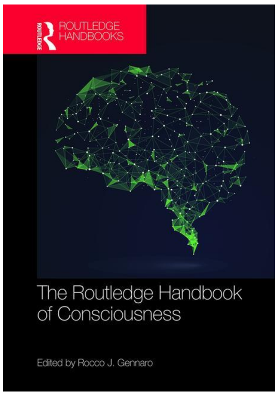

The Routledge Handbook Of Consciousness

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The Neural Correlates of Consciousness

Publication details
https://www.routledgehandbooks.com/doi/10.4324/9781315676982-18
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Published online on: 26 Mar 2018

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THE NEURAL CORRELATES OF CONSCIOUSNESS

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1 What Is the Neural Correlate of Consciousness?

At first blush, it seems that explaining what the "Neural Correlate of Consciousness" (NCC) is should be straightforward: it is whatever that happens in our brains when we have a conscious experience that is lacking when we are not having conscious experiences. But this simple answer is misleading. It turns out that there might not be an NCC – even if we adopt a purely materialistic and reductionistic framework for explaining consciousness.

To explain more definitely what NCC references, we must first say a bit about what "consciousness" refers to. Although dualists and materialists disagree with each other on just about everything, they do agree, in general, about the phenomena they are trying to explain. As John Searle explains, consciousness refers to "those states of sentience and awareness that typically begin when we awake from a dreamless sleep and continue until we go to sleep again, or fall into coma or die or otherwise become unconscious" (1997: 5).

Being sentient or aware seems to be a pretty straightforward account of consciousness, but a closer look reveals that it does not fully account for the complexity of conscious phenomena. Intuitively, we would want to say that both of the following are instances of being conscious: being aware of the brown table in front of me as being brown and in front of me, on the one hand, and being alert and ready to interact with the environment, on the other. These two cases are different enough from one another that it might make more sense to understand consciousness as a set of phenomena and not as a unitary thing. At least until we know more about what consciousness is exactly, we should divide conscious phenomena into at least two categories: being aware of a perception and being in a state such that we can have such a perception in the first place.

Following David Chalmers (1998, 2000), we can talk about content states of consciousness and background states of consciousness. Content states of consciousness align more closely with what most philosophers mean when they talk about consciousness. These states are "the fine-grained states of subjective experience that one is in at any given time" (Chalmers 2000: 19). They encompass, for instance, the experience of the sound pattern of a song one is listening to, the experience of the softness of a surface one is touching, or the experience of one's own train of thoughts. These conscious states are specific events in our day-to-day experience and Chalmers calls them "content states," because they are usually differentiated by their content (i.e., the specific sound pattern, the specific haptic feeling, the specific thought, and so on). The content states of consciousness are also sometimes called phenomenal states (Block 1995, 2004) or subjective experiences (Dennett 1993) or qualia (Crane 2000; Jackson 1982). These names all refer to "the way things seem to us" (Dennett 1993: 382). While we may not know what consciousness is exactly, we do know a lot about where and how perception is processed in our brains. Some of these experiences are conscious, so perhaps this is the way in to identifying what it is that happens in our brain when we are conscious.

The background states of consciousness are "overall state[s] of consciousness such as being awake, being asleep, dreaming, being under hypnosis, and so on" (Chalmers 2000: 18). This is what most doctors are referring to when they say that their patient is conscious. These states are the common framework for other more specific conscious states (the content states of consciousness) and can influence the latter. For instance, different background states of consciousness, such as being alert as a healthy individual or being alert but with schizophrenia may affect the way one perceives objects and events in the world. We would expect – indeed, we know – that the brains of patients with schizophrenia are structurally different from the brains of normal controls, and that the two different types of brains can react differently when given the same stimuli. We know some things that are going on in the brain that keeps us alert and oriented – though not as much as we do about perception – and perhaps this too is a way in to identifying what it is about the brain that connects alertness with being aware.

It is clear that the two main categories of conscious states are related to each other in important ways, but that they are also connected to different brain structures. The part of our brain that perceives things in our environment is different from the part of our brain that keeps us oriented to the world. And yet, something must distinguish those neurons or neural firing patterns or brain structures that are aligned with consciousness from those that are not. If we could isolate what that something is, then perhaps we will have found the NCC.

