Consciousness and the Binding Problem in Neuroscience

by Catherine Creighton

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Introduction

If consciousness is the subjective experience of, and driving force behind, the body (i.e., the self), where is it located? Paleoanthropologist Richard Leakey observes, “No one has been able to point to a region of the brain and say, This exclusively is the seat of consciousness.”¹ But its location is not the only challenge. Some, like neuroscientist and philosopher Adina L. Roskies, would say that the real “problem of consciousness” is the so-called “binding problem.” In fact, Roskies describes it as “the most mystifying binding problem of all.”² That is, if consciousness is merely a natural phenomenon, how does “something as simple and mechanistic as neural firing” bind, integrate, or unify different stimuli in separate regions of the brain to arrive at the unity of subjective or phenomenal experience, “raw feelings, a self?”³ However, if this self acted upon and directed the physical brain, but existed independently of it (i.e., substance dualism), then the unity of phenomenal experience would no longer be a mystery. Interestingly enough, a 2014 study of cardiac arrest survivors revealed that “consciousness may be present despite clinically undetectable consciousness” since many survivors experienced “a broad range of cognitive themes” while they were unconscious.⁴ This would seem to indicate that there is, as neurosurgeon Wilder Penfield explains, “a second fundamental element and a second form of energy” that “has a continuing existence.”⁵

Yet most neuroscientists reject substance dualism as mystical,⁶ anti-rationalistic and magical.⁷ They assume that the mind is identical with the brain so that it is just a question of discovering the precise neural correlates of consciousness (NCCs) using current technology, such as neuroimaging techniques (EEG, PET, fMRI, and MRI). Nonetheless, the binding problem remains, even for perceptual binding and objectual unity (i.e., the unity of features belonging to same object). How does an individual consistently and correctly identify a single unified experience of perception when the different stimuli as features or attributes (color, shape, movement, etc.) are processed in different pathways, regions or modules in the brain?⁸ This paper will demonstrate that current physicalist and naturalistic hypotheses and models fail to resolve the binding problem while substance dualism continues to provide the best explanation for the unity of phenomenal experience.

³ Ibid.
Specialized Conjunction Cells

Research associate at the Center for the Study of Language and Information at Stanford University, Leonardo P. G. De Assis, explains that the “so-called ‘Neural Binding Problem’ is an important and unresolved problem in neuroscience.” Various neural models have been proposed to resolve this problem, one of them being a single location in the brain dedicated to feature binding. This has been called the cardinal cell hypothesis (specialized conjunction cells), convergence zone, and integration site. But neuroanatomical and neurophysiological knowledge has denied this view due to the combinatorial explosion problems. That is, there are unlimited combinations of features that far exceed the brain’s capacity. As Francis Crick and Christof Koch stated, “one single very large neural net, with everything connected to everything else, would make the brain both cumbersome and prohibitively large.” Moreover, this model does not distinguish between identifying and “seeing.” It cannot explain how novel objects as well as novel perspectives (whether in relation to oneself or to other objects) are immediately bound (“seen”) without accessing previously learned visual information stored in such a single, specialized location. Therefore, the cardinal cell hypothesis is insufficient and must be rejected.

Neural Synchronization

Another solution to the binding problem is neural synchronization. That is, the underlying neurons of the separate features, “though distributed in geographically different areas…are said to be activated at the same time and in phase (at about 35-75 hertz).” There are several problems with the neural synchronization hypothesis. First, Finnish cognitive neuroscientist Antti Revonsuo noted that the 40-Hz synchronization “does not directly correlate with the content of visual awareness per se, but with the construction immediately preceding the emergence of such content into visual awareness.” But it is the content of visual awareness, the fact that a single unified image is perceived, that requires an explanation. How is it that we do not experience a chaotic mess of random colors, shapes, lines, and movement rather than a single, unified perceptual experience if

