Information as Ontologization

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The traditional view of data, information, and knowledge as a hierarchy fosters an understanding of information as an independent entity with objective meaning—that while information is tied to data and knowledge, its existence is not dependent upon them. While traditional conceptions assume a static nature of information, expressed by the equation information = data + meaning, we have argued that this understanding is based on an ontologization of an entwined process of sense making and meaning making. This process starts from the recognition of a pattern that is interpreted in a way that influences our behavior. At the same time, the process character of meaning making makes us aware of the fact that this ontologized hierarchy is in fact an interwoven process. We conclude that the phenomenological analysis of this ontologization that makes into being data, information, and knowledge has to go back to this process to reveal the essential underlying dependencies.

The traditional view of the relations between data, information, and knowledge is often described as a data-information-knowledge hierarchy (Rowley, 2007). It sees information roughly as data plus meaning and knowledge as information plus context. This idea of hierarchy recently reappeared in Floridi's (2009) information concept, where information is defined as comprising sets of well-formed (i.e., syntactically precise) and meaningful data that has a truth function. Meanwhile, others (Machlup, 1984a; Tuomi, 1999) have raised the question whether this hierarchy really makes sense, because the understanding of data is a process that depends on knowledge—in fact, data, information, and knowledge can be "said to be a specific type of each of the others, or an input for producing each of the others, or an output of processing each of the others" (Machlup, 1984b, p. 647). We want to address this question by examining the processes

and relations between data, information, and, to some extent, knowledge in more detail.

In this article, we will show that data basically describe patterns. We argue that it is only the process of sense making that makes data of patterns or, in other words, that we use the term data to describe patterns that have undergone a process of sense making. The result of this process gives clues about the environment that provide orientation for our actions (Stegmaier, 2008). These clues become manifest in the way they influence our behavior. By this, we mean that in a world without information, we would not be able to act in a well-directed way due to the plethora of possibilities; information reduces this variety by providing clues that reduce these possibilities, a phenomenon that is also known as inverse relationship principle (Barwise & Seligman, 1997; Floridi, 2006). Before we go into details explicating these ideas, we first give a brief recount of existing theories of information to show the diversity of information concepts. Instead of contributing to this diversity, this article aims at integrating certain aspects in these information concepts. After having offered a detailed analysis of information, we advocate for the adoption of a phenomenological perspective in information science.

A Brief History: The Evolution of the Concept of Information

Capurro and Hjørland (2003) as well as Cornelius (2002) have written detailed histories of the concept of information, and we do not want to recapitulate that here. Instead, we will trace a general trajectory of the concept that has evolved among information scientists and philosophers since the introduction of information theory (Shannon & Weaver, 1949). Information has been cast as subjective, as process, as physical, and as evidence. It has been considered as situational, social construct, and propositional statement. The myriad ways in which information has been

TABLE 1.   Information perspectives and approaches.

Perspective or approach	Description	Favored by
Subjective/situational	Information is dependent upon a cognitive interpretive agent who is able to interpret both data elements and context	Buckland (1991); Floridi (2003)[a(a)]; Bates (2005, 2006)[(b)]; Bawden (2007)[(a)]; Hjørland (1992, 2007)[(a)]; Bateson (1972)[(c)]; Yovits (1975)[(c)]; MacKay (1969); Saracevic (1999)[(d)]
Process	Information is a process and not an objective entity	Boulding (1956)[(a)]; Brookes (1980)[(a)]; Shera (1970)[(a)]; Pratt (1977)[(a)]; Belkin (1990)[(a)]
Objective/physical	Information is an objective entity with physical properties	Shannon (1948)[(a)]; Shannon & Weaver (1949); Stonier (1997)[(b)]; Bates (2005, 2006)[(a)]; Bawden (2007)[(a)]; Dretske (1981); Wiener (1961)[(a)]
Epistemic	Information serves as the basis for knowledge about the world	Furner (2004)[(a)]; Floridi (2003)[(a)]; Shannon (1948)[(a)]; Dretske (1981); Harms (1998)[(a)]
Phenomenal	Information manifests as phenomena that cannot be separated from either the subject or the objectified world	Boulding (1961)[(a)]; Brookes (1975, 1980)[(b)]; Dervin (1983, 1999)[(b)]
Social construct	Information is a social construct in the traditional constructivist sense and has no real objective correlate in the physical world	Pratt (1977)[(a)]; Belkin (1978)[(b)]; Cornelius (2002); Day (2001)[(a)]; Hayles (1999)[(b)]; Rayward (1992)[(a)]; Hjørland (2002)[(b)]; Wersig (1997)[(d)]
Propositional	Information is an element in an explanatory construct	Dretske (1981)[(b)]; Derr (1985)[(b)]; Fox (1983)[(b)]

[a]For references see (a) Furner (2010); (b) Bates (2005); (c) Capurro & Hjørland (2003); (d) Cornelius (2002).

conceptualized makes it "notoriously a polymorphic phenomenon and a polysemantic concept" (Floridi, 2005). More recent efforts to delineate a unified theory of information[1] include Hofkirchner (2009) and Fuchs (2008). Table 1 briefly captures the variety of theoretical perspectives concerning information. One of the aims of this article is to show that some of these meanings result from an ontologization of the sense-making process that belongs to the concept of information.

The information theory of Shannon and Weaver (1949) sees information centrally related to a technical communication processes. Their information theory takes information as an objective entity that can be quantified and measured independently of sender and receiver. A message allows for different possible codifications but is regarded as a static mapping. A central question that has been raised is that of measuring the "amount" of information, which accompanied the introduction of the bit as a unit of information by Shannon and Weaver. However, depending on the context, one bit can carry the same information as one page of text so that the bit is a unit of data rather than a unit of information. Further questions regarding information concern the nature of its relationship to meaning and its truth-value.

