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73 Consciousness and Its Access Mechanisms

SID KOUIDER AND JÉRÔME SACKUR

ABSTRACT Consciousness is a fundamental dimension of our mental life that involves both cognitive functions (attention, verbalization, working memory, and so on), and subjective, experiential aspects. During the past two decades, thanks to conceptual and methodological progress, a cognitive neuroscience of consciousness has emerged and gained full respectability. However, this science remains challenged regarding whether the subjective dimension of experience can be fully accounted for by the neuronal and cognitive mechanisms underlying conscious access. In this chapter, we first review the progress and challenges of the cognitive neuroscience of consciousness. We then discuss recent proposals that vindicate specific approaches to the subjective, phenomenal dimension of consciousness while denying the importance of access mechanisms. In contrast to these proposals, we argue for a unified approach to consciousness, whereby experiential and cognitive dimensions of consciousness rely on the same set of core neural mechanisms.

Despite all the progress made recently in the scientific study of consciousness, there are still intense controversies regarding what a theory of consciousness should be. In particular, the lack of consensus concerning the psychological definition of consciousness has rendered the study of its neural basis somewhat inconclusive. In this chapter, we review the progress made so far in uncovering the neurocognitive mechanisms of conscious access, and we emphasize the dependence of such progress on precise, operational definitions of consciousness. We outline some of the main issues that research on this topic faces today, in particular the issue of whether consciousness can be envisioned independently of its access mechanisms.

Moving on without definition

Nowadays, the vast majority of scientists reject dualist interpretations of consciousness that imply a separation between mind (consciousness, thoughts) and matter (the brain, neurons). Consciousness is amenable to a materialistic approach, with a biological perspective: we will understand how and why we are conscious by studying the cerebral and neuronal features of the brain. Yet the lack of a consensus definition of consciousness and the reduction of mental states to neuronal structures are daunting challenges that consciousness researchers face no less than in other fields of cognitive neurosciences. How then, could any progress be achieved in the field? Two strategies have eased these issues and led to considerable progress over the last two decades, and both critically depend on a psychological operationalization of "consciousness." The *contrastive approach* put forward by Bernard Baars (1989) allows moving on without formal definition, while the search for a *neural correlate of consciousness* (hereafter NCC) put forward by Francis Crick and Christof Koch (1995) allows moving on without focusing too much, at least for now, on the necessity of a reduction to elementary brain structures and processes. The combination of these two approaches has constituted the core of most recent successes in the scientific study of consciousness.

The contrastive approach

The contrastive approach is based on the idea that even if we don't know *what* consciousness is, not to mention *why* we are conscious in the first place, we at least know *when* it happens. Consciousness is thus considered as an outcome variable (absent/present), allowing us to compare situations where it occurs to close situations where, all other things being equal, it doesn't. This approach enables researchers not only to delineate the conditions for a stimulus to access consciousness, but also to specify the extents of unconscious processes.

This strategy has been most successfully applied to perceptual consciousness, that is, consciousness about an external event. Many experiments use very brief visual stimuli that are sometimes visible and sometimes invisible. Subjects have to report whether they saw a stimulus, which is taken as an index of whether they were conscious of it or not. By comparing the two situations, one can tell apart which cognitive mechanisms are shared, and which are specific to conscious processing. Using this methodology, it was shown that some high-level processes are triggered in the absence of perceptual consciousness (for instance, extracting the semantic information of a word or digit; Marcel, 1983a, 1 1983b; Dehaene et al., 1998), while some others seem to require that participants be conscious of the stimulus (e.g., applying a rule; Sackur & Dehaene, 2009; but see Sklar et al., 2012). Notice that, critically, the use of this methodology implies that one can trust participants in their reports of whether they are conscious or not.