Francis Crick and Christof Koch (1990) were the first ones to discuss the idea of NCCs in the scientific press in a serious fashion (see also Crick 1994; Crick and Koch 1995; Koch 2004; Rees et al. 2002). They started by assuming an unabashedly materialistic position and argued that eventually consciousness has to be explained by something at the neural level. They then assumed that "all different aspects of consciousness … employ a basic common mechanism or perhaps a few such mechanisms" (1990: 264). That is, they just assumed that whatever consciousness is, it can be explained by a single thing in the brain – the thing that distinguishes conscious brain activity from unconscious brain activity. This is an important and significant presumption, for they were claiming more than consciousness being just correlated with some sort of brain activity (despite the name "neural correlates of consciousness"). They are claiming that understanding the difference between conscious and unconscious phenomena will depend fundamentally on understanding something about the brain.

In their original paper, they argued that consciousness is realized by a group of cortical neurons all firing together in unison at some particular frequency (see also Hardcastle 1995; Singer 1999). This is one possibility for what the mechanism of consciousness might be, but many other proposals have been floated over the years. For example, at about the same time as Crick and Koch were postulating neural oscillations as the correlate for consciousness, Gerald Edelman (1989) hypothesized that consciousness was localized to the thalamocortical and limbic systems; ten years later, in a similar vein, Antonio Damasio (1999) claimed consciousness was to be found in the frontal-limbic nexus.

Edelman distinguishes between two types of immediate consciousness awareness: primary and higher-order. "Primary" consciousness refers to awareness of objects and their properties present in the world around us. "Higher-order" consciousness refers to being aware that we are aware. It is the mental model we have of ourselves as a thinking, experiencing creature. He notes that the interactions of our thalamus and cortex allow us to perceive things in the world around us. When our thalamocortical system is connected to our limbic system, we are then able to assign valances and values to things in the world. Edelman claims that a special reentrant signaling process evolved in our cortical systems that permit us to connect our memories of valued things with incoming perceptions in real time and in parallel across multiple sensory systems. With the advent of this special process, primary consciousness appeared.

Damasio also postulates two types of consciousness: core consciousness and extended consciousness. These map directly onto Edelman's primary and higher-order consciousness. Like Edelman – and unlike Crick and Koch – he does not see consciousness as a single unified phenomenon. Also much like Edelman, Damasio believes that the interactions among the limbic system, the thalamic region, and cortical areas are the correlates for his "core" consciousness. Though he emphasizes different aspects of the structures (less importance is attached to reentrant signaling; more is given to the contributions of the posteromedial cortex), in both views, the thalamocortical system is key to understanding the neural correlate of primary or core consciousness.

Both Edelman and Damasio conclude that multiple brain regions underlie higher-order or extended consciousness, for our self-models need access to many different memory systems, among other things. Later research suggests that perhaps the "default network" recently uncovered in imaging studies might be a central actor in the neural correlates of our conscious sense of self (Addis et al. 2004;Vogeley and Fink 2003). (The default network [or default mode network, as it is sometimes called] refers to the multiple interconnected regions of the brain that remain active when a person is not thinking about or noticing anything in particular. It is what is active by default, as it were.)

Other proposals for the NCC have included left hemisphere based interpretative processes (Gazzaniga 1988), global integrated fields (Kinsbourne 1988), the extended reticular-thalamic activation system (Newman and Baars 1993), intralaminar nuclei in thalamus (Bogen 1995), neural assemblies bound by NMDA (Flohr 1995), action-prediction-assessment loops between frontal and midbrain areas (Gray 1995), hemostatic processes in the periacqueductal gray region (Panksepp 1998), and thalamically modulated patterns of cortical activation (Llinás 2001). Suffice it to say, there really is no agreement among scientists or philosophers regarding what the NCC might be.