Several researchers have criticized this concentration on signal transmission. One of them was MacKay (1969), who emphasized that information is inseparable from meaning. He has defined information "as that which does logical work on the organism's orientation" (pp. 95–96). This view sees information as becoming manifest in the organism's

cognitive structures as reaction to its environment and therefore takes a broader perspective towards information than Shannon's. MacKay's conception goes beyond communication processes and includes natural sources of information, as, for instance, the height and direction of the sun that can provide us with information about the time of day.

Qvortrup (1993) challenged Shannon's theory as describing only the technical aspects of information. The sender needs to select from a possible range of messages, hence some meaning is attached to the decision regarding which message to select. The position of the receiver is also ambiguous, as it ignores the context of sender and receiver who must belong to one social system; this context makes the message mutually intelligible. Qvortrup points out that the exclusively technical perspective of information theory leads to a contradiction: Shannon views information as entropy, whereas Wiener (1961) views information as negative entropy. Their "mutual problem [is] that information is information only in relation (be it directly or inversely proportional) to an observer's idea of order, organization, etc." (Qvortrup, 1993, p. 8).

A principle problem of the criticized approaches is their substance concept of information, as Qvortrup described it, which regards information as an object transferable from one location to another. He pointed to several flaws of such a conception. By the transfer of information, for example, the sender does not lose anything. Moreover, the information received by the recipient is not identical with the sent information. Here, additional process aspects come into play, which Brookes (1977) expressed in his fundamental equation:

$$K[S] + \Delta I = K[S + \Delta S],$$

where K[S] symbolizes the subject's knowledge structure before receiving the information ΔI, while K[S + ΔS] symbolizes the subject's knowledge structure after receiving it. It regards information as a process that changes the subject's

knowledge and not as something that is simply added to the receiver's mind.

The idea that information is inseparable from meaning ranges from individual comprehension to the whole sociocultural context, in which both sender and receiver are situated. This has led to a commonly accepted view of information as "data + meaning" (Floridi, 2005; Saracevic, 1999). Describing information in this way allows us to account for both the signal that exists independently of a cognitive being (i.e., data) and the result of the interpretive processes (i.e., meaning); Winograd and Flores (1987) pointed out that even if we assume a stable standard meaning of data, the respective context generally requires an interpretative adaptation. Can the objective and subjective dimensions of information be considered independently? Is the idea of data really independent of the idea of information? If data appear as independent, then what is it exactly? How do semantics manifest—as an interpretive, constructivist, or phenomenological process? Can the meaning of something be isolated from either the cognitive agent or the process by which it manifests? These are the questions we wish to explore in this article.

A Brief Roadmap: From Data to Information to Knowledge

The starting point of our investigation is the insight that information cannot be described as data that possess an objective meaning. We rather see information resulting largely from a schema-based interpretation of data, in which the subject makes sense of a given pattern. Which sense is made of such patterns depends on our background knowledge (Searle, 1997). Dretske (1981) describes it in the following way: "the information one receives is a function of what one already knows" (p. 81). This means that the term data already presumes the informational character of the respective pattern. This informational character, which we call sense, describes the scope of possibilities afforded to the subject by the data. We also say that data provide the clues for the subject's orientation (Stegmaier, 2008), which enable the subject to cope with the situation and identify action opportunities. The character of these clues definitely depends on the person's individual capabilities. For a stock market trader, the latest revenue announcement of a company can mean a clear signal to buy or sell shares, while the layman does not know how to interpret the data. Information is closely related to these identified action opportunities, as derived from the sense-making process. Therefore, information is a product of a subject's capability, rather than an aggregation of data objects imbued with objective meaning.

In most cases, sense making is not a single interpretative process but a multifaceted one, in which data and information appear at different interpretational levels. For example, a letter provides a pattern that becomes data in the context of a word, while the word appears as a pattern that becomes data in the context of a sentence. Later, we will relate this observation to Polanyi's idea of stratification. This view helps to better articulate the mutual dependence of data and information. While the term data describes the physical manifestation of interpretable patterns, information refers to the subjective process and the resulting clues. The idea of data cannot be thought of without the idea of information so that the concept of data already presumes its informational character.

This might seem curious because we sometimes call some patterns data, even if we are not able to make appropriate sense of them. For example, we refer to a hieroglyphic text as data even if we cannot read it. In such case, however, we assume that there has been at least one competent interpreter of this text, for example, the author. An automatically produced random text can only count as data inasmuch as it comprises interpretable patterns. In this case, it might happen that such a text comprises meaningful words but meaningless sentences for a reader so that the sense-making process, and therefore the information, remains rather limited.

On the other hand, the reference to data is the main differentiator between information and knowledge. The latter describes a persistent capability (Riss, 2005) as an internal point of reference, while information is—at least partially—the transient result of a data-based, sense-making process that is based on an external point of reference. Here, we prescind from the fact that knowledge might have a physical manifestation in the brain because this is not accessible to the subject in the way that data are accessible. We can clearly recognize the distinction of information and knowledge from our use of the two words. If we say that A possesses the information that p, it suggests that there is some data from which this information originates; if we say that A knows that p, this suggests that A might have learned this by herself. Knowledge does not primarily rely on (physical) data, whereas information depends on it. In any case, we realize that both information and knowledge are bound to persons. We will come back to this point later.

