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Information: Modern Concepts

The paper reappraises our understanding of information without favoring any specific perspective. The paper presents the various conceptualizations of information, including biological information, natural information, pragmatic information, physical information, quantum information, quantified information, relative information, semantic information, semiotic information, epistemic information, ontological information, and syntactic information, together with some of their variants. In the search for a unifying perspective on information, the paper looks at two general theories of information: the General Definition of Information (GDI) and the General Theory of Information (GTI), arguing that the GTI appears to be the better of these two options. The paper is intended to be as complete and comprehensive as possible, sacrificing the analytical part (that may be found in referred sources) for the breadth of coverage.

Keywords: *information, epistemic information, ontological information, information in nature, GDI, GTI*

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1. Introduction

The modern concept of information was introduced by Shannon (1948), and later followed up by Shannon and Weaver (1949) and Weaver (1949). Despite a flood of research publications on this topic (e.g. Seising 2009), we are far from being certain what information is.[1] The growing list of novel definitions of information and ongoing discussions on the Internet discussion group dedicated to information[2] and conferences (International Society for Study of Information) attest to this. In fact, the list of questions about the nature of information is wide open,[3] with many research topics left to be investigated. In this paper, we try to provide a comprehensive list of modern concepts of information and unifying theories of information, realizing that such tasks will never be completed because of the dynamics of the problem. Still, we hope that such an overview, despite its shortcomings, may improve the general understanding of information and provide a focus for further studies. Due to the limitations of the allocated space, we sacrifice the analytical part (which may be found in referred sources) because of the breadth of coverage it would require.

We first discuss the various conceptualizations of information. Next, we present two concepts of information — epistemic and ontological — and then two unifying theories of information, namely the General Definition of Information (GDI) and the General Theory of Information (GTI). The references provide an ample resource for exploring the discussed ideas information in greater detail. The paper is a compressed longer research report on the same topic.

2. Varieties of Information

The varieties of information are too numerous to be listed in their entirety. Under the proviso that any selection will inevitably be subjective and incomplete, we discuss several classes of information, including biological information, natural information, pragmatic information, quantum information, quantified information, relative information, semantic information, semiotic information, and syntactic information, together with some of their variants that have been mentioned in publications.

2.1. Information: Variety of Conceptualizations

Biological information: Biological information describes processes related to genetic processes, cellular functions, or other biochemical processes in organisms. We denote this class of information as informationB. Conceptualizations of biological information have been discussed by scholars such as Maynard Smith (2000), Schneider (2000), Griffiths (2001), Godfrey-Smith (2002), Jablonka (2002), Roederer (2003,

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[1] For historical notes on the concept of information, see Vreeken (2005), Adriaans (2023), or Gleick (2011).

[2] see <http://listas.unizar.es/cgi-bin/mailman/listinfo/fis>

[3] The more systematic list from Krzanowski (2020, 2022) proposes some open research problems to be investigated.

2005), Stegmann (2005), Yockey (2005), Terzis and Arp (2011), and Moffat (2016). More specifically we have:

Natural information: Natural information is information conveyed by natural signals in a communication process. The source of this message may be a natural phenomenon like a fire (a natural root sign), or it can be a human agent communicating through language, a map, a diagram, and so on. In all these cases, however, the message is carried in natural phenomenon, a physical carrier, and this medium can be considered an *infosign*. Millikan's natural information is connected to the concept of teleosemantics in a theory for the meaningfulness of representation in terms of biological functions (Millikan 2004, 2017). Millikan's concept of natural information is based on Dretske's work on semantic information (Dretske 1999). Baker later extended Dretske's work by proposing concepts like nomic factive information (denoted as informationNf), the counterfactual theory of information (denoted as informationNcf), and even exemplar thermometer information (denoted as informationNt) (Baker 2021). There are also other definitions of natural information. Sweller and Sweller, for example, define natural information (denoted as informationNm) as information that governs activities in natural entities, and this relates to the concepts of morphological computing and biological information processing (Sweller and Sweller 2005). We will refer to this class of information as informationN. Conceptualizations of natural information have been discussed by scholars such as Scarantino and Piccinini (2010), Piccinini and Scarantino (2011), Kraemer (2015), and Symons (2016).

