How to be pluralistic about Neural Correlates of Consciousness

CHENG, Tony

Abstract

Discussions of neural correlates of consciousness (NCCs) occupy a central place in both scientific and philosophical studies of consciousness. In addition to many developments in the past decades, there is a recent trend to go pluralistic about NCCs. Here I follow this line of thought and propose a specific way to be pluralistic. Section 1 sets the stage by situating issues concerning NCCs in the context of the recent debate between the posterior and the anterior theories. Section 2 develops the proposal that there are two kinds of perceptual phenomenal consciousness – one is rationality-related and the other is not – and argues that they have different though overlapping NCCs. It will also be argued that attention plays a crucial role for rationality-related perceptual phenomenal consciousness. Section 3 critically discusses a different pluralistic proposal and argues that it is based on inaccurate understandings of NCCs and the contrast between the posterior and the anterior theories. Section 4 concludes with an observation that there is a recent tendency of downplaying conceptual issues in the studies of the mind, which needs to be resisted and countered if we wish to make better progress in such studies.

Keywords: Attention, NCCs, Perceptual phenomenal consciousness, Pluralism, Posterior and anterior theories, Rationality

1 NCCs and the debate between the posterior and the anterior theories

The search for neural correlates of consciousness (NCCs) – roughly, the brain circuits that correlate with conscious episodes – has been one of the central projects of the science and philosophy of consciousness since the end of the previous century. The classic definition offered by Crick & Koch (1990) regards the correlates as the minimal neural mechanisms that are together *sufficient* for conscious percepts (also see their 1998, 2003). The first thing to be noted is that the original characterisation focusses on *perceptual* consciousness(1); later researchers have broadened the scope to seek NCCs for other varieties of consciousness; this will be important for the following narratives, so we will come back to it later. David Chalmers (2000) offers a useful though non-exhaustive list of candidates for NCCs before the 21st century: Edelman (1989), Newman & Baars (1993), Llnas et al. (1994), Bogen (1995), Flohr (1995), Milner & Goodale (1995), Hobson (1997), Scheinberg & Logothetis (1997); for a longer list, see Chalmers (1998). In recent decades, many modifications and improvements have been proposed, but consensus has not been reached (Fink, 2016; Fink & Lin, 2021, and various papers included in the 2021 special issue). The latest developments can be divided into two broad categories: on the one hand, some have argued that the project of searching for NCCs should be replaced by the project of building *theories of consciousness* (Seth & Bayne, 2022); on the other hand, others have clung on to the project of searching for the NCCs, but suggested that instead of the original, *unified* assumption that there is one set of NCCs that is responsible for all consciousness, we should go *pluralistic* with respect to NCCs. In Cheng, Lin, and Tseng (2022), we have argued that the former is a non-starter, as claims about NCCs are always theory-laden, and theories of consciousness in the relevant sense all make predictions about NCCs. On this occasion I will go for the second route, and offer a specific proposal about how to go pluralistic. To anticipate, I will argue that there are two

(1) They "mainly concerned with *visual awareness*" (ibid., p. 263; emphasis added).

kinds of *perceptual phenomenal consciousness* (characterised below), and they have different though overlapping NCCs. I will then contrast this proposal with a recent one by Biyu J. He (2023a; also see her 2023b, 2024), who proposes a new "joint determinant theory" (JDT), which contains many insights, but is based on inaccurate understandings of NCCs and the contrast of the posterior and the anterior theories, i.e., the debate concerning which parts of the brain are responsible for consciousness.(2) Since this contrast is crucial for the entire paper, I will begin with some basic characterisations of it now.

As mentioned above, the original definition of NCCs relies on a certain notion of *sufficiency*: they are neural states that are minimally sufficient for certain mental states to be conscious. Although there have been many refinements of this original definition, let's not challenge it for now.(3) Given this understanding, we can ask the following crucial question:

> Is the prefrontal cortex (PFC) part of the neural correlates or substrates of perceptual phenomenal consciousness?(4)

For this question to make sense, some assumptions and provisos need to be a place. First of all, we need to bear in mind that in this context the focus is *perceptual* consciousness. Secondly, it relies on a certain notion of phenomenal consciousness, i.e., the what-it-is-likeness of experiences, which will be detailed in section 2. Thirdly, it presupposes that the posterior sensory cortices are parts of the NCCs. What is at issue is whether PFC is *also* part of the NCCs. This will be a crucial point in section 3.