Let us come back to the internal representation of knowledge. Here, it is known that the ability to employ knowledge relies on active cognitive patterns called schemas (Strauss & Quinn, 1997, p. 140). Schemas help us to structure information, which (a) facilitate our knowledge capacities with respect to information as part of our individual experience and (b) enable us to share information with others in ways that allow us to narrow the possible senses of data into a more specific and culturally shared meaning. To express the latter aspect, we say that we are involved in meaning making, where we distinguish subjective sense from intersubjective meaning (Vygotsky, 1986). If we develop different cultural schemas, our knowledge becomes structured differently, and the sense making and meaning making in which we engage will yield different information and data. Because we are never without our schemas, we are continually bringing our knowledge to bear on the patterns we encounter, making sense and meaning of them such that they yield information and let us see the underlying patterns as data. The introduction of schemas into our discussion enables us to situate the concept of information within a phenomenological perspective as a way of better understanding the interpretive process related to it.

What we have shown so far already indicates that the view of a data-information hierarchy (Rowley, 2007; Tuomi, 1999) must be revised in favor of such a phenomenological perspective. In particular, we posit that information is accompanied by a process of ontologization.[2] The core of this ontologization process comprises the transformation of patterns through an entwined process of individual sense making and social meaning making, through which we can discern and understand the underlying data as well as the resulting clues, which are merged into one being (hence ontologization): *information* as an ontological whole. In the following subsections we explore the view in more detail.

In the next sections, we examine the process of sense making in more detail and describe how we discern data from patterns by their informational nature. We continue with a detailed discussion of ontologization that reveals information's process character. We proceed to an examination of schemas and the meaning-making process that allows us to discern knowledge, which is also informational in nature. Finally, we reflect on how our orientation helps to bias our ontologization of data-information-knowledge and to shape the stratification of information inherent to our communication of data-information.

From Data to Information

In this section we explain why we think that we can understand data only in relation to a process of sense making. To this end, we start with the concept of pattern, by which we mean any recognizable and physically manifest structure. This can be a reoccurring event, a thing, or any other perceivable entity. A pattern may vary from simple geometrical patterns such

as a Penrose tiling or the regular ticks of a metronome to sequences of letters, words, or entire sentences. The recognition of such patterns is to be seen as an act of abstraction (Saab & Riss, 2010) that prescinds from individual particularities of an object and subsumes it under a common identity. As we know from physical measurements, even the ticks of a metronome are not completely identical if we examine them in sufficient detail. Pattern recognition is essential to all kinds of living beings and provides a central means of orientation in the environment (Bich, 2010; Hutchins, 2000/1; Maturana & Varela, 1998; Riedl, 1987). Such capability can be innate or learned. For instance, the recognition of patterns such as faces is a mainly innate capability, arising out of evolutionary processes, though there are cultural differences to which degree certain features of the face are taken into account. Generally, the recognition of patterns is based on acquired capabilities that are more complex and depend on our individual experience as well as our sociocultural background. For instance, we are only able to recognize a bill and distinguish it from an ordinary piece of paper because of our education (Searle, 1997).

An important point is the affect of a pattern on us, which can be significantly different between individuals or at different times. Some patterns (e.g., ornamental patterns) have only a minor influence on our behavior even if they may be aesthetically pleasing. Other patterns such as traffic signs have a much more significant influence on our behavior. Does this mean that it has more meaning for us? What is the difference between these two cases if we compare the ornamental pattern to a traffic sign? Although we clearly recognize both, there are different affordances in play in our encounter with each. We stop our vehicles at a stop sign, which helps us avoid accidents, but if we stopped while driving at every ornamental pattern encountered, we'd more likely cause accidents. We must not confuse impact on our behavior with meaning. We would not say that a traffic sign is more meaningful to us than Shakespeare's *King Lear*, although its immediate influence is likely to be more significant.

This makes clear that we need clarification of the role of meaning. We will use a distinction that has been introduced by other authors, namely, that of sense and meaning. While sense is personal and situational, meaning is more stable and determined by the sociocultural context. Vygotsky (1986) describes the meaning and sense, respectively, as follows: "A word in context means both more and less than the same word in isolation: more, because it acquires new context; less, because its meaning is limited and narrowed by the context" (p. 146). Engeström and Sannino (2010) interpret the difference in the context of activity: meaning refers to general activity (as part of sociocultural context), while sense has the focus of individual action. For instance, they see a medical treatment under the aspect of maintaining health (meaning) or under the aspect of treating the problem of a particular patient (sense). Stegmaier's philosophy of orientation relates sense with our personal need for orientation to clarify our action opportunities (Stegmaier, 2008). Such orientation requires making sense of a situation.

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[2]Ontologize and ontologization have been used in a variety of ways in different domains. Semantic technologists use it to refer to the aggregation or linking of lexical units to taxonomies and computational ontologies (Kozareva & Hovy, 2010; Pantel & Pennacchiotti, 2008; Pennacchiotti & Pantel, 2006). Social and cognitive psychologists use it to refer to categorical exclusions of others and the making of outgroups (Roncarati, Perez, Ravenna, & Navarro-Pertusa, 2009; Schoeneman, Schoeneman-Morris, Obradovic, & Beecher-Flad, 2010). Ecologists use it to refer to the organizing conceptualization of ecosystems (Schizas & Stamou, 2010). Our use of the term ontologization refers to the parallel processes of sense making and meaning making in which data-information-knowledge is "made into being," to recognize it as being, as existing as part of one's conceptualizations that are grounded in a real-world experience. As part of our conceptual networks, whatever is ontologized is also stratified such that parts of the conceptual network can be segmented into ontological wholes and include/exclude/subsume various relationships with other ontological wholes that may also be expressed as categories, taxonomies, or formal ontologies. We see stratification as a multilayering and multifaceting of that which is being ontologized and which allows us to move in the conceptual space between sense making and meaning making. We use ontologize rather than reify to so as to not lose focus on the cognitive processes involved, to keep the discussion focused on the processes of sense making and meaning making rather than just the object that has been reified. For example, we could argue about the reification of a particular entity or phenomenon as to whether it actually exists, but it is much less arguable as to whether or not it has been ontologized by a person or culture. We discuss ontologization extensively in a subsequent section.