The neural correlates of consciousness

According to Crick and Koch (1995), the best starting strategy for a neurobiological science of consciousness is to search for the NCC. These are defined as "the minimal set of neuronal mechanisms or events jointly sufficient for a specific conscious percept or experience" (Koch, 2004, p. 16). A candidate for the NCC would therefore be a structure involved only during conscious experience and would never be active outside conscious experience. According to this approach, neuroscientists should actually leave aside, at least for the moment, the problem of reducing conscious mental events to their associated physiological structure and processes. Rather, they should focus first on "correlating" them and finding out about their relations, which will ultimately lead to a better understanding of the whole issue.

In experimental practice, this strategy implies a contrastive approach, aimed at characterizing the neural, rather than cognitive, features that are specifically involved during conscious as opposed to unconscious processing. Here also, the search for NCCs depends on the admission of subjective reports as valid experimental data: in order to test whether any brain structure is an NCC, one has to trust subjects regarding the classification of their own mental states as "conscious" or "not conscious."

The prefrontal cortex

Early uses of the contrastive method in the search for NCCs relied heavily on the progress made in neuroimaging methods in the 1990s. Earlier studies used binocular rivalry and pointed to the ventral stream of the brain as critical for visual awareness. Binocular rivalry consists of presenting a stimulus (e.g., a face) to one eye and another stimulus (e.g., a house) to the other eye. Perceptually, the two objects do not merge, but give rise to alternating percepts: we see the house for a few seconds, then the face for a few seconds, then the house returns, etc. Thus, while the input stimulation is constant, the content of consciousness varies, and one can directly estimate which regions are associated with conscious percepts, everything else being equal. This technique revealed that the primary visual cortex is activated by objects regardless of whether they are perceived consciously or not (Leopold & Logothetis, 1996). These posterior regions thus cannot be considered as NCCs. Instead, regions located more anteriorly and more ventrally in the inferotemporal cortex were involved specifically during conscious perception of a face as opposed to an alternative percept (Leopold & Logothetis, 1996; Tong, Nakayama, Vaughan, & Kanwisher, 1998). The visual ventral stream could thus be considered a potential NCC.

But in the early 2000s, Stanislas Dehaene and his colleagues showed that this was not always the case (Dehaene et al., 2001). They used the method of visual masking: a word was presented very briefly (about 30 msec) and temporally surrounded by abstract and meaningless shapes (the masks) that render the word invisible (subjects see a flicker of shapes, but report seeing no word). By removing the temporally surrounding masks, one can render the word visible—thus creating a contrastive situation (see figure 73.1). Dehaene and colleagues showed that the inferotemporal cortex, which is part of the ventral visual stream, is activated by unconscious masked words. Although the strength of this activation was much lower than for conscious perception, these findings ruled out the ventral stream as an NCC. By contrast, in this study, the parietal and prefrontal cortices were activated exclusively in the conscious situation. Since then, numerous studies have shown the particular importance of the prefrontal cortex for consciousness (see Dehaene & Changeux, 2011, for an extensive review), making this region a candidate NCC.

The use by the same group of alternative imaging methods with better temporal resolutions, such as magnetoencephalography and electroencephalography, has more recently led to a better understanding of the temporal dynamics giving rise to conscious experience. They reveal that perceptual consciousness is a relatively late phenomenon that is preceded by a cascade of neural events operating in an unconscious manner. Indeed, they found evidence for a two-stage mechanism for visual awareness (Del Cul, Baillet, & Dehaene, 2007; Sergent, Baillet, & Dehaene, 2005): in a first stage, lasting for about 200–300 msec, visual stimulations induce activations in the visual areas of the brain, more specifically in the occipitotemporal cortex. Activity in these sensory areas tends to increase with the strength of the visual stimulus (duration, contrast, energy, etc.), irrespective of whether it is consciously perceived.

