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Brains and Minds

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Abstract

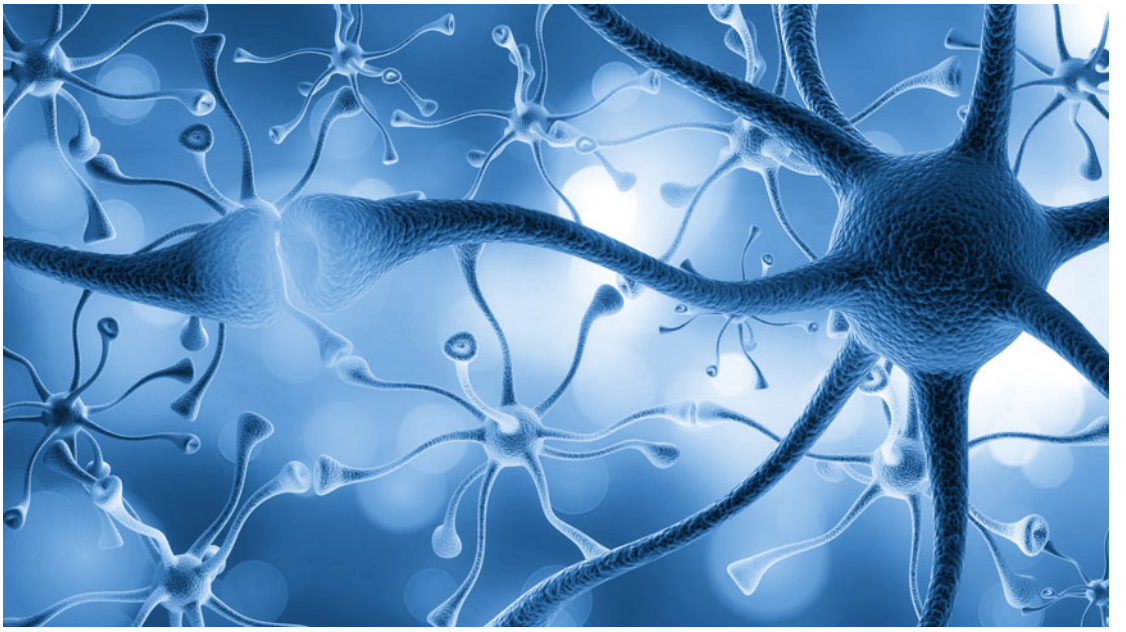
How can and does science – and especially neuroscience – inform the philosophical puzzle of mind and body?

What is Neurophilosophy? It is a field that seeks to make progress on traditional questions about the nature of the mind by collaborating with neuroscientists, geneticists, anthropologists and psychologists. Such topics include decision-making, the self, ethical values and consciousness. Neuroscience studies nervous systems at many levels, from whole systems (e.g. vision, planning) to single cells (neurons) to chemicals that transmit signals between cells (e.g. serotonin). Only very recently have technological inventions made it possible to get real data on brains at all levels. Hitherto, these big-scale questions about the mind were the province of philosophers and their speculations. In addition to the brain sciences, genetics, physics, computer science, psychology and evolutionary biology contribute to progress on big-scale questions about the mind.

As the ancient Greeks saw things, philosophy (meaning 'love of wisdom') encompassed all bodies of knowledge, including mathematics. Natural philosophy targeted phenomena in the natural world, thus embracing subjects we now consider part of science – physics, chemistry, astronomy, geology, anthropology. Moral philosophy, in Aristotle's view, targeted practical matters, whereas natural philosophy and mathematics sought true laws and explanations.

In the last two decades, philosophy, as a 'big-questions tent', has undergone reconfiguration in its problem space as well as in its approach to addressing problems. This is especially so for the topic referred to as the *philosophy of mind*, but also in related subjects such as linguistics and computation. For much of our history, the basic question was whether the mind is part of the natural world, as the brain is. Or instead, maybe the mind is a spiritual or spooky thing, completely unlike the physical brain.

The words 'mind' and 'brain' are distinct. Even so, that linguistic fact leaves it open whether mental processes are in fact processes of the physical brain. (Remember: water and H_2O are different words, but they do name the very same stuff.) A favoured theory in philosophical thought, championed by Plato, and developed by Descartes, holds that just as the words 'mind' and 'brain' are distinct, so too are the processes. This approach is known as *dualism* – a *'two stuffs'* theory, postulating both physical stuff and the absolutely different, soul stuff. Thinking and awareness, according to dualism, are processes of the non-physical mind or soul.



Digestion is what a physical body can do. For dualists, such as Plato and later Descartes, the mind–body problem is the problem of how a physical state of the brain can causally interact with a totally non-physical state of the soul. After all, if I press one eyeball, I see double, so there seems to be a connection. And how can the non-physical mind be studied?

