Towards a Formal Ontology of Information. Selected Ideas of Krzysztof Turek

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Abstract

There are many ontologies of the world or of specific phenomena such as time, matter, space, and quantum mechanics[1]. However, ontologies of information are rather rare. One of the reasons behind this is that information is most frequently associated with communication and computing, and not with 'the furniture of the world'. But what would be the nature of an ontology of information? For it to be of significant import it should be amenable to formalization in a logico-grammatical formalism. A candidate ontology satisfying such a requirement can be found in some of the ideas of K. Turek,

[1] Any good book on metaphysics will contain an ontology section discussing basic properties of the Universe. See (Loux, 1998; Loux, 2001; Wilshire, 1969; Taylor, 1992). Specific ontologies of physical phenomena can be found in books on the given subject, for example (Jammer, 2000; Janik, 2010; Whithrow, 1975; Bergman, 1966; Heller, 1990; Collins & Clark, 2015).

presented in this paper. Turek outlines the ontology of information conceived of as a part of nature, and provides the 'missing link' to the Z axiomatic set theory, offering a proposal for developing a formal ontology of information both in its philosophical and logico-grammatical representations.

Keywords

information, formal ontology of information, set theory, form-matter complex, substance, structures, relations

1. Introduction

This paper is an attempt to present selected thoughts of K. Turek, a Polish-language philosopher whose writings remain inaccessible to non-Polish speakers. Turek discusses the conceptualization of information, its formal ontology and its representation using the Z axiomatic set theory. Turek's ideas on the nature of information, though written between 1978 and 1981, may still be of relevance today.

Turek perceived information as a formative element of the Universe[2], and the third element of reality in its own right, with

[2] Information, from this perspective, is as much a part of the physical universe as are matter or energy. However, it is also of a yet-unknown nature, in some ways like matter, space, time or energy. For the statement of the nature of energy see for example (Feynman, 1971).

matter[3] and energy being the other two. Information in this view is neither an abstract concept nor a number, nor a function or an algorithm[4]. Turek does not assume that information has any non-natural qualities - it belongs to nature as we understand it in science, without any mystical or metaphysical (with metaphysical understood as "out-of-worldly") qualities. In Turek's view, information is metaphysical in a sense of being at the foundations of the real, retaining Aristotelian understanding of metaphysics. Metaphysics, as Aristotle conceived of it, does not deal with something 'after' or 'beyond' physics; it is the study of nature but understood in the most general terms. As Wilshire puts it: "(...) metaphysics and natural science hold the single realm of Nature as a common object of study (...)" (Wilshire, 1969). Thus, in this view information is the metaphysical concept *par excellence*; its nature is fundamental to nature, but does not go beyond it.

Information has been viewed as an element of reality by many philosophers, including Gitt, Hidalgo, Weaver, Collier, Stonier, Dodig-Crnkovic, von Weizsäcker, and even Floridi with

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[3] Matter should not be understood here as a "stuff" like in Democritus, but as a prime matter, rather a potential formless.

[4] This discussion relates to the fundamental ontological problem posed of the world of things, but this has not been explicated for information: Does information exist as *ens per se* (as an independent element) or *ens ab alio* (through the existence of something else)? The simple and clear division into *ens per se* and *ens ab alio* appears not so obvious under closer scrutiny. However, as a first approximation of the problem of existence of things it is acceptable.

his informational structural realism (among others) (See for example Hidalgo, 2015; Stonier, 1990; Gitt, 2002; von Weizsäcker, 1971; Collier, 1990; Dodig-Crnkovic, 2012; Floridi, 2010c). So, Turek is not on his own. However, his philosophy probes deeper than others into the nature of the ontology and its formal expressions – and that is why I think it deserves to be more widely known.

The "third element" view of the nature of information in no way invalidates or diminishes any of the concepts of information proposed by Shannon, Chaitin, Floridi, Fisher, Burgin, Carnap, Bar-Hillel, Capurro, and many others working within a similar paradigm[5] – it merely puts them in a different perspective. Thus, Turek's ideas should not be regarded as a conflicting proposal but as another view of the nature of information that fits well with the current research in the area. As we will see, these views are surprisingly close to most modern concepts of information and physics.

