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Reply to Commentaries

Awareness as a perceptual model of attention

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We proposed a theory of consciousness in which the machinery for social perception constructs awareness, and awareness is a perceptual model of the process of attention. One can attribute awareness to others or to oneself. Awareness of X is the brain's perceptual metaphor for the deep attentive processing of X. A set of ten comments on our hypothesis are included in this issue. Each comment raises specific points some of which directly challenge the hypothesis. Here we respond to these specific points and challenges.

We thank all the authors who contributed commentaries. The many thoughts and criticisms are well informed, insightful, useful to us, and undoubtedly interesting to readers. Here we address each of the commentaries in brief.

Leopold asks an age-old question: what species are conscious? Few species have a full-blown, human-like ability for theory of mind. Yet in our hypothesis, awareness does not depend on social cognition in general, but instead on one specific aspect of it, the perceptual reconstruction of attention. In our hypothesis, any animal that can construct a rich model of another's attentional state knows what awareness is; and any animal that maintains a perceptual model of its own attentional state is aware. Whether a particular species has these abilities is an empirical question, but the bar is lower than for advanced social cognition such as solving the false belief task. Leopold is correct: our hypothesis suggests that consciousness is widespread in the animal kingdom.

Koch is a proponent of the view that consciousness is related to complex, bound information. He agrees with some of the points raised in our article. The commentary, however, mainly challenges our theory. We suggest that Koch criticizes the theory for failings that it does not have.

First, at the start of the commentary, Koch states, "I completely agree with the viewpoint that consciousness is information. However, it just can't be any information in the Shannon sense." He notes that the liver contains information but isn't conscious. Our article does not suggest that consciousness is any information such as that found in the liver. Rather we suggest that it is a specific type of information computed in a specific brain system. The first half of the commentary therefore elaborates on an irrelevant criticism.

Second, Koch interprets our theory in an overly specific manner. He suggests that the theory deals only in spatial location — in perceiving the spatial source and spatial target of attention. He states, "what is completely missing from this account is that Abel is not just aware where Bill is attending to (i.e. spatial location) but he is aware of many of the attributes of objects at that location." Yet this criticism does not pertain to our article or our theory. As we point out, "In the present hypothesis, awareness is the perceptual reconstruction of attention, and therefore anything that can be the subject of attention can also be the subject of awareness." One can attend to color, to shape, to smell, to a thought, to a great diversity of items. Spatial location is a relevant part of the issue; it is one of the many aspects of attention that must be captured in a perceptual model of the process of attending to something; but it is not the entire story.

Carruthers and Picciuto are a proponent of the link between consciousness and social cognition. He takes a positive view of our approach. He does raise a specific point about hemispatial neglect with which we disagree.

Carruthers and Picciuto (C&P) argue that neglect is not a true deficit of awareness. In neglect, the patient fails to notice, orient to, or verbally report items in the affected region of space. Some unconscious processing such as priming survives. According to C&P, however,

if a person has a pure deficit in awareness, that person should be able to react to a stimulus, point to a stimulus, and talk about a stimulus, and should lack only the inner awareness of the stimulus.

To counter this argument, we begin with a hypothetical case that we do not support. Suppose that awareness is an epiphenomenon. It is an inner feeling that serves no function and has no outward impact on behavior. In that case, C&P would be right. A loss of awareness should produce a zombie that acts normally but has no inner experience. C&P's view of neglect, we suggest, comes from inadvertently thinking of awareness as mainly an epiphenomenon.

The difficulty with the epiphenomenon view is that it is logically impossible. We can report that we are conscious. Indeed everyone participating in this print discussion has acknowledged the presence of consciousness. Therefore whatever it is, it has an effect on human behavior.

In our theory, consciousness is a perceptual model. Like all perceptual models, it serves the purpose of guiding behavior. Awareness may help to guide attention, cognitive analysis, and behavioral choice. It certainly has an impact on verbal report. Yet even beyond the normal influence on behavior that any perceptual model may have, awareness has a property that makes it unique. In our theory, awareness is a representation of the enhancer of representations. A natural resonance, a positive feedback loop, must exist between awareness (a representation of attention) and attention (the enhancer of representations). Awareness and attention are situated something like two mirrors facing each other. Because of this resonance, awareness must profoundly influence attention and therefore signal processing and behavioral response.

We argue that without awareness, behavior would be crippled, and that at least some forms of neglect do indeed match the deficit one expects from damaging the mechanism of awareness. Hemispatial neglect is, classically, a loss of awareness of anything in the affected half of space, as well as a loss of awareness that there is such a thing as that half of space.

Frith was one of the first to propose a link between consciousness and social intelligence. We are therefore delighted that he takes a positive view of our approach. He also raises several specific concerns about our theory, and here we address a particularly important one.

Frith notes that when a person processes someone else's attentional state, that processing can sometimes occur automatically, without awareness. How can an unconscious process be the source of awareness?

