Information

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Abstract
A selection of representative definitions of information is drawn from information science and related disciplines, and discussed and compared. Defining information remains such a contested project that any claim to present a unified, singular vision of the topic would be disingenuous. Seven categories of definitions are described: Communicatory or semiotic; activity-based (i.e., information as event); propositional; structural; social; multitype; and deconstructionist. The impact of Norbert Wiener and Claude Shannon is discussed, as well as the widespread influence of Karl Popper's ideas. The data-information-knowledge-wisdom (DIKW) continuum is also addressed. Work of these authors is reviewed: Marcia J. Bates, Gregory Bateson, B.C. Brookes, Michael Buckland, Ian Cornelius, Ronald Day, Richard Derr, Brenda Dervin, Fred Dretske, Jason Farradane, Christopher Fox, Bernd Frohmann, Jonathan Furner, J.A. Goguen, Robert Losee, A.D. Madden, D.M. McKay, Doede Nauta, A.D. Pratt, Frederick Thompson.

INTRODUCTION

The concept "information" is of signal importance to all the information disciplines. Perhaps for that reason, it is a term that has been defined in countless ways, over many decades. It would be fair to say that there is no widely agreed-upon definition or theoretical conception of this term. The meaning of this term is still highly contested. In this regard, the status of the term is similar to that of "communication" in the communication sciences.

In light of the lack of agreement about the definition of the term "information," the main objective of this entry will be to lay out some of the major classes of definitions and theoretical constructions of the term that are currently or recently in play. No effort will be made to capture and discuss every definition that has been provided in the literature; rather major types will be presented, as well as popular ideas that are recurrent in the literature. The discussion draws from writings over the last 60 years; the approach is by category rather than by chronology.

The effort to define information is active in other disciplines besides those explicitly concerned with the topic; philosophy, cognitive science, electrical engineering, computer science, and systems theory, among others, have been active players on this scene as well. The objective of this entry, however, is to concentrate on the ideas about information that have been either developed within the information disciplines or, in a few cases, which have come from other fields but have also been influential in the information disciplines. For coverage of other approaches to the concept, the reader is directed to reviews by Aspray,[1] Belkin,[2] Capurro and Hjørland,[3] Cornelius,[4] Meadow and Yuan,[5] and Wersig and Neveling.[6]

Some authors embed a discussion of information within a much larger philosophical or theoretical program. In other words, exposition of the meaning of the term "information" is not a primary goal, but only incidental to much larger projects. It is beyond the focus of this entry to attempt a review of these larger intellectual programs. Prime examples include: Søren Brier's "cybersemiotics,"[7] Benny Karpatschof's dissertation on "Human Activity,"[8] Howard Resnikoff's analysis of information within a mathematical, physical, and signal detection framework,[9] Jan Kåhre's "mathematical theory of information,"[10] and Stonier's 3-volume disquisition on biology, physics, and information.[11–13] Another author in this category is Luciano Floridi, a philosopher, who is developing and promoting an area of philosophy to be known as "Philosophy of information."[14] He develops his own view of information as a philosopher, with attention to the issues of concern to that discipline in the entry "Information."[15]

Because Norbert Wiener's and Claude Shannon's ideas of information were so influential at the dawn of the "Information Age," their influence is discussed in a preamble below. Shannon's actual "information theory," however, is reviewed elsewhere in an entry by that name in this encyclopedia.

After the preamble, conceptions of information of the following types will be reviewed, in succession:

- Communicatory or semiotic
- Activity-based (i.e., information as event)
- Propositional
- Structural
- Social

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- Multitype
- Deconstructionist

Between these categories, we will take two interludes, one to discuss the "Problem of Popper's Worlds," regarding the philosopher Karl Popper, and the other to address "DIKW" or the commonly discussed sequence known as "data-information-knowledge-wisdom." Both of these, Popper's "three worlds" concept, and the DIKW sequence, have motivated so much discussion in the information sciences around information, that they merit separate discussion.

In the process, the work of the following people will be addressed: Marcia J. Bates, Gregory Bateson, B.C. Brookes, Michael Buckland, Ian Cornelius, Ronald Day, Richard Derr, Brenda Dervin, Fred Dretske, Jason Farradane, Christopher Fox, Bernd Frohmann, Jonathan Furner, J.A. Goguen, Robert Losee, A.D. Madden, D.M. McKay, Doede Nauta, A.D. Pratt, and Frederick Thompson.

In this entry, no summary conclusion is made about "the best" or "the truest" understanding of the concept of information. Rather, the purpose is to present the array of ideas flowing around this core concept in the information disciplines, so that the reader may become acquainted with the issues.

PREAMBLE: THE ROLES OF WIENER AND SHANNON

It is almost impossible to overestimate the impact of Claude Shannon's ideas about information on the (American) intellectual culture of the 1950s and 1960s. In that era there was a tremendous amount of attention directed to the technical revolution(s) that had become possible with the development of computers, television, new communication technologies, and a new way of thinking about information. This new way of thinking percolated out of the academic world into the society at large, and imbued at a subconscious level the thinking of people who had no understanding of Shannon's ideas per se.

Today, many scholars write dismissively about the concept of information (see the last portion of this entry), and reject the earlier excitement around the "Information Age" and the "Information Society" as a love affair with a cold, technical, even militaristic conception of the technology-driven society.[16] Indeed, Frank Webster, writing in this encyclopedia about the "Information Society" analyzes the term's many weaknesses and confusions, without seeming to recognize the positive value originally gained from the ideas carried by the concept. Shannon appears in Webster's discussion only in terms of the "deracinated" definition of information that arises out of Shannon's writing. Ironically, as we shall see, it was, in fact, the very fecund power of that deracinated definition of information—i.e., a concept of information as independent of meaning—that allowed an explosion of scientific and social development around information and its social and technical role.

The new conception of information that came with Shannon was so fundamental, so pervasive in science and engineering, that today's critics do not actually see *it as it was to people then*. The several streams of new thinking on information were startling, different, and stimulating, compared to prior understanding. I believe that the impact was so fundamental that an earlier generation can be forgiven for inventing ideas like the "Information Age," the "Information Society," and "information explosion." The consciousness of information was so new, and changed so many established ideas, that it really felt to the participants like a new age marked by the new awareness of information.

