PHILOSOPHICAL TRANSACTIONS B

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Invited reply

Cite this article: Pitts MA, Lutsyshyna LA, Hillyard SA. 2019 Reply to Montemayor and Haladjian. *Phil. Trans. R. Soc. B* **374**: 20190003. http://dx.doi.org/10.1098/rstb.2019.0003

Accepted: 9 January 2019

Subject Areas:
neuroscience

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The accompanying comment can be viewed at http://dx.doi.org/10.1098/rstb.2018.0517.

THE ROYAL SOCIETY PUBLISHING

Reply to Montemayor and Haladjian

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1. Varieties of attention and their relationship to phenomenal consciousness and cognitive access

We appreciate the comments made by Montemayor and Haladjian (M&H) and take this opportunity to clarify several points that may not have been explicit in our original article [1]. First, M&H argue that recurrent processing theory (RPT) is committed to the double dissociation view which hypothesizes that conscious content can be experienced without any attentional selection. While it is certainly true that some of the main *advocates* of RPT are committed to the double dissociation view, RPT, at its core, requires no such commitment. In describing an early formulation of RPT, Lamme [2, p. 497] stated, 'What seems necessary for conscious experience is that neurons in visual areas engage in so-called recurrent (or re-entrant or resonant) processing where high- and low-level areas interact.' In a more recent, updated version of RPT, only certain types of recurrent processing are proposed to be linked with conscious experience, e.g. those that involve a spatio-temporal extension, create super-positioned representations and lead to synaptic plasticity and learning [3]. None of these definitions of RPT contain a fundamental requirement of a double dissociation between attention and consciousness. It was only in the refutation of evidence against RPT (e.g. neural correlates of recurrent processing were observed during inattentional blindness) that such a link was formed between the theory itself and the double dissociation view [2]. This apparent counterevidence, however, does not necessitate such a link, as it can be accommodated in the updated formulation of RPT [3]. For example, some types of recurrent processing may occur during inattention, while the key types that are necessary for conscious perception may not. Therefore, RPT does not in fact mandate a mutual independence of (all types of) attention and consciousness.

Second, attention does not necessarily lead to cognitive access. We outlined this point on page 3 of our original paper [1], and M&H have written extensively in agreement [4]. The currently accepted broad definition of attention is *a set of mechanisms that bias (select) a subset of information for further processing*. It should be emphasized that *further processing* is not synonymous with *cognitive access*. For example, attentional modulations have been repeatedly observed to occur at 70–100 ms after stimulus onset in early visual areas V4 and MT in both humans [5–7] and non-human primates [8–11]. These attention effects indicate that low-level selection processes lead to further processing in these cortical areas, but it is not clear that such early visual processing is necessarily involved in (or leads to) cognitive access. Accordingly, we disagree with M&H's definition of attention provided in their comment as, 'selective processing of information that provides *access to contents* [4]'. We are confused by this definition as it seems to contradict the excellent review of the varieties of attention by the same authors, including what they call 'low-level attention' [4]. Perhaps instead of providing access of contents to *cognitive systems*, M&H's definition includes providing low-level areas in sensory hierarchies access to contents from even earlier stages? If so, we would agree, but would still conclude that such attentional modulations are not equivalent to *cognitive* access.

A third comment by M&H pertains to the distinction between phenomenal consciousness and cognitive access. Phenomenal consciousness has been defined as *raw subjective experience*, or *what it is like* to perceive, think or feel [12]. Cognitive access, on the other hand, refers to a stage in which these more basic phenomenal experiences are made available to cognitive systems such as those involved in