Conscious representations arise only afterward, when neuronal activity exceeds a certain threshold. Activity induced by the perceived object suddenly spreads to the prefrontal cortex and is dispatched to other cortices. In

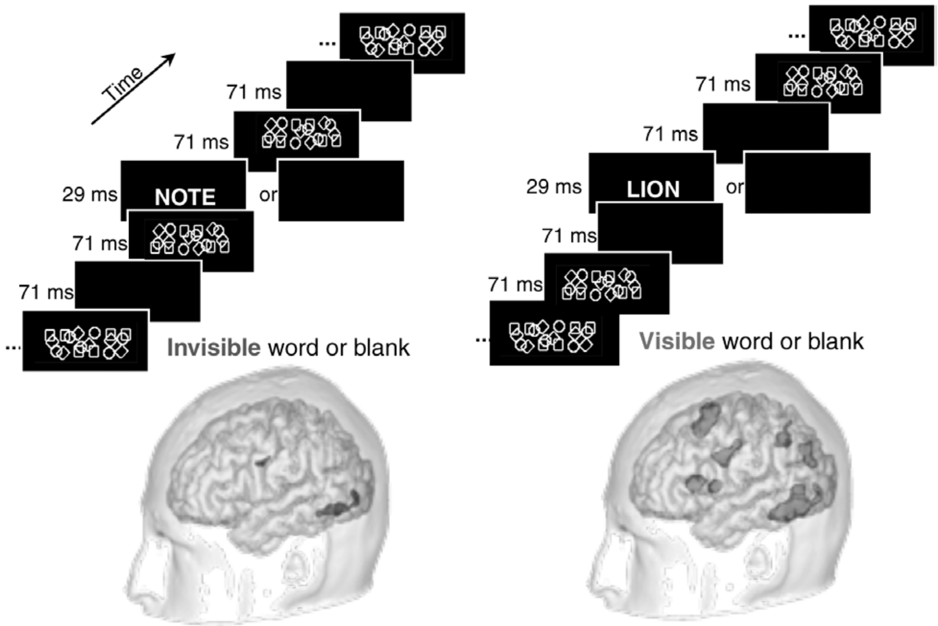

FIGURE 73.1 Contrast of unconscious and conscious processing in functional MRI (Dehaene et al, 2001). While the neural activation induced by invisible words is primarily restricted to occipitotemporal regions (left panel), conscious perception is associated with the involvement of a parietofrontal network (right panel). (See color plate 64.)

other words, the neural mechanisms that are specifically implicated in consciousness are only involved at the final stage of a long chain of unconscious events. Further, these studies pointed to the prefrontal cortex as an area where neural information converges, creating global brain activity and allowing sensory areas to interact with other, task-relevant regions.

The global neuronal workspace

Such findings have been integrated in a theoretical framework by Dehaene and his colleagues, Jean-Pierre Changeux and Lionel Naccache (Dehaene & Changeux, 2011; Dehaene et al., 2006; Dehaene & Naccache, 2001). Called the global neuronal workspace, it is a neurobiological extension of the cognitive global workspace theory originally proposed by the psychologist Bernard Baars (1989).

According to this theory, the cerebral architecture is composed of two qualitatively distinct types of elements. The first type is represented by a large network of domain-specific processors, in both cortical and subcortical regions, that are each attuned to the processing of a particular type of information. For instance, the occipitotemporal cortex is constituted of many such domain-specific processors, or "cerebral modules" (movement processing in MT/V5, face processing in the fusiform face area, etc.). Although these neural processors can differ widely in complexity and domain specificity, they share several common properties: they are triggered automatically, they are encapsulated (their internal computations are not available to other processors) and, importantly, they operate unconsciously.