Instead of publishing full translations of Turek's papers, I have opted to present a selection of his ideas most relevant to us today, supported by substantial quotations from his original writings[6] and a critical commentary. Of course, any imperfections in the presentation of Turek's views are my own.

[5] For a fairly complete review of different information concepts see (Nafria, 2010).

[6] The presentation of Turek's ideas on information focuses on the ontology of information while leaving out epistemological interpretations, which are included in Turek's papers.

The presentation of Turek's concept of information will be based on two of his papers: "Philosophical aspects of the concept of information" (Turek, 1978) and "Examination of the concept of structure" (Turek, 1981). They were both published in Polish in the journal *Zagadnienia Filozoficzne w Nauce* (Philosophical Problems in Science) in 1978 and 1981, respectively. The first paper discusses the general concept of information and its interpretation as a special kind of form. The second paper discusses analogies between the set theory and the form-structure concepts of information.

2. Turek's information philosophy

2.1. Preliminaries

Information is used to denote many things; sometimes its meaning can extend well beyond an original definition, making it a catch-all term for many diverse ideas, while sometimes it is restricted to a very narrow domain as a technical term without meaning outside one specific area[7]. Efforts to pin down the nature of information are reminiscent of Socrates's struggle with concepts of wisdom, virtue, or justice.

[7] What Turek wrote in the 1970s about the multivalent meaning of the concept has been echoed by Floridi (Floridi, 2010a) and many others. So, the situation has not changed; we just have more 'definitions' to choose from.

As we do not have a clear conception of what information is, we cannot formalize its ontology[8], that is, formalizing in the sense of applying formal logical language and concepts. Application of any formal method (theory of categories, theory of sets, mereology or mereotopology are among possible candidates[9]) to the concept of information (as understood in this paper) will fail, as we do not know what it is that we are trying to formalize[10].

We lack the concepts that would allow us to bridge the gap between the intuitive understanding of information and formal methods[11].

Informal ontologies of information may be based on the concepts of reality of Whitehead (Whitehead, 1957; Ingarden, 1964; Thomasson, 2012) or the formal ontologies of Ingar-

[8] The formal ontology of information bears the promise of capturing the essence of what information is, bringing the possibility of clarity to the over-complicated and over-crowded semantic space of information – a reward surely worth striving for.

[9] One such proposal is discussed in (Smith, 2009). Another discussion on the formal ontology of parts can be found in (Koslicki, 2009). See also Ingarden for the application of the set theory to the modeling of information (Ingarden & Urbanik, 1962).

[10] To put it differently, the ontological interpretation of the formal methods in the context of information is not clear.

[11] In applying formal methods to real things there is no escape from reality; the successful formal ontology of the reality "(...) should provide a logically perspicuous representation of our common-sense understanding of the world, and not just of our scientific understanding". (Cocchiarella, 2007).

den, among others; but the question of which of these should be adopted as the ontology of information for formal methods is open[12]. It seems to me that concepts of form and structure, as proposed by Turek, are possible candidates (after some clarifications) for the role of this 'missing link'[13].

2.2. Form and matter

The meaning of the term 'information' is derived from its Latin roots as 'in-form-a(c)tion'; the internal 'in' configuration makes it more of a process than a static element. The meaning of this internal shape can be found in the concept of the 'hylomorphism', as Turek calls it – a form-matter composite.

[12] Formal ontology can be explained as follows: "Formal ontology is both a theory of logical forms and a metaphysical theory about the ontological structure of the world. What makes it a theory of logical forms is that different ontological categories or modes of being are represented in it by different logico-grammatical categories. It is specified in this regard by what might be called an ontological grammar that determines how the expressions of those logico-grammatical categories can be meaningfully combined so as to represent different ontological categories of the world" (Cocchiarella, 2007). Thus, we may refer to Ingarden's ontologies as formal ontologies as we may talk about formal ontologies when those ontologies are expressed in some sort of logical language.

