

Article

When ‘The Difference That Makes a Difference’ Makes a Difference: A Bottom-Up Approach to the Study of Information

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Abstract: The concept of information is foundational to many disciplines yet also problematic and contested. This article contributes to the understanding of information through discussion of the findings of the interdisciplinary Difference That Makes a Difference (DTMD) project. DTMD used international conferences and workshops to bring together individuals from a wide range of disciplines to share how their field understands information, to engage in interdisciplinary conversations, and to contribute to edited publications. A simple answer to the question ‘what is information?’ is not forthcoming, but, it is argued, should no more be expected than would be an answer to ‘what is matter?’. Nevertheless, through exploration of the areas of consensus that emerged from the bottom-up process of interdisciplinary dialogue, this paper offers ten assertions about the nature of information narratives for further debate. The assertions range from ‘information requires a body’, through ‘information always has meaning’ and ‘information cannot be stored or communicated’ to ‘information is always shaped by power, authority and hierarchy’. This article finishes by illustrating and testing the assertions against an information case study of a team of medical experts disseminating information to the general public about the COVID-19 virus.



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1. Introduction

Information is remarkably elusive, although it was more than 70 years ago that it emerged as a field of study. In 1948, Norbert Wiener [1] (p. 155) wrote that:

information is information, not matter or energy; no materialism which does not admit this can survive at the present day.

In the same year, Claude Shannon published *A Mathematical Theory of Communication* [2], which founded the engineering discipline of Information Theory. Yet despite accelerating research effort ever since, information, unlike either matter or energy, remains contested. There exist treatises on information, and authors who believe that they have solved the conundrum of information. Mark Burgin, for example, has been working on an extensive and comprehensive theory of information for many years (see [3] for an early paper discussing a General Theory of Information) and Luciano Floridi has developed a corpus built on *The Philosophy of Information* [4]. However, it remains a contested field, and has yet to settle on an agreed canon that might, for example, form the basis for the curriculum of a university undergraduate module on Information.

It is still not certain whether a single unified theory of information, as sought by Wolfgang Hofkirchner and his collaborators [5], is even possible; and for some authors, the attempt to answer the question ‘what is information’ is misguided. Marcin Schroeder [6] put it like this:

Discussions about information begin from, and frequently end with the deceptive question ‘What is information?’ The large and increasing variety of significantly different answers shows that the expectation to find somewhere something

awaiting revelation, which exists independently from those who ask about it and which necessarily should be called 'information' is naïve. Equally naïve would be expectation that the question 'What is matter?' has a unique 'correct' answer.

For Pedro Marijuán, 'what is information' is an 'outdated question' and:

Like similar obnoxious questions along the history of science, what they should produce when successful is not a neat and crisp response but the booming of a new discipline or a fertile new branch of technology. [7]

The booming of the new discipline requires explorations around information. Questions about information need to be asked, such as Hofkircher's *Twenty Questions About a Unified Theory of Information* [5], the usage of the language needs to be interrogated [8] and classifications generated [9]. The interdisciplinary project known as The Difference That Makes a Difference (DTMD), discussed in this article, contributed to the booming of the new discipline by inviting contributors from a wide range of perspectives to discuss what is it that they are calling information [10]. The title of the project drew on the classic definition of information by Gregory Bateson [11] (p. 453).

The project (described in more detail in Section 2.5 below) ran for over 10 years involving more than 70 participants, and was conceived and coordinated by the authors of this article. They attended all of the presentations, read the papers and participated in the discussions of the project, and this article is their provisional (because all information is provisional) concluding narrative for the project. It would be impossible, in a single article, even to begin to do justice to all of the topics that came up in DTMD, and, despite the scope of DTMD, there are many aspects of information (such as consciousness and computing) that never appeared in DTMD, or else were addressed but not explored in depth. This article is not and cannot be comprehensive in that sense. However, this article represents an attempt by the authors to share what they found most significant from the DTMD project and what has shaped their view of information. Presented as ten (contestable) assertions about information, it is a narrative of information that they have reached by leading the project, and they offer it to the information community as a contribution to the debate. Readers, however, are also encouraged to make use of the primary resources of the project, the presentations and papers of the DTMD events, which can be accessed through the references in Appendix A.

2. Starting Points

Although the DTMD project sought to take a bottom-up approach to the understanding of information (looking at its use in a range of disciplines, and seeking to find connections and similarities between those disciplines), there were a number of intellectual starting points which guided the discussions, and which shaped the workshops. Five of these starting points are discussed in this section.

2.1. Data, Information, Knowledge and Wisdom

A widely-used framework for understanding information and related concepts is the data–information–knowledge–wisdom (DIKW) hierarchy, which is presented in increasing order of complexity, with a transformation occurring from one level to the next. This hierarchy has no clear single origin, as Rowley [12] discusses, although it is often attributed to Russell Ackoff in a talk given in 1988 [13], and sometimes beyond that to a 1934 poem by TS Eliot. Although the DIKW hierarchy is widely discussed and used in textbooks, the nature of each of its components is somewhat unclear. One of the clearer definitions of information within the DIKW hierarchy is given by Checkland and Scholes [14] (p. 55) who argue that 'information is data to which meaning has been attributed in a particular context'.

Each of the first three of these components was discussed at some length during the workshops. Data and information are addressed throughout this article, and there is a discussion of knowledge in Section 3.5. Less discussion was had on the concept of wisdom, apart from a tantalising suggestion that there could be a discipline of 'wisdom management' to parallel knowledge management [15].

The DIKW hierarchy was implicit in many of the workshops, and one of the foundational ideas behind many of the talks, but not often explicitly addressed. One paper which did so, by Holwell [16], argued for a sequence of distinctions between, data—those data which we consider relevant in the world (*capta*, in her terms)—information, and knowledge. Holwell described the sequence as ‘three distinctions created by our actions of: selecting data, attributing meaning to this selected data, and assembling larger structures of meaningful data’ (pp. 74–75).

