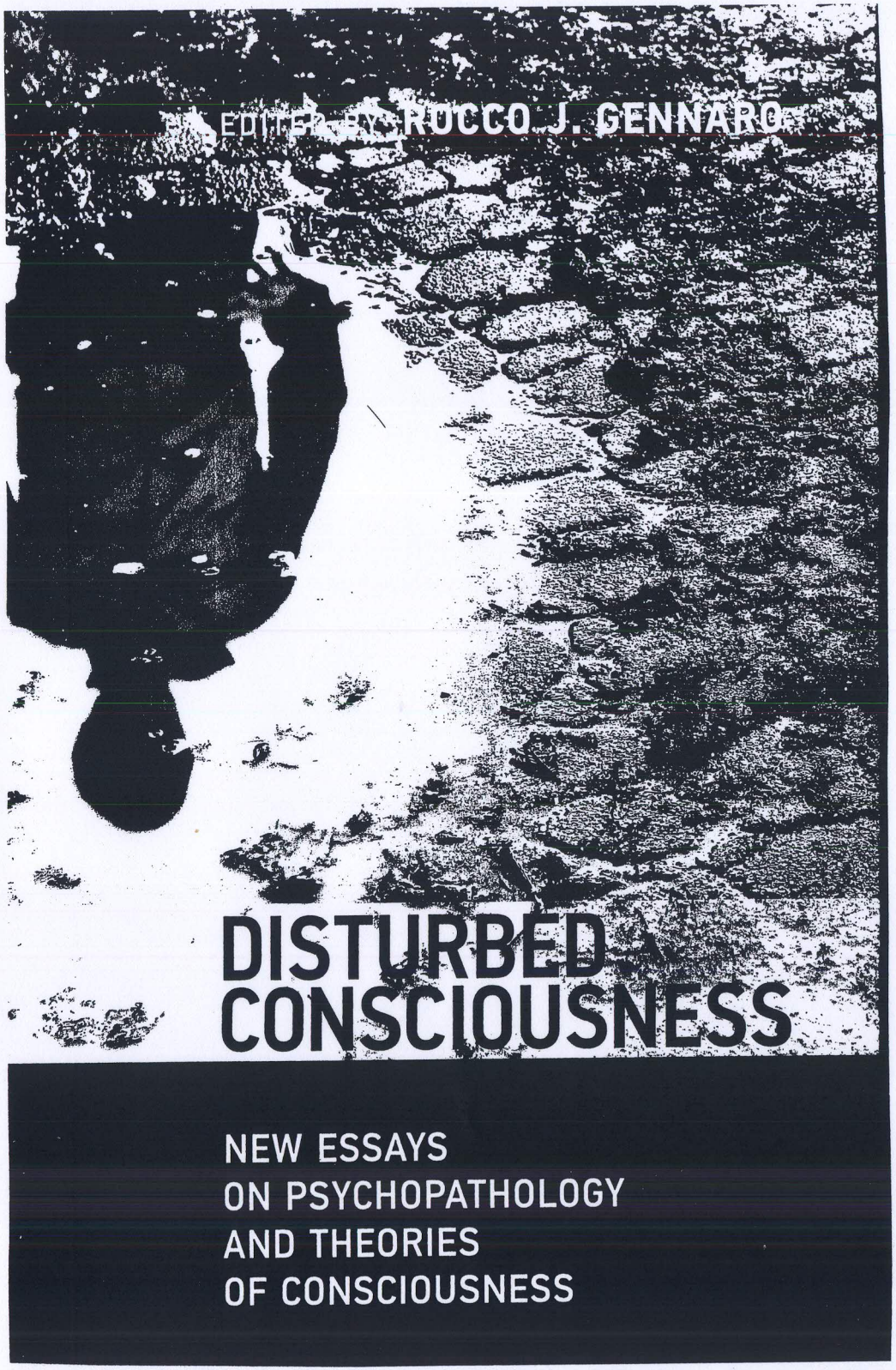

10 Consciousness despite Network Underconnectivity in Autism: Another Case of Consciousness without Prefrontal Activity?

William Hirstein

1 Introduction

Recent evidence points to widespread underconnectivity in autistic brains owing to deviant white matter, the fibers that make long connections between areas of the cortex. Subjects with autism show measurably fewer long-range connections between the parietal and prefrontal cortices. These findings may help shed light on the current debate in the consciousness literature about whether conscious states require both prefrontal and parietal/temporal components. If it can be shown that people with autism have conscious states despite such underconnectivity, this would constitute an argument for the claim that conscious states can exist in posterior cortex without associated prefrontal activity. This in turn lends support to a class of theories according to which *microconsciousness* is possible—consciousness in small areas of cortex without active connections to the prefrontal cortex, as opposed to the higher-order thought (HOT) theory of consciousness, according to which conscious states can only occur when posterior cortical areas (in the parietal or temporal lobes) have active connections to the prefrontal cortex. In this chapter, after listing several candidate examples of consciousness without accompanying prefrontal connections, I will argue that autism provides yet another such example. I will also examine a recent version of the higher-order theory that acknowledges these cases of consciousness without prefrontal activity and, instead depicts consciousness as sometimes requiring higher-order thoughts located in posterior cortex. In the final section, I will examine the consequences of these views for our understanding of the metaphysical nature of consciousness itself—the classic mind-body problem.

Over the last two decades, a surprising number of philosophers have given up on the prospect of developing a materialist theory of consciousness as a brain process. Rather than learning about the brain, they have