Pragmatic information: Pragmatic information represents the impact of a message on a system. This is considered a perspective-based notion, so it requires an explicit description of the context. The definition of pragmatic information depends on concepts of meaning, complexity, and similarity or dissimilarity. Pragmatic information also covers other concepts of information, such as negative information, information on the way, structural information (see later section), latent information, potential information, and active information. We may surmise that pragmatic information generally represents the impact of a message on a system's pattern or patterns of behaviors. Some claim that pragmatic information is a purely biological concept (e.g. Roederer 2016). Conceptualizations of pragmatic information have been discussed by the likes of Bar-Hillel and Carnap (1953), Gernert (2006), Kornwachs (1998), Weinberger (2002), Andrew (2003), Roederer (2016), and Chen (2018). We will label this class of information informationPr.

Quantum information: Quantum information is defined as information about the state of a quantum system, where the quantum system (e.g., electron, photon) is a carrier of information. Some deny that quantum information exists at all, while others claim that it is not qualitatively different from classical (i.e., non-quantum) information. Nevertheless, quantum information is expressed in qubits, and two-state systems encode information in two quantum states: |0> and |1>. A quantum bit, or qubit, can be in a superposition of different states at the same time, so a qubit can be both in the |0⟩ state and in the |1⟩ state simultaneously. The state of a qubit can be manipulated by quantum gates, which are unitary physical operators that can be represented as rotations on the Bloch sphere, with a qubit often being expressed as a vector in the Bloch sphere.

Quantum information may be seen as a generalization of classical information to quantum systems, so many measures from classical information theory could also be generalized for quantum information, such as Shannon's entropy, which is represented in quantum systems as Von Neumann entropy. We label this class of information informationQ.

Conceptualizations of quantum information have been discussed by among others by Nielsen and Chuang (2000), Le Bellac (2006), Jaeger (2007), Rieffel and Polak (2011), Harshman (2016), Lombardi et al. (2016), Timpson (2008, 2013, 2016), and Zygelman (2018).

Relative information: Relative information was proposed by Rovelli (2016a, 2016b) as information that expresses the number of possible states in which two physical systems can be together relative to the hypothetical number of states that is logically possible for these two systems. Rovelli claimed that relative information is purely physical. Relative information expresses a relation between hypothetical (i.e., nonexistent) states and factual (i.e., that which exists) states. Relative information expresses what-if situations or counterfactual conditions, so it clearly expresses conceptual situations and abstract ideas rather than real ones. We label this class of information informationRl. The conceptualization of relative information has been discussed by Rovelli (2016a, 2016b).

Semantic information: Semantic information is closely related to the concept of communication and the meaning of a message. (In some definitions, message is replaced with data [Duch 1993].) Semantic information may be instructional or factual, and it needs the presence of a cognitive agent, whether artificial or natural, for whom the information has meaning. Semantic information may also refer to a subset of the syntactic statistical correlations between systems, one that has some meaning or significance for a given system. Conceptualizations of semantic information have been discussed by the likes of Bar-Hillel and Carnap (1953), Brillouin (1956), Duch (1993), Dretske (1999), Floridi (2010, 2013, 2019), Johannsen (2015), Zhong (2017), and Kolchynski and Wolpert (2018). We label this class of information and its variants informationSm.

Semiotic information: Semiotic information refers to interpreting information under the theory of signs or semiotics, particularly biosemiotics. It assumes that information is an implicit semiotic term. Semiotic information is a sign that can be interpreted by an agent. A sign carrying information is known as passive information (i.e., it exists objectively), while an interpreted sign is active information (i.e., it carries valuable epistemic knowledge). In the semiotic view, information is seen as either reducing "entropy and favoring adaptation and survival with regard to living entities" (the determinate view) or always being indeterminate due to the "abductive nature of information" (the indeterminate view). The first type of semiotic information above is also referred to as functional information (Cannizzaro 2016). Conceptualizations of semiotic information have been discussed by various scholars, such as Batenson (1979), Sebeok (1991), Sharov (2010), Cannizzarro (2016), and Thellefsen et al. (2018). We label this class of information informationSo.