Consciousness involves a second type of element, namely the cortical "workspace" neurons that are particularly dense in prefrontal, cingulate, and parietal regions. These neurons send and receive projections to many distant areas through long-range excitatory axons, breaking the modularity of the nervous system and allowing the domain-specific processors to exchange information. The global workspace provides a common communication protocol by allowing the broadcasting of information to multiple neural targets. A mental state is conscious if two conditions are met. First, the content of the mental state must be represented as an explicit neuronal firing pattern that can reach workspace neurons. Second, top-down amplification mechanisms mobilizing the long-distance workspace connections must render the representation accessed, sharpened, and maintained. A mental state, even if it respects the first condition (explicit firing pattern available to workspace neurons), will remain unconscious until its neural signal is amplified. This amplification is the neural counterpart of top-down attention, which, in this framework, is a necessary condition for consciousness. Whether consciousness requires top-down attention is a highly debated issue (Cohen, Cavanagh, Chun, & Nakayama, 2012; Dehaene et al., 2006; Koch

& Tsuchiya, 2007; Lamme, 2006). This framework enriches the traditional search for the NCC: according to the global neuronal workspace theory of consciousness, no single area is viewed as necessary and sufficient for consciousness. Rather, it stresses a particular type of neural interaction between a set of interconnected areas. The necessary and sufficient condition for consciousness of a mental representation is that the information that implements this representation should be distributed and shared among a global network of densely connected areas.

The hard problem of consciousness

The strategy of looking for neural correlates of consciousness has, up to now, been fruitful. We now have a better view of which neural mechanisms are important for consciousness, and scientific theories provide functional descriptions and testable predictions regarding conscious processing. Yet many have criticized the very foundations of this approach, arguing that functional explanations come at the price of sacrificing the "phenomenal" aspects of consciousness: functional explanations are restricted to the cognitive mechanisms (i.e., attention, working memory, etc.) underlying access to conscious contents, ignoring the problem of how these contents arise in the first place. Indeed, some philosophers (Chalmers, 1996) have concluded that there is not one single problem, but actually two problems of consciousness: they distinguish between the "easy problem" and "hard problem." In a nutshell, the easy problem consists in explaining the functional properties of conscious representations. They are intrinsically accessible: one can verbalize to some extent any conscious content, reencode its information in any format available, store it in memory, integrate it in reasoning, focus attention on it, and so on. These properties can be studied by means of the usual objective methods of experimental cognitive neuroscience.

By contrast, the hard problem consists in explaining the subjective, qualitative side of conscious representation—using the phrase of Thomas Nagel (1974), the sense of "what it is like" to be conscious. It is argued that even if all the functional cognitive properties of conscious representations were unfolded, there would still be a subjective remainder. With the help of cognitive neuroscience, we can hope to understand how we put to work the representation of a red signpost on the side of the road: why we notice it, how we associate it with specific behaviors, and so on; still, the specific subjective feeling that *this red* elicits in the observer would, according to this perspective, stand as something of a mystery. The functional aspects of consciousness are considered "easy" from an epistemological standpoint (although they may be immensely intricate and complex empirically) because they constitute information-processing challenges; the problem of qualia is "hard" because it involves crossing the objective/subjective, public/private divides.

Dissociative approaches to consciousness

With respect to the epistemic distinction between an easy and a hard problem, Ned Block has proposed that consciousness should be dissociated into two components, namely access and phenomenal consciousness (Block, 1995, 2007). Phenomenal consciousness is related to the private, first-person experience. Access consciousness corresponds to the fact that some representations are "poised for direct control of thought and action" (Block, 1995); it designates the functional cognitive properties of conscious contents, which can be explained in terms of computational mechanisms and are linked to global broadcasting (Block, 2005) in agreement with workspace theories of consciousness.

