

Information and the Hard Problem of Consciousness

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Abstract

Information plays a vital role in our conscious experience. After all, consciousness is about how we experience the world, how we feel. Thus, it comes as no surprise that information theory is at the foreground of any attempts to define consciousness scientifically. In this paper, we argue that if we think of (phenomenal) consciousness as different from attention, information theory as we know it can be used for the latter but not for the former.

1 Introduction

Consciousness has an information problem. On the one hand, we seem to receive copious and uniquely valuable information about the world and ourselves through our conscious experiences. Many philosophers, perhaps a substantial majority, think that

conscious awareness is the source of knowledge and moral reasoning. Conscious perception provides first-hand evidence about properties and objects in the immediate environment that seem fundamental for grounding epistemic justification. With respect to information capacity, consciousness seems, in fact, to be so rich that some authors think that it overflows cognitive access to information [**block'attention'2010**, **block'consciousness'2007**, **block'perceptual'2011**], thereby implying that consciousness has more information than any other cognitive process, including working memory and action-control.

On the other hand, there is the hard problem of consciousness [**chalmers'facing'1995**, **chalmers'conscious'1996**]. Succinctly stated, the problem that phenomenal consciousness (or what it is like for you to experience the intense and fragrant smell of a flower [**nagel'what'1974**]) cannot be reduced to any functional or structural explanation [**chalmers'facing'1995**]. This impossibility of reduction is quite a strong and striking claim considering scientific method's enormous success. This "impossibility" claim follows by entailment from arguments concerning cases, guided by intuition, which allegedly demonstrate that no descriptive, third-personal, scientific account could even come close to closing the "explanatory gap" between conscious awareness and physical reality (for opposing views, see [**dennett'consciousness'1991**, **frankish'illusionism'2016**]).

For the science of consciousness, this conclusion is the equivalent of a "proof" of the incommensurability of conscious information. This is because science can only produce explanations about the structure and function of psychological or neural states. Therefore, there cannot be a science of phenomenal consciousness and its intrinsic subjectivity. In other words, we cannot have a scientific theory of what we consider to be the most informative cognitive state.

This situation is, to be sure, paradoxical. We have a relatively clear understanding of different kinds of information (e.g., semantic, algorithmic, syntactic) and a rigorous mathematical theory of information capacity and complexity. We also have a good under-

standing of how to define the main characteristics of phenomenal consciousness and various ways of demonstrating why phenomenal consciousness is very informative. Nevertheless, providing a clear characterization of how consciousness is informative seems extremely difficult and, according to the arguments just mentioned, perhaps impossible, particularly because of the hard problem. But what would it mean for consciousness to be uninformative? What would consciousness be without information?

Our purpose in this paper is twofold. We believe that there are problems concerning the definition of cognitive states that are informative. We identify these ambiguities by distinguishing different levels of information processing relevant to human psychology. We also offer a classification of information in terms of different types of consciousness and attention because we believe this more exact categorization may help move the debate on phenomenal information forward.

2 Layers of information processing

Cognitive information comes in many varieties. Some seem to be non-linguistic, map-like, or analog [**maley'analog'2011**]; some seem to be formatted in both “digital” and “analog” formats, such as time cognition [**montemayor'minding'2012**]. Empathic forms of communication also seem to concern non-linguistic cognition and can be found in many species [**de'waal'mamas'2019**]. Linguistic communication and attention to language might be a uniquely human feature because of syntax processing [**montemayor'perception'2017**], but a substantial portion of our linguistic skills are shared with other species [**fitch'evolution'2010**].

An obvious question is whether phenomenal consciousness is in a specific format or whether this issue is even relevant. Is analog formatting necessary? Or is language and more digital/symbolic formatting necessary? Because of the difficulties described above, there is no conclusive way of answering these questions. A more fruitful approach focuses on the possible relation and dynamics between con-

sciousness and attention [**montemayor'consciousness'2015**], independently of the issue of information encoding or formatting—and related difficulties concerning the content and the vehicle or medium of information.

It seems evident that many information-processing mechanisms that evolved to reproduce and sustain life are not cognitive. However, even here, there is debate. We know that most living organisms process information selectively and in ways that seem representational or at least intelligent. For example, organisms that navigate complex environments, seek food, and avoid predators must process relevant information to perform the behaviors necessary for survival. Attention evolved to perform these tasks at various levels of sophistication. But plants and bacteria select information in complex and intelligent ways. Are they “paying attention?” Could they even be phenomenally conscious? How to decide this pressing issue without a theory of conscious information?

