vol. 1: 1857-1866*. Bloomington, IN: Indiana Univ. Press (cited as W1:page).

Peirce, C. S. (1984). *Writings of Charles S. Peirce, vol. 2: 1867-1871*. Bloomington, IN: Indiana Univ. Press (cited as W2:page).

Peirce, C. S. (1998). *The essential Peirce. Selected philosophical writings, Vol. 2: 1893-1913* (Peirce Edition Project, Ed.). Bloomington, IN: Indiana University Press (cited as EP2).

Ransdell, J. (compiler) (2005). *Passages from Peirce, chronologically ordered, on the role of icons in predication*. Retrieved April 12, 2012 from http://www.cspeirce.com/rsources/quotes/iconrole.htm

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

Stjernfelt, F. (2011). Signs conveying information: On the range of Peirce's notion of propositions: Dicisigns. *International Journal of Signs and Semiotic Systems, 1* (2), 40-52.

Weizsäcker, E. von. (1984). Überraschung und Bestätigung gibt Information. In G. Schaefer (Ed.), *Information und Ordnung* (pp. 89-98). Köln: Aulis.

Freeman, O. (2006). *Metal Storm*. Oil on canvas; 150 x 120 cm.