In the process of sense making, the person realizes what she can do with the data when she sees them as a possible starting point for action. Hereby, the data become a clue, a reference point for action. Let us go back to our traffic sign example. The fact that it is a pattern only means that we have seen something similar before, and the fact that it is data means that the observer can connect it to some prior knowledge, for example, what it means in terms of known and commonly understood traffic rules; the fact that it is a clue describes that it influences her behavior how to cross the street in a specific way, which is not a direct consequence of the knowledge but leaves space for alternative action—for instance, she can cross the street although the traffic light is red because she is in a hurry.

Moreover, sense is developing in time, meaning that I might react in another way if I have more time to make sense of a pattern. The longer we reflect on a pattern the more senses we might discover. Imagine, for example, you get a message from a friend telling you that she cancels an appointment that you had arranged some time ago. In this case, you might reflect on the message for some time to discern possible reasons for this cancellation (e.g., Has she been very busy recently? Have you and she recently argued? Is her canceling a common occurrence?) and what consequences it might entail. The more you reflect on the message the more possibilities might come to your mind, and each possibility brings about different starting points for action, that is, more clues. Sense making, therefore, is an open and ongoing process that can lead us to multiple possible meanings and multiple clues, i.e., various starting points for action.

How do we distinguish random patterns from meaningful ones? An example that is often discussed in this respect are texts that we take for meaningful information, although we do not understand them, such as the Egyptian hieroglyphs before the discovery of the Rosetta stone (Floridi, 2005). The hieroglyphs seem to support the view that meaning is inherent in the object and independent of the observer, who cannot read them. This view is based on an assumption, namely, that someone has purposefully written these texts to communicate some message. However, such expectation is always based on a number of scientific assumptions, and we could imagine an Egyptian artisan who simply mixed informative data with senseless but decorative textual patterns. Even if such an assumption is unlikely, we cannot exclude it as long as we do not completely understand the hieroglyphs.

Ontologization and Stratification

As the hieroglyph example shows, information is generally ascribed to objects. This is expressed, for example, when we describe information as meaningful data. In this section, we will further advance the view that this is only one aspect, and that information includes other aspects such as that of a process. This view is reflected in Buckland's distinction of information-as-thing, information-as-process, and information-as-knowledge (Buckland, 1991). However, we cannot consider these in isolation, which would serve only to amplify the ambiguity of the concept of information, but rather as distinct yet interdependent aspects of information.

We discussed above how information is closely interwoven with sense making, starting from a recognized pattern that informs the observer and ending with the determination of clues. The fact that we nevertheless regard information as a unity is because of an ontologization of this process. Generally, to ontologize is to "make into being" and being is always what we understand, however implicitly, in our encounter with entities (Cerbone, 2008). To better understand ontologization let us start with an example that illustrates what we mean: If we consider the arithmetic expression "$2 + 3$," we can understand in two different ways. On the one hand, we can understand it as an expression that is equal to "5". On the other hand, if we consider this object in more detail, we can realize that it actually stands for a process (Sfard, 1991), namely, the process of counting to "2" that is followed by the process of counting to "3." In this interpretation, the expression "$2 + 3 = 5$" just describes that this process yields the same result as the process of directly counting to "5." We state that we use the term information in the same way as we use the expression "$2 + 3$," that is, as an expression for the result of the process of making sense of the respective data that consists in the clues that we derive from it.

In the same way as we use the description "$2 + 3$" to refer to the object "5" while keeping the process of addition in mind, we also phenomenologically use the ontologization of information to refer to the derived clues while keeping the original sense making of information in mind. We can also realize this from another phenomenon. If we say that two documents contain the same information, we do not necessarily mean that the two documents are identical, but that we derive the same clues or action possibilities from it in the same way as we say that "$2 + 3$" and "$1 + 4$" are identical.

It is interesting to note that we can also consider ontologization from a Polanyian perspective (Polanyi, 1962). For example, when someone reads a word, she sees the individual letters but her focus is on the word as a whole; the reader is subsidiarily aware of the letters but her focal awareness is placed on the word as a whole. The same holds for words and sentences. In the same way as "2" becomes a summand under the process of addition, patterns become data under the process of sense making. When we focus our attention on the pattern, we are aware that the process is still subsidiarily, which we express by denoting the pattern as data. When we focus on the results, the clues, we are also still subsidiarily aware of the process and its origin and call it information. As Polanyi has described it, we can shift the focus of our attention from the process to the underlying objects and back, but in doing so there is still a subsidiary awareness of the other constituents. The idea of subsidiary and focal awareness nicely illustrates what we mean by saying that data presume information; if we talk about information as data, we mean the pattern, but we are still subsidiarily aware of the sense making and the resulting clues. In the same way, if we focus on information as the process of sense

making, we are still subsidiarily aware of the pattern and the resulting clues.

