Deflating the deflationary view of information

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1.- Introduction

Information is everywhere, shaping our discourses and our thoughts. In everyday life, we know that the information spread by the media may trigger deep social, economical and political changes. In science, the concept of information has pervaded almost all scientific disciplines, from physics and chemistry to biology and psychology. Philosophy has echoed this situation in a number of articles in journals and books devoted to elucidate and analyze the concept of information in its different meanings.

In the field of the philosophy of physics, Christopher Timpson (2003, 2004, 2005, 2006, 2008, 2013) has published several works where he accurately designs an interpretation of the technical concept of information, that is, of the concept as used in information theory. In particular, he proposes a deflationary view about information, according to which the term 'information' is an abstract noun and, as a consequence, information is not part of the material contents of the world. This innovative and well articulated view has had a great impact on the philosophy of physics, especially among authors interested in the use of the concept of information for interpreting physical theories. For this reason, Timpson's proposal deserves to be critically analyzed in detail, in order to assess the consequences usually drawn from it. The main purpose of the present article consists precisely in supplying such a critical analysis.

On this basis, in Section 2 we will begin by recalling certain basic distinctions regarding the concept of information: this will allow us to focus on the technical statistical concept of information. Then, in Section 3, we will analyze Timpson's reading of Shannon's theory, considering the conceptual consequences of that reading. Section 4 will be devoted to recall and analyze the arguments appealed to by Timpson to ground his deflationary view of information; this analysis will lead us to claim that information is an item even more abstract than what Timpson claims. This conclusion will lead us, in Section 5, to wonder if the abstract nature of information prevents us to conceive it as a physical item. The negative answer to this question will allow us to consider, in Section 6, the differences between the epistemic and the physical interpretation of information, and to propose, in Section 7, in contrast with Timpson's monist interpretation, a pluralist view about information, according to which, even on the basis of a single formalism, the concept of information admits a variety of interpretations, each one useful in a different context.

2.- Which information?

As many recognize, information is a polysemantic concept that can be associated with different phenomena (Floridi 2010). In this conceptual tangle, the first distinction to be introduced in philosophy is that between a semantic and a non-semantic view of information. According to the first view, information is something that carries semantic content (Bar-Hillel and Carnap 1953; Bar-Hillel 1964, Floridi 2013); it is therefore strongly related with semantic notions such as reference, meaning and representation. In general, semantic information is carried by propositions that intend to represent states of affairs; so, it has intentionality, "aboutness", that is, it is directed to other things. And although it remains controversial whether false factual content may qualify as information, semantic information maintains strong links with the notion of truth.

Non-semantic information, also called 'mathematical' or 'statistical', is concerned with the statistical properties of a system and/or the correlations between the states of two systems, independently of the meanings of those states. The classical *locus* of mathematical information is the paper where Claude Shannon (1948) introduces a precise formalism designed to solve certain specific technological problems. Shannon's theory is purely quantitative: it ignores any issue related to informational content: "[the] *semantic aspects of communication are irrelevant to the engineering problem. The significant aspect is that the actual message is one selected from a set of possible messages.*" (Shannon 1948, p. 379).

Although very widespread (see also Floridi 2013, Adriaans 2013), the distinction between semantic and non-semantic information is not considered by Timpson. According to the author, the first and most important distinction is that between the everyday notion of information and the technical concept of information, such as that derived from the work of Shannon (Timpson 2004, pp. 4-5).[1] The everyday notion of information is intimately associated with the concepts of knowledge, language and

[1] Here we will always refer to Timpson's PhD dissertation at the University of Oxford (Timpson 2004), and not to the published version (Timpson 2013), because the dissertation was the original source of the great impact of Timpson's proposal.

meaning; information in the everyday sense displays intentionality, it is directed towards something, it is about something. By contrast, a technical concept of information is specified by means of a mathematical and/or physical vocabulary and, *prima facie*, has at most limited and derivative links to semantic and epistemic concepts.

In turn, the semantic view of information and the philosophers interested in it are barely mentioned in Timpson's work. One exception is given by his analysis of Fred Dretske's proposal: "*The claim that the everyday and information-theoretic notions of information are to be kept distinct is defended against the view of Dretske (1981), who sought to base a semantic notion of information on Shannon's theory*." (Timpson 2004, p. v).[2] This quote and others –"*Does this establish a link between the technical communication-theoretic notions of information and a semantic, everyday one?*" (*ibid*. p. 36)– suggest that Timpson equates the semantic and the everyday views of information. This suspicion is reinforced by the fact that the everyday concept is endowed with the same features as those traditionally used to characterize semantic information. In this way, Timpson seems to deprive the semantic view of any technical status, in opposition to many authors who are convinced that the elucidation of a technical concept of semantic information, with its links with knowledge, meaning and reference, makes philosophical sense (Dretske 1981, Barwise and Seligman 1997, Floridi 2013). As will be pointed out in the next sections, Timpson's explicit estrangement from any semantic ingredient in the concept of information stands in tension with some of his further claims.

Whereas Timpson devotes a couple of pages to the everyday notion of information and its relation with knowledge (2004, pp. 5-9), he announces that, since he is concerned with quantum and classical information theories, his work addresses the technical concept of information. He also stresses from the beginning that, although there are different technical concepts of information other than Shannon's (Fisher

[2] Timpson (2004, pp. 34-39) offers a criticism of Dretske's position based on pointing out a formal error. However, the error can be consistently remediated and the core of Dretske's proposal still deserves to be considered (see Lombardi 2005). Moreover, Timpson clasifies Dretske (1981) as a "semantic naturalizer", that is, one of those philosophers who "*hope, or expect, to achieve the reduction of semantic and related concepts to respectable physical ones*" (*ibid*. p. 30). But Dretske's purpose is to formulate a semantic theory of information by endowing the formalism of Shannon's theory (adequately adapted to deal with individual events) with semantic content, in order to explain sensory and cognitive processes in informational terms. Therefore, it is not clear at all that this purpose amounts to the attempt to reduce semantic concepts to physical ones: sensory and cognitive processes are not semantic items, and Shannon formalism is not, in principle, a physical theory.

information, algorithmic information, etc.), he will focus on the best known technical concept of information, the Shannon information, along with some closely related concepts from quantum information theory. So, let us begin by recalling the basic notions of Shannon's theory.