The DIKW hierarchy, however, is only one example of a number of forms of layered thinking that can be used to help understand information [17]. Layered protocols are widely applied in the engineering of information technology; levels roughly aligned to the semiotic levels of syntax, semantics and pragmatics were used by Warren Weaver to develop Shannon’s work for the general problem of communication (see Section 2.4 below); and the method of Levels of Abstraction is a key component of Floridi’s Philosophy of Information [4].

2.2. Hard and Soft Models of Information

One of the ways in which dialogue in the DTMD project has been framed is through Ramage’s distinction between a hard and a soft model of information [18,19], closely related to hard and soft conceptions of cybernetics. Hard models of information, such as those of Shannon [2] and Wiener [1], tend to treat information as if it were a physical object in its own right, devoid of its original context. Soft models of information, such as those of Bateson [11] and Mackay [20], tend to emphasise the importance of meaning attribution by the sender and receiver of information, and thus treat context as central.

Binary distinctions are problematic and it is clear that many approaches to information fall between these characterisations of hard and soft, or transcend them completely; nonetheless, we find the distinction pragmatically useful. In this, we follow the lead of Chandler [21] (p. 107), who observes that binary distinctions ‘help to generate order out of the dynamic complexity of experience’ but that they ‘exist in sign systems rather than the world’. Our distinction is closely related to the distinction between hard and soft systems thinking made by Checkland [22]. This hard–soft distinction is different in principle from the way information is typically handled in the physical and social sciences, although there are some overlaps. Hofkirchner [23] (pp. 6–7) used a related but different distinction between approaches to information which he associated with hard and soft science, respectively, characterised by ‘objectivism, materialism and externalism’ (hard), and by ‘subjectivism, idealism and internalism’ (soft).

The ways in which these two models of information shaped the DTMD project are examined in the next two sections.

2.3. Soft Cybernetics

As discussed above, the project took its title from Bateson’s definition that information is ‘the difference that makes a difference’, abbreviated here as DTMD. That is, information is produced by an understanding of the state of the social or physical world (a series of differences), but combined with a process of selection which, Bateson argues, implies an observer who attributes meaning to particular states of the world (differences that make a difference).

For the sake of accuracy, we should note that when Bateson first used the phrase [11] (p. 453), he referred to ‘the difference *which* makes a difference’; our preferred version in the project, ‘the difference *that* makes a difference’ is from a later work [24] (p. 228). We see no significant difference (sic) between the two versions of the phrase, and both are widely found in secondary literature.

Gregory Bateson had a significant influence on the fields of anthropology (his original discipline), but also psychiatry, ecology, zoology and cybernetics. One of the present authors has described him elsewhere as ‘perhaps the most wide-ranging and profound thinker in early cybernetics, and his work provides a foundation for much of the important

work that followed, and a still-challenging insight into the problems of the world today' [25] (p. 3). Indeed, we were privileged at one of the workshops to be permitted to show an early copy of an excellent biographical film about Bateson by his daughter Nora [26].

We found Bateson's definition a helpful 'rallying call' in shaping the workshops. The process of selection from a series of observers related well to the bottom-up approach that we were seeking to follow. We also found it helpful to have a basic framework for the nature of information implicit in the workshop titles for attendees who might make considerable use of information in their work without having theorised it closely; and a number of attendees used variants of the phrase 'the difference that makes a difference' in the titles or content of their own talks. However, we made no attempt to impose this definition on attendees, or present it as anything more than the most basic of hooks upon which their own practice and theories could be hung.

2.4. Communication Theory

Shannon's paper which founded the engineering discipline of Information Theory in 1948 was entitled *A Mathematical Theory of Communication* [2]. It was presented as a theory of communication rather than a theory of information, and his work on information came as by-product of his analysis of electrical communication. In order to model communication, Shannon needed a definition of what was being communicated, and this was Ralph Hartley's 'information', measured in information bits. He also famously said that his work was concerned solely with the engineering problem of communicating messages, and that:

Frequently the messages have meaning; that is they refer to or are correlated according to some system with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem. [2] (p. 379)

Warren Weaver, however, in a paper published in 1949 as a companion to Shannon's 1948 paper, said in reference to Shannon's statement:

But this does not mean that the engineering aspects are necessarily irrelevant to the semantic aspects. [27] (pp. 99–100)

Weaver's paper built on Shannon's model to explore what he referred to as the general problem of communication, taking in problems of semantics and beginning a body of work which used ideas from Shannon in explorations of human communication (see, for example, Colin Cherry's 1957 book *On Human Communication* [28]).

Some of the participants in DTMD were engineers or computer scientists, but few of the presentations addressed Information Theory in the sense of the engineering discipline. Their work would not generally find a home in the *Transactions on Information Theory* of the Institution of Electrical and Electronic Engineers (IEEE), for example. Participants schooled in the hard model of information were nevertheless seeking interdisciplinary understanding of information: exploring the general problem of communication, making links to the soft model of information or seeking philosophical insights into Information Theory.

2.5. Dialogue and Narrative

The physicist David Bohm described dialogue as 'a stream of meaning flowing among and through us and between us [which] will make possible a flow of meaning in the whole group, out of which may emerge some new understanding' [29] (p. 302). The DTMD project sought to create this free flow of meaning between academics and practitioners coming from a vast array of home disciplines, all with a common interest in information.

A series of six workshops on information were held between 2007 and 2017 (see Appendix A below). Three of the workshops took place on the campus of The Open University in Milton Keynes, UK; three more were part of larger conferences elsewhere. More than 70 different people contributed as authors, co-authors and presenters at these different events, coming from across the world, and more have participated in the discussions. Selected articles from most of the events have been published, and proceedings of all the events are available at the DTMD website, www.dtmd.org.uk (accessed on 10 February

2021). Four of the workshops were referred to as *The Difference That Makes a Difference*, and two had different titles.