It is fashionable now to deride that earlier absorption with the new concepts, but we are *able* to deride these concepts only because we have so thoroughly absorbed the learning from that time, that it feels easy to dismiss it in favor of newer ideas. The ever-present fact is that people both build on and react to what was present earlier in their lives. Today's critics are, of course, doing that too. This author is old enough to remember that earlier time, and I choose to present that era as I understood it, as a bit of a counter to the somewhat dismissive attitude toward it that is popular nowadays.

Boulding[17] wrote about three levels of organization in life: 1) static structures; 2) clockwork, i.e., the world of mechanics; and 3) thermostats, that is, control mechanisms that maintain a stable condition by responding to feedback from their environment (p. 20).[17] These three levels have some parallel in the development of science in the Western world—the medieval belief in a static world created by God, followed by the Newtonian discovery and analysis of dynamic processes, followed by the cybernetic understanding of the role of information in life processes.

The world of Newton and his epigones was one in which the theory of forces and impacts of recognizable regular, measurable change was developed. The quintessential model of the mechanical universe is that of billiard balls being hit and rolling into other balls and making them move in a certain direction with a certain force.

The movement of the planets was closely measured, the mathematics of change in the form of the calculus was developed, and a deep threat to the medieval concept of the static universe arose. The long history of religious controversy, with Galileo as a prime example, and proceeding through the inquisition, the Reformation, and the Counter-Reformation, was in no small part due to the fundamental challenge offered by this new dynamic idea of how the universe worked.

In the twentieth century, information began to become important in the thinking of science and society. Problems of observation and the impact of observation emerged in early twentieth-century physics. Finally, during the 1940s

and 1950s the role of information was made theoretically explicit in the theory of cybernetics. The term came from a Greek root word meaning to govern or steer. Norbert Wiener's conception of cybernetics involved the governing of action through the feedback of information.[18]

"Feedback" is a tediously trite term nowadays, usually employed in the context of customer relations or group therapy. But the idea behind it was revolutionary in Wiener's day. Wiener illustrated just how significant the idea was in his description of research that he conducted with a physician on physiological processes (Introduction, Chapter 4).[18] Again, grossly simplifying, the thinking in that day in physiology was that when I reach out to pick up a pencil, this process is achieved by my brain sending a signal to muscles and tendons along the lines of "go get it," and the machinery of my arm goes into action and picks up the pencil. This was a classically mechanical concept of my actions. A pulse goes out to my arm to do a certain thing, I act, then the pulse diminishes.

Wiener and his colleague demonstrated that the process did not work that way. Instead, when I start to pick up the pencil, I extend my arm in the direction of the pencil, and then, *utilizing constant kinesthetic and visual feedback*, I microadjust the position of my arm repeatedly and successively until it successfully lands on the pencil, grasps it, and picks it up. Picking up the pencil is not a single, mechanical, act, but rather an extended behavior utilizing continuous information feedback telling me whether my hand is on or off course, and if off course, enabling me to adjust the tension in muscles and the direction of my reach so that I can successfully touch and pick up the pencil (p. 8).[18]

Thus, in cybernetic situations, two processes are going on continuously in parallel—the physical forces, and the detection and utilization of information about the physical forces, which information is used to affect the physical actions. While the billiard ball model was the one commonly used for the mechanical understanding of the universe, with the impact of cybernetic thinking, the household thermostat became the standard model of cybernetics and feedback. In the summer heat, I set the thermostat for a certain temperature. When the heat in the room affects a sensing mechanism in the thermostat beyond a certain point, the air conditioning starts, and cools the room down to where the sensing mechanism again achieves its desired temperature, and the air conditioning shuts off. The sensing mechanism provides continuous information, and the design of the thermostat is such that when the information indicates that the room temperature is outside a desired range, the air conditioning comes on. Governing, or steering, is about utilizing information feedback, to direct the ship of action.

In the larger history of scientific thinking, the development of cybernetics drew attention to the *distinct role of information* in physical and social processes. Previously, the kinesthetic and visual feedback I get while picking up the pencil—as well as in countless other information-based processes—had been almost entirely invisible in the thinking of science. This may be one reason why the 1950s and 1960s were so obsessed with information—the role of information had at last emerged as a focal topic of interest in science; its role in influencing physical and social processes at last came to the fore, and once seen, was studied with fascination in many domains of science.

So what was Claude Shannon's role in all this scientific development? Shannon and Wiener worked on some of the same ideas during this fertile period. Shannon, working at the Bell Laboratories, however, developed the mathematical and engineering theory to put an understanding of information on a firm basis.[19] Strictly speaking, Shannon did not define information at all, at least in any conventionally understandable way. Shannon found a way to measure the *amount* of information going over a transmission channel. As Wiener puts it, "...we had to develop a statistical theory of the *amount of information*, in which the unit amount of information was that transmitted as a single decision between equally probably alternatives" (p. 10).[18]

Since the alternative messages, letters, words, or other units of communication are not always sent with equal probability, the formula Shannon developed measured the amount of information as a function of two things—the number of alternatives out of which a message might be selected for sending, and the probabilities of the various messages. The more possible messages from which the sent message is selected, and the more equiprobable the messages, the greater the amount of information transmitted.

Shannon's analysis was revolutionary in several senses. Before him, engineers really did not have a means of computing the maximum amount of information that could be transmitted through a channel of a given size or configuration. It was assumed that it would be possible to go on improving channels to carry more and more information. Shannon's formulas enable the calculation of the maximum possible information transmission for a given physical configuration.