[13] This missing link is also called "the nexus of predication" by Cocchiarella (2007).

2.2.1. Form matter composite

Turek's form-matter composite is a very narrow concept in comparison to the Aristotelian hylomorphism[14], and as such it does not carry all the baggage of Aristotelian metaphysics[15]. Form is understood by Turek as an element shaping formless matter. It imposes upon it its external contours or shape as well as its internal configuration (Turek, 1981).

The form-matter relationship is illustrated by the example of the collection of identical balls[16]. Say we have a collection of individual objects of the same form, e.g., balls of the same external shape and internal constitution. Matter imposes individuality on every ball as each one is an individual thing. Form shapes the matter into individuals of the same genus. There is no priority between form and matter. Matter and form cannot exist separately. In the example the balls are identical objects because of form, but individual objects because of matter[17].

[14] Aristotelian hylomorphism obviously has several acute problems that stand to eliminate it, as it stands, as a model for information. See for example (Lesher, 2013).

[15] "Based on my analysis, I can conclude that information may be considered a new concept only if we consider anew the narrowly understood Aristotelian concept of form" (Turek, 1978).

[16] This example of identical balls does not include chaotic structures such as snowflakes or rock formations. For example, snowflakes are all unique, shaped by the environmental conditions at the time of formation. Such a process seems to fall outside Turek's example. See (Connors, 2016; Anon, 2015).

[17] "The Universe appears to us as composed of individual, separate, things. Let us take a collection of identical balls. We perceive it not as one ball but as a collection of individual elements, each one being a separate ball. Despite the fact that each one of them is a different

2.2.2. Structure and form

An abstract structure is a system with a given number of collections (sets[18]) and relations between elements of those collections (Turek, 1978). An abstract structure can be exemplified by a DNA polymer, an example of a highly organized complex of interconnected units of molecules forming complexes at multiple levels from atomic to molecular. This is in fact a structure of structures, i.e., a structure whose elements are other structures[19].

element of a collection, we conceive of them under the same concept of 'ball', which corresponds to their (common) form. To explain the existence of many individuals of the same genus (having the same form) we have to introduce another element – a prime matter. The role of the prime matter is to impose individuality on forms. Form shapes matter, matter imposes on form individuality in the representatives of the same genus. There is no precedence in this is relationship that may be considered figuratively as interaction: matter or form cannot exist separately; they always constitute indivisible wholes. Balls are identical in form but different in matter, that is why we can perceive them as individuals." (Turek, 1978).

[18] Strictly speaking, it is a mistake to equate collections with sets.

[19] The example comes close to the following interpretation of the Aristotelian form-matter composite: "On one understanding of matter, it is the counterpart of form – the stuff that gets informed – so that whenever there is a form there must also be some matter that serves as its subject. On this conception, there will often be hierarchies of matter, with the most basic stuff, prime matter, at the bottom, and various form-matter composites at higher levels, which may themselves be conceived of as the matter for some further form. Wood, for example, is a form-matter composite that can itself serve as the matter for a bed." (Pasnau, 2015). This common-sense interpretation of hylomorphism comes from medieval times (Solomon ibn Gabriol); it was controversial even then.

The concept of a structure is contained in the concept of a form, which means that every structure is a form, but not every form must be a structure. We can distinguish:

(1) forms reducible to structures,
(2) forms containing structures, and
(3) forms without structures.

Turek postulates that "the concept of information is a subset of sets of forms reducible to structures"[20].

Forms reducible to structures are investigated by the natural sciences and may be described by logic and mathematics or other formalisms[21]. Examples of such structure-forms are seen in concepts of classical mechanics, expressed[22] as follows:

[20] "The concept of a structure is contained in the concept of a form. This means that every structure is a form, but not that every form must be a structure. In the simplest case, a form is a structure and as such can be expressed in the formalisms of mathematics and logic. Thus, we will differentiate three types of forms: (1) forms containing structures; (2) forms reducible to structures; (3) forms without structures. This differentiation is important if we assume that each existence is characterized by a certain form. In this context a question about the essence of information requires the precise description of the form that corresponds to this concept (of information). I will be attempting to demonstrate that the concept of information means a certain subset of sets of forms reducible to structures." (Turek, 1981).