In the spirit of Bohm's model of dialogue, the events were designed to be participative—there have been a large number of speakers at each one, with extended discussion periods. As a result, this article draws upon 82 different papers which were discussed at one of the workshops and/or subsequently written about.

To illustrate the breadth of discussion at the workshops, the following is a partial list of some of the disciplines represented: information systems, organisational theory, information science, telecoms, logic, semiotics, quantum theory, art, philosophy, biology, ecology, communications, sociology, physics, critical race theory, design, architecture, music, genetics, and cultural studies. More disciplines could have been listed. A key goal of the workshops has been to bring quite different perspectives in dialogue with each other.

An underlying narrative that emerged during the series of workshops, and appeared explicitly in the language of later workshops, was that of narrative itself. Narrative may be defined as 'a story that we use to manage and make sense of multiple sources of information' [30], and the workshops were increasingly seen as forums for developing the narratives to use when discussing information. Furthermore, and self-referentially, the narratives of information themselves incorporated concepts of narrative.

3. Assertions about Information

Each of the following subsections explore assertions about information, drawing on work by Chapman [31]. They are not final claims about information—all of them are contested to a greater or lesser extent—but they provide a convenient framework for exploring the informational language employed by the DTMD project contributors.

3.1. Information Requires a Body

In *Alice's Adventures in Wonderland* [32], the grinning Cheshire Cat disappears until only the grin remains:

'Well! I've often seen a cat without a grin,' thought Alice; 'but a grin without a cat! It's the most curious thing I ever saw in my life!'

An influential insight into the ontology of information is that information has been reified yet simultaneously 'lost its body' [33] (p. 2). Yet whether information has a body or not, we always *encounter* information as embodied. It is always 'as if' information has a body, since we perceive it through our physical senses as, for example, words, numbers, images or sounds [34].

A possible formulation [31] is to call information's body 'data' (another contested concept), and when researchers have attempted simple definitions of information, it has often been some variation on 'meaningful data' [16]. Data without meaning would be just data, not information. So, for example, a painting without any contextual understanding is data and not information [35]. On the other hand, the moment an observer sees a painting, or any data whatever is perceived, a context of sorts is established, and so truly uncontextualised data are an impossibility [31]. On that basis, data need information just as much as information needs data, and starting from information ('top down' rather than 'bottom up'), the body is reified by the information, leading to the idealism of Wheeler's famous 'It from bit' ([36], discussed by [37]): information precedes matter ontologically.

3.2. Information Can Be Quantified

Information is often presented as if it were quantifiable, for example:

According to traditional theories, brain researchers estimate that the human mind takes in 11 million pieces (tokens) of information per second through our five senses but is able to be consciously aware of only 40 of them. [38]

Information as a quantifiable concept is a core part of the hard model of information [19], as part of the quasi-physical treatment of information within that model—indeed, Faichney [39] refers to the forms of information which can be quantified as ‘physical information’.

Within the tradition of hard information, two related measures of quantification can be identified [40]. The first derives from communications theory and is often described as ‘Shannon information’ because it derives from Shannon’s classic paper [2], although, as Bissell [41] observes, it goes back at least to the work of Ralph Hartley [42]. The measure of Shannon information is probabilistic, and a message has more information if it has a lower probability. This is intuitively reasonable because a message carrying unexpected news delivers more information than a message telling you something you were expecting anyway.

The second measure of quantification derives from the discipline of computing and is known as algorithmic Information Theory. The amount of information in a computer file is the smallest number of bits that can be used to represent the file: it is the size of the file after being compressed by the theoretically-best possible compression algorithm. This approach is not solely about data compression—rather it is concerned with ‘finding the absolute minimum number of bits needed to describe a sequence, and therefore to be a measure of the absolute information content of the sequence’ [40] (p. 90), an approach which some authors find superior to Shannon’s method as a measure of information.

Information is less obviously quantifiable in the soft model of information, with its strong focus on meaning and context (both topics discussed in later sections of this paper). Fiorini [38], with whom this section began, later argues that in today’s world, ‘information plays a much broader role, in which what matter is meaning rather than quantity’. Information in the soft model is thus considered to be about concerns which are not readily open to quantification, even if some aspects of information can be quantified. As Bateson [11] (p. 403) argues, ‘the central explanatory quantity, information, is of zero dimensions. Quantities of real dimensions (mass, length, time) and their derivatives (force, energy, etc.) have no place in cybernetic explanation’.

However, many authors within the soft tradition do allow for the use of some degree of quantification. Gregory Bateson had no problem in stating that ‘quantity of information is conventionally expressed as the log to base 2 of the improbability of the actual event or object’ immediately before his argument quoted previously. More strikingly still, the cybernetician Donald Mackay, described by Ramage [19] as one of the exemplars of soft information, had a model of the quantification of information which was broader than Shannon’s albeit developed independently.

In a paper originally presented to the First London Symposium on Information Theory in 1950, Mackay [43] distinguished between the information perspectives of scientists and communications engineers. Scientific information, in his model, had two linked components, both quantifiable based on previous work by others: structural information content (the number of different independent variables to be described), measured with *logons* and metrical information content (the weight of evidence about those variables), measured with *metrons*. Hayles [33] (p. 56) argued that ‘Mackay’s model recognized the mutual constitution of form and content, message and receiver . . . subjectivity, far from being a morass to be avoided, is precisely what enables information and meaning to be connected’.

It seems clear, therefore, that while the soft model of information might mean something different by quantification than the hard model does, quantification is significant to both approaches.

3.3. Information Depends on Context

Whereas matter and energy are influenced by context, context is an integral part of information. A pattern of bits such as 1100001, for example, could be the letter ‘a’ in a text file or a colour specification in a graphics file [44], or it could be a miscellaneous set of bits with no meaning at all. This role of context is associated with the semiotic nature of

information whereby the signifier is seen to be arbitrary. Consider, for example, the context of genetic information [45]. There is no chemical necessity determining which amino acid any nucleotide triplet should code, so the triplet is an arbitrary signifier of the amino acid. For information to have the same meaning at the source and destination, there needs to be the same environmental knowledge (sometimes described as ‘exformation’) in the context of the source and destination [46].