Several neuroscientists have adopted Block's dissociation and explicitly distinguish between two neural correlates of consciousness. For instance, the duplex vision theory of Milner and Goodale (1995) has recently been updated to associate sustained ventral stream activity with phenomenal consciousness, while only the involvement of more anterior (e.g., prefrontal) regions supports conscious access (Goodale, 2007). Similarly, Semir Zeki (2007) has recently linked micro- and macro-consciousness in his original theory (Zeki & Bartels, 1999) with phenomenal consciousness of specific attributes (colors, contrasts, etc.) and bound objects, respectively, while unified consciousness is somewhat analogous to access consciousness. In the local recurrence theory of Victor Lamme (2006), phenomenal experience is explicitly associated with any recurrent neuronal activity (i.e., local or global loops), while conscious access occurs only with global recurrence. Although all these theories diverge in many respects, they all link phenomenal consciousness with posterior (i.e., occipitotemporal) regions, while anterior (i.e., prefrontal, workspace) areas are linked to conscious access (see Kouider, 2009, for a review). They are also motivated by the possibility of probing consciousness in the absence of subjective reports (Lamme, 2006) and are thus committed to the hypothesis that there exists a form of phenomenal consciousness that might be irreductible to access mechanisms. We now turn to the empirical and epistemological consequences of this commitment.

Neural purity and the overflow argument

Two main empirical arguments, which we termed the *overflow argument* and the *neural purity argument* (see Kouider, de Gardelle, Sackur, & Dupoux, 2010), have been offered by proponents of the access/phenomenal consciousness dissociation. The overflow argument is rooted in the intuition that we are conscious of much more than we can describe and manipulate. This intuition was operationalized by Sperling over half a century ago (Sperling, 1960), who used letter arrays to quantify the amount of information available at a given time after presentation of a complex visual scene (see figure 73.2). Using short presentation times and a pioneering cued report method, Sperling showed that the information available for a short period of time after stimulus presentation vastly exceeded the information subjects could spontaneously report. This has been taken as an indication that phenomenal consciousness does indeed overflow access (Block, 2007). Yet, as we discuss below, it remains controversial whether the large amount of available information in cued reports reflects phenomenally conscious representations or unconscious processing that becomes reportable by virtue of the cues (Block, 2007; de Gardelle, Sackur, & Kouider, 2009; Dehaene et al., 2006; Sergent et al., 2012).