[21] In this case it may be asserted that "[f]orm is an internal material content of the material being, as well as its internal and external configuration" (Turek, 1981).

[22] The concept of a structure of natural sciences is taken from (Wójcicki, 1997).

> $((P,Re), s, f, m,g, E_1,...E_r)$
>
> Elements of the set P are material points. In a set Re of real numbers we differentiate a certain interval T, whose elements are time intervals (moments in time). Relations s,f,m,g, defined over the sets P and Re, are basic, non-definable relations and denote notions of location, force with which at a given moment a point acts on another material point, mass of a material point, and the external forces acting on material points. E_i denotes the mathematical relations defined by the theory of classical mechanics. The statement that classical mechanics describes in approximation a certain part of reality is equivalent to the statement that the structure of classical mechanics is 'similar' to the form of this part of reality (Turek, 1978).

Forms containing structures, but not reducible to structures, are forms with (containing) structures to which they are not equivalent. One form not reducible to a structure is the mind. Some aspects of this form have structures that are an object of specific sciences such as biology, psychology, etc. Nonstructural parts of the mind are indicated by philosophy, art, and music among others. Denying the unstructured part leads to a reductionist, mechanical or computerized model of the mind (Turek, 1978) as Turek asserts.

Thus, forms may or may not contain structures. The differentiation between forms containing structures and forms reducible to structures defines the boundary between reductionist and non-reductionist theories, as represented for example in the metaphysics of Alfred North Whitehead[23]. By claiming that every form is reducible to structure, and assuming every structure can be represented in a formal language, we claim that everything is reducible to the language of logic and mathematics, or, equivalently, that the logico-mathematical representation is complete with respect to the Universe.

Forms without structures are mental and real forms in which we cannot differentiate any structure. We can only describe them as a simple, non-definable concept, taken to the limits. This is how Turek explains this class of forms:

> When we consider Aristotelian prime matter we think about it as being internally shaped by the form without structure. Thus, we need to have a way of referring to, denoting, something that is not recognizable to the senses, touching only the material world – a sea of structures delimited by prime matter (Turek, 1978).

[23] "Achievements of physical sciences appear to demonstrate that nature (its non-living aspects) is shaped by forms reducible to structures. One may, however, oppose this view and claim that forms of material, non-living entities, cannot be reduced to structures, just as we cannot reduce to form-structures living beings. This is a non-reductionist thesis" (Turek, 1978).

2.3. Information

To define information Turek uses the concept of a substance. In Turek's view a substance is not necessarily the Aristotelian substance. It is an individual complex of form and matter, but it can be anything that can be differentiated as a form-matter composite. Examples of substances that Turek offers include: language spoken or written, a magnetic tape, a computer punch card, a chromosome, a man, a computer, and a natural object (Turek, 1978). All these entities are concrete and finite and belong to some genus.

Now, if a substance S1 is constituted, formed, by the finite structure I (a structure with a finite number of elements), and a substance S2 may be potentially formed by structure I, then we call this structure I information (Turek, 1978).

Thus, information is a form (in one of three enumerated types) that can either be imposed on matter (prime matter) or found in substance (form-matter composite). In a case where the form has a structure (form 1 and maybe 2) information can be represented by the logical and mathematical formalisms. Information must be, or is, what is realizable, what is realized, in substance (understood as above).

Structures that are infinite and conceptual or express categories or genus are not information in the sense defined by Turek. The nature of such abstract structures is different from the nature of structures defined here[24].

[24] We stop short here of crossing into the nominalism-realism controversy, leaving this interpretation of structures to some other opportunity.

