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From visual awareness to consciousness without sensory input: The role of spontaneous brain activity

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Abstract

This manuscript is an invited commentary on the article "Toward a standard model of consciousness: Reconciling the attention schema, global workspace, higher-order thought, and illusionist theories", by Drs. Graziano, Guterstam, Bio, and Wilterson, published in Cognitive Neuropsychology (2020). We believe this article is a timely attempt to find commonalities among a growing number of theories on consciousness. In our commentary, we highlight the advantages of the Attention Schema Theory (AST) and we illustrate how recent findings are compatible with the proposed link between the AST, a theory based on social cognition, and theories originating from the field of neuroscience. Finally, we describe elements that could be included in future versions of the models of consciousness. In particular, we emphasize that the field of consciousness will greatly benefit from moving beyond how we become aware of external information to consider internally generated conscious experiences.

Keywords

Consciousness; Theories; Visual Awareness; Motor system; Spontaneous thoughts; Ongoing brain activity

Commentary

Definitions of consciousness abound and are rivaled only by the number of theories on consciousness. The article of Graziano and colleagues (2020) is a welcomed attempt to find commonalities among a few of these theories and the Attention Schema Theory of consciousness (AST).

In the last few decades, with the growth of the field of cognitive neuroscience, the neural correlates of consciousness have become a serious topic of research. As the visual and motor systems are the best understood systems in the human brain, they have logically inspired novel theories on consciousness. For many researchers, studying consciousness has become

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equivalent to studying sensory, and in particular visual, awareness, i.e., what happens in the brain when visual information becomes conscious?

In one influential theory, attention, a well-explored cognitive function known to enhance visual processing, was proposed to be the "spotlight" that illuminates a stage (the "Global Workspace" or GW) where actors (conscious information) follow the direction of a director (executive processes) and perform for an audience (the rest of other, unconscious, processes that benefit from the information) (Baars, 1989). The neural implementation of this metaphor proposed that when sensory information reaches the attentional fronto-parietal network, there is a reverberation between sensory and attentional areas and maintenance of the information long enough so that it can become conscious and broadcast to the rest of the brain (Dehaene & Changeux, 2011). This model received support from experiments where masked visual information (not consciously perceived by participants) evoked low activation in areas along the ventral stream, and low or even undetectable activation in the fronto-parietal network, unlike unmasked stimuli (consciously perceived by participants) which evoked high activation in both the ventral stream and fronto-parietal areas (Dehaene et al., 2001).

Such fronto-parietal neural ignition could mainly reflect *access consciousness* as defined by Block (1995), i.e., information is accessed by the executive system so one can report or act on it. *Access consciousness* is similar to the concept of *i-consciousness* described by Graziano and colleagues (2020). However, Block also introduced another form of consciousness, called *phenomenal consciousness*, which would be at the basis of the "what it is like to" feeling originally described by Nagel (1974), similar to what Graziano and colleagues label *m-consciousness*. According to Chalmers (1995), this second type of consciousness is the real "hard problem" of consciousness and it divides philosophers and scientists. On one side are those who attempt to explain such non-reportable (because not accessed by the executive system), yet conscious experience, which has been proposed to be mediated by recurrent activity between different hierarchical levels within sensory areas, e.g., within the ventral stream for vision (Lamme, 2006). The idea of recurrent processing is supported by experiments showing that feedback projections to early visual cortex seem to be essential for perceptual awareness (Pascual-Leone & Walsh, 2001). The other side rejects the idea of a dissociation between *access* and *phenomenal consciousness* (Dennett, 1991), because our intuitive idea of *phenomenal consciousness* is inaccurate. For instance, visual awareness is not a faithful reconstruction of reality in our mind as we might believe, but is rather the way we gather information from the world, e.g., with exploratory eye movements, as detailed in the sensorimotor theory of consciousness (O'Regan & Noe, 2001). Likewise, we have previously advocated for a tight link between eye movement control, attentional resources and awareness based on common networks for these three components (Vernet et al., 2014). In the AST, Graziano and colleagues (2020) take a slightly different stance: *m-consciousness* does not exist as such, yet we can't help to feel that consciousness is more than "just" *i-consciousness*. It is the origin of this overwhelming feeling that needs to be explained and that is originally addressed by the AST.

The AST introduces the idea that we constantly track what and where we and other people pay attention to and that this "model" of attention is the consciousness we attribute to

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ourselves or to others. This model would be implemented in brain areas important for both high-level attentional control and social cognition such as the superior temporal sulcus or temporo-parietal junction. This is the second appealing aspect of the AST: it bridges theories of social cognition and visual awareness. Although there is currently no way to directly test this proposed link, the vast literature on the relationship and dissociation between attention and awareness can be reinterpreted following this social cognition approach. For example, we recently demonstrated that endogenous visuospatial attention can increase visual awareness, i.e., the belief of perceiving, independent of objective visual performance (Vernet, Japee, et al., 2019). Specifically, our participants believed that they saw visual stimuli embedded in noise better when they paid attention to it (i.e., they were more eager to report their presence; note that confidence could involve other meta-cognitive evaluations and was not measured), although they did not objectively see it better. This result is consistent with another study showing that low alpha oscillations – typically associated with increased attentional state – predict visual awareness but not objective performance (Benwell et al., 2017). One interpretation of these findings is that when attention fails to enhance relevant visual signals in the brain, the knowledge of where the attention is allocated is still used to build awareness. In other words, visual awareness could be, indeed, based on a model of one's attentional state.