created new variants of behaviorism called the *embodied mind* or the *extended mind*. Quitting on the original problem, the mind-body problem, has had its rewards. It is flattering to think that there is some special part of us that transcends the material realm, and audiences never tire of having this cherished belief affirmed. Perhaps this special part or property of us even allows us to have free will, in which the nonmaterial part of us is capable of breaking out of the determined materialistic realm. While these philosophers have been ignoring neuroscience, rapid progress is being made. We have our first neuroscientific theories of consciousness, which are in the process of being tested along many fronts. Using imaging techniques, lesion studies, and advanced anatomical and physiological investigation techniques, as well as traditional psychology experiments in which human subjects are shown stimuli and their responses recorded, measured, and analyzed, neuroscientists have begun to narrow down the cortical areas and networks responsible for conscious states. But there are still major obstacles to be overcome, caused partly by a fundamental inability of experimenters to actually be certain that a certain active brain area or network is itself a conscious state.

Among those philosophers and scientists resolved to continue the quest for a materialist theory of consciousness, an interesting debate has emerged between two groups. According to the higher-order thought theory of consciousness, conscious states require at least two components (Rosenthal 1997, 2005, Carruthers 2000, 2005, Kriegel 2009, Kriegel and Williford 2006, Lau and Rosenthal 2011). First, there must be a state in the brain's posterior cortex that constitutes the contents of the conscious state. For instance, in the case of vision, the content of my current state is that which I am visually aware of. But this posterior state must also have active connections to a state in the front of the brain. This frontal state must be directed at the posterior state, or, in different versions, it must be aware of the posterior state, or it must perceive it. More specifically, according to this theory, a state becomes conscious when it either is, or is disposed to be, the object of a higher-order representation of some sort (Carruthers 2007). The event of a state becoming the object of a higher-order thought or representation is the same event as the subject becoming aware of that state. In other words, states become conscious when we become aware of them. This theory has both philosophical and scientific versions (e.g., Baars et al. 2003, Dehaene and Changeux 2011), and this coalescence between the two approaches has made it one of the most clearly delineated and popular theories of consciousness.