13 Ibid.
16 Leonardo P. G. De Assis, “Neural Binding, Consciousness, and Mental Disorders,” 111.
17 Ibid., 106.
these different features or attributes are processed in different pathways, regions or modules in the brain? It would seem like neural synchrony explains very little. In fact, neuroscientist Bill Skaggs is also unconvinced, stating that “neurons activated by features belonging to distinct objects show no temporal coordination.”¹⁹ Psychologist Alex O. Holcombe cautions that “the precise relationship of the phenomenon [of neural synchronization] to perceptual binding remains unclear.”²⁰ In fact, De Assis states that “today no one knows for sure, which specific mechanism the brain uses to accomplish this binding by synchronization.”²¹ Roskies notes that “there is only suggestive but not yet incontrovertible evidence that these [synchronous] signals are used for binding, or that they play any critical role in brain function.”²²

Second, Roskies notes another problem with the temporal synchrony binding hypothesis: the readout problem, which he sees as “one of the most puzzling and fundamental problems for systems neuroscience in general.”²³ How are the synchronous signals read out? How “is the firing of populations of neurons interpreted and transformed by other neurons to result in decision, action, perception, etc?”²⁴ But decision-making is a separate issue. In fact, Penfield discovered that one could not find any place “in the cerebral cortex where electrical stimulation will cause a patient to believe or to decide.”²⁵ However, regarding the readout problem, it would seem to be the subject or self which provides the interpretation of such information (subject unity), not synchronous signals.

Third, philosopher Eric La Rock explores other empirical problems with neural synchrony. Studies have demonstrated that it cannot explain stationary or moving objects.²⁶ Since people and animals regularly observe stationary (mountains, rocks) and moving objects, this hypothesis is clearly insufficient. Moreover, since detecting moving objects would be important and necessary for survival purposes (for example, a gazelle detecting the movement of a lion), it would seem that neural synchrony is also problematic for an evolutionary explanation of the emergence of consciousness.²⁷ Even worse, the synchrony mechanism has been observed in people who were unconscious. Therefore, according to De Assis, it is “not a sufficient condition for the existence of consciousness.”²⁸ So, as La Rock concludes, we “cannot maintain that neuronal synchrony is the special neural correlate of conscious objectual unity.”²⁹

²¹ Leonardo P. G. De Assis, “Neural Binding, Consciousness, and Mental Disorders,” 112.
²³ Ibid.
²⁴ Ibid.
²⁵ Wilder Penfield, Mystery of the Mind, 77.
²⁶ Eric La Rock, “From Biological Naturalism to Emergent Subject Dualism,” 107.
²⁷ Ibid.
²⁸ Leonardo P. G. De Assis, “Neural Binding, Consciousness, and Mental Disorders,” 113.
²⁹ Eric La Rock, “From Biological Naturalism to Emergent Subject Dualism,” 108. Emphasis in original.
Moreover, if, as Revonsuo concludes, the 40-Hz synchronization is not “the direct neural correlate of the content of phenomenal visual awareness,” then that begs the question, what is the explanation for such mental content? In fact, neuroscientist Michael Graziano condemns neural synchrony as a “phlegm theory” because it flatters our intuitions about our consciousness but explains nothing. That is, we intuitively feel like our consciousness is associated with our physical brain like the relationship of a tuning fork (the physical brain) with the energy related to it (the vibrations or oscillations of consciousness). However, although this flatters our intuitions, it provides no scientific mechanism, no causal explanation for the phenomenal experience.  

**Information Processing Machine**

Although Graziano rejects neural synchrony as well as integrated information theory, he admits that his proposal, information processing machine theory, “does not explain how the brain generates consciousness” either. But Graziano simply dismisses a subjective, conscious experience as an illusion, a “distorted, cartoon sketch of itself and its world.” However, stating that something is an illusion or a distortion indicates that one has knowledge of the original to draw such a comparison. If one has knowledge of the original, undistorted self, then the subjective conscious experience is not an illusion and, thus, requires an explanation. Besides, one’s phenomenal data and “cross-modal unity” (common subject unifying mental events across different modalities in the brain) provides empirical evidence for subjective conscious experience. In other words, I am the one perceiving a black and white dog barking, growling, then biting my leg while experiencing the pain of that bite, and noticing that I am in pain. These are my sensations and experiences.

But Graziano’s information processing machine theory is also problematic because human beings are not machines but biological organisms. Even physicalists agree that the brain is a complex, organic system, with “dynamic interactions among widely distributed groups of neurons,” or as a “distributed system with a large number of components that process information in parallel.”