Once Shannon developed a firm model of the amount of information, actual and possible, in a channel, he could clarify the role of redundancy, of error rates, and noise in a channel. For example, since the letters of the alphabet do not appear in written text with equal probabilities, the amount of information conveyed with English text is well less than 100% of the amount of information that could be conveyed if each letter were equiprobable. Further, Shannon mathematically analyzed the role of noise in a channel, and the ways in which redundancy could compensate for the noise. These discoveries were immensely important for all sorts of communication engineering situations. Go to the right section of an engineering library, and one can find textbooks full of hundreds of mathematical formulas developed out of these crucial

insights by Shannon. Shannon's work revolutionized communication engineering. His key paper has been cited over 7000 times in the Institute for Scientific Information (ISI) "Web of Science" database.[20]

His impact went well beyond engineering, however. It was as if for the first time people saw the informational regularities beneath the surface variety of the text sent over a wire or the words spoken on the telephone or written in a book. Shannon's model of information is dismissed today because he separated information from meaning. What is currently forgotten, however, is that this separation was in fact an *achievement*. People had not been able to make that differentiation before. Now, with far greater clarity and understanding, the handling of information in quantitative terms at last came on its own. In 1951, the psychologist and linguist George Miller wrote the book *Language and Communication*, which essentially consisted of working out the implications of Shannon's work for those disciplines.[21] In the process, Miller educated a generation of social scientists on this way of thinking.

The fundamental clarification of the relationship between messages and the amount of information they convey (Shannon), and the concomitant recognition of the important role of information throughout life processes (Wiener) led to an enormous surge of research and theorizing throughout science about information. (Other researchers, such as John von Neumann and Oskar Morgenstern, had important roles as well.) Just as those hundreds of mathematical formulas had to be worked out in the engineering world, so also did the social sciences need to work with these same ideas and transform some parts of those disciplines.

The application of Shannon's approach to the social and behavioral sciences was not straightforward, however. There were many insights gained, but many problems encountered as well. After a while, the initial enthusiasm in the social sciences waned—to the point where it is now fashionable to deride these post-War ideas. But we are shaped by those ideas so thoroughly nonetheless, that we can only attempt to throw off their influence.

COMMUNICATORY OR SEMIOTIC DEFINITIONS OF INFORMATION

We begin with definitions/conceptions of information that are framed within a communicatory or signaling context. Some authors even take the approach to the point of identifying meaning with information.

A.D. Madden

As a recent example, in 2000 Madden[22] defined information as "a stimulus originating in one system that affects the interpretation by another system of either the second system's relationship to the first or of the relationship the two systems share with a given environment. . ." (p. 348).[22] In 2004,[23] he simplified it to "a stimulus which expands or amends the World View of the informed" (p. 9).[23] The latter definition is reminiscent of Boulding's concept of the "image," which is the grand total of my (or any individual's) subjective knowledge, my mental image of the world, and my place in it.[17] Boulding argued that behavior depends on this image. So in Madden's approach, information is, in effect, something that alters the image.

Gregory Bateson

Gregory Bateson[24] applied concepts of information and feedback to the psychodynamics of human relations, most famously writing of the pathological, feedback-based, "Double Bind" relationship (pp. 271–278).[24] He also wrote about information science. Expressing the semiotic approach still more generally, Bateson said that information is a difference that makes a difference (p. 453).[24] This approach has its roots in the idea of the single difference being the elementary unit of amount of information, the single bit, the zero or one. The difference that makes a difference, presumably, makes that difference to a sensing being.

B.C. Brookes

Brookes,[25] one of the grand old men of British information science, took a similar tack. The following is his "fundamental equation" for the relationship between information and knowledge.

$K[S] + \Delta I = K[S + \Delta S]$, which states in its very general way that the knowledge structure K[S] is changed to the new modified structure $K[S + \Delta S]$ by the information ΔI, the ΔS indicating the effect of the modification (p. 131).[25]

Thus the (human) knowledge structure in the mind is changed in some way with the input of information.

Doede Nauta

Nauta[26] takes information quite explicitly to be meaning, but in a particular sense. "Information is that which is common to all representations that are synonymous to the interpreter (synonymity is identity of meaning)" (p. 201).[26] Thus, information is the meaning that is common to all the different ways of expressing that meaning. Here, it would seem that only representations can contain redundancies, because information is the common meaning core to all the different possible representations. In this approach Nauta drew on both semiotic and (Shannon) information theoretic approaches.

Robert Losee

Losee[27] developed what he calls a "discipline-independent definition" of information. "Information is produced by all processes and it is the values in the characteristics of the processes' output that are information" (p. 256).[27]

> Information is always informative about something, being a component of the output or result of the process. This 'aboutness' or representation is the result of a process or function producing the representation of the input, which might, in turn, be the output of another function and represent its input, and so forth (p. 258)[27]

Losee takes as his central example the baking of a cake.

> Examining the cake provides information about both the process and the original ingredients.... The choice of high quality ingredients...will affect the outcome.... Varying the process, such as the amount of time in the oven...also changes the final product... (p. 258).[27]

This definition raises a couple of questions. First, what about situations that are not processes? Can there be no information there? Or is process so universal that everything is a result of it?

Second, it is with cake-baking, as with many physical processes, that the information produced from the process is often quite incomplete, and can be misleading. Losee says that examining the cake provides information both about process and original ingredients. But, in fact, the person who had never seen a cake before almost certainly would not know enough to be able to figure out from the output alone all that went into making it, both in ingredients and processes. This is true with many processes. Often, there is an emergent result—yeast does things in the cake not in evidence when the baking begins. The baking causes chemical processes that lead to the final result being very different in qualities from the starting dough.

Thus, in the experience of human observers, information can be limited and distorted coming out of a process, and it can be also be quite unambiguous and complete, as when we know of the process "add +1 to the output of prior process." In the latter case, the information we derive from the result is presumably complete and correct. Thus, it would appear that Losee's general formulation of information includes many situations where the information is limited or distorted, as well as situations where the information resulting from a process is unambiguously clear.

INFORMATION AS EVENT

Allan Pratt

Pratt[28] provided probably the most developed version of a conception of information in which information is an *event*, that is, he looks at the process of being informed and derives the term "information" from that. Pratt, too, draws on Boulding's concept of "the image." He says:

> My Image of the world, and my relationships in it, which includes my perception of cause and effect, of time, of space, of values, of everything which impinges on my consciousness, is different from yours, and from that of every other person in the world (p. 208).[28]

> After a person has received and understood the content of a message, in ordinary speech we say that he has become informed about the matter at hand. This is a surprisingly precise and accurate statement. He has been 'in-formed.'.... He has been inwardly shaped or formed; his Image has been altered or affected.