More importantly, as these suggestions have piled up over time, we are beginning to realize that perhaps Crick and Koch were wrong in their initial assumption that there is a single brain mechanism that would account for all of consciousness. For each suggestion really only attempts to explain how the hypothesized brain structure or activity gives rise to some aspect or other of consciousness. For example, global fields or transient synchronous firing assemblies of neurons might indeed underlie individual subjective experiences, but thalamic projections into the cortex could help knit the diverse individual experiences into a single integrated conscious perceptual experience of the world. Left hemisphere interpretative processes could explain our sense of conscious self-awareness over time, and the reticular-activating system could help to account for our background sense of alertness. It is possible that each of these distinct neural theories is true, with each contributing some partial explanation of the full complexity of consciousness.

Despite Crick and Koch's initial assertion, there is no reason to think that consciousness cannot be realized in various locations or by utilizing a number of different mechanisms. Perhaps there is no single NCC, but we should be looking for several different neural mechanisms to account for the full range of conscious phenomena. Instead of the "neural correlate of consciousness," we should seek instead the "neural correlates of consciousness" (the NCCs).

The complexity of what the brain might be doing that differentiates being conscious from not being conscious suddenly becomes enormous. A better research agenda might be to investigate different aspects of conscious awareness, looking for different NCCs that underlie each one.

In hindsight, simply assuming an NCC appears to be theoretical overreach. And yet, even if we adopt the more sophisticated approach for identifying underlying brain activities or processes associated with aspects of consciousness, there are still several troubling problems with this putative research agenda.

2 Some Problems with NCCs

Consciousness is often described as being completely puzzling – McGinn (1991) refers to it as a "residual mystery." Such a description is completely understandable because of consciousness's ill-defined boundaries, its fully subjective character, the vividness of our phenomenological experiences, and, perhaps most importantly, the complete opacity of its purpose. What does being conscious do for us? Or what does it allow us to do? For any particular human activity, it seems that we (or perhaps a computer) could do the same task without being conscious. And indeed, for many human abilities, we do have machines that can mimic them successfully. This hazy status of consciousness in relation to human thought and behavior raises questions regarding its relation to the science of psychology or neurobiology. Here, we look at two of these problems: the *explanatory gap* and the *hard problem of consciousness*.

The "explanatory gap" (Levine 1983; Horgan 1999) is the name given to the inability of physical theories to fully account for the phenomenology of consciousness. Any scientific account of consciousness – any brain theory about the NCC – faces the problem of explaining how the rich Technicolor of conscious phenomenology just is, or is the product of, some non-experiential physical interaction. Saying "the experience of the color red just is coherent oscillations of such-and-such neurons in area V4" says nothing about how these oscillations give rise to the feeling of seeing the color red. While the experience of the color red might be *correlated with* neural oscillations, that is not the same thing as them being reducible to or identical with these oscillations. Any putative reduction of consciousness to some physical interaction seems to leave out the very thing it wants to explain: the conscious experience itself. There is necessarily a gap in any putative scientific account of consciousness and its target of explanation.

And this of course creates problems for people like Crick and Koch, who believe that identifying the NCC will provide a theoretical explanation for what consciousness is. If there is an explanatory gap, it will not really help us to know that coincident oscillations in the brain co-vary with consciousness, for example, because brain oscillations are just too different a thing from conscious mental states. We have no intellectual or theoretical bridge from one to the other. Without such a bridge, knowing about these sorts of co-variations is not going to be explanatorily helpful, and if it is not explanatorily helpful, then it will not provide a good foundation for a scientific theory of consciousness.

Discussions of the explanatory gap come in different degrees of severity. Some think the explanatory gap is a kind of practical inability of our current scientific theories (Dennett 1991; Nagel 1974). In principle, it might be possible to bridge the gap, but our current scientific theories are not ready to do it yet. Others agree that it is in principle possible to bridge the explanatory gap; however, it is impossible for creatures like us to do it (McGinn 1991, 1995; Papineau 1995, 2002; Van Gulick 1985, 2003). Human beings are just lacking the cognitive capacity to close the explanatory gap. Finally, there are those who claim that the explanatory gap is impossible to resolve in principle, that the gap is conceptually unbridgeable (Chalmers 1996, 2005; Jackson 1993). Dualists primarily believe this strongest version.