According to the alternative approach to a materialistic theory of consciousness, which has become known as the theory of microconsciousness, only one brain state is required in order for consciousness to be present: the state located in the brain's posterior cortex (Zeki and Bartels 1999, Zeki 2007, Lamme 2003, Pins and ffytche 2003, Hirstein 2012). As its name indicates, this theory allows for conscious states to exist in relatively small, restricted areas of brain tissue, without the need for accompanying frontal activity or for any accompanying cortical activity. Those areas that are capable of producing conscious states, taken along with their connected thalamic nuclei, may be spatially contiguous. One candidate for the process that produces microconsciousness is a type of neural binding process in which the activity of a certain subset of neurons making up an area of the cortex (along with portions of the relevant thalamic nuclei) takes on a certain highly synchronized functional pattern (Steriade and Llinas 1988).

2 Candidate Examples of Consciousness without Associated Prefrontal Activity

Contrary to the higher-order thought view of consciousness, there appear to be cases in which conscious states exist in brains without associated prefrontal activity. In this section, I will review several candidate cases (thanks to Gennaro [2012b] for supplying several of these).

Animals and Infants

Consciousness without prefrontal activity may exist in animals and human infants, in that they might have, for instance, "conscious pains without higher-order thoughts about them" (Block 2007, 288). Several different techniques have now verified the claim that the frontal lobes mature, or *myelinate*, slowly throughout childhood, adolescence, and early adulthood (e.g., Klingberg et al. 1999). This process parallels the development of more sophisticated behaviors in children, such as the ability to inhibit actions and the ability to make higher-level decisions. As with most of the candidate examples we will examine, this one is only able to suggest the possibility of consciousness without accompanying prefrontal activity. With no ability to experience the minds of animals and infants directly, along with no canonical neuroscientific criterion for detecting consciousness from the outside using imaging or other measurement techniques (i.e., the very issue under dispute here), we can only put forward good candidates, not proven examples.

Akinetic Mutism

Neurological patients with akinetic mutism syndrome appear to be awake and conscious but are completely unresponsive to stimuli (Mega and Cohenour 1997). They will apparently stare right at you, but show no sign of actually seeing you, and will not respond to any requests or commands. Patients who have recovered from this state (sometimes via the restoration of blood flow to the damaged area) report that they had conscious states, but simply lacked any desire or impetus to respond. What we may have here is a case of consciousness without the prefrontal activity that must act on it before any behavioral intentions can be formed and executed. The conscious states exist, but they just sit there because they lack important causal connections allowing them to interact with the prefrontal lobes.

Meditation

Deep meditative states are characterized by an absence of activity in the prefrontal cortex. According to Lou et al. (2005), subjects deep in meditation show increased blood flow in posterior areas having to do with imagery, along with decreased blood flow to prefrontal executive areas (which make possible tasks such as inhibition, planning, and decision making). Practitioners of meditation speak of "the self" quieting down or "going away" during these states. Indeed, the ensemble of prefrontal executive processes makes a good candidate for what has historically been referred to as the self in philosophy. The list of mental acts that the self or ego performs is actually a list of executive processes (Hirstein 2011). The ego, says Descartes, is, "a thing which doubts, understands, [conceives], affirms, denies, wills, refuses, which also imagines and feels" (Descartes 1967, Second Meditation). This is, I contend, a list of executive processes.

Perceptual Absorption

Perceptual absorption occurs when people are engaged in a perceptual task or while they are absorbed in a movie they are watching, for example. This produces a state similar to the meditative state, characterized by activity in the brain's posterior perceptual regions, but very little prefrontal activity (Grill-Spector and Malach 2004, Goldberg, Harel, and Malach 2006). A related phenomenon occurs when we engage in activities that are conscious but automatic and unthinking, such as our daily drive home from work. We have driven the route so many times that we don't need to think about what we are doing or be aware of our conscious states. We might arrive at home and be rather surprised that we wound up there without any discernable mental effort on our part. Certainly there were conscious visual states in our brains, though: we consciously saw the other cars and the traffic lights. Yet it may be true to say that we were not aware of these states and were not attending to them. Or so I will argue below.