memory, language, decision-making and action (including verbal and manual reporting of what one has consciously experienced). Contemporary theories of consciousness are generally aimed at explaining the neural basis of phenomenal consciousness [3,13,14]. Global neuronal workspace theory (GNWT) posits that phenomenal experience occurs when information is globally broadcasted within a dedicated network of 'workspace neurons', whose function is to share information between various sensory, cognitive, affective and motor systems [15]. Thus, for GNWT, phenomenal consciousness and cognitive access are closely related, if not identical [16]. Competing theories, such as RPT, propose a separation between phenomenal consciousness and cognitive access [3]. For RPT, the phenomenal experience is possible in the absence of cognitive access, and thus in the absence of the one or more attentional mechanisms that directly enables cognitive access. M&H take the position that some phenomenal experiences can occur in the absence of (all types of) attention. By contrast, our main point here is that many other attentional mechanisms exist, besides those involved in cognitive access (as is pointed out in H&M's scholarly 2015 review [4]), and our working hypothesis, based on current evidence, is that one or more of these attentional processes may be necessary for and closely linked with phenomenal consciousness.

H&M [4] seem to agree with many aspects of our proposal. For example, we agree that attention and consciousness are separate processes that can be dissociated. H&M come to this conclusion based on evolutionary arguments, while we base our views on empirical research on visual attention and conscious perception. We also agree that some varieties of attention interact with consciousness, i.e. there is not a complete, double dissociation. H&M focus on the 'overlap' between attention and consciousness and propose a new term, 'conscious attention', to refer to this overlap. This is where our current hypothesis differs. Instead of proposing an interactive overlap that produces a third entity which requires new definitions and adds additional complexity to an already complicated topic, we focus on the potential causal interaction between known varieties of attention and phenomenal consciousness. Our working hypothesis is that some type(s) of attention may be necessary for phenomenal consciousness. H&M appear to waver on this issue, at times proposing that phenomenal consciousness can occur in the absence of attention, 'One can experience pain and pleasure without having any attention-driven process of selecting information and accessing contents' [4, p. 608]. While at other times (later on the same page) apparently contradicting this statement, 'For example, what it is like to experience pain, and not simply respond to signals from pain receptors without the subjective experience, needs to be associated with the functional aspects of selective and cross-modal attention that are necessary to produce pain experiences' [4, p. 608]. We agree with their latter statement. While painful stimuli are highly salient, therefore capturing bottom-up attention and almost always leading to a conscious experience of pain, there are rare situations in which painful stimuli are not consciously experienced. For example, when athletes are injured during important competitions, they often report not consciously experiencing the pain because their attention was so focused on the task at hand (e.g. winning the match), and only later consciously experience the pain when their attentional resources are freed up.

Finally, we agree with M&H that it is problematic to achieve a situation that guarantees 'zero attention' is being paid to a particular stimulus. In our formulation, zero attention should be viewed as an idealized endpoint of a continuum, but in practice, it is difficult to distinguish a zero from a very minimal allocation. Experimentally, attentional allocation to a stimulus can be graded, for example, by varying the difficulty of the competing task in an inattentional blindness paradigm [17]. Behavioural and physiological measures of stimulus processing can assess the degree of attentional allocation to it [18]. In principle, a zero allocation of attention to a stimulus could be achieved either by a complete withdrawal of attention from it or an active suppression of its processing owing to a focusing of attention elsewhere. These two mechanisms would be difficult to distinguish experimentally unless an appropriate baseline condition is included for comparison. Here, we agree with M&H that designing experiments which can differentiate between various forms of zero/minimal attention and assess their relationship with conscious perception is a topic ripe for future research.

To summarize, we argue that attention and consciousness are clearly dissociable, but not fully (doubly) dissociated, as there is currently a lack of evidence for conscious experience in the absence of (all types of) attention. If our working hypothesis is on the right track, i.e. that some variety of attention is necessary for phenomenal consciousness, investigating this relationship in more detail could provide important clues for understanding the neural basis of consciousness. Here, it seems, we wholeheartedly agree with M&H, as they conclude, 'The task now is to examine this relationship' [4, p. 609].