We can see the hard problem of consciousness (Chalmers 1996, 2010) as the other side of the explanatory gap coin. The explanatory gap refers to the putative impossibility of accounting for subjective experience by physical theories, and the hard problem of consciousness asserts that physical theories cannot account for why subjective experience exists at all. Proponents of the hard problem argue that science cannot account for why some systems are conscious, but others are not. The hard problem of consciousness assumes the veracity of the explanatory gap, in other words.

David Chalmers articulates the issue in the following way:

> What makes the hard problem hard and almost unique is that it goes beyond problems about the performance of functions. To see this, note that even when we have explained the performance of all the cognitive and behavioral functions in the vicinity of experience – perceptual discrimination, categorization, internal access, verbal report – there may still remain a further unanswered question: *Why is the performance of these functions accompanied by experience?*
>
> (Chalmers 1995: 202, emphasis in original)

Even if all of science is completed, there will always remain the further question of why some of the systems science has explained are conscious, in addition to whatever else it is they do. Chalmers believes that such question cannot be addressed in physical terms; otherwise, science would have addressed it. Therefore, consciousness has to be something non-physical. Others believe that the hard problem is just that – a hard problem – and it does not make any further claims about the metaphysics of consciousness.

These two problems affect consciousness studies in general. However, the problems are especially relevant for neurobiological approaches to consciousness, and hypotheses about the NCC in particular. The challenge for NCCs raised by these two problems can be understood as operating at two levels. On the one hand, it is possible that no NCC could ever account for the whole phenomena of consciousness. That is to say, after finding the neural correlate for some specific subjective experience, we still will not be able to know why it is that particular experience that feels that particular way. Even if we have a well-constructed and refined theory of the neural correlates of consciousness, it may never completely explain what we really care about with respect to phenomenological experience. On the other hand, NCCs may simply be the wrong approach to explaining consciousness. If the subjective experience of the color red, or any other qualia, is non-physical, then seeking their neural correlates seems to be a task without a purpose.

Most advocates for trying to identify the NCCs have little patience with these two alleged problems (cf., Churchland 1986; Crick and Koch 1990; Hardcastle 1995). They see the arguments as some sort of exaggerated reasoning from oddness that many dualists have, a kind of intellectual hysteria, as it were. In particular, they believe that proponents of the explanatory gap and the hard problem do not understand how science proceeds. A lot of science tackles strange things and many of its explanations are counter-intuitive and, frankly, intellectually unsatisfying. Quantum mechanics can be like this. That some folk now cannot see how a biological theory of consciousness could account for the raw feelings of phenomenology is not a strike against biology or a victory for consciousness mysterians; rather, it says something about those folk. Perhaps their inability to see how 40-Hz oscillations just are a conscious visual experience points to a failure of imagination on their part, and not to a failure of science.

But more importantly, science is in the business of seeking correlations. Smoking is correlated with lung cancer. Physiologists can dig into the chemistry of cigarette smoke and the biological composition of lung tissue to help flesh out this correlation. We learn that benzo(a) pyrene, a chemical found in cigarette smoke, is correlated with damage to DNA, and chromium, another chemical in cigarette smoke, is correlated with benzo(a)pyrene sticking more actively to DNA, and arsenic, yet another chemical in cigarette smoke, is correlated with slower DNA repair processes. But, it is just correlations all the way down. Some of the correlations we call "causes" to emphasize their importance in our ultimate story, but all scientific investigations can ever give us are a series of correlations.

We can turn the series of correlations into an explanatory narrative: the chemicals in cigarette smoke cause cancer because benzo(a)pyrene damages our DNA, while chromium helps benzo(a)pyrene stick to our DNA, which increases the amount of damage done, and arsenic prevents the DNA damaged by benzo(a)pyrene from repairing itself. And it is this narrative of a series of correlations that gives us the satisfying sense of a good explanation. But it is very difficult, in a pre-narrative state, to argue that any possible story about how something comes about is just not going to work for us. We have to start with the correlations and then build from there.