Frontal Damage

There are cases in which patients show severe frontal damage while continuing to experience and report normal conscious states. There are also cases of profound frontal disconnection caused by damage, intentional (e.g., frontal lobotomy) or accidental, in which subjects continue to have relatively normal conscious mental lives (Pollen 2008, Tononi and Koch 2008). Frontal patients may have trouble using those conscious states to form coherent plans or inhibiting them from causing inappropriate or dangerous behavior, but they seem to nevertheless have conscious states.

Schizophrenia

According to the disconnection hypothesis of schizophrenia, the vivid hallucinations that some schizophrenics experience are caused by disruptions of the processing connections between posterior sensory areas and the prefrontal cortex. There is evidence that the fiber bundles that carry the posterior-prefrontal connections are damaged in schizophrenics (Friston 1998). This may indicate that they experience a type of disordered conscious state that is vivid enough to be distracting and annoying but which is chaotic and/or irrational and may cause dangerous behavior, precisely because the frontal lobes are unable to interact with it in the normal manner.

Coma

Rather than accepting the traditional view that coma patients possess no consciousness whatsoever, Owen and his colleagues performed brain imaging on coma patients while they were asked to imagine doing different things (Owen et al. 2007). Quite surprisingly, even though the patients cannot move a muscle or signal the experimenters in any way, their brains showed activity consistent with the different imagery tasks. In this respect, they may be similar to the patients with akinetic mutism in that their brains contain conscious states that reside in posterior cortical regions but which are causally isolated from the prefrontal cortex. Similarly, patients in a minimally conscious state (who are able to show intermittent behavioral responses) exhibited activity in the temporal cortex in response to hearing personal narratives, but were unable to respond to them behaviorally (Schiff et al. 2005).

3 Consciousness in Autism

Autism has two features: (1) network underconnectivity between the posterior and frontal cortices, and (2) executive deficits, both of which support adding it to the list of possible cases of consciousness without associated prefrontal activity. There is now a large body of evidence showing abnormal and inadequate white matter connections (which link up distant areas of cortex) in the autistic brain between posterior perceptual areas and the prefrontal cortex. Assaf et al. (2010) had subjects with autism simply lie still in the scanner as they monitored the functional connectivity among different cortical regions. They found reduced connectivity between the precuneus, a posterior cortical area thought to be an important node for consciousness, and the medial prefrontal cortex. Cherkassky et al. (2006) similarly found anterior-posterior connectivity to be reduced in autism. Monk et al. (2009) found reduced functional connectivity between the posterior cingulate cortex and the medial prefrontal cortex in autism and noted that this lack of connectivity was associated with worse social function in their subjects. Just et al. (2004), as well as Kana, Libero, and Moore (2011), suggest that this functional underconnectivity might underlie the core symptoms of autism. This lack of frontal connectivity appears to be compensated for by increased local connectivity in the posterior cortex. Monk et al. (2009) found increased connectivity between the posterior cingulate cortex and temporal regions in subjects with autism. In addition, they found that increased repetitive behaviors, a core diagnostic symptom of autism, were associated with increased connectivity between the posterior cingulate cortex and the parahippocampal gyrus.

But what is consciousness like in autism? People with autism certainly report having conscious states. Indeed, several reports on autistic savants appear to show that their visual conscious states are quite large, containing much more information that those of normal people. It appears that such subjects do not, in Crick and Koch's (1995) phrase, get an "executive summary" of their visual contents which accentuates the important features, but are in touch with a large amount of raw conscious data. Similarly, subjects with autism show attention to the periphery of the visual field that is actually superior to that of normal people (Joseph et al. 2009). The periphery of the visual field is a good place to tease apart the higher-order thought and the microconsciousness theories, since consciousness in the unattended visual periphery may be another candidate for conscious states without accompanying prefrontal activity (see Lamme 2003, Hirstein 2012). What the people with autism may show that is of interest here

is perhaps that a greater amount or percentage of their conscious states can continue to exist in a robust form while not being attended to, that is, not having active causal connections with prefrontal, top-down, attentional processes, which are a type of executive process. Those of us without this gift nevertheless experience a full visual field, although we are bad at reporting what is out there (e.g., Rensink et al. 2003). This brings us to the issue of reportability.