Syntactic information: Syntactic information is connected by the concept of the structure (syntax) of a message. Syntactic information therefore expresses the amount of statistical correlation between systems, so, from this perspective, information is seen as it is expressed in Shannon's theory of communication (Shannon 1948). Syntactic information also relates to the grammatical features of a message (grammatical information), assuming that the message is coded in some language – as it must be, being a message. Related terms used in the context of syntactic information are morphosyntactic information (Kamide et al. 2003) or case-marking information. We label this class of information informationSyn. Conceptualizations of syntactic information have been discussed by the likes of Sells (2001), Kamide et al. (2003), and Kolchynski and Wolpert (2018).

Quantified information or measures of information: Quantified information refers to mathematical measures of some form of physical phenomenon that has been designated as either information or a carrier of information. This category of information encompasses, as the better known formulations, Shannon's entropy of information, Chaitin's and Kolmogorov's algorithmic complexity metrics (Chaitin 2004; Kolmogorov 1965), and Fisher's (Frieden 1998) and Klir's (Burgin 2010) information metrics.

Measures of information are operationally useful, but they do not convey what information actually is, so they are not regarded as good definitions of information. From this point of view, referring to Shannon's information is not appropriate, but referring to Shannon's measure of information is. The same logic applies to Kolmogorov's information, Fisher's information, and other similar measures of information. We call this class of information informationQT under the proviso that this term pertains to measures, rather than definitions, of information.

Conceptualizations of quantified information have been discussed by researchers like Shannon (1948), Chaitin (1997, 2004), Peirce (1961), Shannon and Weaver (1949), Kolmogorov (1965), Klir and Folger (1988), Avery (1993), Solomonoff (1997), Frieden (1998), Burgin (2010), Stone (2015), and Ly et al. (2017).

We also cannot rely on measures of information to give us a deeper understanding of what information actually is. For example, Shannon's entropy of information has proved very useful in various applications (Shannon 1948; Shannon and Weaver 1949; Hartley 1928), while other metrics—such as the Fisher metric (Frieden 1998) and Kolmogorov's (1965) and Chaitin's (2004) algorithmic metrics, among others—are mathematical formulas that are called information measures, but they are designed for specific purposes under specific assumptions. These quantified concepts of information are therefore not of general import, even if they have been applied successfully in many domains and "interpreted" as fundamentally defining information.

We mention also Fisher information that is a statistical measure of how much information one may obtain about an unknown parameter from a sample. Technically, Fisher information is the inverse of the variance of the Maximum Likelihood Estimator (MLE) for a parameter Θ from a sample X (for a normally distributed X). (The MLE is the maximum of a function of a specific parameter Θ given a random sample.) To simplify this, the concept of Fisher information allows us to find the value of the parameter(s) of a function fitted to the experimental data such that it minimizes prediction error (see applications of Fisher information in Frieden [1998] and Ly et al. [2017]). For George Klir (Klir and Folger 1988), information is a reduction of uncertainty. Uncertainty may be considered as ambiguity or vagueness. Such uncertainty may be measured by Shannon's entropy of information (a measure of ambiguity), the Hartley measure (H), or measures of fuzziness. Both Fisher and Klir define information as a reduction in uncertainty based on information from perceived observations, so these concepts clearly belong to the class of epistemic information.

A quite extensive list of quantified models of information is also provided by Burgin (2010, 131–132), but the sheer number (32 formulas—probably more by now) of models for measuring information does not translate into clarity about the nature of what is being measured. In fact, the models listed by Burgin measure quite different properties of abstract constructs, usually probability spaces, so they do not necessarily convey the same concept of information. Multiple measures for information do not translate into a better understanding of what information is—it shows only a range of possible interpretations (Hintikka 1984, 175–181).