By contrast, according to an equally venerable if less fashionable tradition, there is only the brain; mental processes are processes of the physical brain whose exact nature remains to be discovered. This approach is sometimes known as 'physicalism', and historically found adherents in Hippocrates, Aristotle, Hume and Helmholtz. Physicalists realize there is no problem about how the mind and body interact, inasmuch as there are not two things, but only one thing: the brain. The mind is what the brain does. For them, the important problem concerns how the brain learns and remembers, how the brain enables us to see and hear and think, how it enables us to move our eyes, legs and whole body. Traditionally, their problem concerns the nature of the brain mechanisms that generate mental phenomena. How can brain mechanisms of colour vision or thinking be studied?

As the brain sciences, and biology more generally, made revealing advances in the twentieth century, dualistic theories seemed increasingly implausible. This sort of resolution of old debates is common in history. Very often empirical discoveries bumped up against what had seemed obviously true. For example, having made detailed observations, Galileo showed that yes, in fact the Earth *does* move around the Sun, not the other way around. This was considered heresy by the Catholic Church, and Galileo spent his last years under house arrest. Grinding his own lenses for his microscope, Leeuwenhoek observed spermatozoa, red blood cells and bacteria, revealing things hitherto invisible. Heresy, once more, though no house arrest, mercifully. In the case of brain tissue, Cajal used his microscope to examine brain tissue, and found very tiny cells, unusual cells that had tree-like tops and long – sometimes very long – tails. These brain cells (neurons) were very unlike blood cells or muscle cells. Observing the anatomy is essential, but we want to know more. How do neurons and networks of neurons work?

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To be sure, physicians from ancient times had noted paralysis following spinal cord lesions, or speech loss following a stroke. While important, these early observations remained just intriguing observations because they lacked a background framework regarding the anatomy and electrophysiology of the basic units of nervous systems – neurons. In the 1950s, Hodgkin and Huxley performed benchmark experiments showing something unexpected – neurons ran on *electricity*. They did not know exactly how they worked, but it was evident that neurons sent and received electrical signals. The function game was on.

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Brain Sciences Begin to Mature

By the middle of the twentieth century, some philosophers began to suspect that discoveries about the brain would impact conventional ideas about the mind in much the way that they saw discoveries about DNA, genes and RNA impacting traditional ideas about the nature of life. One striking phenomenon was seen in a patient who had suffered bilateral damage to the *hippocampus* (a small curved structure tucked into the cerebral cortex), as a result of surgery to control epilepsy. The patient suffered a catastrophic loss of the ability to learn new things (known as *anterograde amnesia*). His old memories were intact, but he could remember nothing after his surgery. This finding initiated a massive research programme to understand the relation between learning and memory, and the hippocampal structures. We now understand that the hippocampus is essential for learning new things. We also know quite a bit about how the hippocampus works. For example, neuroscientists have discovered that memories acquired during the waking hours are consolidated during sleep, as the hippocampus hands information off to the cortex where it gets more permanent storage. Sleep is not just rest.

One of the most dramatic observations of mind–brain dependency came from the split-brain studies published in the late 1960s. These studies involved patients whose cerebral hemispheres were surgically separated in order to treat drug-resistant epilepsy. The nerve sheet connecting the two hemispheres – the corpus callosum – was cut, thereby disconnecting the cortex of the right and left hemispheres. The aim was to aid the patient by preventing a seizure from travelling from its origin in one hemisphere to the other hemisphere. Astonishingly, tests of 'split brain' subjects showed that the mental life of the two hemispheres was also disconnected; the right hemisphere might see something or decide something that the left did not, for example.

The implications for the mind–body problem were obvious: if mental states were not brain states, why would cutting the corpus callosum have the disconnection effects? Although a defiant dualist might invent some story to accommodate the facts (and a diehard few did this), the best and most reasonable explanation for the disconnection effects was simply that a physical change interrupted a pathway essential for mental unity. Soul stuff was just not in the game. As Michael Gazzaniga (2015), one of the leading split-brain researchers puts it, consciousness can be split.

Developments in psychology, especially visual psychology, tended to dovetail well with the neuroscientific findings on the visual system. Explanations of human colour vision, for example, showed that the colours we see depend on the three cone types (red, blue and yellow) in the retina. Dogs, however, can see in the ultraviolet range as they have retinal cones sensitive to ultraviolet electromagnetic radiation (light), but

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they have only yellow and blue cones and hence cannot see red. No point in getting a red ball for Fido. It was well appreciated that much in the world – such as ultraviolet and radio waves – could not be detected by our visual system because of its physical structure. In particular, the cones in the human retina are not sensitive to and do not respond to ultraviolet and radio waves. Genetics played a role here too, for some humans have deficits in one or other cone type, and cannot see the full range of colours that typical humans can, a feature that can be inherited.