We believe this criticism stems from lumping together two items that in our theory are dissociable. There is a distinction between a perceptual model of someone else's attentional state (assigning awareness to someone else) and a perceptual model of one's own attentional state (assigning awareness to oneself). The two may depend on similar neuronal machinery, but they are two different perceptual models. The fact that we can process someone else's attentional state without ourselves being aware of it does not strain the theory. In our hypothesis, to process someone else's attentional state, and therefore to assign awareness to someone else, and at the same time to be aware that we are doing it, requires an extra layer. It requires a perceptual model of how one's own attentional state is focused on someone else's attentional state. The theory predicts that much of the perceptual processing of other people's attentional state, and thus much of the attribution of awareness to other people, occurs outside of one's own awareness. The underlying logic is straightforward, even if its application to specific circumstances sometimes requires recursive complexities.

Bridgeman emphasizes the behavioral impact of awareness. He also emphasizes that, because it has behavioral consequences, it is subject to evolutionary pressure. This emphasis is, in our view, exactly right. By searching for a neuronal basis for consciousness one is necessarily accepting a scientific, biological framework. In that framework, traits evolve and are retained because they have some specific impact on an organism's survival. Our hypothesis provides a possible behavioral utility to consciousness, thereby providing at least a theoretical account of its evolutionary path.

Van Elk and Blanke discuss the issue of first person perspective and the out of body experience. We agree with most of their points and find their ideas on different types of first person perspective to be of great interest. However, we do not agree that a body schema, by itself, is a form of consciousness. The brain clearly computes a body schema, which contains information on the spatial instantiation of the self. The body schema is complex and probably multifaceted. But an informational model of the body, constructed in the brain, cannot by itself account for awareness. That is where our theory becomes useful. In our theory, awareness is information. It is an informational model, a schema computed by the brain. But it is specifically a schema that describes what it means to attentively process information. It is the brain's metaphor for the deep processing of information. Without that metaphor added to the mix, the body schema by itself would be merely a simulation of the body without awareness.

Kievit and Geurts offer an insightful comment on autism. To put this comment in a broader perspective,

here we point out a challenge sometimes directed at social theories of consciousness. Autistic people have impaired social perception. If consciousness is linked to social perception, then shouldn't autistic people show some deficit in consciousness? Kievit and Geurts answer the question: they do. Autism may indeed be associated with some loss of awareness of at least some mental processes. Consciousness normally encompasses only a small fraction of the processes in the brain; continuing to study how autistic and non-autistic people differ in this respect may be of great interest.

Banissy, Walsh, and Muggleton discuss the phenomenon of mirror-touch synesthesia. A mirror-touch synesthete will actually feel a touch on his or her own body when merely watching someone else being touched. This phenomenon suggests that the ability to build a perceptual model of the experiences of others is somehow related to one's own perceptual awareness. The phenomenon of mirror-touch synesthesia does not necessarily support the specific theory of awareness that we propose in our target article, but it does add support to the general approach. The authors also correctly point out that social perception is likely to involve many brain structures in addition to the few emphasized in our article.

Smallwood discusses an important area of the literature left out of our target article: the default mode network and its possible role in stimulus independent thought. The commentary is informative and compelling. Smallwood suggests that research on the default mode network supports our proposal of an overlap between regions of the brain involved in modeling others, in modeling the self, and in awareness.

Iacoboni comments mainly on the issue of mirror neurons in social perception and their relation to the brain regions discussed in our article: STS, TPJ, and DMFC. Iacoboni is quite correct that STS is the only one of these regions to be specifically experimentally linked to the mirror neuron system. The other areas thus far are less well characterized and have not been associated with the mirror neuron system. We would point out, however, a potentially limiting aspect of the work on mirror neurons. The experiments almost always involve the perception of motor acts performed by the hand, whereas social perception obviously encompasses a much larger domain. Perhaps one reason for the apparent anatomical focus of the mirror neuron system – in STS, posterior parietal lobe, and premotor cortex – is that the experiments are limited in scope. Whether TPJ, DMFC, and other areas implicated in social perception really have a specific role in informing simulation mechanisms such as mirror neurons is of course speculation on our part, and only further experiments will clarify the issue.

We end by considering a question pertinent to all of the commentaries and to our target article. What experimental predictions does our theory make? The most direct predictions involve compromising awareness by damaging specific brain regions. Certainly a large lesion to the social machinery should, by hypothesis, also affect one's own awareness. We argue that this relationship explains why lesions to the right TPJ and STS can result in hemispatial neglect.

But more specific hypotheses can be formulated. If the task of social attention – of building a perceptual model of someone else's attentional state – is emphasized in specific neuronal structures, then by hypothesis damage to those specific structures, or targeted reversible disruption of them, should lead to a deficit in one's own awareness.

Likewise in neglect in which the patient's awareness is impaired in one spatial hemifield, the patient should also be impaired in perceiving when someone else is directing attention to that same hemifield.

The specificity of these predictions is important. The theory does not predict that neglect patients should be generally lacking in social cognitive abilities. Likewise, the theory does not predict that awareness should fade given any neural damage or autism-like disability related to social perception. The proposed relationship between awareness and social perception is more specific and therefore more experimentally approachable.

In summary, we are encouraged by the many useful comments from colleagues, and we see potential for future experiments. The proposed theory of consciousness is specific, conceptually simple, and testable.

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