Quantified theories of information also include topological information and information geometry. Information geometry was defined by its founder Shun'ichi Amari (2016) as "a method of exploring the world of information by means of modern geometry." Information geometry studies information science (an umbrella term for statistics, information theory, signal processing, machine learning, and artificial intelligence [AI; Nielsen 2020]) through geometry. Information geometry provides a pure, context-free method for studying relations like distances, such as between probability distributions. Information science is viewed as a science for deriving models from data, represented as the geometry of decision making (e.g., curve fitting, classification, etc.) (Nielsen 2020, 2022).

Topological information in turn views information as being topological in the sense that the relations between systems that manipulate and exchange information can be represented topologically. Such a topological representation of information and computing allows for Turing machines and computing to be generalized to the manipulation of information on tangle machines.[4] (For more information on topology, see the work of Moskovich and Carmi [2015] and Carmi and Moskovich [2014].)

The numerous conceptualizations for information convey how the concept of information appears to be fragmented, malleable, and elusive. Thus, is there a way out of this quandary?

3. Ontological and Epistemic Information

To simplify things somewhat, we propose that the concept of information can be viewed from two perspectives, namely epistemic and ontological. The concept of

[4] "Tangle machines are topologically inspired diagrammatic models. The novel feature of tangle machines is their natural notion of equivalence. Equivalent tangle machines may differ locally, but globally they share the same information content. The goal of tangle machine equivalence is to provide a context-independent method to select, from among many ways to perform a task, the 'best' way to perform the task" (Moskovich and Carmi 2015, abstract).

ontological and epistemic is seen as defined by John Searle (Searle 1983, 1998, 2013a, 2013b, 2015a, 2015b).

3.1. Information: The Epistemic View

From this viewpoint, information as a concept is centered on humans or other conscious agents.[5] We call this epistemic information, because it emphasizes its relation to knowledge and meaning and denotes informationE. The concept of epistemic information has seen many incarnations, so there is no single definition that is acceptable to everyone or even some nebulous majority. Take, for example, the works of Bar-Hiller and Carnap (1953), Brooks (1980), Rucker (1987), Buckland (1991), Devlin (1991), Losee (1998), Dretske (1999), Casagrande (1999), Floridi (2010, 2013, 2019), Lenski (2010), Vernon (2014), Dasgupta (2016), Millikan (2017), or Carroll (2017); this list is by no means exhaustive. Each of these authors has created a somewhat different version of epistemic information, but they all associate information with meaning, knowledge, or semantics, thus providing a common thread that allows them to be collected under one heading.

Thus, epistemic information is associated with knowledge, belief, or a communication process in its more generally and broadly understood meaning.[6] We limit the application of meaning to cognitive systems with some form of linguistic capacity, whether artificial or biological. Epistemic information thus exists only if someone or something recognizes it as information.

Epistemic information is defined within the context of a communication system, so there is a sender, a receiver, and a communication process. This communication system may take many forms (e.g. Cherry 1978; Shannon 1948; Maynard Smith 2000; Vernon 2014), but it will follow the general format described by Casti (1989). Epistemic information exists specifically in, and for, the minds, which are broadly understood as complexes of cognitive faculties, of the receiver and the originator. Epistemic information exists when communicated (i.e., created, sent, and received) as a message. This dependency on the sender and the receiver, as well as their cognitive functions, makes information epistemically and ontologically subjective. In other words, this information depends on something else to exist.

3.2. Epistemic Information and Data

When we look at definitions of epistemic information, these definitions often, if not almost always, claim that information (i.e., epistemic information) is "data + meaning" (Floridi 2013). There are similar claims that "information is derived from data"

[5] The term "a conscious agent" may, in some studies, in addition to human agents, include animals and artificial systems.

[6] A review of theories of meaning lays beyond the scope and purpose of this work, but an extensive list of references can be found in Speaks (2021) and other sources.

or "information is data endowed with relevance and purpose" (Davenport 1997; Drucker 2001), "information is organized data" or it is "interpreted data" (Terra and Angeloni 2010). It somehow seems that we need data to get information, that data is some kind of input to the process of creating information, that data differs from information, or that data is some "primitive stuff" from which information is formed. Data certainly seems to be not information—they are different.