The third advantage of the AST is that it gives a purpose to consciousness. The danger, for neuroscientists studying consciousness, is to fall into the fallacy of dualism: picturing consciousness as a homunculus in the brain, observing what we are conscious of as if it was projected on a screen (Dennett, 1991). Great care must be taken to avoid this pitfall. For example, in the GW theory, the audience of conscious information is not a homunculus, but rather unconscious processes that benefit from having access to conscious information (Baars, 1989). But why then should such broadcasting of information give rise to a subjective feeling? In the AST, the subjective feeling is the useful information itself. It might not be accurate, but this "model of attention" is useful to quickly predict the behavior of others as well as our own behavior.

Despite its advantages, the current description of the AST does not yet take into account all conscious phenomena. The most common description of *m-consciousness* is not necessarily that it is made of "beams of mental energy that stream out of the eyes and affect other people" (Graziano et al., 2020). When awake, most of us believe that we are experiencing a stream of consciousness (James, 1892/2001), which would be made of external or internal images, sounds and other sensations, or words (e.g., when talking to ourselves). However, such a stream is not necessarily as continuous and rich as it appears at first sight. Famous experiments where participants failed to notice massive changes in the visual world are interesting because participants would not have predicted their own lack of awareness (Beck et al., 2007). To explain such surprising findings, it has been proposed that multiple sensations are simultaneously processed in the brain, being neither conscious nor unconscious, and only when probed, would a final narrative be elaborated (Blackmore, 2002; Dennett, 1991). Thus, at random times either internally or externally chosen, the content and level of consciousness can be probed by allocating attention to them: the main ongoing process is thus "precipitated" to become the acknowledged conscious process.

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Such a conceptualization of consciousness attempts to explain a wider aspect of consciousness, not restricted to its visual or social components. It also bridges the gap between studies of the content of consciousness which explore what people are conscious of, for example, during visual perception (Kay et al., 2008) or dreams (Horikawa et al., 2013), and studies of the states of consciousness which, for instance, contrast dreaming versus non-dreaming sleep states (Siclari et al., 2017) or distinguish different conscious states, such as quietly resting, remembering events, doing calculations or silently singing (Shirer et al., 2012). Indeed, an important question for studying consciousness (and a recurring question concerning any resting-state study) is what happens precisely during the state of quiet resting? We believe that to make further progress on a scientific understanding of consciousness, we must unpack the conscious experience associated with spontaneous brain activity.

It is well known that spontaneous ongoing activity in the brain can predict whether or not an upcoming visual stimulus will reach awareness. For instance, the conscious perception of an external visual stimulus or of a phosphene (sensation of light triggered by the stimulation of the visual cortex) depends on the power and phase of alpha and theta oscillations in occipito-parietal areas (Busch et al., 2009; Romei et al., 2008) and entraining alpha oscillations in occipital areas, or high-beta oscillations in prefrontal areas can modulate conscious perception (Chanes et al., 2013; Romei et al., 2010; Vernet, Stengel, et al., 2019). Manipulating activity of fronto-parietal areas can also impact the stability or volatility of conscious percepts when observing ambiguous visual stimuli (Vernet et al., 2015). But ongoing brain activity is more than just gating, or interpreting, upcoming external information. It can also generate information that can be conscious or unconscious, depending on whether it is probed or not, e.g., by allocating attention to it. Such information, if probed, could be, for instance, the spontaneous thoughts that a person might report as being experienced. Spontaneous ongoing brain activity can thus determine both the content (information) and state (quality) of consciousness. As neuroscience goes back and forth between collecting data and elaborating theories, we believe that the field of consciousness will greatly benefit from moving beyond how we become aware of external information to consider such internally generated conscious experiences, which could be integrated with future descriptions of the AST.

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References

Baars BJ (1989). In the Theater of Consciousness: The Workspace of the Mind. Cambridge: Cambridge University Press.

Beck MR, Levin DT, & Angelone B (2007). Change blindness blindness: beliefs about the roles of intention and scene complexity in change detection. Conscious Cogn, 16(1), 31–51. [PubMed: 16531072]

Benwell CSY, Tagliabue CF, Veniero D, Cecere R, Savazzi S, & Thut G (2017). Prestimulus EEG Power Predicts Conscious Awareness But Not Objective Visual Performance. eNeuro, 4(6).