3.- Timpson on Shannon's theory

According to Shannon (1948; see also Shannon and Weaver 1949), a general communication system consists of five parts:

- A *source S*, which generates the message to be received at the destination.
- A *transmitter T*, which turns the message generated at the source into a signal to be transmitted. In the cases in which the information is codified, encoding is also implemented by this system.
- A *channel CH*, that is, the medium used to transmit the signal from the transmitter to the receiver.
- A *receiver R*, which reconstructs the message from the signal.
- A *destination D*, which receives the message.

The source *S* is a system with a range of possible states $s_1,...,s_n$ usually called *letters*, whose respective probabilities of occurrence are $p(s_1),...,p(s_n)$. *S* produces sequences of states, usually called *messages*. The *entropy of the source S* is defined as

$$H(S) = \sum_{i=1}^{n} p(s_i)\log(1/p(s_i)) \qquad (1)$$

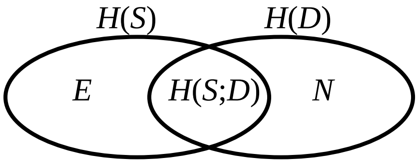
Analogously, the destination *D* is a system with a range of possible states $d_1,...,d_m$, with respective probabilities $p(d_1),...,p(d_m)$. The *entropy of the destination D* is defined as

$$H(D) = \sum_{j=1}^{m} p(d_j)\log(1/p(d_j)) \qquad (2)$$

When 'log' is the logarithm to the base 2, the resulting unit of measurement for $H(S)$ and $H(D)$ is called '*bit*', contraction of *binary unit*. If the natural logarithm is used, the unit of measurement is the *nat*, contraction of *natural unit*, and in the case of the logarithm to base 10, the unit is the *Hartley*.

The channel *CH* is defined by the matrix $\left[p(d_j/s_i)\right]$, where $p(d_j/s_i)$ is the conditional probability of the occurrence of the state d_j at the destination *D* given the occurrence of the state s_i at the source *S*, and the elements in any row must add up to 1.

The relationship between $H(S)$ and $H(D)$ can be represented as follows:



$H(S;D)$: *mutual information*

E : *equivocation*

N : *noise*

The mutual information $H(S;D)$ is the information generated at the source *S* and received at the destination *D*:

$$H(S;D) = H(S) - E = H(D) - N \tag{3}$$

E is the information generated at *S* but not received at *D*, and *N* is the information received at *D* but not generated at *S*. Equivocation *E* and noise *N* are measures of the dependence between source and destination and, therefore, are functions not only of *S* and *R*, but also of the channel *CH*. Thus, they are computed as

$$N = \sum_{i=1}^{n} p(s_i) \sum_{j=1}^{m} p(d_j/s_i) \log(1/p(d_j/s_i)) \tag{4}$$

$$E = \sum_{j=1}^{m} p(d_j) \sum_{i=1}^{n} p(s_i/d_j) \log(1/p(s_i/d_j)) \tag{5}$$

where $p(s_i/d_j) = p(d_j/s_i)\,p(s_i)/p(d_j)$. The *channel capacity C* is defined as:

$$C = \max_{p(s_i)} H(S;D) \tag{6}$$

where the maximum is taken over all the possible distributions $p(s_i)$ at the source. *C* is the largest amount of information that can be transmitted over the communication channel *CH*.

One of the most relevant results in Shannon's theory is the *noiseless coding theorem* (or *First Shannon Theorem*), according to which the value of the entropy $H(S)$ of the source is equal to the average number of symbols necessary to code a letter of the source using an ideal code: $H(S)$ measures the optimal compression of the source messages. In fact, the messages of *N* letters produced by *S* fall into two classes: one of approximately $2^{NH(S)}$ typical messages, and the other of atypical messages. When $N \to \infty$, the probability of an atypical message becomes negligible; so, the source can be conceived as producing only $2^{NH(S)}$ possible messages. This suggests a natural strategy for coding: each typical message is coded by a binary sequence of length $NH(S)$, in general shorter than the length N of the original message.

In turn, the *noisy coding theorem* (or *Second Shannon Theorem*) proves that the information transmitted over a communication channel can be increased without increasing the probability of error as long as the communication rate is maintained below the channel capacity. In other words, the channel capacity is equal to the maximum rate at which the information can be sent over the channel and recovered at the destination with a vanishingly low probability of error.

Up to this point, the entropies $H(S)$ and $H(D)$ were not yet associated with the word 'information'; nevertheless, it is clear that they play the role of measures of information in Shannon's theory. But, what is information? In many presentations of the theory, $H(S)$ and $H(D)$ are defined directly in terms of the probabilities of the states of the source and the destination and, therefore, they are conceived as measures of the information generated at the source and received at the destination, respectively. This is Shannon's strategy, who was interested in the engineering problem of transmitting very long messages with low probability of error. However, from a conceptual viewpoint, it makes sense to ask for the information generated at the source by the occurrence of one of its states. Moreover, since eqs. (1) and (2) have the form of a weighted average, it also makes sense to define the individual magnitudes on which the average is computed. Therefore, the amount of information $I(s_i)$ generated at the source by the occurrence of s_i and the amount of information $I(d_j)$ received at the destination by the occurrence of d_j can be expressed as

$$I(s_i) = \log(1/p(s_i)) \tag{7}$$

$$I(d_j) = \log(1/p(d_j)) \tag{8}$$

When defined by eqs. (1) and (2), $H(S)$ and $H(D)$ cannot be conceived as average amounts of information to the extent that individual amounts of information were not previously defined. But once $I(s_i)$ and $I(d_j)$ are introduced, the entropies $H(S)$ and $H(D)$ turn out to be *average amounts of information per letter* generated by the source and received by the destination, respectively, and can be defined as (see, e.g., Abramson 1963, p. 12; Lombardi 2005, pp. 24-25; Bub 2007, p. 558)

$$H(S) = \sum_{i=1}^{n} p(s_i)\, I(s_i) \tag{9}$$

$$H(D) = \sum_{i=1}^{n} p(d_j)\, I(d_j) \tag{10}$$

The distinction between conceiving the entropies of the source and the destination as amounts of information or as average amounts of information might seem an irrelevant detail. However, this is not the case when we are interested in elucidating the very notion of information –in Shannon's sense–. In fact, Timpson takes the first strategy and does not define the amount of information generated by a single letter of the source: "*It is crucial to realise that 'information' in Shannon's theory is not associated with individual messages, but rather characterises the source of the messages.*" (Timpson 2004, p. 11). In the few cases in which he speaks about the information that we would gain if the state s_i were to occur (Timpson 2003, pp. 13-14), it is conceived as a "surprise information" associated with s_i, which only makes sense when s_i is the outcome of a single experiment considered as a member of a long sequence of experiments –where, apparently, the probabilities are conceived as frequencies–.