It seems that the differentiation between data and information is somewhat arbitrary, a matter of interpretation as to what constitutes raw data versus analyzed data, no special meaning versus assigned meaning, collected versus processed, formal formats (tree, tables, graphs) versus linguistic interpretations, symbols versus ideas, and so on. These differences are not very well accentuated, so the boundary between data and information seems to be somewhat fluid, and the multitude of definitions of data only confirms this impression. Zins (2007) documents no less than 130 definitions for data (see also e.g. Machlub, 1983; Zeleny 2005; Livesley 2006; Rowley 2007; Akerkar and Sajja 2010). For the sake of completeness, we also need to mention the so-called metadata. Metadata, as a concept, represents what we may call "data about data."[7] Metadata is therefore nothing more than data about data—it does not enjoy any special metaphysical or ontological status.

3.3. Information: The Ontological View

From this alternative viewpoint, we see information as a form or organization of nature. We do not ask, "What is information?" in the context of a specific domain, cognitive agent, or communication process. Instead, we conceive information as an objective, mind-independent phenomenon. We see it as something that is a part of the natural world, so people or other cognitive systems are not generally reference points for it. Information is less frequently conceptualized as an ontological phenomenon, yet, as can be seen from the published studies, it is well justified as such. We denote this information informationO.

The list of researchers conceptualizing information as something ontological includes von Weizsäcker (1971), Turek (1978, 1981), Mynarski (1981), Heller (1987, 2014), Collier (1989), Stonier (1990), Devlin (1991), De Mull (1999), Polikghorne (2000), von Bayers (2006), Seife (2006), Dodig-Crnkovic (2013), Hidalgo (2015), Wilczek (2015), Carroll (2017), Rovelli (2016a), Davies (2019), and Solé and Elena (2019). This list is certainly not exhaustive, but the above sources give a comprehensive overview of the current discussion for this topic.

The idea of information as an ontologically objective phenomenon has been seen in diverse contexts. In these studies, ontological information is regarded as a phenomenon that exists independently of any observer, even artificial or biological

[7] Metadata is structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource. Metadata is often called data about data or information about information (see Riley 2017; see also Snowden 2019).

ones. Ontological information exists independently of any mind,[8] whether natural or otherwise, or any kind of cognitive system or process. Ontological information is objective in the sense that it is not dependent on any observer. It is a natural phenomenon in the same way as all natural objects and phenomena, an element of nature itself.[9] Researchers often interpret ontological information by recognizing its existence in the structure or order of nature, and it is often equated with the form or shape of a natural object or an artifact,[10] although this is not entirely accurate.

At present, we do not have a physical interpretation of ontological information. We only claim that, from the current studies, it seems that ontological information has several properties that we can attribute to a physical phenomenon.

InformationO and informationE may be succinctly defined thus:

- Ontological information or informationO is defined as a physical phenomenon; it exists objectively, has no intrinsic meaning, and is responsible for the organization of the physical world.
- Epistemic information or informationE is a (artificial or biological) cognitive agent's interpretation of physical stimuli or the abstract and non-linguistic concepts created by a conscious agent without direct link to the outside stimuli. InformationE is relative to a cognitive agent, i.e., it is ontologically subjective (ontologically subjective in Searle's sense).

The precise boundary between ontological and epistemic information depends to a certain degree, ceteris paribus, on our understanding of meaning.

The terms ontological and epistemic information have been used by Zhong (2017) but with a different meaning from the one used here. We denote Zhong's objective information informationZO and epistemic information informationZE. Zhong defines objective information as representing "the set of states at which the object may stay and the pattern with which the states vary."[11] The equivalent name for ontological information is object information. Object information, informationZO, indicates that information about the object comes only from the object itself, without any input from a subject. Epistemic information (or perceived information) is information that an epistemic subject has about an object.[12] Epistemic information,

[8] The word *mind* is understood here as a set of cognitive faculties including consciousness, perception, thought, judgment, and memory. It can also be understood as an artificial system that has a subset of cognitive-like functions.

[9] The word "nature" has many meanings (see, e.g. the entries in Honderich 1995) and (Lalande 1956), and there are obvious differences between the common usage and the scientific and philosophical usage.