Now, the canonical view about perceptual NCCs would answer "no" to the above question. According to this view, the PFC is for decision-making, planning, thinking, etc. (Block, 2005; Lamme, 2004). By contrast, the revisionary view would answer "yes" to it, holding that parts of the PFC are *also* responsible for perceptual phenomenal consciousness (Lau and Rosenthal, 2011; Michel and Morales, 2020).(5) In the next section we will see that the proposed pluralistic picture will answer "yes and no" to the question. Focussing on the contrast between the posterior and the anterior theories for now, the former holds that:

> Consciousness depends mainly on the activity of posterior parts of the cortex (Lamme, 2006) or of a "posterior hot-zone," which includes roughly the entire cortex *minus* the insula and the PFC (Koch, Massimini, Boly, & Tononi, 2016; Tononi, Boly, Massimini, & Koch, 2016). (Michel & Morales, 2020, p. 494)

The latter, i.e., the anterior/PFC theories, includes global workspace theory (Baars, 1988; Dehaene & Changeux, 2011) and higher-order theories (Brown, Lau, & LeDoux, 2019; Lau & Rosenthal, 2001; LeDoux & Brown, 2017; also "centralists" in Lau, 2022); the basic idea is this:

> Some neural mechanisms in the PFC are responsible for rendering unconscious contents conscious, and that neural mechanisms elsewhere in the brain normally do not have this capacity. (Michel & Morales, 2020, p. 494)

Now the contrast should be quite clear. How do researchers go about making progress here? Traditionally, the so-called "contrastive analysis" (Baars, 1988) is invoked to tackle related issues. This method "consists in comparing neural activity from trials in which subjects consciously perceive a stimulus with trials in which they perceive it unconsciously" (Michel & Morales, 2020, p. 496). This method requires experimenters to figure out whether participants are conscious of specific stimuli, and this is typically done

---

(2) In the literature, the contrast is often between the "posterior" and the "prefrontal" theories. On this occasion we call the latter the "anterior" theories simply because both "posterior" and "prefrontal" begin with the letter "p," which can sometimes generate unnecessary confusions. For our purposes here, we do not consider global (neuronal) workspace theory (e.g., Baars, Geld, and Kozma, 2021), which is definitely relevant too in principle.

(3) See Wu and Morales (2024) for a brief summary.

(4) This is taken from Michel and Morales (2020). Not everyone agrees with this way of seeing things. For example, some higher-order theorists would think that the NCCs are in the prefrontal cortex *only*, because it is the higher-order states or activities *and nothing else* that make consciousness happen. See the third assumption below.

(5) But also see the qualification is the previous footnote.

via subjective reports. There are different versions of them, including confidence ratings (Cheesman & Merikle, 1986), reports on the visibility of the stimulus (Sergent & Dehaene, 2004), reports using the perceptual awareness scale (Ramsøy & Overgaard, 2004), and post-decision wagering (Persaud, Mcleod, & Cowey, 2007), etc. Crucially, in the core contrastive analysis participants are required to report on their conscious episodes in some ways; if this core is problematic, then many consciousness studies would have no solid basis. During the process, experimenters would use EEG or fMRI etc. to monitor brain activities to make inferences about consciousness. Along the way they need to control for perceptual signal strength, performances, attention, etc. Posterior theories hold that the PFC is responsible for consciousness-related *cognitive* processes, as opposed to *perceptual* processes (Aru, Bachmann, Singer, and Melloni, 2012; De Graaf, Hsieh, and Sack, 2012). Usually, these cognitive processes are generated by subjective reports. Recently, innovative no-report paradigms have been designed to address worries of subjective reports in consciousness studies, though they are not entirely unproblematic (Tsuchiya, Wilke, Frässle, and Lamme, 2015; Block, 2019; Chen, Cheng, and Hsieh, 2022).

The debate between the posterior and the anterior theories is heated and ongoing, but for our purposes the above brief selective summary should be enough. I now turn to my specific proposal that there are two kinds of perceptual phenomenal consciousness, and they have different though overlapping NCCs.(6) In order to make sense of this proposal, we need to make a detour to notions of consciousness, attention, and rationality.