While it is an insight from semiotics that the signifier is arbitrary, that is not to say that the style of data is irrelevant. The meaning read from data depends both on context and style. For example, the structure of a physical sign [47] or the design of an arrow [48] brings with it multiple layers of meaning beyond or on top of the apparent message on the surface.

In another field, the detailed design and conventions of technical diagrams can be used variously to create information or to convey information. In engineering, for example, diagrams are important in presenting and understanding fundamental concepts—diagrams created to illustrate a mathematical concept can eventually stand alone, communicating information without explicit reference to the source model [41]. Furthermore, the use and construction of diagrams that was one of the factors leading to the emergence of information as a concept, as seen in the diagrams of early German work on biology [49]. A different set of images to convey information are photographs, such as those which Rosewell [50] described for use in biological identification, especially when combined with words and numbers.

Visualisation techniques can be used for identifying and communicating information within data [51], or for extracting information from sources such as Twitter [52]. Such approaches raise questions as to the provenance of the information identified by visualisation. Are the techniques ‘extracting’ something that exists within the raw data? Or is the information created by the visualisation? In principle it might be argued that diagrams and visualisations are associated with agreed interpretations. It is less clear whether art forms have such firm relationships with information—as in the case of painting, their interpretation is varied and perpetually changing [35], and, in the case of music, the informational content very much requires an appropriate mechanism for interpretation [53].

3.4. Information Cannot Be Stored or Communicated

This is perhaps the most controversial of the assertions in this paper and would be rejected by some of the participants in the DTMD project. Many of the contributors spoke as if information were a substance that can be handled like packets of biscuits. So information is described as being sensed, collected, organised, processed, and maintained [54]; as being collected [55], stored [56] and used [16] and as a currency [57]. Information is said to flow [49,58], and to be circulated and grow [59]. Speaking about information as a substance is one aspect of the hard model of information [19] and it emerged historically, through a process of reification: transforming information from being conceived as something abstract into a concrete object [49,60,61].

By contrast, the soft model of information [19] explicitly rejects any physical interpretation of information, building on a tradition arising from the work of Gregory Bateson (among others). In this interpretation, information is ‘not a thing or an event’ [11] (p. 458). Perhaps information is a concept that cannot even be defined in general, but is used when discussing specific situations—in a way, parallel to Wittgenstein’s ideas for the concept of ‘truth’ [8].

Alternatively, it may be possible ‘to avoid any direct ontological commitments for the concept of information’ by Schroeder’s formulation of information as the categorical opposition of the one and many ‘since the reference to the category of the many (carrier of information) leaves open the question of mode of existence’ [6].

If information is not a physical entity, the idea of storing or communicating it is more difficult to interpret. Furthermore, a consequence of the context-dependent nature of information is that it exists at one time and one place [16]—information in a different place

and/or a different time is different information [31]. This leads to the (controversial) claim that information cannot be stored or communicated. *Data* can be stored and communicated, but information is always constructed from the data at a given time and place.

There is an apparent contradiction between the assertion that information cannot be stored or communicated and the assertion that it can be quantified, since the original quantification of information due to Shannon was quite explicitly a measure of the amount of information transferred through a communication channel. The contradiction might disappear if we argue that there is, in the language of Donald Mackay [20], a difference between the measure of the thing and the thing itself. To return to the analogy of biscuits: sweet biscuits are sent but the recipient finds savoury biscuits—the same number of savoury as sweet. Even that, though, is too simplistic for information, and there might be a different number of savoury compared to sweet biscuits: still measurable, but giving a different number at each end of the communication channel.

This assertion would be contested both by proponents of the soft model of information and proponents of the hard model of information. It would be less controversial to say, in the language used in discussions of layered models of communication, that the communication of information is *virtual* communication [62] (p. 5). That, however, would hide the deep significance of the contextual nature of information; that information only exists at a given a time and given place. Information at a different time and/or a different place is always different information. When the (apparent) storage or communication of information is under discussion—as it invariably is—we can use an ‘as if’ formulation. It is *as if* information is being stored or communicated, but it must always be borne in mind that the information extracted cannot be the same information that was transmitted or stored. When a letter is sent through the post, the same sheet of paper is extracted from the envelope as was put into the envelope, but the information extracted from reading the letter is not the same as the information that was put into it when it was written.

3.5. Information Always Has Meaning

As discussed previously, a simple definition of information that is often used is that of ‘data + meaning’ or ‘meaningful data’ [16]. Luciano Floridi formalised this in the General Definition of Information (GDI) [4] (p. 104):

GDI σ is an instance of information, understood as semantic content if and only if:

1. σ consists of n *data*, for $n \geq 1$;
2. The data are *well formed* (wfd);
3. The well-formed data are *meaningful* (mwfd = δ);
4. The δ are *truthful*.

In addition, central to the soft model of information is the importance of meaning attribution. Indeed, Chapman argues that ‘all the significant philosophical questions about information hinge on “meaning”’ [63] (p. 897). It is therefore important to explore an understanding of the concept of ‘meaning’.

Meaning can be difficult to define. Díaz Nafria and Zimmerman suggest that information is always meaningful, insofar as ‘meaning is related to an effective course of action, so, instead of being regarded as an epistemological category—like in Floridi—it is conceived onto-epistemologically’ [64]. Thus, meaning is related to purpose—it is a feature of semiotics [21], which is important in many approaches to information, that signs always refer to something other than themselves and thus their meaning is critical. A related understanding from the perspective of logic is the argument:

Meaning is understood through entailment, the logical relationship between sentences—if you understand the meaning of a sentence, you should be able to work out for that sentence and any other sentence whether one entails the other. Further, to understand the meaning of a sentence we need to understand its truth-conditions—the circumstances under which it is true [65].