Any science of consciousness follows exactly this pattern. Perhaps we find some correlations in the brain between neural activity and consciousness. Neurophysiologists can then dig into these correlations to learn more precisely what is correlated with what, which we can then turn into an explanatory narrative. There is nothing different about consciousness that makes its science suspect or more difficult. The only thing that is different is that people cannot see how the narrative might go before we have the correlations. But we daresay that that has been true for a lot of things we would like to have had explained: like the plague before we knew about bacteria, or fire before we knew about oxidation. Who could have antecedently imagined germs or invisible chemical reactions before we uncovered correlations that indicated that these things existed? At best, right now, we can say that science should do its work and then later we can see where we stand with respect to moving from NCCs to a story about where consciousness comes from and what it is. It could be that we never will be able to develop an intellectually satisfying neurobiological explanation of consciousness. But even if we cannot, it is unclear, at this stage in the game, whether this would be because consciousness falls outside the realm of what science can explain, or because we failed in our scientific endeavors, or because we do not like what our science is telling us.

3 Embodied Approaches to NCC

A different sort of problem for uncovering NCCs comes from positions that are purely materialistic, but not brain-centered. We are speaking of "embodied cognition" approaches to understanding the mind (Calvo and Gomila 2008; Shapiro 2014). Embodied cognition refers to a wide range of theories of cognition that assume that any explanation of a cognitive process will also have to reference both the body and the environment. As such, embodied cognition approaches challenge brain-exclusive explanations of cognitive phenomena.

Andy Clark and David Chalmers (1998) highlight the relevance of body and environment for cognition using the following demonstration. First, they challenge students to do a difficult multiplication problem (each multiplicand is ten digits long, say) in their heads. This is hard, if not impossible, for most math-literate students to complete successfully. Then, they pose the same challenge again, but this time the students get to use pencil and paper. The task suddenly becomes much easier. What differentiates the two tasks? The math problem is exactly the same. What changes are the resources available to accomplish the assignment. If a pencil, a piece of paper, and a hand to write with are all crucial for accomplishing this cognitive task, then it would seem that any explanation of mathematical ability requires more than simply a description of brain activity. Proponents of embodied cognition believe that these sorts of examples demonstrate that body and environment have to be included in our explanations of the mind, for our minds can only function in our particular bodies interacting with our particular environment. And we need to understand our bodies and our environment in order to understand our minds.

Consciousness seems to be a cognitive phenomenon and, as such, should therefore perhaps also be considered embodied. This means that NCCs alone will not suffice in explaining subjective experience. For defenders of embodied cognition, as much as we have to appeal to a pencil, paper, and a hand in offering a complete explanation of the cognitive process behind multiplication, we would also need to appeal to the relevant aspects of body and environment in order to offer a complete explanation of consciousness. Hence, NCCs might form some part of a scientific theory of consciousness – they could potentially help us understand connections between bodily action and conscious experience – but, in and of themselves, they would never be a complete explanation of the phenomena (see also Hutto and Myin 2013).

For example, we have data concerning the neural correlates of consciousness in action. Increased activity in the posterior parietal cortex, which is tied to our intending to move and our picking out which action we want to select (Tosoni et al. 2008), is correlated with our experiences of motor execution in the environment (Desmurget and Sirigu 2009, 2012). When surgeons gently stimulate Brodman's areas 39 and 40 (which form part of the parietal cortex) in awake and alert patients undergoing brain surgery, the patients report experiencing intentions to move, as well as illusory movements themselves. When the electrical stimulation increases, patients believe they actually have moved, even though there is no neuromuscular activity. In contrast, when surgeons stimulate the premotor region, the area of the brain associated with actual bodily movements, the patients have no conscious awareness of any action, even though they really do move (Desmurget et al. 2009).

Interestingly, our conscious experiences of action seem to be independent of the physical movements themselves. Instead, we become aware of intentions to move just slightly in advance of the movements themselves (cf., Haggard 2005), and these experiences double as our experience of the movement itself (cf., Desmurget and Sirigu 2009, 2012). Conscious awareness then seems to co-occur with intending to move purposefully in the world instead of actually moving. That is, consciousness (or, more accurately, some aspect of consciousness) might be correlated with our planning how to move our bodies in our current environments.

If embodied cognition is the right approach for explaining cognition, then we are left with two questions for explaining consciousness. First, what are the relevant features of body and environment that would be included in a complete theory of consciousness? And second, what kind of descriptions and methodologies should be used to integrate NCCs, the body, and the environment into the one explanation? We explore two different approaches to answering these questions using embodied perspectives: *neurophenomenology* and *extended conscious mind*. The first supports the project of identifying NCCs; the second does not.