> In-formation is the alteration of the Image which occurs when it receives a message. Information is thus an event; an event which occurs at some unique point in time and space, to some particular individual (p. 215).[28]

He compares the concept "information" to the concept "explosion." "Every explosion is unique; no two are identical." "Further, explosions cannot be stored or retrieved. One may, of course, store and retrieve potentially explosive substances...." Later, he admits: "informative event" may be a more felicitous term than "an 'information'" (p. 215).[28] Here he comes upon the practical problem of the mass-noun usage of the word "information"; "an information," as a count noun, just does not fit into English usage.

PROPOSITIONAL DEFINITIONS OF INFORMATION

Propositional definitions are ones in which a piece of information is considered to be a claim about the world, a proposition.

Richard Derr

Perhaps the most accessible such definition is that of Derr[29]: "...information is an abstract, meaningful representation of determinations which have been made of objects." "A determination is a judgment of what is the case" (p. 491).[29] Using the example of an ordinary sentence, he elaborates as follows:

Five necessary conditions of the truth of the first sentence have been identified: In order for Sentence 1 to be true, it is necessary that:

1. Information be a representation,
2. The representation be abstract,
3. The representation be meaningful,
4. The representation consists of determinations which have been made,
5. The determinations have been made of certain objects (p. 491).[29]

Derr states that "[n]one of these conditions by itself is sufficient to insure the truth of this sentence; however, jointly, they constitute a set of sufficient conditions" (p. 491).[29] He goes on to argue that, based on these five essential properties, four derivative properties of information can be identified as well: Information is *communicable*, *informing*, *empowering*, i.e., one can take action based on having the information, and *quantitative*, i.e., information varies in amount (pp. 493–494).[29]

Fred Dretske

Dretske,[30] a philosopher, has been widely influential in his conceptualization of information. He draws heavily on the Shannon conception of information. Much of his book is taken up with working through the logical and philosophical implications of his position, and no attempt will be made to expatiate that here. Instead, let us take his simpler, introductory description of information.

Roughly speaking, information is that commodity capable of yielding knowledge, and what information a signal carries is what we can learn from it. If everything I say to you is false, then I have given you no information. At least I have given you no information of the kind I purported to be giving (p. 44).[30]

Later: "Information is what is capable of yielding knowledge, and since knowledge requires truth, information requires it also" (p. 45).[30] Thus, to be information, a proposition must be true. Dretske takes his analysis through many complex arguments, but at the heart of every argument is the core statement "s is F." The latter is the generic statement of a proposition, a claim.

He distinguishes information from meaning in the following way. A sentence, such as "Joe is at the office," has a meaning that arises straightforwardly from interpreting the sentence for anyone literate in English. A sentence may, however, carry much more information as well, beyond the meaning of the sentence itself.

> The acoustic signal that tells us someone is at our door carries not only the information that someone is at the door, but also the information that the door button is depressed, that electricity is flowing through the doorbell circuit, that the clapper on the doorbell is vibrating, and much else besides (p. 72).[30]

Thus, Dretske's sense of information includes all the demonstrable implications of a proposition, not only the (more limited) meaning of the proposition itself.

Christopher Fox

Fox[31] takes his propositional view of information through many transformations as well. Again, using the simplest formulation for our discussion here, Fox is essentially claiming that the information (if any) contained in a set of sentences in a particular context is the proposition p such that, first, p is the conglomerate proposition expressed by the set of sentences in that particular context, and second, that the agent of that context is in a position to know that p (p. 203).[31] Put still more colloquially, information is the collective propositional claim of a set of statements in a given context, provided the agent in that context is in a position to know that p.

Fox titles his book *Information and Misinformation*, and spends some time analyzing the latter concept as well. He disagrees with Dretske in that he does not feel that the act of "informing" necessarily means informing someone of a *true* proposition. He concludes, through a series of arguments based on the logical and linguistic character of true and false statements, that *informing* does not require truth, that is, the claim "that p" need not be true for someone to be informed of it. He argues, however, that we use "misinform" in a stronger sense—that to misinform someone necessarily means that the person is being informed of something that is not true. So we *inform* people of things that may or may not be true, but when we *misinform* someone, it necessarily involves telling the person something that is not true (p. 154ff.).[31]

We are now in a position to return to Losee's conception of information. Losee's position admits of misinformation too. He says, "The value of a variable is information about the input; when the information is only partial and is tainted by error, it is better understood as misinformation. Essentially, this is information that is partly or wholly false" (p. 267).[27] So in Losee's conception, the value produced by a process may indeed be inadequate or inaccurate, and should then be known as misinformation.

STRUCTURAL DEFINITIONS

In addition to Frederick Thompson, discussed below, we will review two other authors whose definitions are largely structural, D.M. MacKay and Marcia Bates. Their definitions are "multitype," however, and will be reviewed in the section on multitype definitions.

Frederick Thompson

Thompson[32] makes a discursive argument about information as a kind of structure. He recognizes the ways in which the structuring and organizing of information contains its own information, and is therefore likewise informative. He describes information as "a product that results from applying the processes of organization to the raw material of experience, much like steel is obtained from iron ore" (p. 305).[32] He also compares the scientist to the artist, in that "[d]ata are to the scientist like the colors on the palette of the painter. It is by the artistry of

his theories that we are informed. It is the organization that is the information" (p. 306).[32]

Commonly, in daily life, the forms of organization of information are seen to be neutral, content-free. Indeed, they are often taken for granted, and not even noticed. Thompson brings out the ways in which these organizing activities are themselves content, influencing, to a greater or lesser extent, the overall meaning of the text or other body of information. This is an intellectual position—highlighting the impacts of the form and organization of information—that has been taken up by many more recent scholars, for example, Geoffrey Bowker and Leigh Star.[33]

SOCIAL DEFINITIONS

The definitions considered to this point are drawn largely from logical and scientific points of view. This is sometimes known as a *nomothetic* approach; the fundamental effort in the sciences is to discover causes, effects, patterns, and tendencies that underlie the surface variety and particularity of life. The humanities perspective of valuing and studying the unique, specific characteristics of a situation, social group, or event, known as an *idiographic* approach, has not yet been represented here. In fact, probably due to the influence of the post-World War II scientific interest in information, many people coming from a humanities point of view have dismissed "information" as a specifically technological and heartless concept, to be perennially contrasted with the rich detail of specific institutions and historical moments, such as a study of the library in nineteenth century Illinois. However, the authors discussed in this section do embrace the concept of information, but argue that it must be seen as embedded in a social context.