Assuming the conceptual priority of $H(S)$ over individual amounts of information allows Timpson to *define* the concept of information in terms of the noiseless coding theorem: "*the coding theorems that introduced the classical (Shannon, 1948) and quantum (Schumacher, 1995) concepts of information$_t$* [the technical concept of information] *do not* merely *define measures of these quantities. They also introduce the concept of* what it is *that is transmitted,* what it is *that is measured*." (Timpson 2008, p. 23; emphasis in the original).[3] In other words, Shannon information measures "*the minimal amount of channel resources required to encode the output of the source in such a way that any message produced may be accurately reproduced at the destination. That is, to ask how much information$_t$ a source produces is ask to what degree is the output of the source* compressible*?*" (Timpson 2008, p. 27; emphasis in the original). In the same vein, Timpson relates mutual information with the noisy coding theorem: "*The most important interpretation of the mutual information does derive from the noisy coding theorem.*" (2004, p. 19).

The first thing to notice here is that the strategy of defining information via the noiseless coding theorem turns the theorem into a definition. In fact, now the entropy $H(S)$ of the source is not defined by eq. (1) as the average amount of information per letter generated by the source, but it is defined as the average number of bits necessary

[3] Although in Section 1.2 of his thesis Timpson considers two other interpretations of Shannon information, from the whole text it turns out to be clear that the one based on the noiseless theorem is considered as the most relevant, and that the others are subsidiary to that one.

to code a letter of the source using an ideal code, and eq. (1) becomes a theorem resulting from a mathematical proof. Of course, there is no formal mistake in this strategy, but it causes a kind of uneasiness when considered from a conceptual viewpoint.

In fact, if the noiseless coding theorem says *what it is* that is transmitted, now we know what $H(S)$ is. But what about $H(D)$? If information is defined through the noiseless coding theorem, either $H(D)$ does not represent information, or it is defined by eq. (2), breaking down the symmetry between eqs. (1) and (2) as the basic definitions of the theory. Moreover, if information is defined in terms of an ideal codification, what happens in the case of non-ideal codifications? Can we still say that a same amount of information can be better or worse codified?

As said above, the coding theorem is demonstrated in the case of very long messages, strictly speaking, for messages of length $N \to \infty$. Thus, it says nothing about the relation between the information $I(s_i)$ generated at the source by the occurrence of the state s_i and the length of the binary sequence used to codify it. Therefore, if the noiseless coding theorem embodies the very nature of information, $I(s_i)$ is deprived of its meaning as an individual amount of information. Not only that, but one wonders whether short binary messages can be conceived as embodying information to the extent that they are not covered by the noiseless coding theorem.

The fact that the entropy $H(S)$ can be expressed in different units of measurement (bits, nats, Hartleys, etc.), and that the messages of the source can be coded using different sets of symbols (Q-ary alphabets), also points to the conceptual difference between the amount of information associated with the occurrence of a state of the source and the number of binary symbols necessary to codify that event. In fact, one could measure the entropy $H(S)$ of the source in Hartleys but codify the messages with a coding alphabet of two symbols, or measure $H(S)$ in bits but codify the messages with a coding alphabet of ten symbols. In these cases, the result of the noiseless coding theorem has to be adapted by introducing the necessary change of measurement units. Of course, this might not be convenient from a practical viewpoint, but has nothing to do with the meaning of the concept of information. This situation is analogous to measuring a length in meters and decimeters, but then expressing it in a hexadecimal numerical system: this fact does not affect the meaning of the very concept of length.

When explaining the elements of the general communication system, Shannon (1948, p. 381) characterizes the transmitter as a system that operates on the message coming from the source in some way to produce a signal suitable for transmission over the channel. In many cases, such as in telegraphy, the transmitter is also responsible for encoding the source messages. However, in certain cases the message is not codified. For instance, in traditional telephony the transmitter operates as a mere transducer, by changing sound pressure into a proportional electrical current. If one insists on defining information in terms of the noiseless coding theorem, how should one talk about information in those situations where no coding is involved?

None of these observations is an insurmountable criticism against defining information via the noiseless coding theorem. However, this definitional move conflates two aspects of communication that the traditional textbooks warned us not to conceptually confuse: the information generated at the source, which depends on its states and the probability distribution over them and is independent of coding –even of the very fact that the messages are coded or not–, and the number of symbols necessary to codify the occurrence of those states, which also depends on the alphabet used for codification. For Timpson, the conflation of these two aspects is not a serious problem to the extent that, as we will see in the next section, his deflationary position renders the concept of information void of any content other than referring to the entire protocol involved in communication.

4.- The deflationary interpretation of information

Timpson (2004, p.2) introduces a quote by Peter Strawson as the epigraph of the first part of his now famous PhD thesis: "*To suppose that, whenever we use a singular substantive, we are, or ought to be, using it to refer to something, is an ancient, but no longer a respectable, error*." (Strawson 1950, p. 448). And, immediately at the beginning of that section, he recalls a quote by John L. Austin: "*For 'truth' itself is an abstract noun, a camel, that is of a logical construction, which cannot get past the eye even of a grammarian. We approach it cap and categories in hand: we ask ourselves whether Truth is a substance (the Truth, the Body of Knowledge), or a quality (something like the colour red, inhering in truths), or a relation ('correspondence'). But philosophers should take something more nearly their own size to strain at. What needs discussing rather is the use, or certain uses, of the word 'true'*." (Austin 1950, p. 25). By relying on the analogy between 'truth' and 'information', Timpson takes these quotes to support his claim that ‘information’ is an abstract noun: “*Austin’s aim was to de-mystify the concept of truth, and make it amenable to discussion, by pointing to the fact that ‘truth’ is an abstract noun. So too is ‘information’.*” (Timpson 2004, p. 3). So, much of the plausibility of that claim depends on the reliability of the analogy.