Turek also recognizes the concept of information as a representation of the multitude of forms. This is more or less the concept of information as defined by Hartely (1927). The number of bits in this approach is a measure of the complexity of a finite structure. This number of bits is defined as information "or an amount of information or simply a number" (Turek, 1978), Turek concludes. Such a definition of information is not opposed to Turek's concept. It represents a completely different idea.

2.4. Structure of reality and set theory

Reality, the word-as-it-is, is characterized by existence of many things (see the earlier example of the collection of balls) sharing the same essences. The structure of reality, in which the same essences exist in many things, is called a genus-individual structure[25]. A genus-individual structure is defined by three concepts: genus, individual, and membership or affiliation. These are primitive, non-definable concepts, relating to basic properties of reality[26].

[25] 'Genus-individual structure' is almost a word-for-word translation of Turek's concept of 'struktura gatunkowo-jednostkowa'.

[26] "Neither a genus nor an individual can be defined, as these concepts cannot be separated. Defining an individual by its membership in a genus, or defining genus by indicating individuals belonging to it, does not define either of them; it defines only their co-relation." (Turek, 1981).

In the set theory the concepts of a set and the elements of sets are also primitive, non-definable concepts[27]. Sets are usually specified by an example without any ontological underpinning. A set is a mental construct[28], not in principle any representation of reality. The set theory may be founded on a set of axioms like the Zermelo axioms (Z). Now, the system of concepts is as follows: a set, a member of a set, and membership of a set with axioms we may call a structure of a set.

Despite similarities, a genus-individual structure (genus, member of a genus, and affiliation) and the structure of a set are not equivalent:

> Each genus-individual structure may be represented by the set, but each set cannot be represented by a genus-individual structure (Turek, 1981).

[27] "We do not define either the set or the element of a set; their meanings can be understood intuitively (not needing definition). However, we say that a set is any collection of definite, distinguishable objects, and we call these objects the elements of the set." (Karoly, 2015).

[28] "Sets are not objects of the real world. They are created by our minds. A heap of potatoes is not a set of potatoes; the set of all molecules in a drop of water is not the same object as that drop of water. The human mind possesses the ability to abstract, to think of a variety of different objects as being bound together by some common property, and thus to form a set of objects having this property. The property in question may be nothing more than the ability to think of these objects (as being) together." (Hrbacek & Jech, 1999).

Sets can be constructed with Z axioms, which cannot constitute a genus. A set of apples, cars and monkeys is an example of such a set. A genus represents reality, the properties of nature; a set is only a mental construct (as explained in the footnote) that represents our ability to mentally group concepts.

The critical difference between a genus-individual structure and the structure of a set is contained in the Axiom of Extensionality, which states that two sets are equal (i.e., are the same) if they have the same elements.

The membership of a genus is defined not by membership of its elements but by the possession by the elements of a genus of some common essence. Thus,

> When we try to substitute the concept of genus with the concept of a set we are losing the essence of what genus is. We still can create the mental object as a set of members of a genus, but such a construct would not possess its essence. Any description of the real world that uses the theory of sets is then incomplete, as it abstracts from what genus is. This is a price we have to pay for the clarity offered by the abstract theory (Turek, 1981).

3. Turek on the Shannon/ Wiener concept of information

Turek provides an interesting interpretation of Shannon's concept of information (Shannon, 1948)[29]. He writes:

> (...) Wiener and Shannon considered finite structures and denoted them as information. Abstract interpretations of information detached this concept from individual things and allowed a 'new' means of representing several scientific problems. In this way one of the oldest philosophical concepts imposes itself on the consciousness of 20th-century people, but under a very limited and restricted meaning and under the old name. More and more, we talk not about the understanding but about the communication of information. Again we see here the return to the Aristotelian thought, though significantly impoverished, according to which cognition is understood as an imprint of the form of the world on the mind (Turek, 1981).