Implicit in these definitions is a sense that meaning must be attributed by people, and this point is made explicitly by Holwell [16], who argues that it is people who attribute

meaning to data in order to create information. A similar argument is made by Jones [34] that ‘information is defined and construed by people’.

Nevertheless, there may be interpretations of ‘meaning’ which do not require people. Chapman [63,66] uses the layered architecture diagrams approaches from communications engineering to model the transmission and processing of information. He argues that using this framework, ‘the concept of meaning corresponds to the identification of an entity within an abstraction [allowing] meaning to be identified in a wide range of contexts, which may or may not involve people’ [63] (p. 908). Perhaps, though, information ultimately operates on the receiver’s mind [20], so information needs people [47] (p. 52) and other uses are anthropomorphism.

The concept of ‘knowledge’ arose on a number of occasions during the workshop, as a step further on from ‘information’ which Holwell defined as ‘larger assemblies of related information’ [16] (p. 74). These larger assemblies of information are often seen as being generated through collective processes of selection and meaning attribution within organisations or societies, and a number of speakers mentioned ideas such as knowledge management and the knowledge economy. Indeed, Bissell argued in a paper published in 2011 that ‘Knowledge’ has so much more status than ‘information’—and ‘data’ certainly carries no ‘cachet’ [67] (p. 28), a view that would be less widely held today given the prominence of ‘big data’.

3.6. Information Does Something

The idea that information necessarily does something—that is, has a discernible effect upon the world—goes back to Donald Mackay, as described by Hayles: ‘whereas Shannon and Wiener define information in terms of what it *is*, Mackay defines it in terms of what it *does*’ [33] (p. 56). ‘Doing something’ may mean an effective course of action [64], or it may be a context change [58].

If we say that information causes something, however, there remain questions about whether there is intentionality in the cause and whether the information can be said to have a purpose. For Holwell [16] information serves purposeful action whereas for Faichney [39] there is a distinction between physical information and intentional information, where intentional information is ‘information that is about something, whether the referent is real or not, whether or not the information is true’. Intentional information generalises semantic information by removing the veridicality restriction from semantic information (cf. [4]), and Faichney sees intentional information as a step towards answering the ‘hard problem’ of human consciousness (an issue also addressed by Jones [34]).

For Monk [47], individuals and communities are embedded within ‘sign games’ (after the ‘language games’ of Wittgenstein [68], §23) and we only need to think of information as relevant to signs when:

we try to stand outside of a sign game either because we wish to explain the operation of an institution or because we need to describe the connection between an institution we are a part of and another institution where we have little or no fluency. Information is therefore instrumental and attributed to signs which are produced in one institution but find a place in the sign games of another. [47] (p. 62)

3.7. Information Is Provisional

Information can only ever be provisional [63] because it is impossible to know, with complete certainty for all time, whether something is true, and, according to Floridi’s veridicality thesis of information [4], information has to be true otherwise it is not information. Similarly, context affects truth-value [65]—truth is a moving target [69], and ‘what seems to be an uncontested fact to one person might not even be noticed as a piece of information by another’ [30].

The veridicality thesis, however, is itself contested. For many authors, the issue of whether information is true or not is a legitimate question, so it is easier to talk in terms of

information being true or false than to insist that if it is false it is not information. Signs for Monk [70] can be false and ‘facilitate lying, cheating and masquerading’ and in identity theft and fraud [71] the information can be false. Jones [72] further argues, quoting Virginia Woolf, that our ability of ‘laying together many varieties of error’ is essential to making sense of, and utilising, information. Informationally, perhaps truth or lies are less useful than good stories.

Taylor [73] draws on postmodern ideas whereby truth is discussed as one element of information quality and becomes subjective, so that truth-value is replaced by utility value. Maybe, however, saying that truth is subjective is not so very different from saying that context affects truth value. Using a very different approach, Díaz Nafria and Zimmerman [64] provide a mathematical formulation in which a truthfulness criterion is defined as part of the mathematical model and comes with a degree of tolerance.

3.8. Information Is Never Ethically Neutral

During the whole of the DTMD series of events, no participant disagreed with the contention of Ramage and Bissell that ‘the gathering, analysis and distribution of information is inherently tied up with ethical issues’ [74].

Two of the greatest political and social issues of the period when these workshops took place were the financial crash of 2008, and the growing public awareness of the risks as well as the benefits of ‘big data’. The financial crash had many informational aspects—it was caused among other factors by the manipulation of information associated with money—but Smith [57] observed that it can be framed specifically in terms of ‘information risk’, where many corporate and governmental risk assessment teams existed and were aware of growing problems but were unwilling to act.

Over the years of the workshops and since, the rise of big data has been inexorable. Huge amounts of data about individuals are collected through their online behaviour, through mobile phone use, through shopping, through surveillance cameras and others. These data are used extensively by governments and corporations. They are reshaping corporate behaviour, for example through the deep data mining carried out by firms such as Experian, and even reshaping the nature of quantitative social research as huge datasets become available [59]. Further increases in data presence can be seen from the rise of the ‘internet of things’ with related trends such as smart cities—Sliwa [75] argued that these pose substantial risks in terms of surveillance and an over-protecting use of technology to control, as well as many potential benefits.

Among the behaviours observed in the aftermath of the financial crash and the rise of big data, three stand out. The first has been the attempt by governments across the world to regulate the Internet, whether through technology such as the ‘Great Firewall of China’ or sometimes questionable legal processes in a variety of countries, which Corrigan [76] (p. 148) describes as ‘the way that information and associated technologies are conceptualised through narratives (rather than evidence) leads directly to laws’. A second response has been cybercrime (by states, individuals and groups), which exploits the capabilities of big data to ‘perpetrate information crime and disorder across our networked world’ [77]. A third response has been public interest journalism, often supported by whistleblowing, which has exposed inappropriate behaviour by governments (especially surveillance bodies and the secret services) and the involvement of technology firms in these practices, such as the activities of Cambridge Analytica in manipulating public opinion via social media [78].