Strawson’s and Austin’s quotes are taken from a well-known debate between the authors about the concept of truth. Whereas Austin intended to vindicate the correspondence theory of truth by reconstructing it in terms of certain demonstrative and descriptive conventions, Strawson took a deflationary stance according to which the predicate ‘is true’ has a performative rather than a descriptive function. In turn, the whole debate is framed in a semantic context in which truth is a prototypical semantic notion and the predicate ‘is true’ belongs to the metalanguage. Nothing of this sort happens in the case of the notion of information: in principle it is not one of the semantic concepts that have been traditionally analyzed by the philosophy of language, and it does not belong to a metalanguage that speaks about another language –object language–. On the other hand, the discussions about abstract nouns in general focus on the relation between the abstract-concrete dichotomy and the universal-particular dichotomy, on abstraction as the operation of removing particular features, on the different kinds of abstract nouns –those referring to mathematical entities, those derived from nominalization of adjectives or verbs, those naming fictional characters or musical or literary compositions, etc.–, among other issues; however, the semantic notion of truth does not appear in those discussions since it involves peculiar difficulties that are completely alien to the abstract-concrete question. Therefore, the appeal to the analogy with truth to argue for the abstract character of the word ‘information’ sounds as a forced analogy in the context of the philosophy of language.

Timpson recalls that very often abstract nouns arise as nominalizations of various adjectival or verbal forms. On this basis, he extends the analogy between truth and information: “*Austin leads us from the substantive ‘truth’ to the adjective ‘true’. Similarly, ‘information’ is to be explained in terms of the verb ‘inform’*” (Timpson 2004, p. 3). But, what does ‘to inform’ mean? “*To inform someone is to bring them to know something (that they did not already know).*” (*ibid*. p. 3). In other words, the meaning of ‘information’ is given by the operation of bringing knowledge. However, as pointed out above, later in the text we are said that only the everyday concept of information has meaningful links with knowledge; thus, the analogy with truth and the transition from the verb ‘inform’ to the noun ‘information’ only applies to the everyday concept:

"*'Information' in the technical sense is evidently not derived from a nominalization of this verb.*" (*ibid*. p. 20). Therefore, the reason why 'information', in its technical sense, is an abstract noun is not given yet, and must be based on a further argument. In fact, immediately below, Timpson gives not one, but two arguments.

The first argument relies on defining Shannon information as a measure of the compressibility of messages (on the basis of the First Shannon Theorem) and mutual information as a measure of the capacity of the channel (on the basis of the Second Shannon Theorem) (Timpson 2004, p. 21). Of course, these definitions favor the claim that information in its technical sense is an abstract item. However, as argued in the previous section, the entropy of the source can be defined as the average amount of information produced at the source without reference to coding (see eqs. (1) or (9)), and the strategy of defining information via the noiseless coding theorem can be objected for different reasons. Analogously, mutual information can be defined as the information generated at the source and received by the destination without reference to the capacity of the channel (see eqs. (3), (4) and (5)), which, in turn, can be defined in terms of the mutual information as usual (see eq. (6)). These definitions of the concepts of Shannon entropy and mutual information, are different from those proposed by Timpson: taking eq. (1) and eq. (3) as the definitions of Shannon entropy and mutual information respectively, as usual, is compatible with interpretations of the technical concept of information which are different from the "abstract-noun" reading, in particular, with a physical interpretation of information (we will come back to this issue in Section 6). The point to emphasize here is that, in this first argument offered by Timpson, the conclusion about the abstract nature of information –in its technical sense– is a direct consequence of the previous decision about the way in which the relevant magnitudes are defined. In other words, this argument retrieves from the definition what was injected in it from the very beginning.

The second and best known argument relies on the philosophical distinction between *types* and *tokens*. Let us consider that the source produces the sequence of states $s_8, s_5, s_1, s_2, s_2, s_4, ..., s_7, s_7, s_2, ..., s_9, s_3, s_1$. According to Timpson, what we want to transmit is not the sequence of states itself, but another *token* of the same type: "*one should distinguish between the concrete systems that the source outputs and the type that this output instantiates.*" (Timpson 2004, p. 22; see also Timpson 2008). The goal of communication, then, is to reproduce at the destination another token of the same type: "*What will be required at the end of the communication protocol is either that* *another token of this type actually be reproduced at a distant point*" (Timpson 2008, p. 25). Once this claim is accepted, the argument runs easily: since the information produced by the source, that we desire to transmit, is the sequence type, not the token, and types are abstract, then information is abstract and 'information' is an abstract noun (see Timpson 2004, pp. 21-22; see also 2008).

Of course, this argumentative strategy allows Timpson to dissolve many problems involved in the transmission of information, in particular those related with communication based on entanglement. For instance, in teleportation it is said that the very large –potentially infinite– amount of information required to specify the teletransported state is transferred from the source to the destination by sending only two classical bits and without a physical channel between them. This has lead many physicists to search for the physical link that can play the role of the carrier of information: for some, the information travels backwards in time to the event at which the entangled pair was produced and then travels forwards to the future (Penrose 1998; Jozsa 1998, 2004); for others, the information travels hidden in the classical bits (Deutsch and Hayden 2000). With his abstract-noun interpretation of information, Timpson cuts the Gordian knot of teletransportation: "*Once it is recognized that 'information' is an abstract noun, then it is clear that there is no further question to be answered regarding how information is transmitted in teleportation that goes beyond providing a description of the physical processes involved in achieving the aim of the protocol.*" (Timpson 2006, p. 599).

Although very convincing at first sight, the argument deserves to be examined in detail. If information is abstract because it is the type transmitted, and information can be measured, what is the measure of a type? In turn, is it true that the goal of communication (in the context of Shannon's theory) is to reproduce at the destination a token of the same type produced at the source? As Shannon stresses, in communication, "[t]*he significant aspect is that the actual message is one* selected from a set *of possible messages*." (1948, p. 379; emphasis in the original). The states d_j of the destination system *D* can be any kind of states, completely different than the states s_i of the source system *S*: the goal of communication is to identify at the destination which sequence of states s_i was produced by the source. Timpson explains that "*if the source X produces a string of letters like the following:* $x_2, x_1, x_3, x_1, x_4, ..., x_2, x_1, x_7, x_1, x_4$ *, say, then the type is the sequence '* $x_2, x_1, x_3, x_1, x_4, ..., x_2, x_1, x_7, x_1, x_4$ *'; we might name this 'sequence 17'. The aim is to produce at the receiving end of the communication channel another token of* *this type. What has been transmitted, though, the information transmitted on this run of the protocol, is sequence 17*." (2004, pp. 21-22). But this is not the case: what has been transmitted is not sequence 17, but that sequence 17 is *the actual message selected from the set of the possible messages* of the source. Indeed, the fact that sequence 17 was produced in the source can be identified by means of the occurrence in *D* of a sequence $d_7, d_4, d_3, d_4, d_5, ..., d_7, d_4, d_7, d_4, d_5$, which can hardly be regarded as a token of the type '$x_2, x_1, x_3, x_1, x_4, ..., x_2, x_1, x_7, x_1, x_4$'. Therefore, in principle the sequences of the source and of the destination do not need to be tokens of the same type in any sense that does not empty the very philosophical distinction type-token of any content.