Ian Cornelius

In 1996, Ian Cornelius[34] wrote about an "interpretive viewpoint" to information. Taking the practice of law for his example, he argued that information should be seen as socially constructed within a set of practices. A practice is a "coherent set of actions and beliefs which we conform to along with the other people in our practice (whatever it may be, profession or game), and it has its own internal logic and ethic" (p. 15).[34]

> My claim is that information is properly seen not as an objective independent entity as part of a 'real world,' but that it is a human artefact, constructed and reconstructed within social situations. As in law, every bit of information is only information when understood within its own cultural packaging which allows us to interpret it (p. 19).[34]

Further,

> . . .[T]here is no separate entity of information to discover independent of our practices. Up to the point that it is sought by a practitioner within a practice it is not information and cannot be interpreted.
>
> When a practice is seeking to impose meaning on something, that thing will already have come within the interpretive range of that practice and will already be at an early stage in a process of interpretation (p. 20).[34]

Thus, information must be seen within the dense context of social relations, negotiations, and understandings operative in a particular social context. Cornelius compares the embeddedness of information received and interpreted with the embeddedness of most interpretations of the law.

Joseph Goguen

Writing a year later, Joseph Goguen[35] developed a more detailed concept of socially embedded information. His more idiographic approach may have succeeded in humanizing and de-technologizing the concept for those of a more social science or humanities bent. He defines information as follows: "An item of information is an interpretation of a configuration of signs for which members of some social group are accountable" (p. 31).[35]

He argues that all information is situated within a context, and can only be fully understood within that context. He then addresses the question of whether any information is ever context-free; is some information more bound within a specific context than other information is? He describes a continuum of the character of information, from "wet" to "dry." He states that processes of abstraction and formalization are attempts to take information out of contexts and make it as generally applicable as possible. The more decontextualized, the "drier" the information (p. 32).[35]

Certainly, many scientific results fit this description. We do not need to know the specific circumstances in which Robert Boyle discovered Boyle's Law (physics), in order to gain full value from the use of Boyle's Law. On the other hand, enormous amounts of contextual knowledge is needed in order to properly to interpret the reasoning and strategy involved in directing the prosecution of World War II, or, in the information system design context, the hostile attitudes toward use of an information system in a particular government agency.

Goguen:

> In general, information cannot be fully context sensitive (for then it could only be understood when and where it is produced) nor fully context insensitive (for then it could be understood by anyone in any time and place).
>
> According to our social theory of information, meaning is an ongoing achievement of some social group; it takes *work* to interpret configurations of signs, and this work

> necessarily occurs in some particular context, including a particular time, place and group. The meaning of an item of information consists of the relations of accountability that are attached to it in that context, and . . .the narratives in which it is embedded (p. 34).[35]

He draws on ethnomethodology for the *principle of accountability: "Members are held accountable for certain actions by their social groups; exactly those actions are the ones constructed as socially significant by those groups"* (p. 40).[35]

It should be understood that Goguen is developing this concept of information in the context of information system design and usability testing. He refers to the numerous instances where massively expensive information systems were abandoned because they were dysfunctional for the organization for which they were designed. He argues that the close observation of people as called for in ethnomethodology is the gold standard for learning how a group organizes the work of their institution—what systems of categories, what contrasts, what relationships matter to the group, how the group divides up the processes and objects in their world in order to carry out their ongoing activities. Goguen:

> In particular, ethnomethodology looks at the *categories* and *methods* members use to render their actions intelligible to one another; this contrasts with presupposing that the categories and methods of the analyst are necessarily superior to those of members (pp. 40–41).[35]

This is a powerful conceptualization of information that incorporates its social role. Goguen argues that information, as understood through his construction of the term, is *situated*, *local*, *emergent*, *contingent*, *embodied*, *vague*, and *open* (pp. 34–35).[35] Recall Derr's characterization of information and compare it to Goguen's view: "abstract, meaningful representation of determinations which have been made of objects" (p. 491).[28] The idiographic and nomothetic world views are on display in this contrast. For my part, they both carry a lot of truth. I do not see that one or the other approach has to "win" in the culture wars. By incorporating both approaches in our thinking, we may end up with the richest possible understanding.

FIRST INTERLUDE: THE PROBLEM OF POPPER'S WORLDS

We interrupt this recital of different approaches to the concept of information in order to consider the role of the work of Karl Popper,[36] a well-known twentieth century philosopher of science, in discussions of the nature of information. Popper was not himself interested in the concept of information, and used the word very little. However, he developed another idea, of three worlds in the scientist's life, that has had enormous impact in information science, and recurs again and again through the literature on information. Popper wrote over a number of years about what he called three "worlds": "We can call the physical world 'world 1,' the world of our conscious experiences 'world 2,' and the world of the logical *contents* of books, libraries, computer memories, and suchlike 'world 3'" (his italics) (p. 74).[36]

It was important to Popper to distinguish one person's subjective understanding of a scientific topic from a more objective existence of knowledge of science that is independent of individual people. Once Robert Boyle died, the knowledge of "Boyle's Law" did not die with him. It was expressed and recorded in the literature of science, and was in the minds of many people who studied science. In short, scientific learning has a public, independent, and thus, reasonably objective existence apart from any one person's subjective understanding of a scientific finding.