2 The way to go pluralistic: Consciousness, attention, and rationality

Consciousness and attention (roughly, the ability to focus and select) have been an odd couple in the studies of the mind. A (distorted and simplified) textbook vision has it that there was a time when "consciousness" was regarded as unscientific due to difficulties of operationalisation, so "attention" became a certain kind of surrogate for consciousness, as it seemed easier to be manipulated. However, in recent decades consciousness has regained its central place in the studies of the mind, so to get clear about the relations between consciousness and attention becomes urgent. Is attention necessary to consciousness [the overflow debate, e.g., Block, 2007; Phillips, 2011]? Is attention sufficient for consciousness [the blindsight debate, e.g., Kentridge, Heywood, & Weiskrantz, 1999; Phillips, 2018]? We do not take side with respect to these issues here.

What about rationality (and reason), i.e., the capacity for making inferences and decisions? In a way it seems to be the strange other person. For example, Johannes Roessler discusses the relation between perceptual *attention* and the space of *reasons* (2011), while John Campbell investigates the relation between visual *attention* and the *rational* role of *consciousness* (2011). Now our empirical hypothesis begins with the idea that there are *two kinds* of perceptual phenomenal consciousness, and only one of them is tied to attention and rationality. This might help us adjudicate the debate between the posterior and the anterior theories. But before that, we need to be clear about what we mean by "phenomenal consciousness." According to Ned Block,

> Phenomenal consciousness is *experience*; what makes a state phenomenally conscious is that there is something "it is like" (Nagel, 1974) to be in that state. (1995, p. 228; emphasis added)

Block distinguishes phenomenal consciousness from both access consciousness and monitoring consciousness; we do not need to look into the definitions of the other two. What is crucial here is that given this understanding of phenomenal consciousness, we need to distinguish between two kinds of it – one is *rationality-related* and the other is not. For simplicity, in what follows we use "P-consciousness [R]" for the former and "P-consciousness [~R]" for the latter. The empirical hypothesis is that perceptual P-consciousness [~R] is fully sustained by the relevant parts of the back of

(6) Block (2005) argues that there are two NCCs, one for phenomenal consciousness and the other for *access* consciousness. The current proposal stays neutral about access consciousness, and holds that there is a crucial division *within* the category of phenomenal consciousness.

the brain, while perceptual P-consciousness [R] involves *both* the posterior and the anterior; more specifically, parts of the PFC. Note that they are *both* phenomenal consciousness, as both fit what Block calls "experience," e.g., the *painfulness* of pain, a. k. a. the subjective aspect of the mind that creates the "hard problem of consciousness" (Chalmers, 1996).

Now what is the initial plausibility of this proposal? On the one hand, consider cases such as human infants, feral children (i.e., humans who were raised by other animals), and animals without the PFC or with less developed PFC. Of course they are (or at least can be) phenomenally conscious! The absence of a fully functioning PFC would not make one a philosophical zombie. But on the other hand, we also grant that phenomenal consciousness seems to play some crucial roles in *inferences* and *justification* (e.g., Dretske, 1997; Smithies, 2019). At least sometimes, epistemic inferences need to be done *via* consciousness. The conjecture is that P-consciousness [R]'s neural correlates include the PFC, so that it can play the relevant rational roles. Note that only P-consciousness [R] overlaps with actual access, while P-consciousness [~R] can be accessible only, which fits Block's definition of access consciousness: "A state is access-consciousness if, in virtue of one's having the state, a representation of its content is… poised for rational control of action" (1995, p. 231). They are accessible or poised in the sense that information on the posterior can be transmitted to the anterior. But again, I stay neutral about the NCCs for access consciousness.

It is worth noting that in a very different context, there is another important distinction between being responsive to reasons and being responsive to reasons *as such* (McDowell, 2006). The former is what we share with human infants and other animals, such as running away from predators, being attracted by some conspecifics, and so on. The latter is what's distinctive about humans like us: we can be responsive to reasons *as reasons*, and adjust our reasonings and actions, which requires a mature PFC in our cases. It is also important to emphasise that the relevant areas of the posterior brain plus the PFC is *sufficient* for P-consciousness [R], but *not necessary*, because we need to make room for multiple realisability (Putnam, 1967): consider artificial systems, for example. In one sentence, according to the current empirical hypothesis, our capacities to be responsive to reasons *as such* and to be P-consciousness [R] share the PFC as their neural correlates.