There is a fundamental distinction between the mechanical (or strictly causal) transmission of information and the meaningful usage of information, which is deeply related to the issue of agency as a hallmark of cognitive processing. We need to separate primitive cognition from machine output without being too anthropocentric. Even bacteria can be drawn towards light and consume other organisms. Unicellular organisms are consumers of information regarding their immediate environment, but it seems very difficult to attribute any kind of mentality or cognition to them. After all, our own cells consume information in a similar fashion, with the rest of our bodies as “environment.” Still, bacterial “cognition” could be a kind of agency without full cognition because bacteria are goal-oriented, adapt to situations, and learn from their environment [**fulda'natural'2017**]. Bacteria appear to be neither full-blown cognizers nor mere machines.

Different varieties of cognitive agency, from the very minimal to the very complex and highly integrated, can be understood in terms of various types of attention (see [**haladjian'evolution'2015**] for a classification of different kinds of attention; see [**fairweather'knowledge'2017**]

for a characterization of attention as epistemic agency). Where does consciousness fit in? Attention is clearly informative. In fact, attention is the clearest example of a cognitive capacity that can be computationally and informationally described. Some kinds of attention are best understood in terms of “just noticeable differences” and according to the classic signal-to-noise ratio. Other kinds of attention, such as object and feature-based, are more semantically structured, inferentially specified, and algorithmic [**montemayor’inferential’2019**]. Finally, self-monitoring and meta-monitoring kinds of attention can also be understood in terms of meta-hypotheses or meta-functions that specify information classification and salience at early stages [**montemayor’perception’2017**]. In fact, attention is defined by its functions and its informational structure. It is highly informative in ways we can model and understand. But by definition, consciousness cannot be understood in any of these ways per the hard problem.

Bacteria seem to be consumers rather than mere transmitters of information, and thus they seem to have a particular type of agency. Still, it is difficult to justify the claim that they are attending to the environment. Attention seems to be more semantically structured, intentional (or directed towards contents), and algorithmic or inferentially structured. Perhaps this kind of information consumption and minimal agency is more prevalent in nature than we assume, and maybe it involves a primitive kind of mentality that is necessary for attention: a primary signal-to-noise information gathering that helps structure basic behavior.

What is the status of information processing in plants? Figdor’s “literalism” holds that scientific statements like “plants make decisions” or “bacteria converse” should be interpreted literally [**figdor’pieces’2018**]. Across human and non-human contexts of evaluation, we mean the same things with these statements or predicates. The central claim here is not that plants in fact think and cognize. Instead, the claim is that they could because the sentences used to describe their cognition or communication capacities should be considered as being either true or false. The emergent field of “plant

cognition” confirms this hypothesis [**segundo-ortin’are’2019**], and the verifiable statements about plants could, in principle, include phenomenally conscious states (e.g., a plant being in pain or having a certain motivation).

The prospect of developing a theory of plant cognition presents intriguing possibilities. From a scientific perspective, these possibilities must be studied by analyzing information processing, how it is done or measured in plants, and what kind of information processing it involves (is it really cognitive?). To assess whether the statements about plant cognition are true or false, we cannot reason simply by comparison, imagination, or analogy. It is one thing to attribute by analogy or by imaginative projection conscious states to plants or bacteria. It is an entirely different task to understand what their being conscious could mean in terms of information processing.

Attention skills are perfectly suited for this kind of cross-species comparison precisely because they are defined in terms of their informational structure and functional role. Research on different cognitive capacities across species relies on this functional role for fruitful comparisons. The navigational and largely statistically structured capacities of animals that could potentially be found in plants are very well-documented and include magnitudes such as time, rate, space, and number [**gallistel’organization’1990, montemayor’minding’2012**]). Attention in these cases is distributed and allocated in terms of likelihoods and predictions about speed and trajectory. But there is a debate about whether objects are the basis for spatial attention’s allocation and statistical properties [**pylyshyn’tthings’2007, treisman’feature’1988**]. If objects are at the basis of the structure of perceptual space (perhaps differing in structures and geometry from one modality to the other), then attention would involve not only statistical predictive signal-to-ratio information, but also built-in assumptions about which aspects of space constitute perceptual objects. This can all be measured in terms of function and structure.

One way to approach this difference between statistical information and more precise categorical information about objects is

their format. But even if one decides to approach this issue in terms of analog and digital formatting, that is still very much a functional and structural characterization. The essential point is that structurally-dependent attention is relevant for navigation that is fuzzy or approximate rather than precise and algorithmic. Plants and bacteria may “attend” to these statistically salient features in ways that differ radically from animals with a brain and a nervous system. More precise, categorical, and even symbolic-based attention may depend on conceptual or predicate-like classifications of information that depend on specialized brain areas that classify quite specific information in an algorithmic and inferential fashion.