Another Polanyian idea that is related to subsidiary and focal awareness is that of stratification (Polanyi, 1962). For example, the recognition of letters allows for the identification of words, to which a sense is given that goes beyond that of individual letters. In the same way, we proceed from words to sentences, from sentences to paragraphs, and from paragraphs to the entire content of a text (Lyre, 2002). The meaning that we find at a lower level helps identify a larger pattern as data. However, as we said before (referring to Vygotsky), the sense of a word is also influenced by the sentence to which it belongs. Here, we discover what Gadamer (1975) has called a hermeneutic circle. This stratification often leads to an ambiguous use of the term information because we do not explicitly specify the respective level of interpretation—usually it is implicit in our communication and others infer the level for interpretation. Such stratification refers to the segmenting of patterns at different levels of abstraction (Floridi, 2008) such that they form meaningful ontological wholes. Polanyi (1962, 1969) describes this integration process (of ontological wholes) with a comparison to Gestalt theory. Recall Sfard's above-mentioned example regarding the mathematical expression "$2 + 3$" and the process it exemplifies. This expression ontologizes the process of adding at a particular level of stratification: this includes the sum "5" as the upper and determining level of stratification and the summands "2" and "3" as the lower level that are connected by the process of adding.

A slightly more complex example would be the ontologization of as the golden ratio derived originally the process of segmenting a square and use that measured segment to extend one side of the square to create a rectangle. Repeating this simple sequence of measures and extensions, creates a proportional shape that produces structurally-sound architectural forms, has been recognized in the shape of the nautilus' shell arising from evolutionary processes over eons, and reveals an underlying mathematical formula for gauging aesthetic beauty in both natural and artificial forms. Φ symbolizes and encapsulates the ontologization of a fairly complex process enacted in various contexts, but that is belied by its simple form. The information and data discerned from patterns can be determined only from the perspective of the receiver and depends on how they ontologize it. An architect might ontologize Φ differently than a mathematician, for example, recalling the Parthenon as opposed to the Fibonacci sequence. We can recognize the informational content only after the interpretation, after we have ontologized the pattern of data and information at a particular level of stratification. At each of the levels of stratification that occur during the sense-making process, we find subordinate sense-making processes that are mostly automatically integrated as part of the enactment of schemas. Hereby, the interpretation of the subordinate level helps identify larger patterns that are then integrated again. This stratified sense-making process becomes largely schematic based on shared cultural experience.

From Information to Schemas

How does knowledge manifest, i.e., emerge as part of our experience? We can say that the external manifestation of information is transformed into internal schemas. Strauss and Quinn (1997) describe schemas as "networks of strongly connected cognitive elements that represent the generic concepts stored in memory" (p. 6). D'Andrade (1995) expands on this concept and describes schemas as "flexible configurations, mirroring the regularities of experience, providing automatic completion of missing components, automatically generalizing from the past, but also continually in modification, continually adapting to reflect the current state of affairs" (p. 140). Schemas facilitate our cognitive functioning, including use of our knowledge, in a world overflowing with all kinds of patterns.

People recall schematically embedded patterns more quickly and more accurately than schema-inconsistent patterns or events. In fact, schemas hold such sway in our cognition that people may falsely recall schematically embedded events that did not occur (DiMaggio, 1997). They are more likely to recognize patterns embedded in existing schemas because of repeated activation of the schemas. This repeated activation evokes expectations within cognition and the easy recognition of contradictory or challenging information that does not conform to those expectations formed as part of the existing schemas. Patterns that are orthogonal to our schematic expectations are much less likely to be noticed or recalled.

Because schemas also function as pattern-completion processors, they allow us to generate expectations that we use in conjunction with clues to orient ourselves to the environment. Continued exposure to the same or similar patterns will eventually become meaningful in the sense that it will be associated with other ontologized schemas. We rarely encounter isolated patterns in the world; our experience is more complex than that, and our schemas reflect that. As new patterns appear, new clues are generated, which activate other schemas and generate new expectations that enable our active orientation within the world. Experience of varying contexts facilitates the strengthening of schematic conceptual connections and their extension to other concepts.

Sense Making and Meaning Making

Thus far, we have argued for a distinction between patterns and data where the latter connect to clues. We find that the sense-making process associated with data is both objective and subjective—besides its binding to the pattern, as part of its objective facet, it depends on the interpreter's knowledge and the situational context in which it is interpreted. To express the difference between the subjective and the objective side, we will distinguish sense making, as a plainly subjective process, from meaning making, as the social dimension of information. In doing so, we want to explain how it is possible that information appears to us as objective even though it is based on an individual interpretative process.
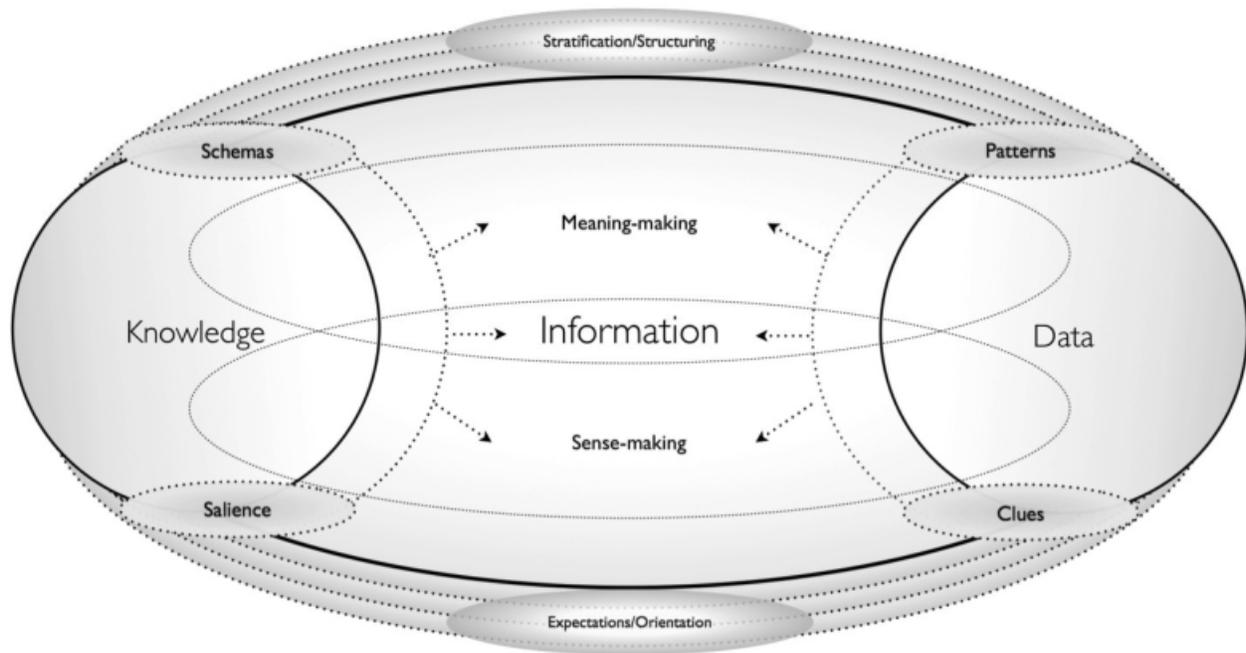
FIG. 1.   Ontologization: The phenomenological character of information.