Turek's interpretation agrees with many modern views on Shannon's communication theory and its distance to the concept of information understood more broadly than just as a numerical property of digitized sequences of signs (see Pierce 1961; Cherry 1978). Shannon's concept of information is constructed

[29] An edition with invaluable glosses on Shannon's work (Shannon & Weaver, 1964).

with the clear goal of measuring the capacity and efficiency of a communication channel for transferring text (or symbolic) messages. And it works well in this context. The problems begin when the concept is extended beyond its original context and regarded as a 'measure'[30]. Shannon's 'information' means

[30] "In 1948, Claud Shannon published a paper called 'A Mathematical Theory of Communication'. This paper heralded a transformation in our understanding of information. Before Shannon's paper, information had been viewed as a kind of poorly defined miasmatic fluid. But after Shannon's paper, it became apparent that information is a well-defined and, above all, measurable quantity. Shannon's theory describes a subtle theory which tells us something fundamental about the way the universe works." (Stone, 2015). The author places too much emphasis on the calculus of probability; the fact that something can be computed does not make it real, and does not even explain its nature, as the example of energy (or gravity or other physical phenomena) shows. Shannon's theory is about how to reproduce a message on the basis of its symbolic codification. A message (defined not as some meaning but as a sequence of empty signs) and the transmission of it have nothing to do with information as commonly understood, but everything to do with telecommunication, and this has to be kept in mind. Shannon's conclusions regarding the importance of low-probability messages, or uncertainty and information, make perfect sense if and when applied within the reference model to coding, decoding or compressing of the transmission signal.
Pierce writes: "Primarily, however, communication theory is, as Shannon described it, a mathematical theory of communication. The concepts are formulated in mathematical terms, of which widely different physical examples can be given. Engineers, psychologists, and physicists may use communication theory, but it remains a mathematical theory rather than a physical or psychological theory, or an engineering art." (Pierce, 1961, p. 9). Pierce is trying to point to problems with the interpretation of Shannon's information, stating that "pictures of completely random patterns are mathematically most surprising [informative, according to Shannon's theory] but the dullest of all patterns, and to a human being one random pattern looks like another." (Pierce, 1961).

something different to the ancient and traditional term[31]. Similar is true for Shannon's use of entropy[32].

4. Turek's information and hylomorphism

Turek defines a formal ontology of information and provides its interpretation using the set theory formalism. The price paid for this is the use of Aristotelian-like concepts such as form, prime

[31] See footnote 26.

[32] Pierce writes: "We see that the ideas which gave rise to the entropy of physics and the entropy of communication theory are quite different. One can be fully useful without any reference at all to the other." He goes on: "Several physicists and mathematicians have been anxious to show that communication theory and its entropy are extremely important in connection with statistical mechanics. This is still a confused and confusing matter. The confusion is sometimes aggravated when more than one meaning of information creeps into a discussion. Thus, information is something associated with the idea of knowledge through its popular use rather than with uncertainty and with resolution of uncertainty." (Pierce, 1961). And: "So in Shannon's language, information and entropy are functionally equivalent because the number of bits you need to specify the message (Shannon's information) is a function of the number of possible messages that could be transmitted (the multiplicity of states, which we know as entropy). Yet, this does not make entropy and information the same thing." (Hidalgo, 2015). For a really down-to-earth discussion of this topi*c* see (Libbs, 2012). Just a short quotation from this work's opening page gives a sense of the content: "The equations used in communication theory have absolutely nothing to do with equations used in thermodynamics, statistical mechanics, or statistical thermodynamics." These opinions do not prevent many from holding diametrically opposed views about entropy and communication theory.

matter, substance, and essence. The meaning of these terms is very restricted, almost non-Aristotelian, one could say, or very technical. This approach prevents Turek's proposal from being overloaded with defunct Aristotelian metaphysical notions and consequences (Aristotle's theory of mind and soul), which usually of course is easily done[33]. What would happen to Turek's proposal if the Aristotelian concept of the form-matter composite (even if restricted) were shown to be lacking?

The form-matter composition that is at the foundation of Turek's proposal may explain the existence of similar balls (see Turek's example above). However, it seems to break down (at least following the example of the balls) when trying to explain forms of nature that are unique and result from many interacting environmental conditions. Examples include mountains, snowflakes, shapes of rivers, or systems of underground caves or calcite formations; all of these result from the dynamic interaction of changing environmental forces (Kaye, 1993). These objects did not have any form imposing its shape on the matter; they were more or less created 'on-the-go'.