Attention comes into the picture at this stage. Consider the two networks of attention described by Corbetta & Shulman (2002): the dorsal frontoparietal network and the ventral frontoparietal network. Our further hypothesis is that the *ventral* network filters the information from the back to the front of the brain. On this view, P-consciousness [~R]'s neural processes in the posterior brain have *not* been filtered by attention (i.e., certain version of the overflow view). After the relevant pieces of information get transmitted to the frontal brain, *via* attention's selections and modulations they become P-consciousness [R], which can facilitate inferences and decision-making. One potential difficulty is that here we have not distinguished between different kinds of attention (Wu, 2024), and that will be a future project.(7) Another future task is to combine the above ideas with the "higher-order statistical decision theory of consciousness," according to which subpersonal statistical decisions are done in the PFC, and these decisions can be one variant of computations indicated in the predictive processing framework (Cheng, 2023).

The dualisms of P-consciousness and of rationality correspond to a third dualism, i.e., the one between the *world* and the *environment* (Gadamer, 1960/2004; McDowell, 1996): while all beings share this physical environment, only human beings like us enjoy *world-disclosing* experiences: human infants and many other animals are phenomenally conscious, but they do not possess a *meaningful* world, a *second nature*: they do not enjoy perceptual P-consciousness [R]. They are locked in solicitations in the phenomenological sense (Dreyfus, 2006, 2007a, 2007b; McDowell, 2007a, 2007b; Cheng, 2021).

To summarise, the debate between the posterior and the anterior theories has been a heated one, and the *empirical* details of it have become extremely complicated and daunting. However, this does not mean that *conceptual* refinements play no significant role. The above sketch is an attempt to make progress by empirically-informed conceptual discussions. Now it is time to look into another recent pluralistic pro-

(7)　For some preliminary discussions, see Cheng (2017).

posal and see why mine is more plausible. The next section will first introduce the competing pluralistic proposal and then argue that it is problematic because it rests on inaccurate understandings of NCCs and of the posterior/anterior debate.

3 The way not to go pluralistic: Misinterpreting the dialectic

In "Towards a pluralistic neurobiological understanding of consciousness" (2023a), Biyu J. He proposes a new framework for scientifically studying consciousness. As indicated above, the general background for this discussion is the contrast between the unified and the pluralistic accounts of NCCs. He argues that "the search for generic neural correlates of consciousness may not be fruitful," and instead proposes that the new "joint determinant theory" (JDT) "may be capable of accommodating different brain circuit mechanisms for conscious contents as varied as percepts, wills, memories, emotions, and thoughts, as well as their integrated experience" (p. 420). While the case studies surveyed in that paper are useful, and the framework opens up new directions for this field, He exaggerates the contrast between the unified approach and the pluralistic approach. In what follows I will argue that He's specific proposal is unmotivated due to two problems, one about how to understand the classical definition of NCCs, and the other about how to understand the contrast between the posterior theories and the anterior theories.

He also relies on the classical definition invoked above, so it can be assumed that we are not talking past each other, at least initially. However, as indicated above, noted that the original discussion was about *perceptual* NCCs, although unfortunately, the "perceptual" part is often omitted for simplicity. In missing this, He seems to believe that the definition implies that percepts, wills, memories, emotions, and thoughts, if conscious at all, share the same NCCs that are *sufficient* for them being conscious. But as He points out, this has been shown to be false by the various studies cited. The crucial problem here is that in missing the "perceptual" qualification, He's reading of the sufficiency claim is incorrect: others are misattributed the implausible view that we have been seeking a core NCC that is sufficient for percepts, wills, memories, emotions, and thoughts, etc. But this is incorrect: the posterior theorists, for example, do not and should not think that the relevant part of the posterior brain is part of the NCCs for thoughts, for example.

How about the second point? Consider this remark by He: "the debate [is] about whether NCC lives in the 'front' or 'back' of the brain" (p. 426). But as we have seen in section 1, another plausible way to think about the debate is "[w]hether the prefrontal cortex is *part of* the neural substrates of consciousness" (Michel & Morales, 2020, p. 493; emphasis added), but this was not considered by He at all. That is to say, for some anterior theorists, the PFC by itself is not "the minimum neural mechanisms." The question, at least sometimes, is about whether it is *part of* NCCs, not about whether NCC *lives in* the "front." In other words, the anterior theories need not and perhaps should not deny that (say) V1 is part of the visual NCCs.(8)

