The Mind-body Problem and Cognitive Neuroscience: A Brief History and Outlook

Alex Ball

Abstract

Cognitive neuroscience investigates the relationship between mental processes (such as perception, attention, thought, and memory) and physical states of the nervous system. This relationship gives rise to the mind-body problem, which has long been the subject of debate in philosophy. Over the last century, discussion of the problem has been informed by a deluge of empirical evidence from brain and mind sciences. While promising as a method of inquiry, cognitive neuroscience runs into an exceptional difficulty in explaining how non-conscious physical systems gain the ability to have an internal, first-person conscious experience that is characteristic of a mind. The challenge of this gap in explanation is commonly known as the "hard problem" of consciousness. Unlike the conceivably resolvable "easy problems" for cognitive neuroscience, such as merely correlating specific brain states with wakeful mental states, the "hard problem" does not have a readily apparent path to solving it. This article will explore early conceptualizations of consciousness, how cognitive neuroscience and related fields have changed how we think about conscious mental states, and what future possibilities there are for achieving a complete understanding of the conscious mind.

The Challenge of Consciousness

The mind-body problem is a long-standing question in philosophy: what exactly is the causal relationship between the properties of the mind, particularly conscious experience, and the physical brain? Consciousness, while a notoriously contentious term, generally means possessing subjective experience with varying levels of wakefulness. A person, animal, or thing is said to be conscious when they are in some capacity phenomenally aware of the contents of their cognition, such as thoughts, perceptions, beliefs, and emotions. Such contents are referred to as mental states in philosophy of mind, and a person possesses conscious mental states in wakeful life or when dreaming and is seemingly absent of them when in deep dreamless sleep, a coma (Laureys, 2005), or under sufficient general anesthesia (Alkire et al., 2008; Pavel et al., 2020).

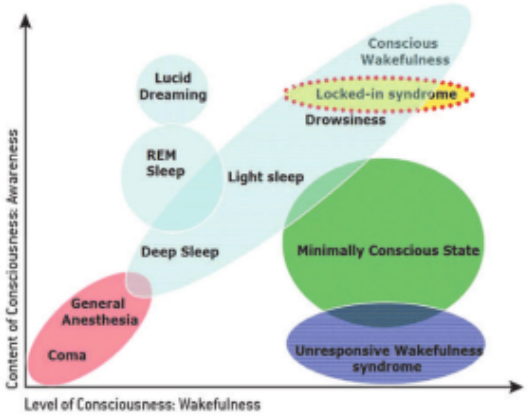

Figure 1. Schematic Diagram of GPCR Structure (Neumann et al., 2014).Figure 1. Schematic Diagram of GPCR Structure (Neumann et al., 2014).

Conscious mental states are considered to be part of the mind; they are mental phenomena. For cognitive neuroscience, the challenge of the mind-body problem lies in explaining the precise relationship between such mental properties and the physical brain in an objective manner to establish a unified scientific understanding of both mind and body. Intuitively, the mental is separate from the physical. There is an apparent difference between the third-person objectivity of the world examined by the sciences and the first-person subjective nature of conscious mental states, which has historically led to the mind and body being thought of as fundamentally separate (but related) phenomena.

Historical Origin of the Problem and Mind-body Dualism

The mind-body problem may have earlier conceptual origins in western philosophy, but the most influential early attempt to resolve it came from rationalist philosopher René Descartes. Descartes posited that mental and physical activity occurred in a fundamentally separate, but connected view called substance dualism. He claimed that there are two fundamental aspects to reality: the substance of matter, which is spatially extended in the world and includes the physical body, and the substance of mind (or soul), which is immaterial and non-spatial (Descartes, 1641/1986). Descartes speculated that the pineal gland, recognized today as a melatonin-secreting endocrine organ (Axelrod, 1974), facilitated the interaction between mind and body as the "seat of the soul." While research into the pineal gland has failed to support such a hypothesis of interaction, Descartes' idea of the body as a purely physical system paved the way for further objective scientific inquiry into human biology, as immaterial causes were localized to only mental activity and the body largely lost its sacred status (Shapin, 2000). Mind-body dualism continues to be a popular notion in folk psychology. Regardless, the view has fallen out of favor as a viable theory of the mind due to the lack of a coherent explanation for interaction between substances and, chiefly, in light of our modern understanding of the nervous system.