Francisco Varela (1996) first proposed the idea of "neurophenomenology," which combines first-person reports of conscious experiences with the neurophysiological approach typically used in NCC research. Neurophenomenology integrates phenomenological and neurophysiological investigations of conscious experience with each other, while at the same time, trying to make explicit the relationship these two methodologies have to each other.

Phenomenology has a long and multifarious history in philosophy, starting with Edmund Husserl (1900, 1913, 1928) in the early 20th century. But the basic idea behind phenomenology is a rigorous examination of the structure of conscious experience, as experienced from a first-person point of view. The expectation is that all first-person experiences have invariant features, things that are common to all conscious experiences. Identifying those stable features is the ultimate goal of a phenomenological investigation.

The "neuro" of neurophenomenology refers to a physiological account of consciousness, the same as the NCC project. However, proponents of neurophenomenology put a twist on the basic NCC assumptions. The classic Crick and Koch approach to the NCCs is unidirectional, moving from neural activity to conscious experience. That is, something about some particular set of neurons (or their interactions) causes consciousness to occur. But neurophenomenologists believe that neural events, which are embedded in bodies and their environments, and conscious states exist in a bidirectional or "reciprocal" relationship (Thompson and Varela 2001: 418). Conscious states emerge from brain-body-world interactions and then they in turn constrain what the brain-and-body can do in its environment.

Neurophenomenology describes NCCs as part of a larger and more complex system that accounts for consciousness as a whole. Using embodied approaches to consciousness, in general, and neurophenomenology, in particular, means that consciousness must be understood in terms of brain-body-environment interactive systems, with each component constraining and being constrained by the others. Any complete explanation of a conscious experience will have to integrate elements across all these different elements, showing how they are all connected to each other. Classic conceptions of NCCs as the things in the brain that are the only things that are correlated with conscious experiences are wrong-headed. NCCs are likely to be included in any explanation of consciousness, but a complete one will have to take in account other aspects of both the body and the environment.

In addition, neurophenomenology requires that the aspects of the body and the environment that play a role in conscious experiences are constitutive parts of the experiences themselves. The core idea is that, unlike more reductive accounts of consciousness, both body and environment are causally relevant for consciousness; both body and environment are part of the mechanisms of consciousness, just as the NCCs are. There is a multi-directional causal relation between NCCs, the body, and the environment, with each affecting the others as the others are also affecting each. A consequence of this view is that how to articulate what the NCCs are is likely to be extended in space and in time, as the usual ways that the body and the environment affect neural firings in the brain is through very particular neurosensory and neuromuscular junctions.

In general, according to proponents of neurophenomenology, the way to understand the underlying physiology of consciousness goes as follows: a localized neural state causally affects large-scale neural dynamics, which then causes the body to move, which impacts the environment, which causes changes in sensory inputs, which affects the large-scale neural dynamics, which also change local neural states. A full explanation of consciousness should account for all these different types of interactions and the multi-directional relations among them.

Perhaps most importantly, though: "phenomenologically precise first-person data produced by employing first-person methods provide strong constraints on the analysis and interpretation of the physiological processes relevant to consciousness" (Lutz and Thompson 2003: 33). That is, we need our subjective descriptions of conscious experiences to help us interpret what is happening inside the brain. Perhaps, too, as we use our first-person descriptions to inform our neuroscience, then the "third-person data produced in this manner might eventually constrain first-person data, so that the relationship between the two would become one of dynamic 'mutual' or 'reciprocal constraints'" (Lutz and Thompson 2003: 33).