4 Reportability

There is a long tradition in psychology of using reportability as a criterion for the presence of consciousness: subjects can report the presence of a stimulus if and only if they are conscious of it. This criterion may well be an outmoded vestige of behaviorism, however. Behaviorists insisted that any mental state that could not be cashed out in behavioral terms was suspect or not a proper object of science. The criterion also creates a problem in that some theorists are confusing neural processes associated with giving the report with the conscious state the report is about. That is, these theorists regard reportability as essential to consciousness, and they also believe that prefrontal activity is essential to consciousness (e.g., Dehaene and Changeux 2011). The prefrontal activity they are seeing may be due to the processes required to report the state. Thus, according to this line of thought, their belief that prefrontal activity is essential for consciousness is, in some cases, an artifact of their insistence on reportability.

One type of argument against the necessity of reportability to consciousness points out that we are always conscious of more than we are able to report. One simple experiment that shows this exposes a subject briefly to a five-by-five grid of random letters. The subject is shown the grid for a limited period of time and then must report what she saw. Normal people are unable to hold the entire grid in visual short term memory, and hence cannot report all of the letters. But this does not show that there is not a large conscious state containing the entire grid during the exposure period (Block 2007, but see Kouider et al. 2010). Hulme, Friston, and Zeki (2009) argue that they were able to tease apart the neural structures required for consciousness and those associated with reportability by using signal detection theory during the reporting task, a finding which supports the idea that consciousness can be present without reportability.

Some linguistic distinctions may be useful here. There are three grammatically different types of claims we make about consciousness and conscious states. In the subject type, we refer to a person who is the subject of

consciousness or of the conscious state, as in "Joe is conscious." This type admits of a grammatically intransitive sense, as in the previous example, as well as a transitive sense, as in, "Joe is conscious of a blue jay," and "Joe is conscious that a blue jay is in the tree." In addition to these two, we use a third type of report that focuses on the mental state, not the subject. This third type allows us to focus on the states themselves, as when we speak of conscious states in general or a conscious state in the subject's brain.

It may be correct to claim that when a person is conscious of *x*, that person can report awareness of *x*. But, I suggest, this is because this grammatical form actually describes a fact about the brain in which the prefrontal processes are in contact with the posterior state. But it does not follow from that claim that every conscious state in a person's brain is reportable by her. We need to examine what facts in the brain make reports about conscious states true. To say that "Jan is conscious of *x*" is to describe a fact in which there is a conscious state in the posterior of Jan's brain that has the right sort of active connections to Jan's ensemble of executive processes, I submit. However, to say that "There is a conscious state in Jan's brain" is to commit only to the posterior brain state, not to the prefrontal connections. Thus, to say "Jan is conscious of *x*, but she cannot report that *x*" is, in most ordinary contexts, a contradiction. But to say "There is a conscious state in Jan's brain, but she cannot report its presence or correctly describe it" is not a contradiction. A claim like this might be true, for instance, of the unattended visual periphery. I have argued that the fact that sentences of the form, "Jan is conscious of *x*," have additional truth conditions (compared to the "there is a conscious state" construction) indicates that the noun phrase of the sentence (in this case, "Jan") is actually making a sort of reference to these extra facts (Hirstein 2012). The extra facts include certain prefrontal executive processes as well as their active reciprocal white matter connections to the conscious state itself, according to my hypothesis. Following Perry and Crimmens, who argue for a much more restricted form of it (Crimmens and Perry 1989, Crimmens 1992), I call this type of reference *tacit reference*.