The corrosive effects of information gathering by corporations and governments has been widely documented in recent years. To take just one example of many, Zuboff describes the terms of service of Google’s Nest thermostat as having ‘oppressive privacy and security consequences in which sensitive household and personal information are shared with other smart devices, unnamed personnel, and third parties for the purposes of predictive analyses and sales to other unspecified parties’ [79] (p. 7). The same trend can

be found in a wide range of other technologies. Information can sometimes be positive, but it is never neutral.

3.9. Information Is Co-Constructed with Human Identity

Key to a number of the workshops was the relationship between information and identity, in a series of realms including social, political, class, religion, gender, race, sexuality and nationality. This has especially been seen in discussions of the impact of online communications upon identity, but it also applies in other situations.

Identity is built up through information and through relationships. The clues we give to the world about our identity—through speech, dress, appearance, action, opinion and so on—are made up of multiple forms of information. Likewise, we receive information from our communities and wider society about others' identities, about what is or is not acceptable as an expression of identity in a given context, and about the way that identities change over time.

At many different stages of our lives, individuals shape a picture of themselves based on the information they have about the world and different forms of identity [80]. There are many different ways that identity is mediated, from the purely transactional based on product marketing [81], through everyday negotiation of identity based on conversation and online tools such as instant messaging [82], to fundamental aspects of life such as one's sense of nationhood [83] or race [84]. In each of these areas, the information we learn from others and share with others is critical. The constant shaping of identity through information means that 'identity, like all information, is always provisional' [63] (p. 907). Questions of transgender identity have become a prominent contemporary example of the mutual shaping of information and identity, as well as the way in which societal awareness and expectations can change rapidly.

Information and identity are mutually shaping in a social as well as an individual context. For example:

- The use of social tools for online learning—Kear et al. [85] identified the way in which a perception of self is reinforced by how much personal information is revealed through personal profiles on social networks and forums;
- Social movements such as trade unions—Walker [86] argued that 'central to social movements is the struggle over information and its alternative meanings' (p. 97);
- Political movements and groupings—Sliwa [83] argued that Polish political life is split into two deeply opposing political groups with little real communication, internally reinforcing their sense of truth through repetition of shared opinions and with very different narratives around apparently common information. The recent rises of populism, arguments around 'fake news', and consequent political events such as the election of right-wing populist leaders and the departure of the UK from the European Union are closely linked to these struggles around political interpretations of information.
- Racial identity, both self-ascribed and given by others—Ali [84] (p.104) argues not only that 'systemic conceptions of race and racism are readily interpreted in terms of information theoretical concepts and processes' but also that 'racial concepts and processes may be embedded within information theory'. This last point was elaborated by in terms of the Occidental–Oriental divide, both racial and religious, which is both tacitly present and explicitly absent in many Western scholarly discourses [87].

If information shapes identity, it is threatened by various online phenomena, most obviously the rise of commercialisation (both legal and illegal) of identity through data mining, targeted advertising and identity theft [77]. Social media can enable its users to shape and express their identity, but can also imprison identity by the 'narratable narration' permitted in the walled garden of a social media platform [88] and through the deliberate manipulation of social media for financial gain, that Zuboff [79] has termed 'surveillance capitalism'. Indeed, it was argued that if society does not find ways to manage the speed with which information use (both online and offline) and the reflexive shaping of identity

is growing, ‘we risk being expelled from the exhaust pipe of hyperhistory in to post-history, where narrative, both personal and societal has completely evaporated, leaving us confused and dizzy in the white-noise fog of a banal, content apocalypse’ [89] (pp. 960–961).

3.10. *Information Is Always Shaped by Power, Authority and Hierarchy*

Underlying the issues previously discussed of ethics and identity is that of power. Narratives of information are constructed by those in power, sometimes in ignorance of the less powerful and sometimes deliberately to exclude those with less power. As with identity, race forms an important aspect of power, and we must beware a form of analysis in which ‘power relations—or rather, power differentials—remain both masked and unexplored’ [84] (p. 103). More fundamentally, the operation of colonial logic is embedded in the discourse of the information society [90].

The claim is often made in popular writing that society is in the midst of an information revolution, one that will radically flatten hierarchies (e.g., [91]). This is an old claim—Bissell [67] observes that it has been made many times about information and communications technologies, going back to the 1830s with the introduction of the penny post. Bissell argues that ‘despite all the changes and possibilities brought about by the various new networks and techniques, the basic structures of society are arguably unchanged’ (p. 33). Indeed, if we look historically, perceptions of time itself have been shaped by power, with the introduction first of the monastic hours then the village clock and lastly the uniform national time zones required by the railways, as a growing form of control deeply entwined with information [92].

However, the relationship between information and power is an important one to understand. As Foster-Jones [55] explains, the role of the librarian in Western culture has slowly shifted ‘from gatekeeper or custodian to providing access to all’ (p. 92)—she observes that an early term for the monastic librarian was the *clavipotens frater*, the brother with the power of the keys. The political and religious turbulence across Europe in the 16th and 17th centuries was made more potent by the rapid dissemination of ideas through pamphlets, diplomatic networks, and early newspapers, which both spread and shaped information about ideological, religious and political revolutions from one part of the continent to another [60]. The rise of new information technology can reinforce power structures, but sometimes allow those on the margins to gain new forms of social capital and thus power [53].

On the other hand, information may reinforce neoliberal structures in society, through the entanglement of information with consumption [93] and with marketing [81]. Indeed, as Kirkpatrick argued, ‘digital technologies have been used by neo-liberalism to impose a specific experience of the world and a particular way of being a self’ [94] (p. 104). The same can be said for the concept of knowledge—drawing on the work of Lyotard, Taylor [93] argued that, within postmodern society, knowledge is ‘a central force for production and the production, acquisition, and accumulation of knowledge [has] become a significant power base within the economy and society at large . . . knowledge [has] lost its “truth-value” and instead merely [has] a utility value (use-value)’ (p. 927).