It seems that the example of chaotic structures (referring to natural objects) should force the rethinking of the form-matter concept inherited from Aristotle, as well as the whole concept of information based on the idea of the (static) form (i.e., as some static factor imposing or bestowing some structure). In the case

[33] See the discussion on the shift from forming to communicating the concept of information in Capurro (2009).

of chaotic phenomena a 'form' is a dynamic process rather than an 'Aristotelian statue'. Thus, we could think of the form-matter composite as an interplay of physical forces dynamically acting within the constraints of nature, unfolding as they interact. Of course, such an idea would require further elaboration[34].

It is worth posing the question of whether Whitehead's (Whitehead, 1957) ideas about processes in nature would provide some help in reformulating the concept of a form as a dynamic (Whitehead), rather than static (Aristotle) shaping factor[35].

In evaluating, or criticizing, Turek's ideas one needs to take into account the fact that the form-matter theory was always controversial, and that, historically, there was no single agreed-

[34] The hylomorphism (or some form of it) cannot be easily dismissed. As Werner Heisenberg observed, what we call matter is in fact a field of potentiality more akin to the shapeless prime matter of Aristotle than to the solid thing we imagine matter to be. "In experiments about atomic events we have to do with things and facts, with phenomena that are just as real as any phenomena in daily life. But atoms and the elementary particles themselves are not as real; they form a world of potentialities or possibilities rather than one of things or facts (...) The probability wave (...) mean[s] a tendency towards something. It's a quantitative version of the old concept of potentia from Aristotle's philosophy. It introduces something standing in the middle between the idea of an event and the actual event, a strange kind of physical reality just in the middle between possibility and reality." (Herbert, 1985). Thus, if there is a prime matter (pure potentiality) then the shaping factor should exist. We may call this a form.

[35] The question with respect to the nature of form is this: Is a form a static, *a priori*, given complex, or is it a dynamic, shaping phenomenon? Turek's definition of information may seem to attribute both natures.

upon version but rather many, frequently conflicting interpretations[36]. No theory based on Aristotelian concepts of form-matter can therefore be accepted without question.

5. The concept of information today and Turek's model

Concepts of information (Capurro, 2009; Nafria, 2010) can be categorized, probably with some exceptions, as either epistemological or ontological (Krzanowski, 2016). Epistemological definitions see information as phenomenon dependent on the existence of conscious mind with the obvious corollary that in the absence of the mind no information would exist. Ontological definitions define information as – fundamental elements, if not foundational, of nature, existing whether or not there is **a** mind to perceive it. In some models, unfortunately, ontological and epistemological distinctions are lost (Gitt, 2002; von Weizsäcker, 1971).

Table 1 below lists the main features of ontological and epistemological models. The listing is not exhaustive, but selective.

[36] "The historical record suggests that (...) there has never been any such thing as the theory of form and matter."

Table 1. Classification of information concepts

Model Category	Main Characteristics	Selected Authors
Epistemological	• Information results from the mind interacting with nature; it is what the mind abstracts from the natural phenomena • The mind can be an origin or a receiver of information • Information can be communicated, created, or destroyed • Information is often recognized as knowledge	Hartley (1927), Shannon (1948), Shannon & Weaver (1964), Cherry (1978) Chaitin (2005, 2006, 2007), Floridi (2004, 2009, 2010abc)
Ontological	• Information is a foundational element of nature, possibly together with energy/matter • Information is perceived as a structure, form, or organization. It can be perceived as an invariant element behind mathematical models of natural phenomena • It is a static (structure) or a dynamic (shaping and transforming) element in nature	Turek (1978, 1981), von Weizsäcker (1971), Stonier (1990), Heller (2009), Dodig-Crnkovic (2012), Hidalgo (2015)

This classifications may be further simplified, as the ontological perspective appears to be more fundamental than the epistemological one (Krzanowski, 2016). In this view epistemological aspects of information are derived from the ontological properties of nature, thus are secondary to, or dependent on, the ontological level.