The methodology of neurophenomenology is bidirectional as well. On the one hand, using a phenomenological analysis, subjects will provide refined and precise reports of conscious experiences to researchers, which could provide important details that otherwise might be glossed over. Such a practice might describe distinctions between two similar conscious events that would have remained unnoticed without this type of analysis, for example. This then might improve the analysis of the physiological data, as the target of investigation would be clearer. Small differences in EEG results, for example, could gain a new meaning, if small differences in conscious experiences are articulated. On the other hand, a more detailed physiological analysis of the NCCs might constrain additional phenomenological analysis of conscious experiences. For example, by understanding the changes at the neurophysiological scale, subjects might be able to understand their own conscious states better or to see new distinctions among them. So, not only could the phenomenological analysis of conscious events lead to a better understanding of the physiological results, but improved physiological analysis leads to a better phenomenological interpretation of consciousness. This bi-directionality of theory and methodology are the cornerstones of neurophenomenological approaches to understanding conscious experiences.

To take a concrete example: focal epileptic seizures start in specific parts of cortex and then remain confined to that area or spread to other parts of the brain. Where the seizure originates and how it spreads determine the symptoms of the seizure. Often these symptoms include changes in the conscious experiences of the patients. Patients with epilepsy often experience "auras," or sensory hallucinations (usually visual or auditory, though sometimes olfactory or gustatory), at the onset of a seizure. Temporal lobe seizures can also result in the experience of familiarity, or *déjà-vu*. Walter Penfield (1938) discovered that stimulating small areas in the temporal lobe also causes this experience of familiarity. It follows that activity in the relevant area in the temporal lobe is relevant to the experience of familiarity. The local neural event helps account for a global sensation.

The converse appears to be the case as well. We know that both bodily states (like stress or lack of sleep) and the surrounding environment (flashing lights) can trigger seizures in those with epilepsy (Engel 1989). About half of patients with epilepsy experience warning signs (headaches, nausea, irritability) that a seizure in immanent. Scientists are now able to align these symptoms with changes in the global dynamics of brain activity as well as with changes in bodily states and the environment (Le Van Quyen et al. 2001; Le Van Quyen and Petitmengin 2002). Importantly, it appears that some patients can use these experiential and environmental cues to decrease the probability that they will have a seizure by using biofeedback and classical conditioning techniques (Fenwick 1981; Schmid-Schönbein 1998). The patients are using global parameters, including their own insights regarding their conscious experiences, to affect local neural events.

Neurophenomenology seems to articulate the way the science of consciousness actually proceeds. As the examples recounted above show, scientists who study aspects of awareness spend their time measuring behavior and environmental events, as well as brain changes, and trying to account for how they all impact personal experiences. Philosophical analyses of neurophenomenology help clarify the importance of accurate and full first-person descriptions of experiences and, we hope, we will be able to see its influence in seeking NCCs going forward.

The other dominant embodied approach to understanding consciousness is the Embodied Conscious Mind (ECM). Alva Noë is one of its main proponents. He argues that, "for at least some experiences, the physical substrate of the experience may cross boundaries, implicating neural, bodily and environmental features" (2004: 221). The main thesis of ECM is that consciousness itself is not exclusively located at neural level, but it crosses boundaries at the brain-body-environment system.

Notice that this is a more radical position than neurophenomenology, which remains agnostic regarding where consciousness resides exactly. Neurophenomenologists hold that brains, bodies, and environment are all necessary for understanding what consciousness is and how it functions, and that there is a causal bi-directionality between experience and neural states, but most are perfectly comfortable with the idea that particular brain states or activities correlate with particular conscious experiences. It is just that the brain states or activities come about via an interaction with other experiences, bodies, and the environment. ECM, in contrast, holds that the correlates of consciousness itself run outside of the brain. Neurophenomenologists believe some version of NCCs exists, but ECM-ers explicitly deny that there is such a thing as NCCs.

We can understand ECM as a particular instance of the extended mind thesis in general (Clark and Chalmers 1998). Just as pencils, paper, and hands comprise part of the cognitive process of multiplication, so too do bodies and the environment comprise part of conscious experience. From the extended mind perspective, these external (or non-neural) objects constitute, at least in part, the very physical substratum of mental states.

One way to appreciate the ECM perspective is to consider how we project ourselves through objects in the world. A blind man using a cane, for example, does not experience the cane while he taps his way down a sidewalk; rather, he experiences the world at the end of the cane. Similarly, when we write with a pencil (perhaps when we are doing multiplication) we feel the end of the pencil writing on the paper, even though of course our nerve endings do not extend to the end of the writing implement. We are projecting our bodily awareness through the end of the pencil. Or when we walk in shoes, we can feel the pavement below us; we do not feel the inside of the shoes. We project ourselves through our shoes. Proponents of ECM say that the cane, the pencil, and the shoes all become part of our conscious system.