The sense making of patterns allows for the discernment of data, which provide clues for possible action as an orientation bias for the subject. We cannot say how much sense we must have to discern data within a pattern because this is a continuous process and depends on the amount of time we invest in it. The longer we reflect on a pattern the more sense we can associate with it, and the more clues it provides to us. Our schemas, which are necessarily tied to previous experience, generate these clues.

Though sense making is a process of an individual, it also takes place in a shared environment that produces similar experiences in cognitive agents who are furthermore embedded in similar sociocultural contexts. These two factors—sharedness and embeddedness—lead to a streamlining of the individual sense-making processes towards a cultural meaning-making process. This streamlining comprises a continuous, mutual adaptation of individual sense and social meaning via communication and collaboration. It is the manifestation of Gadamerian play, where the player is acting within the context of the game, but is simultaneously aware of the rules of the game that are shared among all the players. This requires that the individual subject is usually aware to what degree the sense that he or she gives some pattern deviates from the average sense that others might give and which are reflected in others' schemas—in other words, where there is a fusion of horizons as part of a hermeneutic circle (Gadamer, 1975). For instance, for some people, the concept of liberty includes the free disposal of firearms while the same means a constriction of liberty for others. Regardless of which understanding of liberty adopted (sense-making), one has to take the positions and arguments of both sides into account when one takes a public stand in an open discussion in order to avoid misunderstanding or plain confrontation (meaning-making). In terms of meaning making, we also have to take our own family, social, and historical background into account as basis of our attitude.

Heretofore, we have discussed patterns, information, data, clues, orientation, stratification, sense making, and meaning making as integral parts of ontologization. We have made mention of underlying schemas, but haven't explicated their roles in ontologization. Figure 1 above depicts how we see the process and character of ontologization. With this representation in mind, we will delve further into the role of knowledge, schemas, salience, and the sociocultural dimension of meaning making as part of this process in the next section.

In pattern completion, schemas function, in some sense, as flexible experience-based filters that make us attend to the salient features of a pattern while filtering out the nonsalient. Schemas' role in regulating what is salient and nonsalient is essential to our understanding of sense making and meaning making. What is salient in a particular context depends on the focus of our sense making and meaning making, as the focus of our ontologization. This does not mean that that which is not salient at any given moment is not being ontologized, rather it is simply subsidiary to the salient. It can be meaningful only if we have the appropriate schemas for recognizing its salience. Our assertion here contrasts with Dretske's assertion that information does not have to be meaningful to a subject to be information; it can simply reflect a stable pattern, such as relevant contextual or background information available to a subject. Being relevant means being salient to some degree, which does not imply that what is less salient is not meaningful, only that it is subsidiary to that which has greater salience at that moment. Ontologization and stratification, through the enactment of schemas, reveal that the patterns we perceive

are always meaningful in that we are able to identify what is more salient and comes to occupy our focal awareness and what is less salient and comes to occupy our subsidiary awareness. Dretske was correct in that we should not confuse information with meaning, but we also assert that we should not confuse meaning with salience, nor should we mistake schematic for "not meaningful."

So, how do we acquire an understanding of what is salient, which becomes integral to our schemas? Certainly, we develop schemas individually, as they are part of our cognitive networks. But we also develop cultural schemas, which are those schemas we co-develop with others. The notion of what becomes salient often depends on our sociocultural interactions with others, though it may also arise out of purely personal experience as when encounter something that is about to cause us injury. The co-development of schemas does not require people to have the same experiences at the exact same time and place, but rather that they experience the same general patterns. Our experiences as agents in the world are organized in ways that ensure ease of interaction, coordination of activities, and collaborative interaction. Because of this fact, people in the same social environment will indeed experience many of the same typical patterns and interpret them in a similar way. In experiencing the same general patterns, people will come to share the same common understandings and exhibit similar emotional and motivational responses and behaviors. However, because we are also individuals, there can be differences in the feelings and motivations evoked by the schemas we hold. "The learner's emotions and consequent motivations can affect how strongly the features of those events become associated in memory" (Strauss & Quinn, 1997, p. 133). Individuals will engage the external world structures and experience the same general patterns. Similar stimuli and experiences will activate similar schemas. It is in that sense that we considered them shared schemas. It's their quality of sharedness that makes them a dimension of the cultural.