Turek's information model obviously belongs to the ontological category together with the models proposed by Hidalgo, Heller, Dodig-Crnkovic and others. All these models postulate the existence of information as a forming element of nature, not dependent on the existence of the mind and is not perceived as knowledge. The main assumptions of these models are summarized in Table 2 below. The comparison between Turek and more recent ontological models in Table 2 is instructive as it shows how understanding of information has evolved over past years.

Table 2. Selected ontological models of information

Author of the concept	**Main claims postulated by the model**
von Weizsäcker (1971)	• Information is the third **thing**, independent of matter or consciousness • Information may be understood only in the context of the pair matter-form • Information may be understood as a form or a structure • Information is not a visible form, but a form at the higher level of abstraction
Stonier (1990)	• Information is the third, besides matter and energy constitutional element of nature • All organized structures contain information • Increase in information is expressed in the increased organization of the system • Information may be transferred or released by **an** organized system
Heller (2009)	• The world contains information encoded in its structures; the world is a structure or information and information saturates and creates the world • We cannot currently distinguish between structures in nature and their content; we cannot decide whether information is a structure or it is contained in the structure • Information may be what is invariant in models of nature

Dodig- -Crncovic (2012)	• Information is a fundamental ontological category • Patterns are information • Information is a fabric of reality
Hidalgo (2015)	• Information has physical origins • The physical order is information; information is not a thing • Information is not incorporeal but it is always physically embodied.

Probably the most prominent feature in the above models is the departure from the Aristotelian hylomorphism (with the exception of von Weizsäcker); hylemorphism is not considered as a viable option for the description of nature anymore. All authors do agree that information exists as a basic element of nature and that it finds expression in patterns or organization. The most recent addition is the proposal that the nature processes are in fact information processing phenomena (Dodig-Crnkovic). Thus, in describing the nature of information researchers do agree that information is related or expressed through structures or order in things, that it is an ontological category and that probably is not directly perceivable. There is no agreement on whether information is a structure or is in structures and if it is, what is its essence. What the proposed models of information are missing are the bridging concepts allowing information to be expressed in a formal language. This "bridging concept" **can be found** in Turek's work.

6. Conclusions

Turek's concept of information is constructed using the concept of a form-matter composite. It is a type of form that may be reduced to, or be made equivalent to, structure. It cannot exist on its own and is fused with matter, but no priority is given to either of the two elements. Information is embodied in individual substances, but not in the understanding of Aristotle, and does not exist as some kind of universal idea.

The structure of individual substances (as defined by Turek) is in some ways analogous to the Z axiomatic set theory. Turek stipulates that the set theory may be used to represent information as embodied structures. While Turek's conceptualization of information and its link to Z axiomatic set theory is interesting, it is certainly not complete. The question remains open as to whether the Z axiomatic set theory is the right formalism for information, or whether some other approaches proposed recently (e.g., mereology and mereotopology) should be preferred, particularly as such approaches seem already to be linked to ontology through the work of Husserl (Husserl, 2001).

Despite certain conceptual problems Turek's concept of information seems similar to those being supported by current research in the field (with the exception of information models based on the communication paradigm, of course). Turek's limited concepts of form, matter, and substance find some analogues in modern physics. Thus, despite being of Aristotelian origin, these concepts seem to retain their validity in this reduced, modern shape. The proposal to express information-structures in the set theory formalism, even if incomplete, parallels modern research into the formal ontologies of the real world, or structures. One should also observe that, in general, Aristotelian concepts are not dead; they are very much alive and are undergoing constant discussion (see for example Marmodoro, 2013; Takho, 2012). to find coherent modern interpretations, consistent with our evolving understanding of nature. Thus, we can conclude, without risk of drifting into philosophical backwaters, that Turek presents very interesting ideas for the development of a formal description of information, even if his ideas require further refinement.

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