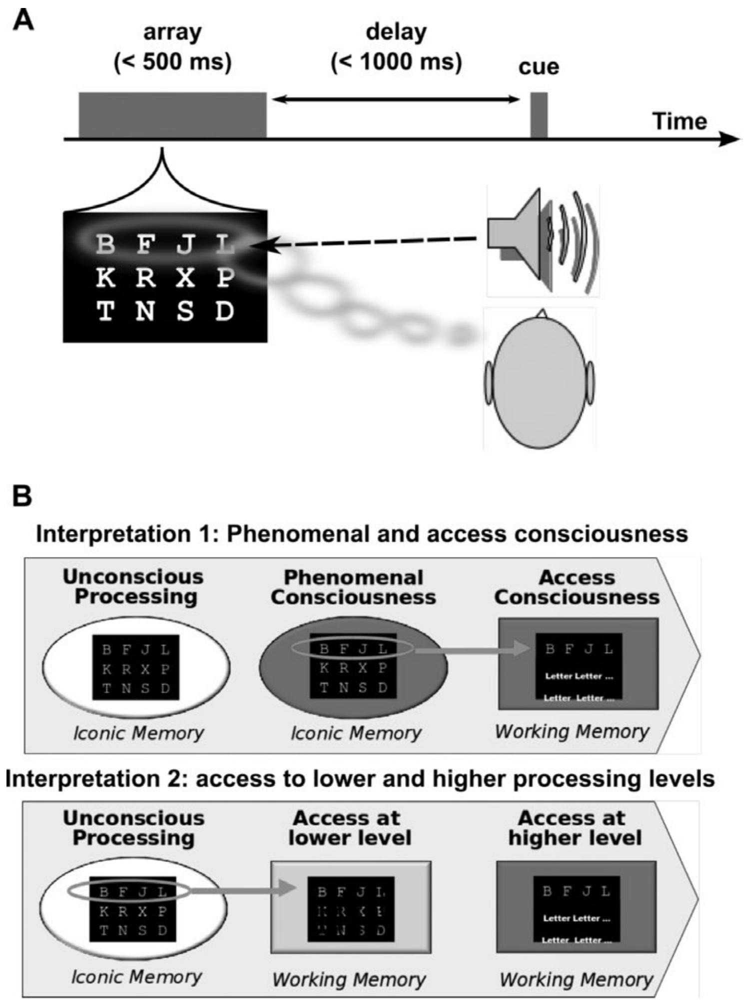

FIGURE 73.2 The Sperling paradigm (Sperling, 1960) and its interpretations. (A) Experimental procedure for the cued report. A brief array of letter is shown, followed by a random tone cue (high tone in this example). The pitch of the cue (low, medium, high) instructs subjects to report one of the three rows (lower, middle, or higher row, respectively). When participants are not cued and have to report all letters in the array, performance is restricted to about 4 out of 12 items. However, when using the post-stimulus cue to report a specific row, performance increased to 3 out of 4 items. This suggests that a large amount of information is available but decays by the time of reporting. (B) Two interpretations of the results. Interpretation 1 assumes that subjects are phenomenally conscious of the whole content in iconic memory demonstrated by the high-level performances at short delays. Interpretation 2 hypothesizes that subjects access both high- and low-level information from iconic memory. Low-level information is reconstructed at higher levels. (See color plate 65.)

The neural purity argument follows from the assumption that there exist specific neural mechanisms for phenomenal experience (e.g., local neural recurrence). Such mechanisms allegedly constitute pure indices of consciousness, more reliable than subjective reports, which are limited by verbal, memory, and attentional abilities. For instance, Block and Lamme argue that in paradigms where subjects cannot report the presence of a stimulus due to inattention (e.g., change blindness, inattentional blindness, attentional blink), they might still be phenomenally conscious of the stimulus as long as it induces local recurrence in perceptual brain regions (Block, 2007; Lamme, 2006).

The interplay between the neural purity and overflow arguments is complex with respect to whether one should trust subjective reports. On the one hand, the overflow argument depends on the intuition that there is more to a given conscious experience than we can report. It thus depends on a negative statement: "there is something in my conscious experience that I cannot report." If this statement is to be meaningful, it is a second-order report (a meta-report) of consciousness, because it states the incompleteness of some access-consciousness report. Subjects should be trusted regarding this intuition. On the other hand, the neural purity argument implies that by studying brain activations, we know more precisely than subjects themselves whether they are conscious or not. In other words, their reports should not be trusted.

The limits of dissociative approaches

Arguments for a dissociative approach to consciousness suffer from serious flaws. We have put forward the fact that the phenomenal overflow argument is confounded with situations of partial awareness, while the neural purity argument reflects the confusion between phenomenal consciousness and unconscious perceptual processes (Kouider et al., 2010, 2012).

We start with the overflow argument. First, it is important to stress that limits on (verbal) reportability should not be equated with limits on access. Perception involves nonconceptual contents that are difficult to verbalize, such as shades of colors, smells, and so on. However, the relative poverty of verbal reports in these domains should not be equated with poverty in access. Indeed, the hallmark of psychophysics is precisely to uncover the rich, graded, and multidimensional aspects of domains such as color or smell perception using indirect measures like similarity judgments (Gescheider, 1997; Sackur, 2013). Furthermore, as verbal reports take time and are performed in a sequential manner, accessible information may have disappeared prior to verbalization. Nonetheless, subjects' performance on nonverbal tasks such as detection or discrimination shows that information can be accessed before it fades away. In other words, the overflow argument might only show that access overflows verbal report. Further, the demarcation between expressible and ineffable contents may not be clear-cut: it is well known, for instance, that experienced wine tasters acquire a vocabulary and develop descriptive skills to finely capture nuances of sensory experiences that seem elusive at first. Similarly, early introspective psychologists of the Külpe and Titchener schools developed impressive fine-grained skills in order to describe visual impressions created by stimuli very similar to those later used by Sperling (see, for instance, Dallenbach, 1920). These examples indicate that descriptive powers can be improved, to the point that there may not be any fixed limit to what aspects of conscious experience are reportable versus those that are not. This does not logically rebut the overflow argument, but suggests that whether subjects are to be trusted on their intuition about overflow is itself something that should be put under experimental scrutiny. This leads to the second line of argument against the overflow argument, namely that its apparent compelling force might be illusory.