We can measure the edges of conscious projections experimentally. For example, Tony Chemero and his colleagues devised an experiment that forces change in our extended conscious experience (Dotov et al. 2010, 2017). Undergraduates engaged in a simple video game, using a computer monitor and a mouse. At irregular intervals during each trial, the connection between the mouse and the monitor was disrupted. When students were engaged in the video game, they were not aware of the hand-mouse interface per se, but once the connection between mouse and monitor was altered, then the mouse grabbed their attention and they become aware of it. Once the disruption was over and the connection returned to normal, then the awareness of the hand-mouse connection disappeared. Chemero and his colleagues argue that during the normal phase of the task, the mouse was part of the conscious system. During disruption, it was not. Though the details would take us too far afield, they are able to measure changes in underlying behavioral dynamics that reflect the changes in conscious experience. Their point is that we project ourselves into our environment, and in so doing, we consciously experience the edges of our extended cognitive system.

The remaining question for ECM is how this might relate to putative NCCs. Most proponents of ECM (Hurley 1998; Kiverstein and Farina 2012; Loughlin 2012; Manzotti 2011; Ward 2012) accept that the role neural states play in conscious experience is fundamental. (However, some of the radical embodied approaches to consciousness deliberately and explicitly avoid the appeal to brain states as an explanatory tool [e.g., Silberstein and Chemero 2012, 2015].) They take ECM as a theory that may account for some or most conscious experiences although they agree that some other experiences might be purely internal or brain-dependent (like headaches, for example). However, as Pepper (2013) points out, the way in which ECM relates to NCCs is different from the way the extended mind thesis relates to brain states in general. According to the main proponents of the extended mind thesis, external objects constitute mental events when they are used in the same way that we might otherwise just use our brains to achieve the same end. Using a pencil and paper might help us do a multiplication problem, but the pencil and paper are substituting for what we could do with just our brains if we had to. The case of consciousness, however, seems to be slightly different. It is difficult to imagine an extension of a conscious event in functional terms. But, when we project ourselves into the environment, we are not substituting something external for some inner process of consciousness. Conscious experience is not extended into the environment by causally replicating what we might do internally, but the experience itself is constituted by whatever it is we are projecting ourselves through. In this sense, consciousness "extends beyond the brain by its very nature" (Pepper 2013: 100).

If this is the case, then there is no NCC. Conscious experience is not constrained by the sorts of bodies we have and the types of environments we are interacting with. Rather, consciousness is located out in the world just as much as it is located inside the head.

Of course, there are several who flatly disagree with this perspective (e.g., Gennaro 2017; Metzinger 2000; Revonsuo 2000) and argue that proponents of ECM confuse constituency with causal relevancy. That is, if we lost significant portions of our brain, we could thereby lose consciousness. However, if we lost significant portions of our environment, our ability to perceive our environment, our ability to interact with the world, even if we lost significant portions of our body, we could still be fully and richly conscious. We are reminded of the anti-war classic *Johnny Got His Gun* (Trumbo 1939/1994). The point is, some things in the brain-body-environment complex are more relevant for consciousness than others. The search for the NCC is a search for those things most relevant.

Crick and Koch (1990) articulated a very simple vision for how to investigate and understand consciousness: isolate the thing inside the brain that is correlated with experience and you will have identified what consciousness is. Unfortunately, it turns out that whatever story ends up being told about consciousness is going to be much more complicated. Already we can see that there likely is not a single thing that accounts for the wide variety of conscious experiences we have. Probably, we will find many different neural correlates for many different aspects of consciousness. In addition, it seems naïve to believe that we can understand the brain or our minds in isolation from the bodies they are housed in and the environments in which we live. Hence, understanding consciousness is going to at least require matching changes in brain activity with changes in its surroundings and vice versa. At the end of the day, it remains to be seen whether seeking the neural correlates for consciousness is a productive approach for understanding our phenomenal experiences.

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