As mentioned above, none of these functions can be interpreted as involving phenomenal consciousness because of the hard problem. However, they can easily be interpreted in terms of attention routines. In fact, interpreting them as attention routines is perhaps the best scientific approach to understanding these distinctions.

3 Information and scientific theories of consciousness

All the major scientific theories of phenomenal consciousness strongly emphasize information processing, most of them in terms of the structure and function of neural activations or networks. This is not because they willfully ignore the hard problem. Rather, it is because, otherwise, they would not be scientific approaches to consciousness—various definitions of information are at the very basis of our understanding of cognition. The “global neuronal workspace theory” (or GNWT) explicitly explains consciousness in terms of neural activation concerning algorithmic or statistically relevant information. It implicitly assumes that attention is necessary for consciousness. Thus, GNWT is explicitly a functional or structural theory of consciousness. Higher Order and First Order theories of consciousness are undoubtedly compatible with functional and structural interpretations of consciousness, so neither entails a non-

functional or “non-informational” approach. We expand upon the Integrated Information Theory (or IIT) because it is the theory of consciousness that most explicitly emphasizes information processing and most vigorously accepts the hard problem.

A significant difficulty to examine in future research is whether a non-informational theory of consciousness is both epistemically and metaphysically impossible (inconceivable and outside the scope of reality). If it is both epistemically and metaphysically impossible, what does that mean for the hard problem? We set aside this thorny issue but want to highlight the importance of getting clear on providing an informational account of consciousness.

Another complication concerns the notion of semantic information. The difficulty here is to address how different theories of semantics (e.g., situation, possible-world, or teleological) inform algorithmic information. But note that on all accounts are susceptible of functional analysis. For higher-order theories, adopting a specific semantic framework may have significant repercussions for the kind of regulatory meta-preferential or meta-monitoring routines involved in higher-order representation.

IIT deserves more discussion because of its phenomenal axioms designed to start with phenomenological insights in order to inform the causal, conceptual, and structural account of integrated information—a seemingly “bite the bullet” approach to the hard problem [oizumi·phenomenology·2014]. If the integrated information approach is correct, then there must be a radical difference between conscious and unconscious information, one that not only entails a difference in information complexity and network activation between consciousness and attention, but a difference grounded on a metric of intrinsic information, called Φ .

However, IIT has a problem [de·barros·contextuality·2017, montemayor·implementation·2019]. As its name implies, IIT is a theory that relies on the concept of information. As such, it starts with observable processes that can be associated with a joint probability distribution (Oizumi et al.). This joint can thus be used to compute the amount of information, following

some schema such as computing Shannon’s entropy. Nevertheless, as we pointed out in [de`barros`contextuality`2017] and [montemayor`implementation`2019], joint probability distributions do not exist for contextual processes, exactly the types of processes crucial for understanding conscious experiences (consider, for instance, the case of indexicals). If we consider consciousness as contextual, as many do, how do we measure contextual information? Except for von Neuman’s entropy (and perhaps extensions of Shannon’s entropy to include extended probability theories [de`barros`information`2020]), no appropriate measure of information exists that could provide a measure of contextual information. We cannot, for instance, use algorithmic information, since no true contextuality can exist in algorithmic processes. So, how can we have a scientific theory of consciousness that relies on information without a theory of contextual information? We simply cannot. Chaitin [chaitin`consciousness`2020] examines the information problem regarding phenomenal consciousness, highlighting the need for more precise measures. Our contribution is that contextuality and a clear contrast with attentional information must be at the center of this effort.

The above point makes it evident a distinction between attention and phenomenal consciousness regarding information. Whereas attention is also contextual, its contextuality is purely epistemic, in the sense that more detailed information about the environment and contextual cues could be used to identify the context objectively. Therefore, a theory of information for processes involving attention seems quite feasible. However, phenomenal experiences’ contextuality is not directly accessible to a third party: this is the core of the hard problem. Thus, imposing to phenomenal consciousness an information measure implies an epistemic solution and an ontological structure where “things” are actually non-contextual.

4 Conclusions

In this paper, we discussed the connection between information, attention, and phenomenal consciousness. We saw that attention can and is typically described by information measures, such as Shannon's entropy or algorithmic information. This ability to measure attentional information comes from attention being non-uniquely contextual. Phenomenal consciousness, on the other hand, is uniquely contextual or indexically "centered." For instance, consider the concept of "self-location" or indexical sentences such as "I am hungry now." Those are uniquely contextual and "solipsistic," unlike the semantic context that frames the publicly available and "algorithmic" conversational common-ground. Therefore, any scientific description of phenomenal consciousness using information needs to rely on a theory of information that is indexically contextual. Unless we move to quantum information, with all its difficulties (both epistemic and ontological) and its limitations (following quantum logic structure), such a scientific description is still elusive.