It is the daily bread of the work of people in the information disciplines to address the recorded, "exosomatic" (outside the body) forms of information. When a philosopher writes about objective knowledge, argues for its importance, and is at pains to distinguish it from other "worlds," it may seem that at last someone from outside the information disciplines has paid recorded knowledge the attention that it deserves. At last, the very heart of the work of information managers has been recognized and validated as a key part of science!

Unfortunately, however, a close reading of Popper indicates that he did not view information resources in the way that information professionals do. Though he would sometimes refer to objective knowledge in books and journals, thus making it easy to conflate the "thingness" of books in with the objective nature of scientific findings, in fact, it is evident again and again in Popper's writing that when he is speaking of the objective nature of world 3, he means, as his definition above indicates, the *logical contents* of the books and journals, not the objects themselves. When he pays attention to the books themselves, he always calls them a part of world 1. Indeed, the scientific examples he uses are generally of the very "driest" sort, in Goguen's terms—generally mathematical and physical examples. To make his point about objective science, he is determined to select examples that can live independently in the most unambiguous way from individual knowers.

Popper was a philosopher of science, and was concerned about various debates he was having with his philosopher colleagues. It was important to him to argue for the idea that the body of scientific learning can be thought of as independent from any one individual's (world 2) experience. He called this "epistemology without a knowing subject" (pp. 106–152).[36] A prime argument of his was that we can learn more about epistemological issues associated with science if we attend to the world 3

form of science, rather than to questions of how an individual person comes to know and believe something, the traditional subject matter of philosophical epistemology.

But it appears that he was not particularly conscious of the contents of libraries as a domain of study or professional practice. Indeed, Popper appears to have been unaware of John Ziman's book: *Public Knowledge: An Essay Concerning The Social Dimension of Science,* published in 1968, which took a more socially sophisticated look at the senses in which science has a public existence.[37] Popper was not a social scientist, and he rather ignored distinctions that would be important in the social sciences. He saw libraries as the abode of the logical content, but it was only the logical content that interested him—not the vast infrastructure of information institutions, professional associations, and laboratories supporting these exosomatic forms of information storage. In fairness to Popper, it was the philosophical, not the social or professional dimensions of the material aspects of science that interested him.

Nonetheless, Popper has held a continuing fascination for information studies, and discussion of his three worlds appears in the work of many, including Brookes,[25] Rudd,[38] Neill,[39,40] Capurro and Hjørland,[3] and other information scientists' work. It is not my objective here to analyze these appearances of Popper in information studies, except to say that Popper is often misunderstood, or the subtle distinctions he made are ignored. To take just one example: Capurro and Hjørland define Popper's world 3 as follows: "intellectual contents such as books, documents, scientific theories, etc." (p. 393).[3] Treating scientific theories as being in the same category as books and documents, thus conflating world 1 with world 3, risks perpetuating the confusions.

If the reader finds tackling the large body of writings by Popper to be daunting, J.W. Grove[41] provides a good, knowledgeable discussion of world 3. The best places to find Popper's own discussions of world 3 are in his book *Objective Knowledge*[36] and in chapter P2 of Popper and Eccles, *The Self and Its Brain*.[42]

MULTITYPE INFORMATION DEFINITIONS

Donald Mackay

Donald MacKay,[43] writing at about the same time as Thompson, who was reviewed above, also saw information structurally, specifically, "Information: that which determines form" (p. 160).[43] MacKay took a more rigorous scientific approach to conceptualizing information than Thompson did. Elsewhere, he defines it as "that which adds to a representation" (p. 163).[43] Within this general formulation, three senses of information are distinguished:

1. Structural information content, measured by "logons."
2. Metrical information content, measured by "metrons,"
3. Selective information content, measured by "bits."

MacKay divided the above three measures into two types, constructive and selective. The first two measures are labeled "constructive." The third measure, "bits," corresponds to Shannon-type information, and is labeled "selective." Since the Shannon approach measures amount of information, in part, by the number of options from which a message is selected—a message chosen from 100 possible equiprobable messages is more informative that a message selected from 10 possible equiprobable messages—the amount is measured in an indirect way, in terms of the number of messages *not* sent, hence "selective."

It is interesting, therefore, to contemplate MacKay's effort to measure information in a more direct, or positive way, with his first two "constructive" measures, logons and metrons. The logons he sees as "[t]he number of *distinguishable groups or clusters* in a representation. . .its *dimensionality* or *number of degrees of freedom*" (p. 165).[43] The metron, on the other hand, is "that which supplies one element for a pattern." Later: "Thus the amount of metrical information in a pattern measures the *weight of evidence* to which it is equivalent" (p. 166).[43] This approach is redolent of inferential statistics, though it appears to have been intended to be still more general than that. Whatever the case, it does not appear to have caught on as a general means of measuring information.

Brenda Dervin

Brenda Dervin[44] developed an Information$_{1,2,3}$ formulation of information, drawing heavily on the work of Richard Carter, though the distinctions she makes bear some resemblance to Popper's. (Carter's works were notoriously fugitive, seldom appearing in conventional publication venues.)

Dervin states: "In the most general sense, Information$_1$ refers to external reality; Information$_2$ refers to internal reality." This distinction "forces our attention to the notion that information can be whatever an individual finds 'informing.' It moves our attention away from 'objective' information, toward assessing the 'cognitive maps or pictures' of an individual" (p. 22).[44] She then asks how the individual moves between these two realities. "How does he impose sense on reality when he finds none there?" (p. 23).[44]

She argues that "[b]oth an individual's selection and use of Information$_1$, *and* his creation of Information$_2$ result from some kind of behavior. It is suggested here that these behaviors are in themselves legitimate

informational inputs: $Information_3$." (p. 23).[44] In other words, Dervin sees $Information_3$ as all the ways in which people make sense of their worlds, the set of techniques they have to make this reconciliation between internal and external world. She then provides examples of different ways that people make sense of their experiences: by "decisioning," by using a "liking-disliking procedure," by a "relating to others" strategy, i.e., getting advice from others. In sum, we can say that in Dervin's terms, $Information_1$ is external world, $Information_2$ is internal world, and $Information_3$ is the procedure used to reconcile these two worlds.