Moreover, the brain does not act like a machine when it comes to memory storage. Although certain neurons are activated when remembering an event, this is not the same thing as storing that event in individual neurons as memory storage (like a computer) as if the image itself could be physically

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32 Michael Graziano, “Most Popular Theories of Consciousness Are Worse Than Wrong.”
33 Ibid.
34 Eric La Rock, “From Biological Naturalism to Emergent Subject Dualism,” 110.
located in one neuron or another.\textsuperscript{37} Psychologist Robert Epstein adamantly rejects the information processor metaphor because, unlike the accuracy in computer memory retrieval, human memory can only provide a representation rather than an exact replica. That is, for human memory, an individual might not clearly remember all the fine details of, for example, a dollar bill; or he or she might remember additional or alternative colors and sensations associated with how he or she felt about the dollar bill at a given time. In fact, each time the individual remembers the dollar bill, the image might be slightly different. On the other hand, a computer retrieves an exact replica of the dollar bill, accurate in every detail, every time; nothing more, nothing less. Moreover, for human memory, it is harder to visualize or remember something in its absence than recognize it in its presence. Remembering is about trying to relive an event. But recognition only requires being “conscious of the fact that we have had this perceptual experience before.”\textsuperscript{38} Computer memory is simple, direct, fixed, and replicable. Human memory, on the other hand, is a complex jigsaw or mosaic, dynamic, changed by our unique experience, and irreplicable. It is unique to each individual because each individual has different unique experiences which are attached to those memories. Remembering a dollar bill will always be uniquely different to each separate individual. Therefore, the information processing machine model should also be rejected.

So even though these various physicalist solutions have been offered, the binding problem for the unity of phenomenal conscious experience is still left unexplained if consciousness must be identified with the physical brain.

\textbf{Dualistic Solutions}

But what about some form of dualism, as some philosophical naturalists recommend? David J. Chalmers suggests a solution which transcends the neural states in his “naturalistic dualism.” He notes that “objectual unity cannot unify all of a subject’s conscious states”\textsuperscript{39} since a subject will be observing more than one object at the same time, as well as experiencing other mental states (hunger, physical pain, specific philosophical beliefs). Instead, he proposes “subsumptive unity,” which encompasses the “subject’s \textit{total} conscious state.”\textsuperscript{40} Such a single mental state would need to transcend the physical brain and its respective stimuli in order to unify all other conscious states. This is why Chalmers is a dualist, albeit a naturalistic one. He suggests that “psychophysical laws,” which “are eternal, having existed since the beginning of time,” explain conscious experience, which accompanied physical systems that had


\textsuperscript{38} Robert Epstein, “The Empty Brain.”


\textsuperscript{40} Ibid. Emphasis in original.
evolved to satisfy the “relevant conditions” for these laws.\(^{41}\) But then this would imply some sort of “preestablished harmony” which is, as William Hasker notes, “something that could be the result either of a fantastic stroke of luck, or of the action of an intelligent agent. But the first of these is incredible, and the second is incompatible with naturalism.”\(^{42}\)

Another dualist solution is emergent dualism. That is, consciousness evolved or emerged from the physical brain as a separate physical entity. But how could mental properties have emerged from physical properties? In order for this to have been possible, everything, at its most basic level, would have to have “proto-mental properties.”\(^{43}\) However, as J. P. Moreland explains, such “latent mental potentialities in matter” would violate “the nature of naturalism since it implies that mental properties are ultimate in the universe as potential properties of matter that emerge when matter is organized in certain ways.”\(^{44}\) But if the mental entity just emerged as a brute case without explanation, then that would imply an uncaused entity, something coming from nothing (\textit{ex nihilo}), which would also violate naturalism.\(^{45}\)

Some physicalists would suggest that hierarchical organisms exhibit whole-to-parts causation (top-down), which would explain mental properties being physical emergent properties with causal effectiveness. However, in physical hierarchical structures, “microphysical processes are causally closed to efficient causal intervention from higher levels.”\(^{46}\) That is, higher processes cannot causally interact and affect the lower level processes. Moreover, any movement or causation that has been observed has been “towards wider and wider configurational patterns at the same level of reality, towards larger units of interaction.”\(^{47}\) That is, movement is outside-in, not top-down. Therefore, any “mental” properties in such a physical hierarchy would have no causal effect on the physical brain. Hence, they would be impotent. Therefore, such a “mental” entity could not unify the various features in the brain or provide phenomenal unity; and we are back to monism.