Somebody who seems to suspect that there is something odd in Timpson's argument is Armond Duwell. After publishing an article to argue that quantum information is not different from classical information (Duwell 2003), Duwell changes his mind under the influence of Timpson's works. So, in a later article he also takes into account the distinction between types and tokens, which, roughly speaking, "*is the distinction between kinds of things and their concrete instances, respectively*." (Duwell 2008, p. 199). Nevertheless, he acknowledges that: "*To describe the success criterion of Shannon's theory as being the reproduction of the tokens produced at the information source at the destination is unacceptable because it lacks the precision required of a success criterion*." (*ibid*., p. 199). The reasons are several. First, any token is a token of many different types simultaneously; so the type-token argument leaves undetermined the supposedly transmitted type (*ibid*. p. 199). Moreover, in Shannon's theory the success criterion is given by a one-one mapping from the set of letters that characterize the source to the set of letters that characterize the destination, and this mapping is completely arbitrary (*ibid*. p. 200). Later Duwell notes that the Shannon entropy associated with a source can change due to the change of the probability distribution describing the source, without the change of the types that the source produces tokens of (*ibid*. p. 202). Moreover, the types a source produces tokens of can change without the Shannon entropy of the source changing (*ibid*. 203).

We might suppose that all these correct observations are sufficient to lead Duwell to conclude that the technical concept of information cannot be characterized in terms of the type-token distinction. However, this is not the conclusion drawn by him. On the contrary, he develops a number of distinctions and arguments to retain Timpson's characterization of information. In particular, Duwell distinguishes the *success* of communication from the *goal* of communication, which "*is to produce, at the* *destination, a token of the type produced by the information source. For example, if the information source produces a sequence of letters, the destination ought to produce the same sequence of letters*." (Duwell 2008, p. 199). In this way, he retains Timpson's proposal at the cost of introducing a notion, the goal of communication, which is absent in Shannon's original theory.

Moreover, Duwell considers that the one-to-one mapping that determines the success criterion in Shannon's theory "*establishes an identity between the symbols that characterize the source and destination* […]. *In other words, this function establishes the appropriate conditions for token instantiation of the type that the information source produced tokens of.*" (Duwell 2008, p. 200). But, as stressed above, the mapping is completely arbitrary, and the states of the source and the states of the destination may be of a completely different nature: for instance, the source may be a dice and the destination a dash of lights; or the source may be a device that produces words in English and the destination a device that operates a machine. It is difficult to say in what sense a face of a dice and a light in a dash are tokens of a same type: which is the type in this case? The fact that any token is a token of different types does not mean that any two things arbitrarily chosen can always be conceived as tokens of the same type. As stressed above, admitting arbitrary functions as defining the relation "*x* is a token of the same type as the token *y*" deprives the distinction type-token of any philosophical content and conceptual usefulness (see Wetzel 2011).

In his argumentative effort to retain the relevance of the type-token relationship to the elucidation of the nature of information –in its technical sense–, Duwell recalls the distinction, introduced by Timpson (2004, pp. 20-21), between *Shannon quantity-information*, which "*is that which is quantified by the Shannon entropy*" (Duwell 2008, p. 201), and *Shannon type-information*, which "*is what is produced at the information source that is required to be reproduced at the destination*." (*ibid*., p. 201). However, far from elucidating the technical concept of information, this distinction makes clear that the information usually measured in bits, and which engineers are really interested in, is the quantity-information, which is not a type and has nothing to do with types and tokens. In other words, the information in its technical sense, referred to by Shannon's theory, is the quantity-information. The notion of type-information introduced by Timpson does not correspond to the technical concept of information because, according to Shannon's theory, successful communication does not require that the states of source and destination are tokens of the same type.

The philosophical distinction between types and tokens, although not confined to logic and philosophy of language, finds its paradigmatic example in the difference between a proposition and its concrete sentence utterances: "*one will distinguish in the standard way between the sentence tokens inscribed and what is said by the sentences: the propositions expressed.*" (Timpson 2004, p. 22). This is a difference we have learned when studying logico-semantic topics, in order to avoid the confusion between the concrete instance of a sentence and its semantic content expressed by the proposition. Of course, when Timpson introduces the idea of type-information, he is not endowing types with meaning. However, a type needs to have some content to be able to identify its tokens: the distinction between types and tokens is not merely formal or syntactic. On the contrary, Shannon information is neutral with respect to any content, since the only relevant issue is the selection of a message among many. It seems that, although Timpson explicitly keeps distance from endowing information with any semantic content, certain semantic notions creeps up into his argumentation, in such a way that his concept of information turns out to acquire a sort of content completely alien to Shannon's original proposal.

Summing up, the arguments developed by Timpson in favor of the abstract nature of information are not conclusive. Nevertheless, the task of analyzing them has led us to notice that information in Shannon's theory is even more abstract than types. But, in Timpson's general argumentation, the abstract nature of information is the cornerstone of his claim that information is not physical. Therefore, it seems that, from a different argumentative line, we should arrive at the same conclusion. However, this is not the case, as we will see in the next section.

5.- Why is information not physical?

According to Timpson, in the transmission of information what is transmitted is a type sequence, and "*types are* abstracta*. They are not themselves part of the contents of the material world, nor do they have a spatio-temporal location.*" (Timpson 2008, p. 27; emphasis in the original). Since 'information' is an abstract noun, "*it doesn't serve to refer to a material thing or substance*." (Timpson 2004, p. 20). Therefore, "*one should not understand the transmission of information on the model of transporting potatoes, or butter, say, or piping water*." (2008, p. 31).