Short-term memory can be transiently blocked by a blow to the head or by a drug such as scopolamine; emotions and moods can be affected by alcohol; decision-making can be affected by hunger, fear, sleeplessness and cocaine; elevated levels of cortisol cause anxiety. Very specific changes in whole brain activity corresponding to periods of sleep versus dreaming versus being awake have been documented. Moreover, explanations for the neuronal signature typifying these three states have made considerable progress. Consequently we are beginning to understand more about the brain basis for awareness. In aggregate, these and related findings weighed in favour of the hypothesis that mental functions are a subset of functions of the physical brain, not of some spooky 'soul stuff'.

Maybe Consciousness is Independent of the Brain

A popular argument that aimed to show that neuroscience can never explain consciousness is owed to the contemporary philosopher David Chalmers. Dualist in spirit, the argument consists essentially in a *thought experiment*, which roughly goes as follows: I can imagine a person, like me in every way (attention, short term memory, use of language, laughs at jokes), but completely lacking in qualia – qualitative experiences such as feeling short of breath or seeing the colours of a rainbow fade. My brain and Zombie's brain are, in this story, *exactly* the same. In sum, this individual would be exactly like me, save that he would be a Zombie. So what, you might ask? Here is the conclusion Chalmers wishes to draw: because the scenario is imaginable, it is *possible*; since it is *possible*, then whatever consciousness is, it is independent of the brain.

Does Chalmer's conclusion follow? No, not even a little bit. Not even if you are charitable. The glaring flaw lies in relying solely on what *seems possible* or imaginable to establish some factual hypothesis about what *is actual*. After all, what is and is not conceivable is merely *a psychological fact about us* – about what we can and cannot imagine, given our capacity for imagination. It does not constitute factual evidence about the nature of things. I can imagine running faster than the speed of light, but in reality, I cannot. I can conceive of waking up some morning to find that I am a new-hatched chicken. Nothing follows about me or chickens, except that I have a vivid imagination.

Additional problems loom: if Zombie is, as the thought experiment requires, *exactly* like me, then can it too imagine a world in which there are Zombies without consciousness? It's not clear how to make sense of this. Incidentally, notice too that if Chalmers acknowledges that Zombie has *attentional* capacities but no conscious awareness, he also runs up against the neuroscientific data showing that attention is a feature of conscious states. And the neurobiology of attention is well underway. So perhaps the fanciful Zombie is not exactly like me, after all. Wait: perhaps Zombie *is* like me and hence has conscious experiences because its brain is exactly like mine. The wheels seem to have come off.

The history of science has a parallel to dualism – *vitalism*. Typical of vitalists generally, my high school biology teacher argued thus: no one can explain how living things can emerge from dead molecules. Out of bits of dead proteins, fats, sugars, how could life itself emerge? He thought it was obvious from the sheer mysteriousness of life, that the nature of life could not possibly have an explanation in biology or chemistry. His unwavering intuition about mysteriousness assured him he could just tell that life would require a *non-biological* solution – *vital spirit*. By 1953, with the discovery of the molecular structure of DNA and how its organization embodied a code for making proteins, the vitalist game folded. Done for.

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Both Chalmers's argument and the vitalist arguments are examples of arguments from ignorance (*argumentum ad ignorantiam*, if you want to sound like you took my logic course). Here is the general form of the fallacy: I do *not* know something (e.g. how the brain produces consciousness) so I *do* know something (e.g. that the brain does not produce consciousness). The fallacy is well named.

Additional weight to the hypothesis that the mind is a function of the brain comes from what we understand about brain evolution. Evolutionary biology indicates that nervous systems are the product of evolution, and that the human nervous system is no exception. Comparisons of anatomy between human and non-human nervous systems have revealed that the functional organization, at both macro and micro levels, has been highly conserved over hundreds of millions of years. Although human brains are larger than the brains of most other land mammals (elephants aside), we share the same structures, pathways, innervation patterns, neuronal types, and neurochemicals. Get this: neurons in a fruit fly work essentially the same way as neurons in the human brain. Molecular biology has revealed that the genetic differences between humans and our nearest relatives, chimpanzees (*Pan troglodytes*) and bonobos (*Pan paniscus*), are actually very small (Striedter et al. 2014).