It is this process of creating a mutual cultural understanding of patterns within our experience that we call meaning making. It is sense making on a sociocultural level, where the awareness of others' knowledge capacity allows us to refine the sense of a thing into meaning (Vygotsky, 1986). Both sense making and meaning making are aspects of the interpretative process that appears to us as an ontologization—one allowing us to ground perceived patterns in data tied to the physical world, and the other allowing us to reconfigure the associations of these patterns in ways that can be communicated meaningfully in context.

From Information to Knowledge

Our capacity of meaning making is important to our understanding of information and knowledge. Knowledge is often characterized as information plus context (Nonaka, 1994). We normally think of information as the foundation for building knowledge; however, as we have seen, we need knowledge in the same way to discern information. To understand why this is so, we first have to distinguish different types and sources of knowledge. Then we have to ask which kind of knowledge we get from information. To this end, let us consider the following proposition to get an initial idea of the fundamental difference between information and knowledge:

(1) A knows how to recognize trees.

This proposition is clearly an example of A's knowledge, but not information. More precisely, (1) is a case of knowledge-how, in which (1) describes a specific capability of A, namely, that A can recognize trees in various situations; we can also say that A can actualize her respective capability in an appropriate action. An example of such actualization is the case in which A stands in front of a tree and we realize that:

(2) A knows that this is a tree.

Proposition (2) obviously describes A's knowledge that the respective object is a tree. We infer that A knows this because she sees or is experiencing the tree in some way. She disposes of visual data that she interprets in a way that the object is a tree.

What is the difference between these two propositions and the following one?

(3) A has the information that this is a tree.

In (3), A has information that is not especially characterized as knowledge. However, by reading (3) we would not assume that A is standing in front of the tree, but we interpret the situation in such a way that, for example, she is reading a piece of paper on which this is written. While in (2) we assume that A relies on her capability to (directly) recognize trees, in (3) we assume that A relies on her capability to interpret (mediating) data.

Thus, we pose the question: What is the difference between visual data of the tree and textual data on a piece of paper? First, A has the information because she is engaged in an experience whereby the information that is emerging is doing so as part of A's sensory capacities of sight, touch, smell, etc., which are connected to the patterns she is experiencing, and so through her sense-making ability, she is able to discern information and the corresponding data grounded in a physical world. Repeatedly experiencing this or similar patterns enables the formation of schemas that enable the transformation of information into knowledge. Second, A has the information because someone else has provided it as communicated knowledge, perhaps as a photograph or drawing as part of a science or reading lesson. In (3) we would not assume that she has seen the tree herself. In this second scenario, A is relying on schemas that she has developed (or if A is a very young child, then perhaps still in the process of developing), that, through her meaning-making ability, allow her to incorporate this information into her already existing

knowledge structure. Either scenario is possible, and both illustrate that the transformation of information to knowledge is enabled through schemas. How do we know that A has transformed this information into knowledge? It is simply the case that A can leave the place and still claim to know that the object she had seen was a tree, without any visual information still available—knowledge is persistent, information less so because of its dependence on data.

Both information and knowledge refer to experience and differ only with respect to their point of reference. A person who claims to have information about something refers to some data and must be able to provide the respective data; a person who claims to know something might be required to justify this claim but this justification can be different from data, for instance, it might consist in the accomplishment of a specific action. In that moment that the data have vanished, the subject has to rely on knowledge instead. We can also express this in the following way: information relies on external reference, while knowledge relies on internal reference. Another aspect is that information complies with knowledge-that rather than knowledge-how. However, this assignment is not completely exclusive. For instance, a picture might give us some understanding even if we are not able to verbally express this. In most cases, however, data consist in texts and spoken language, particularly if the intent is to more narrowly constrain a person's sense and meaning making through greater specificity.

Comparison to Other Views on Information

It is interesting to have a look at some existing theories of information and investigate to which extent they comply with the theory that we have described. Because of the plethora of available theories, we have to restrict this to a few, namely, Shannon and Weaver (1949), Floridi (2005), and Dretske (1981).

Although the information theory of Shannon and Weaver is regarded as fundamental, interpretations of its meaning are rare. The theory consists in a drastic reduction of the information concept to a few technical features. The core is the *uncertainty* of an event i, given by

$$I(i) = -\log p_i$$

where p_i describes a discrete probability distribution for a finite set of event $i = 1, \ldots, n$. We can understand the distribution p_i as the background knowledge about a situation that reflects the observer's expectations regarding the occurrence of the event i. If $p_i = 1$, then there is no uncertainty, that is, $I(i) = 0$. According to this interpretation, the occurrence of the event i reduces the uncertainty by $I(i)$. We can also say that $I(i)$ is the information gained by the occurrence of I so that Shannon's formula

$$I = -\sum_{i=1}^{n} p_i \log p_i$$

can be seen as the averaged information gained by the occurrence of an event in the given situation.

An interpretation process, for which we have argued in this article, does not seem to appear in Shannon's theory. Information or reduction of uncertainty depends only on the foreknowledge, expressed in p_i, and the actual occurrence of an event i. However, the assumption of a fixed distribution is not realistic. Let us explain this by an example. If we wait at a red traffic light, our assumption might comprise the states (a) "the traffic light will switch within the next 2 minutes (and we will reach the coming bus)" or (b) "the traffic light will switch later (and we might miss the bus)." The case that the traffic light does not switch at all is assumed to have the probability 0. However, sometimes traffic lights are defective and do not switch at all; after waiting for quite a while, this possibility becomes more and more salient to us. Now the probability of a defective traffic light is definitely larger than 0. Here, our schemas come into play and help us to adapt to the changing situation. This means that the sense making appears in the adaptation of the distribution p_i and hereby reflects the adaptability of our knowledge as expressed in the concept of schema. However, the same also happens if we simply make sense of data that might result in an adaptation of the distribution p_i as well.