The claim that information is not a substance or a kind of stuff is repeated many times in Timpson's works (see, e.g., 2004, p. 34, 2008, p. 28). Even accepting that information is not a substance, one can still ask about its existence: Does information exist? Timpson does not offer a single answer to this question. Sometimes, he claims that his position does not imply nominalism: although information is an *abstractum*, there is no need to conclude thereby that it does not exist, since many *abstracta* are very often usefully said to exist. From a non-nominalist position, "*a sufficient condition for type existence will be that there be facts about whether particular concrete objects would or would not be tokens of that type*." (2008, p. 28). Nevertheless, the quote from Strawson that opens his PhD thesis seems to suggest something different, when pointing out that to assume that any noun refers to something is "*an ancient, but no longer a respectable, error*" (2004, p. 2). One could suppose that the idea that 'information' is a non-referring term, although present in his first works, disappears in his more recent publications. However, this is not the case. In his paper about teleportation we can read that "*there is not a question of information being a substance or entity that is transported, nor of 'the information' being a referring term*." (2006, p. 599), and the quote from Strawson is still there in his very recent book (2013, p. 10). This means that it is not only that information is not a material thing or a substance, but that there is nothing that counts as the reference of the term 'information'.

In any case, the final aim of Timpson's argumentation about the abstract nature of information consists in denying the physical interpretation of information. For him, the dictum '*Information is physical*', applied to the technical concept of information, if not trivial –meaning that some physically defined quantity is physical–, is false precisely because 'information' is an abstract noun. And this leads to all the consequences pointed out above: information is not a stuff or a substance, it is not located in space and time, it is not material. The question is: are these features sufficient to say that information is not physical?

There is, certainly, a previous question: what does it mean to be a physical item? In Timpson's arguments, the physical world seems to be given once and for all, independently of science. The style of his argumentation is typical of the traditional analytical philosophy of language: the physical world is what ordinary language talks about and, consequently, we discover the world's structure by analyzing the grammar of that language. For this reason, the grammatical fact that a noun is abstract expresses the non-existence of its referent in the physical world. It is true that Timpson distinguishes between the everyday notion and the technical notion of information. Nevertheless, in both cases the strategy is the same: to analyze the grammatical role played by the word 'information' in the non-formal language, and to draw ontological conclusions from that analysis. However, it is hard to suppose that physicists appeal to that strategy to decide what is a physical item when they say, as Rolf Landauer (1991, 1996), that information is physical. If one does not want to turn the structure of non-formal languages into the clue witness about what exists and does not exist in the physical world, a more reasonable strategy seems to be to admit that the physical world is the world that physics talks about. Therefore, in order to decide whether or not a certain item belongs to the physical world, it is necessary to see what role it plays in physical science.

From this perspective, the first thing to notice is that it is not necessary to be a substance, or a concrete thing, or a material entity, to be physical. The realm of physics is populated by countless properties, usually referred to as 'observables', which are not substances nor concrete or material things. In fact, physical properties as position, velocity, charge, mass, etc. are *abstracta*, and many of them cannot be conceived as existing in space and time in any meaningful sense: what is the space-time location of position? Nonetheless, they inhabit the world described by physics, they are undoubtedly physical items. Pace Timpson, only from an extreme nominalist perspective can the existence of physical properties be called into question. It could be argued that, whereas position and electric charge are properties, information is not a property. But the decision about conceiving a noun belonging to particular physical theory as naming an individual entity, a stuff or a property is not fixed by grammar, but depends on the interpretation of the particular theory considered. In any case, it is not necessary to be a substance or a material determinate thing to be a physical item.

From a philosophical perspective, it is well known that physics, far from being a static body of knowledge, changes substantially through history. In this process, concepts undergo deep mutations that modify the worldview described by physics. Let us consider, for instance, the concept of a wave, which begins by referring to a property of a physical medium: a wave is nothing else than an abstract description of how a material medium changes its properties in space and/or in time. In this sense, the concept of a wave does not belong to the category of substance, but to the category of property: there are no waves without a material medium that carries them. However, with the development of physics waves become something that do not need an underlying material substratum to exist. Although at present the ontological status of a field is still under debate, it is agreed that a field is something that exists by itself, with no need of a material medium, and that has its own properties and its specific physical description (for a historical account of this transformation, see Berkson 1974).

The example of waves shows that physics, in its evolution, tends to perform a substantialization of certain concepts[4]: from originally being conceived as properties, certain magnitudes turn into substances, but not in the sense of becoming kinds of stuff, referents of mass nouns –the sense used by Timpson–, but in the Aristotelian sense ("primary substance" in *Categories*) of being objects of predication but not predicable of anything else, and being bearers of properties (see Robinson 2014). One might wonder whether the –technical– concept of information is undergoing a mutation analogous to that experienced by the concept of waves, and is beginning to be conceived as a physical magnitude that exists by itself, without the need of a material carrier supporting it.

A concept that immediately comes to one's mind when thinking about a physical interpretation of information is that of energy, since energy also seems to be something "abstract" and non-material, at least when compared to, say, a molecule. Timpson considers the analogy between information and energy, but assumes that, by contrast to 'information', 'energy' is a property name. In the context of this analogy, he asks whether information is "adventitious", that is, added from without, from the perspective of the pragmatic interest of an agent: "*Is it a fundamental one?* […] *Or is it an* adventitious *one: of the nature of an addition from without; an addition from the parochial perspective of an agent wishing to treat some system information-theoretically, for whatever reason?*" (Timpson 2008, pp. 46-47; emphasis in the original). Also with respect to this aspect the comparison with energy is relevant. In fact, in the context of strict Newtonian mechanics, the concept of energy is subsidiary to the dynamical description of a system; in Timpson's terms, it is an adventitious concept designed to measure the capacity of a system to perform a certain task –work–. However, in the framework of physics as a whole, it acquired its own, not merely adventitious, reference, and became one of the fundamental physical concepts. The words of William Thomson in the nineteenth century already express clearly this transformation: "*The very name energy, though first used in its present sense by Dr. Thomas Young about the beginning of this century, has only come into use practically*

[4] This is not the only movement in the evolution of physics; in certain cases, properties applied to a single object become relations.

after the doctrine which defines it had […] *been raised from a mere formula of mathematical dynamics to the position it now holds of a principle pervading all nature and guiding the investigator in every field of science*” (Thomson 1881, p. 475). At present, the word ‘energy’ does not refer to something concrete: if a perturbation in a physical medium is transmitted between two points of space, nothing material is transmitted; nevertheless, there is transference of energy between those points. And although sometimes it is still used as a property name, in general energy has acquired a substantial nature –in the Aristotelian sense– that plays a central unifying role in physics: energy is a magnitude essentially referred to by absolutely all present-day physical theories; it is conceived as something that can be generated, accumulated, stored, processed, converted from one form to another, and transmitted from one place to another.