Here are some more clarifications. Suppose the anterior theories are right in holding that in addition to the sensory areas in the back, the PFC is also part of the NCCs. Does this then imply that conscious percepts, wills, memories, emotions, and thoughts do *not* rely on different brain circuit mechanisms? No! As He points out, so many empirical studies have shown that they involve different brain circuit mechanisms. What is going on here? If the anterior theories are right, then the PFC is part of the NCC *core*. This core is shared by conscious percepts, wills, memories, emotions, and thoughts, but this does *not* imply that conscious percepts, wills, memories, emotions, and thoughts involve *exactly the same* brain circuit mechanisms. The right moral to be drawn is that in addition to the NCC core, which might or might not include the PFC, in order for percepts, wills, memories, emotions, and thoughts to be conscious, additional, and different brain circuit mechanisms are required, at least in the human case. This is a consensus in the literature, so it is *not* the case that most people have missed this, and therefore need to be corrected by He's fine point.

The moral is that He's new framework is indeed a new option that should be taken seriously, but it should not be taken as rejecting the original project. If we bear in mind that the original definition was aim-

(8) As indicated in footnote 4, one complication is that some higher-order theorists might hold that in some cases the PFC itself is sufficient for consciousness. For this line of discussion, see Rosenthal (2005) and Block (2011).

ing at *perceptual* cases, and that the anterior theories *need not* deny that the posterior sensory areas are parts of the NCCs, we see more clearly how future research can make progress in this regard.

4 Conclusion: Taking conceptual issues really seriously

In proposing her new framework, He holds that the proposed approach "will allow the field to build a stronger empirical foundation and become more integrated with other cognitive neuroscience disciplines" (2023a, p. 420). The point is well taken, but non-empirical disciplines of consciousness research is not included at all. I hope the above discussions have shown that to ensure better integration with various empirical disciplines is indeed important and laudable, but it is also crucial to integrate *empirically informed philosophy* to help conceptual clarifications. Actually, the crucial moves above are often from philosophy (e.g., Chalmers, 2000; Fink, 2016; Michel and Morales, 2020; Fink and Lin, 2021). This point should stand even if my specific proposal in section 2 is falsified. The take-home message is that one crucial next step for the cognitive science of consciousness is to take conceptual issues really seriously (Cheng, Lin, and Tseng, 2022).

References

Aru, J., Bachmann, T., Singer, W., & Melloni, L. (2012). Distilling the neural correlates of consciousness. *Neuroscience and Biobehavioral Reviews*, 36(2), 737-746.

Baars, B. (1988). *A cognitive theory of consciousness*. New York: Cambridge University Press.

Baars, B., Geld, N., & Kozma, R. (2021). Global workspace theory (GWT) and prefrontal cortex: Recent developments. *Frontiers in Psychology*, 12, https://doi.org/10.3389/fpsyg.2021.749868.

Block, N. (1995). On a confusion about a function of consciousness. *Behavioral and Brain Sciences*, 18(2), 227-247.

Block, N. (2005). Two neural correlates of consciousness. *Trends in Cognitive Sciences*, 9(2), 46-52.

Block, N. (2007). Consciousness, accessibility, and the mesh between psychology and neuroscience. *Behavioral and Brain Sciences*, 30(5-6), 481-499.

Block, N. (2011). The higher order approach to consciousness is defunct. *Analysis*, 71(3), 419-431.

Block, N. (2019). What is wrong with the no-report paradigm and how to fix it. *Trends in Cognitive Sciences*, 23(12), 1003-1013.

Bogen, J. E. (1995). On the neurophysiology of consciousness, part I: An overview. *Consciousness and Cognition*, 4, 52-62.

Brown, R., Lau, H., & LeDoux, J. (2019). Understanding the higher-order approaches to consciousness. *Trends in Cognitive Science*, 23(9), 754-768.

Campbell, J. (2011). Visual attention and the epistemic role of consciousness. In C. Mole, D. Smithies, & W. Wu (Eds.), *Attention: Philosophical and psychological essays*. Oxford: Oxford University Press.

Chalmers, D. J. (1996). *The conscious mind: In search of a fundamental theory*. Oxford: Oxford University Press.

Chalmers, D. J. (1998). On the search for the neural correlate of consciousness. In S. Hameroff, A. Kaszniak, & A. Scott (Eds.), *Toward a science of consciousness II*. Cambridge, MA: MIT Press.

Chalmers, D. J. (2000). What is a neural correlate of consciousness? In T. Metzinger (Ed.), *Neural correlates of consciousness: Empirical and conceptual questions*. Cambridge, MA: MIT Press.