So it appears that naturalistic dualism also fails to resolve the binding problem. However, neuroscientists need not be restricted to a naturalistic explanation.

\(^{47}\) Ibid., 138.
Substance Dualism

In fact, neuroscientist Sir John Eccles is a substance dualist. He proposes a “commonsense view” of “dualist-interactionism” where the conscious self, the immaterial mind, interacts with the material brain; in other words, the mind and brain as two separate entities.\(^{48}\) Therefore, the “the unity of conscious experience is provided by the self-conscious mind and not by the neuronal machinery of the neocortex.”\(^{49}\) In fact, all that the neural mechanisms of the brain can do is “code” information about lines, shapes, and colors. But it is the mind that reads out this information, giving a unified visual experience, and providing meaning to that experience. The mind selects and interprets all this coded information.\(^{50}\)

Moreover, evidence from neuroplasticity supports substance dualism where the self can control the brain, and is even capable of directing the brain to develop new neural pathways to replace those that have been damaged. In *You Are Not Your Brain*, psychiatrists Jeffrey M. Schwartz and Rebecca Gladding differentiate between the biological brain, the mind, and the “true self.” It is the true self that uses the mind to focus attention and “rewire” the brain to move in more positive directions and make more positive decisions, actions and habits.\(^{51}\) When areas of the brain have been physically damaged, the assumption in neuroplasticity is that adjacent areas in the brain compensate for the damaged area (on the same side of the brain). However, this was not the case for Connie, a sixty-five-year-old stroke victim, whose right brain was damaged so that she lost movement on her left side. Scan evidence demonstrated that Connie was able to train her left brain to “borrow” areas from her right brain in order to move her left hand. In effect, her left brain performed “double duty” of controlling both her left and right hands. Initially this was problematic because she would end up moving both left and right thumbs at the same time. But eventually she was able to “disconnect the two sides” so that she could move either side at will.\(^{52}\) This evidence demonstrates that not only is the self not at the mercy of the brain, but it is able to make major changes to the brain. This would be consistent with a separate, immaterial substance that is correlated with the brain, but able to control it.

Some would object that the substance dualist cannot explain how a nonphysical entity can causally interact with a physical entity. But just because we do not know how A causes B, does not automatically rule out this causal interaction, even if A and B are different. For instance, we know that magnetism, gravity, and atomic forces exist even though we may not know how such forces causally interact with various physical, “solid, spacially located, particle-like entities.”\(^{53}\) Since scientists do not


\(^{49}\) Ibid.

\(^{50}\) Ibid.


\(^{52}\) Ibid., 37-38.

reject such interactions even though their causes have different natures from their effects, then substance
dualism should not be rejected solely on the basis of the mind and body having different natures,
especially considering the evidence supporting such a mind-body interaction; i.e., when we think about
moving our arm and our arm moves, or when a brain injury causes feelings and conscious experiences of
pain. As Eccles noted, it is the commonsense view that such an interaction exists.

Conclusion

The binding problem in neuroscience presents a significant challenge for physicalists. Possible
neural mechanisms and models have been suggested, such as the specialized cell conjunction, neural
synchronization, or the information processing machine, which have been demonstrated to be
unconvincing, insufficient, and problematic. Naturalistic dualism either violates naturalism or lacks
mental causation and, thus, the ability to provide phenomenal unity. Only substance dualism provides the
best explanation for the unity of subjective, phenomenal experience. Moreover, it is supported by
evidence from neuroplasticity. Although some atheist philosophers like Alex Rosenberg would propose
that subjective conscious experience is just an illusion,\textsuperscript{54} commonsense would indicate that an immaterial
subjective self, an “I,” exists that is separate but interacts with the physical brain.

Inc., 2011), 147. Rosenberg’s radical scientism forces him to conclude that our thoughts are not about anything at all (p. 162-93)!
Bibliography