The Mind-Body Relationship Today: Contributions From Cognitive Neuroscience

Dominant philosophical theories of the underlying nature of consciousness, and the most relevant for cognitive neuroscience, are under the umbrella of physicalism: the doctrine that reality, including the mind, fundamentally consists of only physical things. Contrary to substance dualism, only the material substance exists. The popularity of physicalist theories of the mind can be attributed to the empirical study of the brain indicating that the instantiation of the mind is dependent on physical systems, and that its mental processes can be disrupted by physical alteration. For Descartes (1649/1989), the ability to think and to reason was a facet of an immaterial and rational soul. Contrarily, conscious mental processes have been shown to be just as functionally indebted to the physical structure of the brain as the unconscious regulation of the heartbeat, respiration, and digestion. One such example is working memory (WM), which is critical for the conscious manipulation of information.

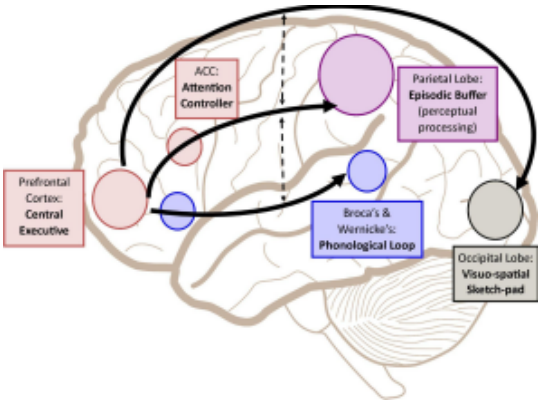

Figure 2. Simplified illustration of Baddeley's (2010) multicomponent model of working memory, demonstrating multiple cortical structures thought to be involved in various tasks (Chai et al., 2018).

Neuroimaging techniques have discovered that the frontoparietal network and regions such as Broca's and Wernicke's areas, the basal ganglia, the thalamus, and the caudate nucleus variously activate depending on the WM tasks performed (Chai et al., 2018). Lesions following traumatic brain injury to such regions (often in the frontal lobe) consistently impair WM tasks (Owen et al.,1990; Barbey et al., 2013).

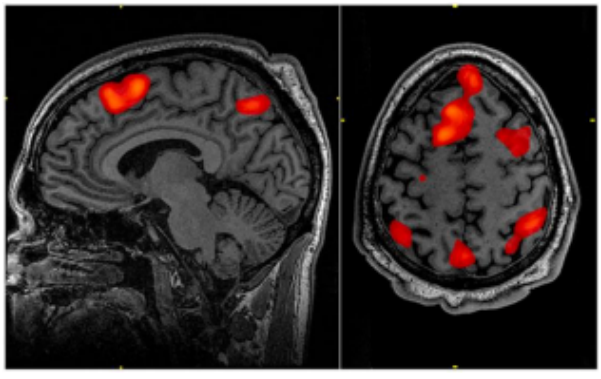

Figure 3. Highlighted regions of an fMRI scan display activity during two different working memory tasks (Graner et al., 2013).

Additionally, WM can be further explored at the genetic and molecular levels. For example, Hsiao et al.'s (2020) findings suggest that boosting or hampering the expression of the gene Gpr12, which encodes the G-protein-coupled receptor GPR12 in mammals, has substantial effects on WM. The researchers associated a higher concentration of GPR12 proteins in the thalamus of mice with better performance in WM tasks in mice, and found that performance suffered when the encoding gene was underexpressed. GPR12 is an orphan G-protein-coupled receptor, meaning its exact endogenous ligand is presently unidentified, but the path to a molecular understanding of WM is entirely conceivable. At first glance, it seems possible for cognitive neuroscience to provide an explanation of the entire causal relationship between particular states of the brain and the functioning of WM and countless other mental processes in the future. However, in the above scientific theories, something vitally important has been left out of the picture. WM is a conscious mental process, and the phenomenal awareness of mental content – one of the most basic properties that separate a conscious state from a non-conscious one – has managed to evade a reductive explanation.