Michael Buckland

Buckland[45] argues for three types of information:

1. Information-as-process: "When someone is informed, what they know is changed." This definition is similar to Pratt's concept of "in-formation" (see above).
2. Information-as-knowledge: "'Information' is also used to denote that which is perceived in 'information-as-process'"
3. Information-as-thing: "The term 'information' is also used attributively for objects, such as data and documents that are referred to as 'information' because they are regarded as being informative…" (p. 351).[45]

Buckland titled his article "Information as thing" and addresses this sense of information the most in the article's discussion. He sees the information disciplines as primarily being concerned with information in this sense. [T]he means provided, what is handled and operated upon, what is stored and retrieved, is physical information (information-as-thing)" (p. 352).[45] In this regard, his thinking most resembles that of Jason Farradane,[46] who defined information as a "physical surrogate of knowledge. (p. 17).[46] Farradane argued that such a tangible concept was needed in order to develop a proper science out of information science.

Citing examples of documents, statistical data, statutes, photographs, etc. Buckland says: "In each case it is reasonable to view information-as-thing as *evidence,* though without implying that what was read, viewed, listened to, or otherwise perceived or observed was necessarily accurate, useful, or even pertinent to the user's purposes." Later: "If something cannot be viewed as having the characteristics of evidence, then it is difficult to see how it could be regarded as information" (p. 353).[45] This characterization does leave the reader wondering if Buckland always distinguishes information-as-knowledge from information-as-thing. Suppose a legal precedent is considered evidence. Is the physical book where the precedent is published the evidence, or the "information-as-knowledge" within the book that is the evidence? It would seem to be important to distinguish the physical form of the record from its logical content.

Buckland goes on to say that most anything can be informative, therefore information is everything. "We conclude that *we are unable to say confidently of anything that it could not be information*" (p. 356).[45]

Buckland concludes by suggesting areas in information science where distinguishing "information-as-thing" could be helpful. He notes that historical bibliography, the study of books as physical objects, and statistical analysis of information objects (now known as "informetrics") are areas where information-as-thing has primacy. Second, in the professional activity of the information disciplines, an understanding of the physical handling of different kinds of objects and materials is vital to effective management of those resources.

Marcia J. Bates

Marcia Bates[47,48] sets out self-consciously to build a conception of information that is suitable and productive for the information disciplines to use in theory and practice.

Her basic definition is a structural one—arguably the most suitable approach for disciplines concerned with the material storage and access to information. "Information is the pattern of organization of matter and energy" (p. 1033).[48]

She aligns with Wiener on the nature of information: Wiener has said, "Information is information, not matter or energy" (p. 132).[18] That is, she argues that information is not identical to the physical material that composes it; rather information is the *pattern of organization* of that material, not the material itself. (This contrasts with Buckland's conclusion that information is everything.)

On the other hand, though the material world is indisputably materially "there" and not a figment of solipsistic imagination, how living beings perceive and conceive of that pattern of organization is immensely variable across species and across individuals and across the same individual at different times. The bug crawling across a checkerboard may not be aware of the alternating red and black squares at all, whereas the game-playing human looking at the board may be so focused on the squares that he or she does not even notice what material the board is composed of. Thus, nature has a physical reality independent of human beings, in which we can posit the existence of patterns of organization, even if we perceive them poorly or not at all, while living beings experience patterns of organization in their lives that may be uniquely their own, either as a species or an individual.

At the same time, she conceptualizes information in the larger context of the development of life on earth, drawing on a conception developed by Susantha

Goolatilake of the evolution of information transfer over the history of life on earth. Goonatilake's view of the broad fundamental types of information is well suited to the needs of the information disciplines.[49]

He argues that over the history of life on earth, information has been stored and transmitted in three fundamental ways: genetically, neural-culturally, and exosomatically, that is, through the genome, through cultural transmission, and through storage devices external to the body. Humans, who began by memorizing and telling stories to pass on culture neural-culturally, developed an explosively growing capacity for exosomatic storage once they began to carve, draw, and write on more or less durable surfaces.

In developing her conception of information, Bates argues that in living organisms, information tends to move back and forth between encoded and embodied forms. Genetic information is encoded in the genome and embodied in the living animal, the phenotype. The phenotype, in turn, encodes the genome in reproductive material to the next generation.

Neural-cultural information is encoded in the brain of an animal, and embodied in the experiences, actions, and communications of the animal. Exosomatic information is encoded in the external materials in which it is stored, whence it is again embodied in human experience during reading, touching, or observing.

All such life-associated information she calls "represented" information, because embodied information can be thought to represent encoded information, and encoded information can be thought to represent embodied information.

To Goonatilake's three channels of information transmission she adds a fourth channel, "Residue." Residue is the flow line of extinction, where previously encoded or embodied information degrades, as in the Biblical "dust to dust." This flow line is important in the information disciplines, because relatively durable information storage does not endure forever, and can degrade to the point where no socially meaningful evidence remains.

Thus, in parallel to Goonatilake's three flow lines, Bates defined the following forms of information:

- The genetic flow line is associated with Genetic information.
- The neural-cultural flow line is associated with Experienced information (in the mind), Enacted information (actions in the world), and Expressed information (nondurable communications).
- The exosomatic flow line is associated with Embedded information and Recorded information. Embedded information is associated with the enduring effects of animals on the earth—from a path through the woods to deliberately fashioned tools, homes, and other objects. Recorded information is communicatory or memorial information preserved in a durable medium. This type of information is the prime domain of most of the information disciplines—libraries, archives, knowledge management, etc.
- Finally, residue is association with Trace information—the pattern of organization of the residue that is incidental to living processes or which remains after living processes are finished with it. The importance of Trace information to the archaeological and museum worlds is self-evident.

Bates argues for the value of such an approach by describing several example applications of these multitype terms for information in information studies. For example, the study of information seeking behavior needs to incorporate an awareness of *all* the forms of information a person takes in.