Power enables and reinforces the regulation of information in a variety of settings. Government regulations such as the Digital Economy Act 2010 in the UK [76] shape the experience of information and were in turn shaped by political power and that of lobby groups with special interests, such as copyright holders. Environmental regulation likewise exists in a mutually-reinforcing relationship with scientific information—policy is shaped by information, but the information sought is shaped by those in power [95]; and a similar story can be told regarding the use of evidence to determine value for money in international development spending [96].

4. Discussion

At the highest level of abstraction, the contributors to DTMD were invariably working with information as some variation of either ‘meaningful data’ or ‘the difference that makes

a difference'. The two are closely related, both having two components: 'data'/'difference'; and 'meaning'/'making a difference'. As with all definitions, however, they beg any number of questions.

For example, information being 'meaningful data' presupposes that there might exist such a thing as data without meaning. However, is it possible to conceive of data without *any* meaning? The moment you identify something—a difference—and say 'this is data,' you imbue it with meaning. Dr. Mustafa Ali (convenor of the Critical Information Studies research group at The Open University, and a participant in several DTMD events) in a private conversation with the authors commented: "there's no such thing as raw data: data always comes pre-cooked".

Interrogating definitions of information, however, is not seen by the authors as the most important contribution of the DTMD project. The understanding of a concept derives at least as much from the surrounding narratives as from the wording of the definition, and the conversations of DTMD contribute to the narratives surrounding the definitions of information. In this paper, the insights are presented as ten assertions proposing rules for the legitimate uses of the concept of information, which are collected in Table 1.

Table 1. Assertions about information.

Assertions	
1	requires a body
2	can be quantified
3	depends on context
4	cannot be stored or communicated
5	always has meaning
6	does something
7	is provisional
8	is never ethically neutral
9	is co-created with human identity
10	is always shaped by power, authority and hierarchy

At this point, we reiterate that DTMD is not a positivist endeavour. There is not something, a thing we are calling 'information', out there waiting to be discovered [6]. We are formulating a usage of the word 'information' which will be helpful in the information age. The ten assertions are not axioms and are not mutually independent. They overlap and in some cases are in tension. Some of the tensions relate to the hard–soft distinction introduced as the start of this paper—#2 on quantification is more obviously linked to the hard model, while #5 on meaning is more obviously linked to the soft model. However, as we have discussed, we believe that all ten assertions can co-exist with both models of information.

Further issues can be seen in the relationship between the assertions and the use of information in various academic disciplines. At first sight, assertions #8, #9 and #10 (never ethically neutral, co-created with human identity and always shaped by power, authority and hierarchy) are difficult to reconcile with information in the physical sciences. How, for example, can the action of a black hole on the total information content of the universe have an ethical aspect, be co-created with human identity or be shaped by power, authority and hierarchy?

There are two ways in which the information explored by an astrophysicist can be seen to be entangled with these soft, human, dimensions. First, the working environment of the astrophysicist is itself a social setting. The work he/she is doing is determined at least in part by funding decisions and a host of other social and political considerations for the research community. Hard-line proponents of positivist, reductionist, science would argue that this is separate from the 'content' of the research, leaving the content untouched, but insights from science and technology studies (STS) suggest otherwise and show how the content cannot be so easily detached from the social environment [97].

Furthermore there are routes within physics itself that let the human dimensions enter into the physicist's information. Physicists grappling with fundamental questions of cosmology are repeatedly, and increasingly, finding that models of the universe cannot exclude (human) consciousness. Consciousness forces itself into physics through quantum mechanics, and, not for want of trying, physicists have found no satisfactory way of getting it out again [37,56,98]. Though it offends the scientific premise of objectivity, according to quantum mechanics, observation appears to change the universe—think of Schrödinger's poor cat, simultaneously dead and alive until Erwin checks up on it.

So all of those soft human dimensions find their way into the very fabric of the universe and there are narratives which tackle the nature of reality by putting information centre stage. According to informational structural realism [4], reality and information are the same thing. Furthermore, for info-computationalism (IC), the whole of nature is a computational process and:

As living organisms, we humans are cognizing agents who construct knowledge through interactions with their environment, processing information within our cognitive apparatus and through information communication with other humans [99].

Information in IC is defined as 'the difference in one physical system that makes a difference in another physical system' and allows for (requires) the communication of information which is at odds with our assertion number 4. Søren Brier, from his perspective of cybersemiotics, has taken issue with the IC definition of information on the grounds that 'it is not information that is transmitted through the channel in Shannon's theory but signals' [100] (p. 242). Nevertheless, both cybersemiotics and IC are founded on constructivist epistemologies and provide a landscape in which the assertions about information presented in this paper may be explored.

To test out and illustrate the utility of the ten assertions in an information narrative, we finish with a brief exploration of an informational activity of the digital age: a team of medical experts (led by 'Dr. Alice') disseminating information to the general public (including 'Bob') about the COVID-19 virus which was at its height when this article was completed. We will explore some assertions in greater depth than others.

This is a problem of communication, but getting information to the public is fundamentally different from, say, delivering face masks. Send a face mask and the recipient will receive a face mask. The face mask unwrapped by Bob is identical to that packed by Dr Alice. Nevertheless, however good the communication, the information about COVID received by Bob will never be identical to the information that Dr Alice was trying to send.

This is because information **depends on context**. It is encoded into messages by the medical team, and read by members of the public. The members of the public do not have the medical expertise of the team so the information that Bob gets from reading Dr Alice's words cannot be identical to the information in the mind of Dr Alice. Even if Bob is a medical expert, he will not be party to the discussions of the team so his context is different. This is what we mean by saying that the **information cannot be communicated**. The public will get information about the COVID-19 virus and it is as if the information has been communicated from the team, but the information gained by the reader is not, and cannot be, identical to that generated by the team. The health team needs to be aware of the fact that they are not delivering information to the public: rather, they are delivering messages (data) to the public from which the readers will construct their own information.