The Explanatory Gap

Physicalism is often thought of in its reductive form, in which a higher-level property (such as heat) can be functionally explained in the terms of its lower-level properties (molecular motion). A reductive physicalist theory of the mind maintains that the basic elements of consciousness, subjective conscious mental states, can be translated into lower-level properties. A completely reductive understanding of the mind needs to take mental phenomena and reduce them to the language of biology, which can be further translated to chemistry and physics, neatly fitting consciousness with our best scientific theories about the world. Reductive physicalist theories of the mind have increasingly come under fire, including from other physicalists who propose that reducing subjective experience to physical terms is an impossible task. Such perspectives emphasize the epistemological limits of science, irrespective of the ontological status of the mind as physical. Nagel's (1974) widely influential article "What is it like to be a bat?" argues that consciousness means there is "something that it is like" to undergo mental states for organisms, such as bats, and that such an internal experience is inaccessible to understanding from the outside. According to Nagel, a human cannot understand what it is like to be a bat just by understanding every physical fact about the animal. Levine (1983) highlights that while we can find certain biological correlates for conscious perceptions such as pain, a scientific explanation for the actual subjective feeling of something like the slow nociceptive pain that seems to result from the activation of C-nerve fibers is nowhere to be found. The central element to these arguments against reductive physicalism is the idea of qualia: a conscious mental state has a qualitative, subjective feeling that is experienced, such as the redness of an apple or the sourness of a lemon. Perceptions like color can be reduced to physical explanations in the objective sense by understanding electromagnetism and how the nervous system converts photons into neural activity, but the

explanation lacks subjective quality, instances of which are called qualia. Trying to explain redness to a congenitally blind person is fruitless because there is, supposedly, no explanatory means to understand qualia without actually experiencing them. If non-reductive accounts of the mind are true, then the intractability of subjectivity is concerning for reductive physicalism and broader hopes that cognitive neuroscience can resolve the mind-body problem.

The gap between explaining physical systems and explaining the capacity for qualia is an important point of the contemporary debate over the mind-body problem. Some reject the commonsense idea of qualia, viewing the concept as a category mistake that requires further progress in neuroscience to truly understand (Churchland, 1985; Dennett, 1988); others posit that qualia are (however rudimentarily) a fundamental aspect of some or all physical things (Strawson, 2017). Regardless, bridging the explanatory gap is what Chalmers (1995) has coined "the hard problem" of consciousness, which every complete theory of mind must address in some capacity. The "easy problems" of consciousness, according to Chalmers, are those that are conceptually possible for a physicalist inquiry into the mind, such as a complete understanding of only the neural correlates of consciousness. As the above arguments from philosophy of mind have demonstrated, finding a place for the phenomenal awareness aspect of consciousness alongside our reductive explanations of the natural world seems to require a radical reconsideration of either qualia or reality itself.

Concluding remarks

Cognitive neuroscience has contributed to the debate surrounding the mind-body problem by narrowing the realm of possibility through the scientific study of the mind's relationship with the body. When it comes to consciousness, cognitive neuroscience may only be capable of fully explaining the far from trivial "easy problems," leaving the explanatory gap unbridged. The fundamental nature of the mind and consciousness may always remain an unsolvable mystery. Alternatively, the present difficulty in reconciling reductive physicalism with certain properties of consciousness may open the door to entirely new ways of thinking about the mind that have yet to be known or even conceptualized. Whether the mind-body problem can be ultimately solved or not, cognitive neuroscience and related fields provide valuable and practical insights into the mental processes of the elusive conscious mind.

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