References

1. Pitts MA, Lutsyshyna LA, Hillyard SA. 2018 The relationship between attention and consciousness: an expanded taxonomy and implications for 'no-report' paradigms. *Phil. Trans. R. Soc. B* **373**, 20170348. (doi:10.1098/rstb.2017.0348)
2. Lamme VAF. 2006 Towards a true neural stance on consciousness. *Trends Cogn. Sci.* **10**, 494–501. (doi:10.1016/j.tics.2006.09.001)
3. Lamme V. 2015 The crack of dawn-perceptual functions and neural mechanisms that mark the transition from unconscious processing to conscious vision. In *Open MIND* (eds T Metzinger, JM Windt), pp. 1–34. Frankfurt, Germany: MIND Group.
4. Haladjian HH, Montemayor C. 2015 On the evolution of conscious attention. *Psychon. Bull. Rev.* **22**, 595–613. (doi:10.3758/s13423-014-0718-y)
5. Martínez A, Di Russo F, Anllo-Vento L, Hillyard SA. 2001 Electrophysiological analysis of cortical mechanisms of selective attention to high and low spatial frequencies. *Clin. Neurophysiol.* **112**, 1980–1998. (doi:10.1016/S1388-2457(01)00660-5)
6. Di Russo F, Martínez A, Hillyard SA. 2003 Source analysis of event-related cortical activity during visuo-spatial attention. *Cerebral Cortex (New York, N.Y.: 1991)* **13**, 486–499. (doi:10.1093/cercor/13.5.486)
7. Di Russo F, Stella A, Spitoni G, Strappini F, Sdoia S, Galati G, Hillyard SA, Spinelli D, Pitzalis S. 2012 Spatiotemporal brain mapping of spatial attention effects on pattern-reversal ERPs. *Hum. Brain Mapp.* **33**, 1334–1351. (doi:10.1002/hbm.21285)
8. Moran J, Desimone R. 1985 Selective attention gates visual processing in the extrastriate cortex.

Science **229**, 782–784. (doi:10.1126/science.4023713)

9. Treue S, Maunsell JH. 1999 Effects of attention on the processing of motion in macaque middle temporal and medial superior temporal visual cortical areas. *J. Neurosci.* **19**, 7591–7602. (doi:10.1523/JNEUROSCI.19-17-07591.1999)
10. Reynolds JH, Desimone R. 2003 Interacting roles of attention and visual salience in V4. *Neuron* **37**, 853–863. (doi:10.1016/S0896-6273(03)00097-7)
11. Chen X, Hoffmann K-P, Albright TD, Thiele A. 2012 Effect of feature-selective attention on neuronal responses in macaque area MT. *J. Neurophysiol.* **107**, 1530–1543. (doi:10.1152/jn.01042.2010)
12. Chalmers DJ. 1998 The problems of consciousness. In *Consciousness: at the frontiers of neuroscience* (eds H Jasper, L Descarries, V Castellucci, S Rossignol), pp. 29–59. Philadelphia, PA: Lippincott-Raven.
13. Tononi G, Boly M, Massimini M, Koch C. 2016 Integrated information theory: from consciousness to its physical substrate. *Nat. Rev. Neurosci.* **17**, 450–461. (doi:10.1038/nrn.2016.44)
14. Dehaene S, Lau H, Kouider S. 2017 What is consciousness, and could machines have it? *Science* **358**, 486–492. (doi:10.1126/science.aan8871)
15. Dehaene S. 2014 *Consciousness and the brain: deciphering how the brain codes our thoughts*. New York, NY: Viking.
16. Naccache L. 2018 Why and how access consciousness can account for phenomenal consciousness. *Phil. Trans. R. Soc. B* **373**, 20170357. (doi:10.1098/rstb.2017.0357)
17. Mack A, Erol M, Clarke J. 2015 Iconic memory is not a case of attention-free awareness. *Conscious Cogn.* **33**, 291–299. (doi:10.1016/j.concog.2014.12.016)
18. Pitts MA, Padwal J, Fennelly D, Martínez A, Hillyard SA. 2014 Gamma band activity and the P3 reflect post-perceptual processes, not visual awareness. *Neuroimage* **101**, 337–350. (doi:10.1016/j.neuroimage.2014.07.024)