5 Gennaro's View

Rocco Gennaro places himself in the higher-order thought camp, but he is unique in accepting that prefrontal activity is not required for consciousness (Gennaro 2012a, chapter 9, 2012b). Gennaro makes objections similar to those listed above to experiments that appear to show that prefrontal activity is necessary, that is, that the reportability criterion is a confound. In addition to explicitly noting several of the apparent cases of non-prefrontal consciousness in my list above, he argues that the experiments of Lau and Passingham (2006) and Dehaene et al. (2006) "tend to demand explicit verbal or meta-confidence reporting, introspection, top-down attentional processes, and/or executive functions which are not necessary for first-order conscious states" (2012b). Gennaro similarly criticizes Dehaene and Changeux (2011) by noting that their experiments leave it "undetermined whether [prefrontal] activation *constitutes* [a neural correlate of consciousness] or is a *consequence* of a conscious perception" (2012b). Gennaro notes that, while Lau and Rosenthal (2011) believe that higher-order thoughts are in the prefrontal cortex, he prefers to move away from the idea that higher-order thoughts are to be identified with executive processes in the prefrontal cortex, arguing instead that executive functions such as attention are better understood as introspective abilities than as higher-order thoughts (2012b). "The PFC activity," concludes Gennaro, "likely has more to do with processes that *follow* or *trigger* conscious perceptions rather than being *constitutive* of the [neural correlates of consciousness] themselves" (2012b, see also Gennaro 2012a, especially chapter 9).

If prefrontal activity is not required, then where are the necessary higher-order thoughts? Gennaro cites Tong (2003) approvingly, who argues that, in the case of visual consciousness, activity in primary visual area V1, together with activity in nearby posterior visual cortices, is sufficient for consciousness. Gennaro suggests that this nearby activity is in fact the necessary higher-order thought. Thus he believes that higher-order thoughts can exist at relatively low levels in the processing hierarchy and in the posterior cortex. Notice that this activity is modality specific—the higher-order thought is still in *visual* cortex. This would suggest that the analogous higher-order thoughts in the case of hearing would be in the auditory cortex.

The initial intuition behind the higher-order theory is that a thought becomes conscious when the person becomes aware of it. This implies, I would argue, that the higher-order thought must in some sense stand in for the person herself. We need to be able to say "*I* am aware of that thought." Gennaro would thus need to show that the nearby activity mentioned by Tong can generate such a claim, that is, the nearby activity must be a referent of "I" in some way, or it must be a sort of *self*. If Gennaro's willingness to allow higher-order thoughts to exist alongside their targets in the posterior cortex works, it may save the higher-order theory, but at a cost of abandoning its initial intuitive support. Without that support, where is the independent motive for requiring a higher-order thought? A related objection to Gennaro's attempt to save the higher-order theory is that the

different higher-order thoughts need to issue from a single, unified source, otherwise, again, much of the intuitive support for the higher-order theory is lost. In everyday parlance, the self must be unified. I take this to mean that, if we want to be materialists, we need to map the self onto a single, unified brain system. Our mental states must have a kind of connectedness in order for us to think coherently about ourselves. The one who is aware of the bear must be the same one who decides not to run from it. It is crucial, for instance in legal contexts, that the same "I" who made the decision to kill also formed the intention to kill and, in the end, performed the action of killing (Hirstein and Sifferd 2011). Gennaro would thus need to extend Tong's findings to show something like this. There cannot be unrelated higher-order thoughts all over the posterior cortex.