In his insistence on depriving information of physical nature, Timpson says that “*Quantum information theory and quantum computation are theories about what we can* do *using physical systems*” (Timpson 2004, p. 33; emphasis in the original). Following with the analogy with energy, one can say that the concept of energy also began as a tool to describe what we can do with physical systems. However, its status gradually changed with the historical development of physics: now energy is an undoubtedly physical item which, although non-material, plays an essential role in physical sciences. In the light of the strong presence of the concept of information in present-day physics, it is not difficult to suppose that it is following a historical trajectory analogous to that followed by the concept of energy in the nineteenth century.

Summing up, it is quite clear that the world described by contemporary physics is not a world of material individuals and stuffs. This traditional ontology was superseded by the world of quantum field theory, where particles lose any classical feature and fields become substantial items (see, e.g., Kuhlmann 2010), and by the general relativistic universe, where energy acquires a sort of “materiality” and space-time is no longer a neutral container of material things (see, e.g., Earman 1989). Once one admits that it is physics and not grammar that decides if an item is physical or not, it is clear that it does not matter what kinds of words are used to refer to properties, such as charge and mass, and to name items that acquired substantiality through the history of science, such as fields and energy. What only matters is that all those items inhabit the world of physics, that is, according to physics they are part of the furniture of the world.

And this implies that contemporary physics offers no grounds to deny the possibility of a meaningful physical interpretation of the concept of information.

6.- The many faces of information

Timpson considers that there is a single correct interpretation of the technical concept of information (or, at least, of Shannon's concept) and, for this reason, he devotes a great effort to elucidate it. This "monist" view contrasts with the "pluralist" perspective adopted by Shannon when claiming that "[t]*he word 'information' has been given different meanings by various writers in the general field of information theory*. [...] *It is hardly to be expected that a single concept of information would satisfactorily account for the numerous possible applications of this general field*." (Shannon 1993, 180). If this pluralistic stance was worthy of consideration in Shannon's times, at present it is even more plausible given the fact that the concept of information has permeated almost all the domains of science. From this perspective, it is philosophically interesting to realize that there are different interpretations of the concept of information, each useful in a different specific context.

Once the focus is on non-semantic information, the first step consists in specifying the formal context that frames the discussion about the meaning of the concept of information. In fact, although Shannon's theory is the traditional formalism to quantify information, it is not the only one. For instance, Fisher information measures the dependence of a random variable X on an unknown parameter θ upon which the probability of X depends (Fisher 1925), and algorithmic information measures the length of the shortest program that produces a string on a universal Turing machine (Chaitin 1987). In quantum information theory, von Neumann entropy gives a measure of the quantum resources necessary to faithfully encode the state of the source-system (Schumacher 1995).

It might be supposed that, when confined to a particular formal framework, the meaning of the word 'information' becomes clear and unequivocal: given the mathematical theory, information is what this theory describes. However, this is not the case. Even on the basis of the same formalism, there may be different interpretations of the concept of information. Although disagreements may arise regarding any formalism, let us consider Shannon's theory.

A concept usually connected with the notion of information is that of knowledge: information provides knowledge, modifies the state of knowledge of those who receive it. As pointed out above, Timpson believes that the link between information and knowledge is a feature of the everyday notion of information, which must be carefully distinguished from Shannon's technical concept. However, the idea of knowledge is present also in the philosophical and the physical discourse about information. In fact, it is common to find authors who even define information in terms of knowledge. For instance, taking Shannon's theory as the underlying formalism for his proposal, Fred Dretske says: "*information is a commodity that, given the right recipient, is capable of yielding knowledge.*" (1981, p. 47). According to Donald MacKay, information is related to an increase in knowledge on the destination end: "*Suppose we begin by asking ourselves what we mean by information. Roughly speaking, we say that we have gained information when we know something now that we didn't know before; when 'what we know' has changed*." (1969, p. 10).

The strong presence of the notion of knowledge is not confined to the works of those who try to add semantic content to statistical information. Some authors devoted to special sciences are also persuaded that the core meaning of the concept of information, even in its technical sense, is linked to the concept of knowledge. In this trend, Jon M. Dunn defines information as "*what is left of knowledge when one takes away believe, justification and truth*" (2001, p. 423), and for Bertram Brookes, knowledge is "*a structure of concepts linked by their relations*", with information defined as "*a small part of that structure*" (1981, p. 131). Also physicists frequently speak about what we know or may know when dealing with information. For instance, Anton Zeilinger even equates information and knowledge when he says that "[w]*e have knowledge, i.e., information, of an object only through observation*" (1999, p. 633) or, with Časlav Bruckner, "[f]*or convenience we will use here not a measure of information or knowledge, but rather its opposite, a measure of uncertainty or entropy.*" (2009, pp. 681-682). In a traditional textbook about Shannon's theory applied to engineering it can also be read that information "*is measured as a difference between the state of knowledge of the recipient before and after the communication of information.*" (Bell 1957, p. 7), and that it must be relativized with respect to the background knowledge available before the transmission: "*the datum point of information is then the whole body of knowledge possessed at the receiving end before the communication.*" (*ibid.*, p. 7). In certain cases, the epistemic interpretation of information is what served as the basis for philosophically motivated attempts to add a semantic dimension to a formal theory of information (MacKay 1969; Nauta 1972; Dretske 1981).

It is worth noting that, from the epistemic perspective, the possibility of acquiring knowledge about the source of information by consulting the state of the destination is rooted in the nomic connection between them, that is, in the lawfulness of the regularities underlying the whole situation. In fact, the conditional probabilities that define the channel do not represent merely *de facto* correlations; they are determined by a network of lawful connections between the states of the source and the states of the destination.

A different view about information is that which detaches the concept from the notion of knowledge and considers information as a physical magnitude. This is the position of many physicists (see, *e.g.*, Rovelli 1996) and most engineers, for whom the essential feature of information consists in its capacity to be generated at one point of the physical space and transmitted to another point; it can also be accumulated, stored and converted from one form to another. In this case, the capability of providing knowledge is not a central issue, since the transmission of information can be used only for control purposes, such as operating a device at the destination end by modifying the state of the source. According to this view, it is precisely because of the physical nature of information that the dynamics of its flow is constrained by physical laws and facts: "*Information handling is limited by the laws of physics and the number of parts available in the universe*" (Landauer 1991, p. 29; see also Bennett and Landauer 1985).