> People get information not just from paper sources, not just from other people, but also from the physical layout of their workspaces, from the design, not just the content, of informational genres, and above all, from the interaction of these various factors in a real situation. All the patterns of organization of matter and energy—cognitive, physical, architectural, social, linguistic—are informative (p. 1043).[48]

Thus, all types and forms of information need to be incorporated in our thinking in doing information behavior research, and having these multiple types of information in mind can promote that awareness and use in research.

SECOND INTERLUDE: DIKW

DIKW stands for Data–Information–Knowledge–Wisdom. Just as Popper's three worlds frequently show up in considering information, so also does this sequence. Discussion of this sequence is based on the assumption that the terms go from the least to most processed or integrated, with data the rawest, and wisdom the most rarefied.

Arguably, this view of these terms comes ultimately from their popular usage. Intuitively, we see each term in the sequence as more developed, "cooked,"[50] or worked through than the term to its left. Discussions of this sequence, in more or less formally worked through thinking, show up many places, including, at least, Houston and Harmon,[51] Hammarberg,[50] Meadow and Yuan,[5] and Ferris.[52] Sharma traced the hierarchy through the knowledge management and information science literature in the 1980s back through to the poet T.S. Eliot in 1934.[53] Thompson suggests that "signal" should be a fifth term in the sequence, preceding data (See the entry on "Telecommunications," p. 5156).

Though this sequence may feel intuitively right, it is difficult to take it from its popular meaning and develop it into something sufficiently refined to be useful for research. Most discussions of DIKW really," at base, elaborate the intuitive understanding, and do not take theory much further.

DECONSTRUCTING "INFORMATION"

"Information" has had so much importance in the thinking of many disciplines, including library and information science, over the last 60 or more years, that it is not surprising that the time has come where authors set out to debunk or "deflate" the importance of the concept of information. They choose various ways of doing this; three are illustrated below.

Ronald Day

In Ronald Day's deconstruction of *The Modern Invention of Information*, he states that

> I attempt to show how professional and authoritative texts about the social importance of information tried to use language (particularly through books) to construct a social, utopian value for information and helped to raise information and its connotations of factuality and quantitative measure to a privileged, even totalitarian, form of knowledge and discourse (p. 2).[16]

He says his objective is not to say what information "really is" nor to conclude that information is good or bad, but "rather that certain connotations of information, and the social and cultural privileging of certain technologies and techniques associated with it, are cultural and social productions that elevate certain values over other values. . ." (p. 117).[16] Thus, he is not defining so much as critiquing the uses of the term "information."

Bernd Frohmann

Bernd Frohmann's objective in his book *Deflating Information* is to replace the centrality of "information" as the focus of much of information studies and science studies with the centrality of practices surrounding documents.[54] His objective is thus not so much defining or theorizing information as it is, as his title says, "deflating information."

> One of the aims of this book is to show how rich and varied the practices with scientific documents can be, especially compared to the simplistic idea that there is no more to the informativeness of a document than what happens in the mind of someone who understands it (p. 16).[54]

Some would complain, however, that good research on information seeking has, from the beginning, also examined scientific practices around documents, and linked those practices to the subjective points of view of the people being studied. Most of the articles on information seeking in the "ancient" 1958 International Conference on Scientific Information,[55] or the 1960s era American Psychological Association's Project on Scientific Information in Psychology[56] could be shown to have done that. What we can say of recent decades, though, is that consciousness of all the practices, situations, and cultural beliefs surrounding information seeking and use has grown substantially, and Frohmann's book-length treatment demonstrates that.

Jonathan Furner

Furner suggests that rather than relating information to epistemology, we should relate it to the philosophy of language. Further, "we shall find that philosophers of language have modeled the phenomena fundamental to human communication in ways that do not require us to commit to a separate concept of 'information.'" And, "[o]nce the concepts of interest have been labeled with conventional names such as 'data,' 'meaning,' 'communication,' 'relevance,' etc., nothing is left (so it may be argued) to which to apply the term 'information.'" In fact, he claims that the entire field may be misnamed and "that its subject matter should more appropriately be treated as a branch of communication studies, semiotics, or library studies" (p. 428).[57] Furner might not call himself a Post-Modernist, but the effort to design an approach that does without *the* central concept in a discipline, has an objective very much in a postmodernist spirit of deconstructing hitherto core values and ideas.

He identifies what he considers to be the several ways in which "information" is used and discussed in information studies, and categorizes them in three broad groupings as follows: "Information-as-particular," namely "Utterances," "Thoughts," and "Situations;" "Information-as-action," namely "Communication;" and "Information-as-universal," namely, "Informativeness," and "Relevance" (p. 438).[57] He then argues that other fields address most of these topics with deeper understanding and research results than information studies does, and that even in those topic areas where information studies has done much work, such as relevance, we can draw from work in pragmatics and the philosophy of language (p. 444).[57]

One can certainly agree that we have not advanced as far as desirable in understanding information, and, as well, that we often lack an adequate theoretical basis out of which to develop our ideas. However, one can see this situation as a problem of failing to date to develop our unique intellectual substrate, rather than that we are re-inventing lumpy versions of other disciplines' well-wrought wheels.

The universe of study of the physicist is the physical processes and dynamics that govern our universe; the universe of study of the biologist is the world of living things. The primary domain of study in the information disciplines is the world of exosomatic information, and human beings' relationship to that world as creators, designers, and users. Heretofore, society has seen that world, if it noticed it at all, as merely an epiphenomenon of the real world of things that matter. Increasingly, as the twenty-first century develops, we are more and more

often grasping the reality that the world of information has become its own universe of study, one of immense importance to human beings, full of intriguing phenomena to observe and understand. That study should surely include identification of key terms, along with the provision of our own disciplinary definitions.

CONCLUSIONS

The understanding of the core concept of "information" in information science remains a highly contested area. Information is seen as

- A proposition, a structure, a message, or an event
- As requiring truth or indifferent to truth
- As socially embedded and under perpetual re-interpretation, or as measurable in bits
- As a worn-out idea deserving of dispatch, or as an exciting conception understandable in terms of evolutionary forces.

The much-debated concept of information remains at the lively heart of information science.

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