We can now turn to the question of how the presented description of information complies with further traditional views. For example, how does this conception of data comport with Floridi's diaphoric definition of data? Actually, it enriches this definition by including the process dimension. The diaphoric definition of data states: "A datum is a putative fact regarding some difference or lack of uniformity within some context" (Floridi, 2011). The term fact here refers to the *Oxford English Dictionary's* definition "something that has really occurred or is actually the case." This corresponds to our understanding of a pattern as a structure that we find in a real object. A lack of uniformity is the negative formulation for the existence of a (potential) pattern. An object that contrasts with a uniform background is something that might reoccur in another context; otherwise it would not be distinguishable from the background. The question is whether this definition actually describes data or only patterns. This is not clear because of the introduction of context in this definition. Floridi's definition lacks a subject, whose abstraction capacities enable recognition of the lack of uniformity and the sense-making process. We can say, rather, that his concept of data corresponds to what we call a pattern, while the process aspects are hidden in the concept of meaning.

As well, Dretske (1981) stands for a traditional understanding of information. Thus, he distinguishes information from meaning by requiring information to be true, because knowledge (as justified true belief) requires information, and therefore information must be true to qualify as information. Although we dissent from him with respect to the traditional conception of information, we agree that data are not informationally barren, per se. However, Dretske also argues that information does not have to be meaningful to a subject to be information as well and that it can simply reflect a stable pattern, such as relevant contextual or background information available to a subject. The problem we see with this

characterization is: How does contextual information acquire its relevance if it is not meaningful? How is meaning separated from the recognition of a pattern and the sense making of data? We argue that the processes of sense making already starts with the recognition—if something is recognized, then it is meaningful at least in some minimal sense. Through the act of recognizing, in which we bring to bear our previous experience and knowledge, we are engaged in a process of meaning making as we try to make sense from the pattern.

Conclusions

While traditional conceptions assume a static nature of information, expressed by the equation information = data + meaning, we have argued that this understanding is based on an ontologization of an entwined process of sense making and meaning making. This process starts from the recognition of a pattern that is interpreted in a way that influences our behavior. More precisely, the pattern provides us with clues that help us to find orientation for our actions. In this sense, information is to be primarily understood as a process that differs from person to person and from situation to situation. It is only this process that makes patterns data. It also tells us that it is a fine line that separates meaningless patterns from meaningful data.

Such interpretative processes are not arbitrary, however. We are bound to objective conditions that become manifest in our experience and a specific cultural background that we share with others. These factors limit the difference in understanding specific data. These convergence factors are also responsible for the fact that different data can result in the same information, that is, the same clues for our actions. On the other hand, we also have to realize that the same data can lead to different clues, as when stock market information causes one trader to sell and another to buy. Ontologization allows us to refer to data, process, and clues by means of one entity in which the respective meaning, that is, the particular aspect we refer to, becomes apparent from the context. The data-based interpretative process is closely related to our schemas, which are internal cognitive patterns and not transparent for the subject. Therefore, the term, information, is used to refer to the schemas that are related to the specific interpretations of data.

Despite the persistence of a static view of information, we think that it is necessary to expose the process character of information. The traditional conception assumes an objective, fixed, and data-dependent meaning that is attached to data. Nevertheless, we have to understand that because of the process character, this meaning is primarily subjective and only becomes objective by shared sociocultural background and experience. We can also say that it is an ongoing task to establish objective meaning of data, which is achieved by permanent communication. It also explains why this meaning can change in the course of longer time horizons. These insights are not completely new. For example, Polanyi already described communication processes as sense-giving and sense-reading (Polanyi, 1969).

Ontologization also supports the stratification of data, as it especially appears in language with its hierarchies of letters, words, sentences, and texts. This stratification brings some order to data. At the same time, the process character of meaning making makes us aware of the fact that this ontologized hierarchy is an interwoven process. The meaning of a word is influenced by the sentence in which it appears—a word can be replaced by a metaphor or be misprinted, and still we can make meaning of it. All this is because of the process character of information.

Regarding technological solutions in information science, one consequence of information as ontologization is that we should never mistake data for information, but also we must always realize that sense making requires specific conditions to be successful. It also tells us that the mere provision of data, as through the Internet, does not result in information if we have neither the time nor the schemas to make sense of it. Nowadays, semantic technologies are able to articulate the required links between data that can help users to engage in sense making. Developers of information-based applications must be aware of their respective applications' requirements, and a more complete understanding of the concept of information, provided here, is a necessary precondition for this.

Recognizing the mutual entanglement of data and information is important with respect to our definitions of information. Information does not depend only on data as part of its definition, but the concept of data already presumes the concept of information and the process of sense making. We have shown that data become mere patterns when we abstain from any sense making: there is a mutual dependence in data and information such that we cannot separate one from the other, even though we generally consider them to be self-contained and independently meaningful entities. In our analysis, data is a moment and not a constituent (pace Vygotsky) of information. The definition of data-information is a simplification that abstracts it from its process character. We hope that we have shown that the phenomenological nature of ontologization necessitates that we consider data, information, and knowledge in such a way that none of the three can exist independently of the others.

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