Cheesman, J., & Merikle, P. M. (1986). Distinguishing conscious from unconscious perceptual processes. *Canadian Journal of Psychology*, 40(4), 343-367.

Chen, Y-K., Cheng, T., & Hsieh, P-J. (2022). P3b does not reflect perceptual contrasts. *eNeuro*, 9(2), https://doi.org/10.1523/ENEURO.0387-21.2022.

Cheng, T. (2017). Iconic memory and attention in the overflow debate. *Cogent Psychology*, (4)1, https://doi.org/10.1080/23311908.2017.1304018.

Cheng, T. (2021). *John McDowell on worldly subjectivity: Oxford Kantianism meets phenomenology and cognitive scientists*. London: Bloomsbury.

Cheng, T. (2023). Higher-order Bayesian statistical decision theory of consciousness, probabilistic justification, and predictive processing. In Cheng, T., Sato, R., and Hohwy, J. (Eds.), *Expected experiences: The predictive mind in an uncertain world*. New York: Routledge.

Cheng, T., Lin, Y., & Tseng, P. (2022). Taking conceptual issues very seriously: One next step for the cognitive sciences of consciousness. *Cognitive Science: A Multidisciplinary Journal*, 46(11), e13213.

Corbetta, M., & Shulman, G. L. (2002). Control of goal-directed and stimulus-driven attention in the brain. *Nature Reviews Neuroscience*, 3(3), 201-215.

Crick, F., & Koch, C. (1990). Towards a neurobiological theory of consciousness. *Seminars in Neuroscience*, 2, 263-275.

Crick, F., & Koch, C. (1998). Consciousness and neuroscience. *Cerebral Cortex*, 8(2), 97-107.

Crick, F., & Koch, C. (2003). A framework for consciousness. *Nature Neuroscience*, 6(2), 119-126.

De Graaf T. A., Hsieh, P., & Sack, A. T. (2012). The "correlates" in neural correlates of consciousness. *Neuroscience and Biobehavioral Reviews*, 36(1), 191-197.

Dehaene, S., & Changeux, J. P. (2011). Experimental and theoretical approaches to conscious processing. *Neuron*, 70(2), 200-227.

Dretske, F. (1997). *Naturalizing the mind*. Cambridge, MA: MIT Press.

Dreyfus, H. (2006). Overcoming the myth of the mental. *Topoi*, 25(1-2), 43-49.

Dreyfus, H. (2007a). The return of the myth of the mental. *Inquiry: An Interdisciplinary Journal of Philosophy*, 50(4), 352-365.

Dreyfus, H. (2007b). Response to McDowell. *Inquiry: An Interdisciplinary Journal of Philosophy*, 50(4), 371-377.

Edelman, G. M. (1989). *The remembered present: A biological theory of consciousness*. New York: Basic Books.

Fink, S. (2016). A deeper look at the "neural correlate of consciousness." *Frontiers in Psychology*, 7, article 1044.

Fink, S., & Lin, Y.-T. (2021). Progress and paradigms in the search for the neural correlates of consciousness: Editorial introduction. *Philosophy and the Mind Sciences*, 2, 3.

Flohr, H. (1995). Sensations and brain processes. *Behavioral Brain Research*, 71, 157-161.

Gadamer, H-G. (1960/2004). *Truth and method*. (J. Weinsheimer & D. G. Marshall trans.) London: Continuum.

He, B. J. (2023a). Towards a pluralistic neurobiological understanding of consciousness. *Trends in Cognitive Sciences*, 27(5), https://doi.org/10.1016/j.tics.2023.02.001

He, B. J. (2023b). New frontiers in consciousness research. *Neuron*, 111(20), 3150-3153.

He, B. J. (2024). Integrating consciousness science with cognitive neuroscience: An introduction to the special focus. *Journal of Cognitive Neuroscience*, online ahead of print.

Hobson, J. A. (1997). Consciousness as a state-dependent phenomenon. In J. Cohen & J. Schooler (Eds.), *Scientific approaches to consciousness*. Hillsdale, NJ: Lawrence Erlbaum.

Kentridge, R. W., Heywood, C. A., & Weiskrantz, L. (1999). Attention without awareness in blindsight. *Proceedings of the Royal Society B: Biological Sciences*, 266(1430), 1805-1811.

Koch, C., Massimini, M., Boly, M., & Tononi, G. (2016). Neural correlates of consciousness: Progress and problems. *Nature Reviews Neuroscience*, 17(5), 307-321.