Indeed, the intuition of a rich phenomenal experience on which the overflow argument is built might be overstated. Observers might overestimate both the quantity and accuracy of the information they experience at one given moment, lured either by a nonspecific "cognitive illusion of seeing" (O'Regan & Noe, 2001), or by perceptual illusions (de Gardelle et al., 2009; Kouider et al., 2010). In addition, if we admit that the intuition of overflow is a meta-report of consciousness, the possibility of consciousness without the involvement of access mechanisms is methodologically dubious: if subjects do not have access to their experience, how could one determine that they are conscious of it? Actually, someone experiencing phenomenology without access should not only be unable to talk about it, she should not even *know* anything about it! In other words, reporting a "rich but unaccessed visual experience" demonstrates that we have access to *some* kind of information.

Finally, the assertion that phenomenal experiences can arise in the absence of access leads to an epistemological impasse: in order to prove that a particular content is phenomenal, one has to ask the subject about it. But if the subject is attempting to report about her experience, it also means that she is attempting to access it. Hence, one faces an *observer effect*: any observation of the internal states of a system changes the state of the system (Kouider, 2009). As such, any attempts to observe internal states prior to access will necessarily be contaminated by access mechanisms themselves.

A potential escape from the problems outlined above might be to accept the neural purity argument, according to which phenomenological consciousness can be probed regardless of reportability, through neural indices. However, this strategy is circular, since validating the neural index in the first place necessarily requires reliance on access mechanisms. Indeed, demonstrating that a specific neural mechanism (e.g., local recurrence) is sufficient for consciousness initially requires the assessment of neural events while probing whether the subject is conscious. As the sole uncontroversial way to prove consciousness relies on access mechanisms, it appears impossible to map neural and phenomenal states without depending on access. This is not to say that we cannot, in some situation, infer conscious contents from brain states. As we gain more insights into the nature of the brain mechanisms associated with conscious experience, we can reapply this knowledge in cases where reports are impossible, for instance in cases of patients with locked-in syndrome and in vegetative states (Laureys et al., 2005; Owen et al., 2006), as well as in the case of preverbal infants (Kouider et al., 2013). But clearly, this extrapolation beyond the domain of reportability is justified, because we had first relied on conscious reports, and thus on access mechanisms.

Finally, the neural purity argument largely reflects a theoretical confusion: it merely shows that the brain processes information without consciousness, but not that there is phenomenal experience associated with these processes. A supposed neural index of phenomenal consciousness in the absence of access may thus simply reflect unconscious processes (Dehaene et al., 2006; Kouider, Dehaene, Jobert, & Le Bihan, 2007). Yet, because one cannot demonstrate whether phenomenal experience is involved or not, the neural purity argument becomes unfalsifiable: if, say, local recurrence is observed in the absence of conscious access, stipulating alternative forms of consciousness, instead of unconscious processing, cannot be verified and simply becomes a matter of faith.

Partial awareness and the illusion of phenomenal richness

Nevertheless, while phenomenal consciousness seems dubious both from methodological and epistemological standpoints, phenomenality in itself is a reality. Our conscious mental content does seem to exceed all possible reports, and it has a qualitative and subjective "feel" that is private. Here, we explain how, by means of the notions of partial awareness, confidence evaluation, and expectations, access mechanisms can mechanistically account for *phenomenality* without reliance on specific and dedicated mechanisms for *phenomenal consciousness*.