The information **requires a body**. The COVID information might be printed on a leaflet sent with a face mask, but more commonly it will be delivered by digital media. Suppose, for example, it was a sequence of tweets. We can drill down, recognising that the tweets are sentences, made up of words, constructed from the letters of the alphabet, digitally encoded by binary digits and finally physically represented by electrical or optical signals on a cable or electromagnetic waves through the air. At another level, the tweets themselves are physically embodied quite differently for different users—for some on an app, for others within a web browser, and each on a variety of devices.

The **quantifiable nature of information** can be seen in the need to fit the data into tweets. However, the quantification of information is not just about the size of the body (the data). It is also, from the insights of Shannon and others, about the novelty and surprisal value of the message. The significance of the quantifiable nature of information is not that we would put a precise number to the amount of information in a message, but that it is meaningful to say that some messages contain ‘a lot’ of information and some contain very little. Since the COVID pandemic is unprecedented, many of the messages will be unexpected and generating a lot of information.

That the **information has meaning** and will **do something** needs little explanation: it has meaning because it is about COVID-19, and it will do something—make a difference—because it will (ideally) make the public better able to protect themselves against the virus. Similarly, since protecting against the virus is evidently a moral good it is easy to argue that the COVID messages are **not ethically neutral**.

The **provisionality** of information about COVID-19 has been one of the most unsettling aspects of the pandemic. During the course of the pandemic, scientific knowledge about the virus and about the best way to protect against it has been constantly changing, so the information from the team can only ever be provisional. However, as people build up a body of knowledge about COVID-19, the context changes, so the information that Bob creates from a message received today would be different from the information he would create from exactly the same message six months ago.

The circumstances are so extreme that few people would need convincing that our identity is being changed by the experience of the COVID-19 pandemic, though there is a step needed to point to the fact that information about the virus and the pandemic that is largely responsible for the change. Certainly those who suffer significant illness from catching the virus are changed directly, but that is a relatively small proportion of the population and most other people are changed by the information exchange associated with the pandemic, such as the information derived from reading the tweets of the team in this example. The information in the tweets, meanwhile, is itself derived in part by the identity of the team members and we see the **co-creation of human identity with information**.

Finally, there are a number of ways in which the information is bound up with **hierarchical structures of power and authority** within society. The status of the team as ‘health experts’, perhaps with the explicit support of the government under which they operate, encourages the public to take note of information derived from their tweets. However, the impact of COVID-19 varies by socio-economic status, race, gender and other aspects, with the result that the tweeted information has variable impact upon different groups of readers.

We started this short case study by distinguishing the dissemination of information about COVID from delivering a face mask, and claimed that the face mask unwrapped by Bob is identical to that packed by Dr Alice. However, insofar as a face mask is itself an informational entity, that is not true. The physical object, the cloth and/or paper of the mask, will be the same, but its interpretation as a ‘face mask’ is not. The physical object is the body of the informational entity which we call a ‘face mask’, and all of the assertions about information may be explored for a face mask too. No one who has followed the news in the USA can, for example, have any doubts about the extent to which face masks are bound up with hierarchical structures of power and authority within society.

There are many other ways in which this example of the dissemination of COVID-19 information could be framed and interpreted. However, the ten assertions, while contested, draw together insights from ten years of collaborative, multi-disciplinary, work to understand the nature of information. We present them in the hope that they will be a difference that makes a difference.

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Appendix A. DTMD Events

There were six events (workshops or conferences) in the Difference That Makes a Difference (DTMD) series, although not all used the title, as follows:

1. *The Nature of Information*, The Open University, Milton Keynes, UK. 8 October 2007. Online programme and notes: <http://www.dtmd.org.uk/past-events/workshop-2007> (accessed on 10 February 2021). Some papers published in an edited book [101].

2. *The Difference That Makes a Difference 2011: What is information?* The Open University, Milton Keynes, UK. 7–9 September 2011. Online programme, abstracts and recorded talks: <http://www.dtmd.org.uk/past-events/dtmd-2011> (accessed on 10 February 2021). Some papers published in a special issue of *Triple C: Cognition, Communication, Co-operation*, 2013, 11(1), 1–126, 2013, <http://triple-c.at/index.php/tripleC/issue/view/26> (accessed on 10 February 2021).

3. *The Difference That Makes a Difference 2013: Space, Time and Identity*, The Open University, Milton Keynes, UK. 8–10 April 2013. Online programme, abstracts and recorded talks: <http://www.dtmd.org.uk/past-events/dtmd-13-conference> (accessed on 10 February 2021). Some papers published in a special issue of *Kybernetes*, 43(6), pp. 846–964, 2014.

4. *Information*, workshop at Images of Europe—Past, Present, Future. ISSEI 2014, Porto, Portugal, 4–8 August 2014. Full papers available in conference proceedings [102].

5. *The Difference That Makes a Difference 2015—Information and values: ethics, spirituality and religion*. 5 June 2015, Vienna (part of the International Society for Information Studies 2015 summit, Technical University of Vienna, 3–7 June 2015). Online programme, abstracts and presentations: <http://www.dtmd.org.uk/past-events/dtmd-15-conference> (accessed on 10 February 2021).

6. *The Difference that Makes a Difference 2017—Information, Narrative and Rhetoric: Exploring Meaning in a Digitalised Society*, Gothenburg, Sweden, 12 June 2017 (part of the International Society for Information Studies 2017 summit, Chalmers University, Gothenburg, 12–16 June 2017). Extended abstracts for all papers: https://www.mdpi.com/2504-3900/1/3#CONFERENCE_DTMD_2017:_The_Difference_That_Makes_a_Difference (accessed on 10 February 2021).

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