Lamme, V. A. F. (2004). Separate neural definitions of visual consciousness and visual attention; a case for phenomenal awareness. *Neural Networks*, 17(5-6), 861-872.

Lamme, V. A. F. (2006). Towards a true neural stance on consciousness. *Trends in Cognitive Sciences*, 10(11), 494-501.

Lau, H. (2022). *In consciousness we trust: The cognitive neuroscience of subjective experience*. Oxford: Oxford University Press.

Lau, H., & Rosenthal, D. M. (2011). Empirical support for higher-order theories of conscious awareness. *Trends in Cognitive Sciences*, 15(8), 365-373.

LeDoux, J. E., & Brown, R. (2017). A higher-order theory of emotional consciousness. *Proceedings of the National Academy of Sciences*, 114(10), E2016-E2025.

Llinas, R. R., Ribary, U., Joliot, M., & Wang, X.-J. (1994). Content and context in temporal thalamocortical binding. In G. Buzsaki, R. R. Llinas, & W. Singer (Eds.), *Temporal coding in the brain*. Berlin: Springer Verlag.

McDowell, J. (1996). *Mind and world*. Cambridge, MA: Harvard University Press.

McDowell, J. (2006). Conceptual capacities in perception. In G. Abel (Ed.), *Kreativität*. Felix Meiner Verlag.

McDowell, J. (2007a). What myth? *Inquiry: An Interdisciplinary Journal of Philosophy*, 50(4), 338-351.

McDowell, J. (2007b). What myth? *Inquiry: An Interdisciplinary Journal of Philosophy*, 50(4), 366-370.

Michel, M., & Morales, J. (2020). Minority reports: Consciousness and the prefrontal cortex. *Mind and Language*, 35(4), 493-513.

Milner, A. D., & Goodale, M. A. (1995). *The visual brain in action*. Oxford: Oxford University Press.

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

Newman, J., & Baars, B. J. (1993). A neural attentional model for access to consciousness: A global workspace perspective. *Concepts in Neuroscience*, 4, 255-290.

Persaud, N., Mcleod, P., & Cowey, A. (2007). Post-decision wagering objectively measures awareness. *Nature Neuroscience*, 10(2), 257-261.

Phillips. I. (2011). Perception and iconic memory. *Mind and Language*, 26(4), 381-411.

Phillips. I. (2018). Unconscious perception reconsidered. *Analytic Philosophy*, 59(4), 471-514.

Putnam, H. (1967). Psychological predicates. In W. H. Capitan & D. D. Merrill (Eds.), *Art, mind, religion*. Pittsburgh, PA: Pittsburgh University Press.

Ramsøy, T. Z., & Overgaard, M. (2004). Introspection and subliminal perception. *Phenomenology and Cognitive Sciences*, 3(1), 1-23.

Roessler, J. (2011). Perceptual attention and the space of reasons. In C. Mole, D. Smithies, & W. Wu (Eds.), *Attention: Philosophical and psychological essays*. Oxford: Oxford University Press.

Rosenthal, D. M. (2005). *Consciousness and mind*. Oxford: Oxford University Press.

Scheinberg, D. L., & Logothetis, N. K. (1997). The role of temporal cortical areas in perceptual organization. *Proceedings of the National Academy of Sciences* USA, 94, 3408-3413.

Sergent, C., & Dehaene, S. (2004). Is consciousness a gradual phenomenon? Evidence for an all-or-none bifurcation during the attentional blink. *Psychological Science*, 15(11), 720-728.

Seth, A., & Bayne, T. (2022). Theories of consciousness. *Nature Reviews Neuroscience*, 23, 439-452.

Smithies, D. (2019). *The epistemic role of consciousness*. Oxford: Oxford University Press.

Tononi, G., Boly, B., Massimini, M., & Koch, C. (2016). Integrated information theory: From consciousness to its physical substrate. *Nature Reviews Neuroscience*, 17(7), 450-461.

Tsuchiya, T., Wilke, M., Frässle, S., & Lamme, V. A. F. (2015). No-report paradigms: Extracting the true neural correlates of consciousness. *Trends in Cognitive Sciences*, 19(12), 757-770.

Wu, W. (2024). *Attention*, 2nd edition. New York: Routledge.

Wu, W., & Morales, J. (2024). The neuroscience of consciousness. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy*.