The notion of "levels of representation" is one of the most venerable notions in cognitive psychology: for instance, a written word might be encoded at the level of nonspecific geometrical features, letter fragments, specific letter shapes, or abstract letters, and then at lexical, phonological, and semantic levels (Vinckier et al., 2007). We know from numerous psycholinguistic tasks that these levels of representation are somewhat independent, in the sense that some tasks can require access to one specific level. This kind of representational hierarchy is implicit and basic in most areas of cognitive psychology, but has been largely ignored for consciousness. Recently, we proposed that different levels of representation of one and the same stimulus might be separately consciously accessed and lead to global broadcasting independently from one another (Kouider et al., 2010). For instance, because of some degradation, a visual stimulus may only be accessed at some lower levels, making it only partially conscious. Thus a word might be accessed at the level of letter features, while remaining unaccessed at higher levels having to do with the whole word form (which does not preclude unconscious processing at these higher levels). But conscious contents are not simply stimulus driven: the cognitive system has some a priori knowledge about the world, with some confidence level about the likelihood of sensory signals. Hence, access to partial information is combined with prior knowledge of what should be perceived: if participants expect to be shown letters and are partially conscious of letter fragments, they illusorily *see* letters (de Gardelle et al., 2009). The intuition of a rich, elusive phenomenality comes from real-life situations, where stimuli are complex and span a large portion of the visual field. Thus, at each moment, various parts of the scene are accessed at different levels, with restricted levels for eccentric and crowded stimuli. Since the pioneering work of McConkie and Rayner (1975), who used eye-tracking methodology to blur a text beyond a window centered at fixation, it has been known that we do not need rich and detailed information over the entire visual field to produce a visual consciousness with the impression of richness. More recently, Freeman and Simoncelli (2011), using more controlled methods, constructed stimuli that looked exactly alike in spite of systematic distortions at the periphery. Again, this suggests that our visual system accesses only low-level geometrical information in the periphery of the visual field, and creates on this basis a conscious representation that is illusorily detailed. Our visual experience is always a mixture of detailed and coarse information: information at fixation is accessed at the highest possible level, while information in the periphery is only accessed at the level of coarse features. However, the visual system does not assume that the world in the periphery is blurred. Rather, our confidence that there is potentially detailed information in the periphery is high. The integration of low-level conscious access and of high confidence about what is potentially discriminable mechanistically yields an impression of ineffable richness, which is precisely the characteristic of phenomenality. The interaction between neuronal processes dealing with sensory signals, prior expectations, and confidence evaluation may thus constitute core mechanisms of conscious phenomenality.

Conclusion

As we have seen in the previous sections, a core issue in cognitive neuroscience is whether consciousness should be extended beyond its access mechanisms. We explained how the idea that one should dissociate access and phenomenal consciousness on the basis of separated neuronal and functional properties was both epistemologically and empirically dubious. With a few simple assumptions involving hierarchized representational levels, prior expectations, and confidence evaluation, one can reframe the issue of dissociable forms of consciousness into dissociable levels of conscious access.

Yet it would be presumptuous to assume that we now fully understand how conscious contents arise from this kind of neurocognitive architecture. Even if a neurocognitive description could account for and predict the occurrence and content of a specific conscious experience, some would certainly still not be convinced that this explains how one goes from the neural level to the experiential one. This has recently led some of the most recognized scientists in the field, such as Christof Koch, who originally proposed the NCC approach, and Giulio Tononi, to abandon this perspective, considering the whole reductionist approach as being intrinsically limited in addressing this issue of how consciousness arises in the first place (Koch, 2012; Tononi & Koch, 2008). Instead, consciousness should be envisioned in terms of complex systems having more to do with information theory than specific properties of the brain. In contrast to this radical shift from the neurobiological approach, we advocate an empirical stance toward the hard problem of consciousness and phenomenality: we believe that within the traditional perspective of cognitive neuroscience, finer-grained distinctions of levels of access and more complex (e.g., Bayesian) mechanisms of integration with priors and expectations may provide a progressive bridging of the gap between functional mechanisms and subjective experience.

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