Gennaro has a response to my claim that the lower-level HOTs cannot function as a type of self, however: he first accepts that higher-order thoughts, together with their target conscious states, can be understood as a form of self-consciousness. He then suggests that the higher-order thoughts located in posterior consciousness might be understood as a sort of "pre-reflective self-consciousness" (2012b). In support of this, Gennaro cites Newen and Vogeley (2003), who distinguish five different levels of self-consciousness, ranging from a fairly low-level "phenomenal self-acquaintance" and "conceptual self-consciousness" up to "iterative meta-representational self-consciousness." However, Newen and Vogeley are writing about different types of self-*representations*. They are employing the assumption, reasonable I think, that when a person is conscious of a self-representation, for instance a representation of his body, this counts as a type of self-consciousness. But what Gennaro needs is a type of self, not a self-representation, to serve as something directed at the conscious state that allows us to say "I am aware of that state." Self-representations represent some aspect of the person. Since Gennaro needs something that will represent the conscious state (and, in so doing, make it a conscious state), such states would have to represent two things: some aspect of the self as well as the conscious state. There would need to be an independent argument that the self-representation also represents the conscious state. Gennaro needs a lower-level self, not a lower-level self-representation.

6 Metaphysical Issues

The relation between the higher-order thought and its target is epistemic, since the higher-order thought is supposed to be aware of, or perceive, its target by representing it. But if you include an epistemic component in your

definition of consciousness, you have created an epistemic-metaphysical simple and, thereby, made the mind-body problem unsolvable. If you similarly include representation in your definition, you create one thing that must be two things, representer and represented—again, a two-part simple. The "simple" part prevents the analysis from progressing any further. You have combined the conscious state and the subject of that conscious state into a unit that cannot be broken if you still want there to be a conscious state. You are done. And yet there still seems to be great complexity there, with much more to be explained.

Bonding the higher-order thought to its target may create another metaphysical problem: only one person can ever experience that conscious state. Since the higher-order thought is a type of self, or "I" that is aware of its target, that self may be the only one capable of experiencing the target state. That makes conscious states unlike every other physical state in the universe, all of which can be experienced by multiple parties. This is exactly the sort of thing that made the theorists mentioned at the beginning of this article give up on the prospect of developing a satisfying materialistic theory of conscious states, one that depicts them as just like every other physical state. And it encourages dualists, who believe that conscious states are not physical. The most straightforward way to respond to this situation is to show that, in fact, conscious states can be directly experienced by multiple parties, by way of brain-to-brain connections (Hirstein 2012). But, this can only be done if we adopt the microconsciousness theory of conscious states (which allow us to separate the conscious state from the "self"). At the very least, this objection forces the higher-order theorists to refine their theory: Is the target state only conscious when it allies with a certain, particular higher-order thought, or can it become conscious when it allies with any sort of higher-order thought, possibly in the brain of another person?

If there can be posterior consciousness, or microconsciousness, without an accompanying higher-order thought, this may indicate that the problem of consciousness has already been solved. An analysis of the properties of posterior conscious states alone can yield a theory of what consciousness is. The current version of this analysis is that the measurable physical property that best corresponds to those cases in which consciousness is present is binding (Singer 1997). Binding occurs when the entire state is unified by coherent, synchronized oscillations. Even if the problem of consciousness has been solved, however, the other half of the mind-body problem remains. The mind-body problem has two parts: (1) the problem of consciousness, and (2) the problem of the self. The problem of the self is caused by the apparent fact that only I, only this self, can ever experience

my conscious states. Thus, according to this conception, my consciousness is deeply private, in that no one else can ever experience it directly. I have suggested that the second problem can be solved by showing (1) the self is the ensemble of prefrontal executive processes (Hirstein 2011), and (2) we can connect one person's self to another person's conscious state (Hirstein 2008, 2012) and, in so doing, breach the wall of mental privacy. Note that if we can achieve this sort of *mindmelding*, we could use it to provide evidence that consciousness exists in the cases mentioned above. We would need to ascertain that the connection itself isn't causing the patient's mental states to become conscious, but there are experimental tests for this. For instance, does anything about the mental state in question change after the connection is made?

Further research on this question will surely illuminate the issues surrounding consciousness, our sense of self, and our minds in general. These issues are difficult, but ultimately resolvable. Breakthroughs in our understanding of consciousness will have immediate medical benefits on exactly the sorts of disorders mentioned in the examples above. If we understand consciousness better, we can better understand its disorders.

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