[10] The term "relationships among the parts of the physical system" seemed to him the most general term capable of covering "applications in mathematics, physics, chemistry, biology and neuroscience" (von Baeyer 2005, 22).

[11] Definition 1 (Object Information/Ontological Information). The object information concerning an object is defined as "the set of states at which the object may stay and the pattern with which the states vary" presented by the object itself (Zhong 2017).

[12] Definition 2 (Perceived Information/Epistemological Information). The perceived information a subject possesses about an object, which is also termed epistemological information, is defined as the trinity of the form (named the syntactic information), the meaning (the semantic information), and the utility (the pragmatic information), all of which are perceived by the subject from the object information.

informationZE, comprises semantic, syntactic, and pragmatic information, all of which have a source in informationZO. Epistemic information is also denoted comprehensive information (informationZC) by Zhong. Zhong's objective or ontological information represents the state of an object that can be perceived by an epistemic agent. It is not the internal structure of an object as denoted by ontological information in this study – informationO. In fact, informationO is never directly perceived by an epistemic subject as is. InformationZO is more akin to natural information, as discussed later in the paper. InformationZE or equivalently informationZC comprises semantic, syntactic, and pragmatic information (see Zhoong's definitions). This composition would imply that InformationZE already exists in some linguistic form with associated symbolism and syntax. InformationE has a much more generalized form and does not imply symbolic representation. Thus, it accounts for animal cognition or other forms of non-verbalized information—like intuitive knowledge or abstract ideas in human subjects.

4. Unifying Theorems

Floridi's (2010) General Definition of Information (GDI) and Burgin's (2010) General Theory of Information (GTI) attempt to somewhat correct the profusion of various conceptualizations and establish some common ground that underlies these definitions. Both theories have a broad scope and are very rich in content, so, in this short summary, we restrict ourselves to their main postulates.

4.1. General Definition of Information (GDI)

Floridi's (2010) GDI is a fairly comprehensive statement about the perception of information, so it is attached to the concept of information as something expressing meaning or knowledge. In other words, it reflects the epistemic perspective that prevails in current philosophy. Moreover, the GDI assumes the existence of a quasi-physical foundation for information through something called the *infon* (σ). Unfortunately, this foundational infon has a rather ambiguous explanation, and the purely epistemic perspective leaves the whole concept behind the GDI wanting. The GDI is defined as follows (Floridi 2010, 2013, 2019):

GDI σ (an infon) is an instance of semantic information if and only if:

GDI.1 σ consists of n data (d), for n >=1;

GDI.2 the data are well-formed (wfd);

GDI.3 the wfd are meaningful (mwfd = δ).

GDI.1 states that semantic information consists of data, while GDI.2 states that semantic information consists of well-formed data according to some rules. GDI.3 then states that semantic information consists of well-formed data that has a meaning within the specific language system.

The elementary piece of information, a *datum*, is defined as:

datum =def. x being distinct from y

where x and the y are two variables to be defined (i.e., content and domain). The definition pivots on the concept for the lack of uniformity as defined by Batenson (1979).[13]

The datum is a relative concept (Floridi 2013), and something may or may not be a *datum*. Floridi denotes it a "taxonomic neutrality." A datum in GDI is further described through typological neutrality, ontological neutrality, genetic neutrality, and alethic neutrality, which are concepts explained by Floridi (2013). To avoid ambiguity, the GDI further constrains semantic information through the GDI.4 condition:

GDI- σ (an infon) is an instance of semantic information if and only if:

GDI.1 σ consists of n data (d), for n >=1;
GDI.2 the data are well-formed (wfd);
GDI.3 the wfd are meaningful (mwfd = δ);
GDI.4 the δ are truthful.

GDI provides a very detailed account of variants, versions, and interpretations of semantic information; it is about semantic information only. Its physical foundation in infons depending on the concept of data or datum is rather weak.