In general, the physical interpretation of information appears strongly linked with the idea expressed by the well-known *dictum* 'no information without representation': the transmission of information between two points of the physical space necessarily requires an information-bearing signal, that is, a physical process propagating from one point to the other. Landauer is an explicit defender of this position when he claims that "[i]*nformation is not a disembodied abstract entity; it is always tied to a physical representation. It is represented by engraving on a stone tablet, a spin, a charge, a hole in a punched card, a mark on a paper, or some other equivalent*." (1996, p. 188). This view is also adopted by some philosophers of science; for instance, Peter Kosso states that "*information is transferred between states through interaction.*" (1989, p. 37). The need of a carrier signal sounds natural in the light of the generic idea that physical influences can only be transferred through interactions. On this basis, information is conceived by many physicists as a physical entity with the same ontological status as energy; it has also been claimed that its essential property is the power to manifest itself as structure when added to matter (Stonier 1990, 1996).

The difference between the epistemic and the physical interpretations of information is not merely nominal, but may yield different conclusions regarding certain common physical situations. For instance, in the important philosophical tradition that explains scientific observation in terms of information (Shapere 1982, Brown 1987, Kosso 1989), the way in which information is conceived leads to very different consequences regarding observation. This turns out to be particularly clear in the so-called 'negative experiments' (see Jammer 1974), in which it is assumed that an object or event has been observed by noting the absence of some other object or event. From the informational view of scientific observation, observation without a direct physical interaction between the observed object and an appropriate destination is only admissible from an epistemic interpretation of information. According to a physical interpretation, by contrast, detection at the destination end does not amount to the observation of the object: the presence of the object is only inferred (see Lombardi 2004). It is interesting to wonder whether taking into account the distinction between the epistemic and the physical interpretations of information could contribute to unravel the puzzles involved in the informational interpretation of quantum entanglement, in particular, of teleportation (see Timpson 2006).

This presentation of the difference between the epistemic and the physical interpretations of Shannon information may suggest that the two interpretations are rival and, as a consequence, it is necessary to decide for one of them. Nevertheless, as it will be argued in the next section, this is not necessarily the case.

7.- Information: formalism and interpretations

Although the physical interpretation of information prevailed in the traditional textbooks used for engineers' training, this situation has changed in recent times: in general, present-day textbooks introduce information theory from a formal perspective, with no mention of transmitters, receivers or signals, and the basic concepts are explained in terms of random variables and probability distributions over their possible values. Only when the formalism has been presented, is the theory applied to the traditional case of communication. A clear example of this trend is the extensively used book by Thomas Cover and Joy Thomas, where the authors emphasize that:

"*Information theory answers two fundamental questions in communication theory* […]. *For this reason some consider information theory to be a subset of communication theory. We will argue that it is much more. Indeed, it has fundamental contributions to make in statistical physics* […], *computer sciences* […], *statistical inference* […] *and to probability and statistics.*" (1991, p. 1).

The idea that the concept of information is completely formal is not new. Already Aleksandr Khinchin (1957) and Fazlollah Reza (1961) conceived information theory as a new chapter of the theory of probability. From this perspective, Shannon information not only is not a physical magnitude, but also loses its nomic ingredient: the mutual information between two random variables can be defined even if there is no lawful relationship between them and the conditional probabilities connecting them express only *de facto* correlations.

If the concept of information is purely formal and belongs to a mathematical theory, the word 'information' does not pertain to the language of empirical sciences –or to any referential language–: it has no extralinguistic reference in itself. Its "meaning" has only a syntactic dimension. According to this view, the generality of the concept of Shannon information derives from its exclusively formal nature; and this generality is what makes it a powerful formal tool for empirical science, applicable to a wide variety of fields.

From this formal perspective, the relationship between the word 'information' and the different views about the nature of information is the logical relationship between a mathematical object and its interpretations, each one of which endows the term with a specific referential content. The epistemic view, then, is one of the many different interpretations, which may be applied in different technical domains, for example, in the attempts to ground a theory of knowledge on informational bases (Dretske 1981), or in psychology and cognitive sciences to conceptualize the human abilities of acquiring knowledge (see, e.g., Hoel, Albantakis and Tononi 2013).

At the same time, the physical view, which turns information into a physical magnitude carried by signals, is appropriate for communication theory, in which the main problem consists in optimizing the transmission of information by means of physical bearers whose energy and bandwidth is constrained by technological and economic limitations. But this is not the only possible physical interpretation: if the source S is interpreted as a system in a macrostate compatible with many equiprobable microstates, $I(S)$ represents the Boltzmann entropy of S. Furthermore, in computer sciences, if S is interpreted as a binary string of finite length, $I(S)$ can be related with the algorithmic complexity of S. Perhaps a kind of physical interpretation is also adequate in molecular biology, where the language of information became ubiquitous, starting from the work of James Watson and Francis Crick in the fifties (see, e.g., Maynard Smith 2000), and even in evolutionary biology, where it has been argued that abstract patterns in evolutionary processes can be described using informational concepts (Harms 2004).

Summing up, from a perspective that conceives the concept of information –in the context of Shannon's theory– as a formal concept, the epistemic and the physical interpretations are no longer rival, but they rather become two of the several possible interpretations of that formal concept. Of course, this pluralist strategy does not solve by itself the many problems involved in the widespread use of informational notions in most fields of science. However, the clear differentiation between the several interpretations of information is a first step towards overcoming those obstacles based in misunderstandings that prevent conceptual agreements.

8.- Conclusions

The concept of information is one of the most elusive in the context of present-day philosophy of science, not only due to its abstract character, but also because it appears in multiple and varied scientific disciplines. It is for this reason that the philosophical analysis of its meaning and scope is nowadays an urgent task. In this sense, the works of Timpson constitute an outstanding contribution to the field, since they have brought to the fore many aspects of the concept of information: the domain of application of Shannon's theory (Timpson 2003), the relation between information transmission and quantum entanglement (Timpson 2005), the interpretation of teleportation (Timpson 2006), the nature of quantum information and its relation with the interpretations of quantum mechanics (Timpson 2008, 2013), among others. Nevertheless, the acknowledgement of the high value of his work does not amount to uncritical agreement.

In this article we have focused, in particular, on Timpson's elucidation of the concept of information, according to which 'information' is an abstract noun and, as a consequence, information is not part of the physical contents of the world. Here we proposed a strategy in a certain sense opposed to that of Timpson: instead of attempting to cut the Gordian knot of the meaning of ‘information’ by means of a notion almost empty of referential content, we embrace a pluralist stance, which recognizes the legitimacy of different interpretations of the concept of information, not mutually exclusive and each useful in a specific context.

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