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Blackmore S (2002). There Is No Stream of Consciousness. What is all this? What is all this stuff around me; this stream of experiences that I seem to be having all the time? Journal of Consciousness Studies, 9(5-6), 17–28.

Block N (1995). On a confusion about a function of consciousness. Behav Brain Sci, 18 227–287.

Busch NA, Dubois J, & VanRullen R (2009). The phase of ongoing EEG oscillations predicts visual perception. J Neurosci, 29(24), 7869–7876. [PubMed: 19535598]

Chalmers D (1995). Facing up the problem of consciousness. Journal of Consciousness Studies, 2(3), 200–219.

Chanes L, Quentin R, Tallon-Baudry C, & Valero-Cabre A (2013). Causal frequency-specific contributions of frontal spatiotemporal patterns induced by non-invasive neurostimulation to human visual performance. J Neurosci, 33(11), 5000–5005. [PubMed: 23486970]

Dehaene S, & Changeux JP (2011). Experimental and theoretical approaches to conscious processing. Neuron, 70(2), 200–227. [PubMed: 21521609]

Dehaene S, Naccache L, Cohen L, Bihan DL, Mangin JF, Poline JB, & Riviere D (2001). Cerebral mechanisms of word masking and unconscious repetition priming. Nat Neurosci, 4(7), 752–758. [PubMed: 11426233]

Dennett DC (1991). Consciousness explained: Little, Brown and Co.

Graziano MS, Guterstam A, Bio BJ, & Wilterson AI (2020). Toward a standard model of consciousness: Reconciling the attention schema, global workspace, higher-order thought, and illusionist theories. Cognitive Neuropsychology doi: 10.1080/02643294.2019.1670630.

Horikawa T, Tamaki M, Miyawaki Y, & Kamitani Y (2013). Neural decoding of visual imagery during sleep. Science, 340(6132), 639–642. [PubMed: 23558170]

James W (1892/2001). Psychology: the briefer course: Dover Publications.

Kay KN, Naselaris T, Prenger RJ, & Gallant JL (2008). Identifying natural images from human brain activity. Nature, 452(7185), 352–355. [PubMed: 18322462]

Lamme VA (2006). Towards a true neural stance on consciousness. Trends Cogn Sci, 10(11), 494–501. [PubMed: 16997611]

Nagel T (1974). What is it like to be bat? THe Philosophical Review, 83(4), 435–450.

O'Regan JK, & Noe A (2001). A sensorimotor account of vision and visual consciousness. Behav Brain Sci, 24(5), 939–973; discussion 973-1031. [PubMed: 12239892]

Pascual-Leone A, & Walsh V (2001). Fast backprojections from the motion to the primary visual area necessary for visual awareness. Science, 292(5516), 510–512. [PubMed: 11313497]

Romei V, Brodbeck V, Michel C, Amedi A, Pascual-Leone A, & Thut G (2008). Spontaneous fluctuations in posterior alpha-band EEG activity reflect variability in excitability of human visual areas. Cereb Cortex, 18(9), 2010–2018. [PubMed: 18093905]

Romei V, Gross J, & Thut G (2010). On the role of prestimulus alpha rhythms over occipito-parietal areas in visual input regulation: correlation or causation? J Neurosci, 30(25), 8692–8697. [PubMed: 20573914]

Shirer WR, Ryali S, Rykhlevskaia E, Menon V, & Greicius MD (2012). Decoding subject-driven cognitive states with whole-brain connectivity patterns. Cereb Cortex, 22(1), 158–165. [PubMed: 21616982]

Siclari F, Baird B, Perogamvros L, Bernardi G, LaRocque JJ, Riedner B, Moly M Postle BR, Tononi G (2017). The neural correlates of dreaming. Nat Neurosci, 20(6): 872–878 [PubMed: 28394322]

Vernet M, Brem AK, Farzan F, & Pascual-Leone A (2015). Synchronous and opposite roles of the parietal and prefrontal cortices in bistable perception: a double-coil TMS-EEG study. Cortex, 64, 78–88. [PubMed: 25461709]

Vernet M, Japee S, Lokey S, Ahmed S, Zachariou V, & Ungerleider LG (2019). Endogenous visuospatial attention increases visual awareness independent of visual discrimination sensitivity. Neuropsychologia, 128, 297–304. [PubMed: 28807647]

Vernet M, Quentin R, Chanes L, Mitsumasu A, & Valero-Cabre A (2014). Frontal eye field, where art thou? Anatomy, function, and non-invasive manipulation of frontal regions involved in eye movements and associated cognitive operations. Front Integr Neurosci, 8, 66. [PubMed: 25202241]

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Vernet M, Stengel C, Quentin R, Amengual JL, & Valero-Cabre A (2019). Entrainment of local synchrony reveals a causal role for high-beta right frontal oscillations in human visual consciousness. Sci Rep, 9(1), 14510. [PubMed: 31601822]