The infon is a concept described by Stonier (1990), Devlin (1991), Floridi (2013), and Martinez and Sequoiah-Grayson (2023). Infons are positioned as elemental (natural) units of information. Floridi (2013) uses the term infon in his GDI. Floridi's infon is the smallest form of an interpretable something, and it is not physical, so it must be abstract. Infons have also been defined by Devlin (1991, 35) in many ways. It is an "item of information" that is theory absolute or representation-independent; it is like real numbers and independent of the form they are in. Infons are semantic objects within the theory they are in. Their nature is that of numbers. Yet another definition of infons is proposed by Martinez and Sequoiah-Grayson (2023). "Their definition is developed in the context of the situation theory of information" (Martinez and Sequoiah-Grayson 2023). Clearly, the infons of Stonier, Martinez and Sequoiah-Grayson, and Devlin are not the same, even if they all seek to play the role of "elementary units of information." As well, an infon is not elemental in the sense that an elementary particle is in physics, nor is it sufficiently well-defined to use it without qualification.

4.2. General Theory of Information (GTI)

The GTI proposed by Burgin (2010, 2017) and Burgin and Feistel (2017) provides us with a fundamental grounding in the concept of information; as such, it offers a foundation for epistemic and ontological information, as well as other derived concepts. Moreover, the GTI may also position the fundamental ontological properties of information as a physical phenomenon with fundamental structural and causal properties.

[13] "In fact, what we mean by information—the elementary unit of information—is a difference which makes a difference" (Batenson 1973).

As Burgin claims (2010, 2017), (Burgin and Feistel 2017), the GTI has three components:

- □ the axiomatic foundations
- □ the mathematical core
- □ the functional hull.

We focus on axiomatic foundations. The axiomatic foundations consist of principles, postulates, and axioms of the GTI (Burgin 2010, 2017; Burgin and Feistel 2017).

- □ *Principles* describe and explain the essence and the main regularities of the information terrain.
- □ *Postulates* are formalized representations of principles.
- □ *Axioms* describe mathematical and operational structures used in the GTI.

There are two classes of principles:

- □ *Ontological principles* explain the essence of information as a natural and artificial phenomenon.
- □ *Axiological principles* explain how to evaluate information and what measures of information are necessary.

There are three groups of ontological principles:

- □ *Substantial ontological principles* [O1, O2, and its modifications O2g, O2a, O2c] define information.
- □ *Existential ontological principles* [O3, O4, O7] describe how information exists in the physical world
- □ *Dynamical ontological principles* [O5, O6] show how information functions.

In a strict sense, information is stratified according to the global structure of the world, as represented by the Existential Triad of the world, which comprises the world's top-level components as a unified whole that reflects the unity of the world. This triadic structure is rooted in the long-standing traditions of Plato and Aristotle and comprises three components: the Physical (i.e., material) World, the Mental World, and the World of Structures (Burgin 2010, 2017). The Physical World represents the physical reality as studied by natural and technological sciences, while the Mental World encompasses different forms and levels of mentality. Finally, the World of Structures comprises various kinds of ideal structures. The Existential Triad involves differentiating information into two fundamental classes: ontological information and mental information. Because of its metaphysical import, the GTI may not be to everyone's liking. But we do not have anything better for now.

5. Conclusions

The sheer volume of ideas that has been produced, and continues to be produced, for information means that any effort "to classify them all" will always be non-exhaustive. The complex of specialized concepts co-associated with information drawing on expertise in physics, mathematics, biology, philosophy of mind, computer sciences, communication, etc.—like mass, matter, energy, complexity, entropy, meaning, chaos, order, form, structure, etc.—makes any single-sided discussion on information a fragile and precarious enterprise (e.g. Reading 2006; Vopson 2019).

Nevertheless, a more coherent picture of the various conceptualizations can be seen to emerge in a form of GTI and GDI.

We therefore have reasons to be both satisfied and disappointed. We know much more, and understand much more, about information than we did in Shannon's time and before it, which is a good thing. However, researchers' attempts to distinguish their own research from that of others by claiming to have discovered something new has resulted in the profusion of information theories that are incomplete and narrow, and that, on the whole, do not form a coherent picture of the concept of information. In other words, the trees have been mistaken for the forest. While we should strive to be precise, the unchecked proliferation of novel concepts makes the idea behind them more vacuous than clear.

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