These evolutionary relationships imply that either no mammals have non-physical souls, or all do. Now questions flood in: if humans and only humans have a soul, where do human souls come from, and why does the soul suddenly appear, some 4 million years after the homo species branched off from our common ancestor with chimpanzees? Did extinct Homo species such as Homo erectus and Homo neanderthalensis have souls too? Based on cranial measurements, anthropologists believe that the brains of Homo neanderthalensis were typically a bit larger than human brains. Fossil remains suggest that Neanderthals probably had some form of acoustic communication. Moreover, genetic data from fossils reveal that they did interbreed with Homo sapiens. What about *their* souls? Still other questions challenge the idea that the human soul, not the human brain, is the repository of all that makes us clever. How can ravens and rats and monkeys solve complex problems as they certainly do, how can they sleep, dream, pay attention, and so forth, if a soul is needed for such functions?

How Do Dualists Explain How a Mosquito Bite Causes Awareness of an Itch?

An ongoing dilemma for dualists concerns the observed dependencies between consciousness and brain activities. For example, administering the anaesthetic propofol to me will cause me to lose consciousness. My dog barks, I hear her. I touch a hot pot, I feel pain, and so on and on. A common dualist strategy is to propose that *conscious states just run parallel to brain* states. This idea may be clarified by the hypothesis that conscious states neither cause nor are caused by brain states – the two streams are causally isolated.

Historically the most renowned defender of this two-way causal isolation was Gottfried Leibniz (1646–1716). Leibniz held this view because he thought that it was inconceivable

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that the soul is physical and inconceivable that completely different substances could interact causally. (Sound familiar?)

The dualist is doomed to peddle a two-stream story, but now the pressing puzzle is this: what keeps the two streams synchronized? Here is how Leibniz dealt with the puzzle: God sets up and maintains a 'pre-established harmony' to keep mental and physical states properly aligned. Good old God, always there to help out a dumbfounded philosopher. Needless to say, Leibniz's miracle solution is *ad hoc*, cobbled together in order to fill an embarrassing chasm.

Chalmers does not appeal to God, but he does wave towards a future physics that he expects will explain the alignment between non-interacting streams of mental and brain events. A revolutionary new physics, according to Chalmers's conjecture, will ultimately explain the nature of consciousness as a non-brain phenomenon. I have been unable to escape the feeling that this is really the old Leibniz gimmick, suited up in the duds of a future physics instead of theology.

Granting that there are remaining questions and unsolved problems in physics, is there a rationale within physics for claiming that a revolution provoked by the mysteries of consciousness is on the cards? According to Chalmers, there must be, because nothing less will explain consciousness. Consciousness is so extraordinarily mysterious that only a revolution in physics will account for it. Physicists generally acknowledge the possibility of a new theory at the subatomic level to link strong forces, weak forces and gravity. But they are quick to point out that these are phenomena in the range of 10^{-17}, not in the range of milliseconds and micrometres (10^{-3}), where neurons exist and function. The puzzles in physics that motivate a possible revision to the standard model are at the wrong spatial and temporal scale to offer even the barest hint of a solution to the matter of explaining consciousness.

Where Now?

The book *Neurophilosophy* (P. S. Churchland) was first published in 1986. Since then, powerful new tools and techniques have been developed in neuroscience, mathematics and computer science that even as recently as twenty years ago would have seemed like pipe dreams. A trend visible in the last century but which has become commonplace is that many fields now boast brilliant thinkers who reflect carefully and productively on the big, broad questions about the mind-brain that once were the province of philosophical speculation. Rather than relying on mere 'thought experiments' about consciousness, researchers craft and run real experiments. Huge arrays of electrodes on the cortex can record what happens when a subject is preparing a movement or is anaesthetized with propofol or is dreaming. Rather than the 'write-a-program' paradigm in computer science, massive artificial neural networks that learn from examples have become insightful tools for generating ideas about how networks of real neurons might accomplish certain tasks such as learning a language. Legal scholars are rethinking some legal issues, such as the insanity defence in criminal cases, in the context of new developments in genetics and neuroscience. Drawing on data across a range of fields, conversations among scientists and empirical philosophers are typically more insightful and productive than the limited speculations of those twentieth-century philosophers who gave priority to thought experiments over real experiments.

A rich carnival of results and hypotheses has emerged from a broad range of thinkers, a range that encompasses many academic fields and that reaches well beyond academic philosophy. I tend to see this broad range in the spirit of ancient Greek philosophy, and in those big-question people such as Euclid, Galileo, Kepler, Darwin and Crick. Philosophy now, as in the Renaissance, is not confined to just those questions that academic philosophers once deemed to be proper philosophical questions. Convention-breaking, along with cross-disciplinary fertilization, has meant that people gleefully learn to talk across boundaries, which results in both clarification and fruitfulness. New ideas sprout and take hold in such fertile conditions. For data-loving philosophers, this freedom to explore and play in the wider biological world has turned out to be a lot more fun than being stifled by data-scoffing philosophy.

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