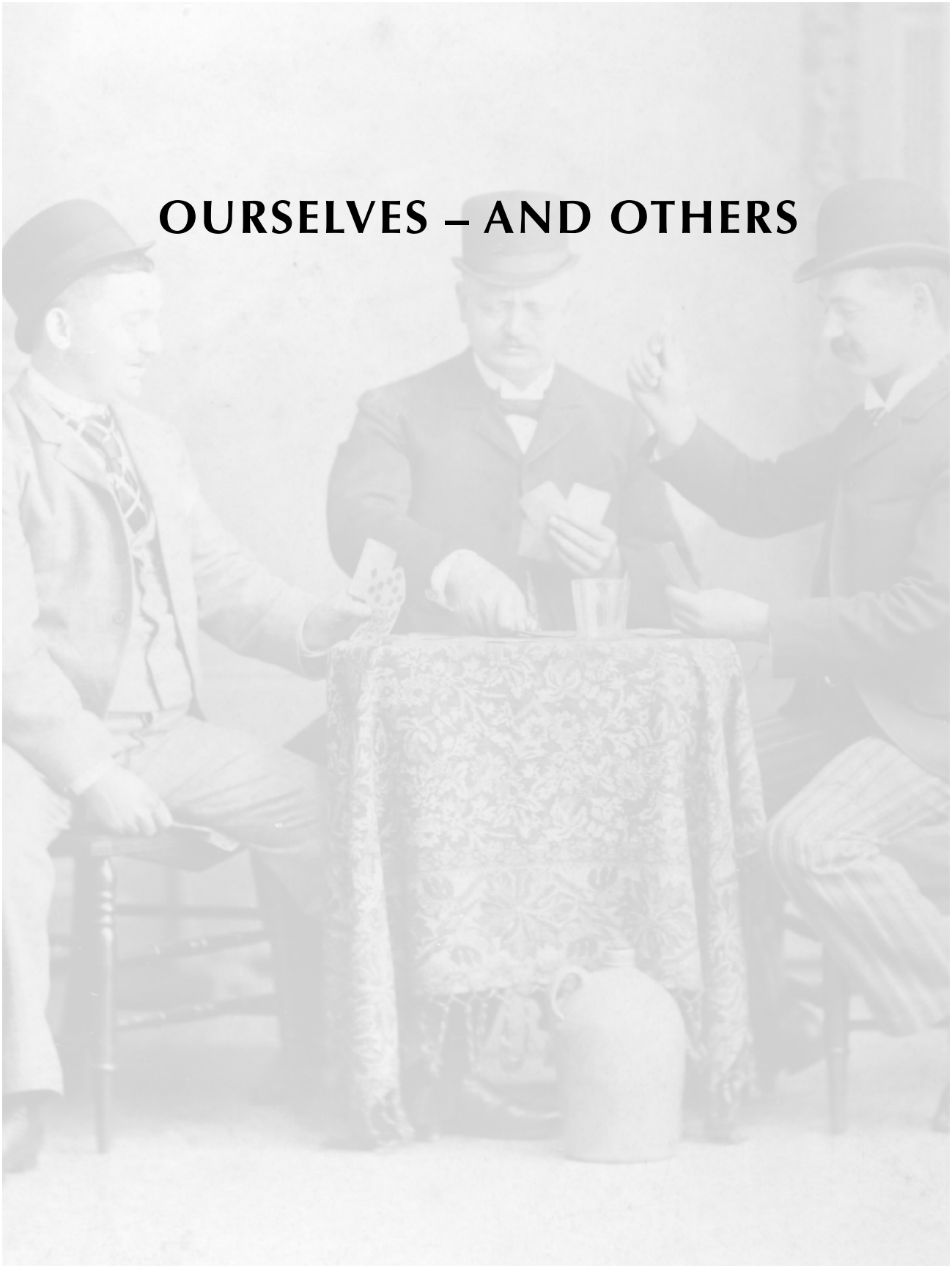
OURSELVES – AND OTHERS



1 Consciousness

IN A NUTSHELL

Consciousness is something we all believe we possess, but saying exactly what it is has long challenged philosophers. Since the mid-1800s, scientists have found ways of probing brain activity, and linking it to traits we believe are vital for consciousness, such as free will and responding to stimuli. Studies of brain activity suggest that consciousness is just a very small part of brain activity, but one which is created from sensory input only after colossal effort. Experiments suggest that it takes around half a second for the brain to make us conscious of outside stimulation – though the delay appears to be "edited out" by the brain to keep it out of awareness. The result is a conscious mind with a model of reality that allows us to do more than merely react to stimuli or the bidding of our unconscious instincts – and turns us into sophisticated beings.

The room is full of people, yet totally silent. Sitting on cushions, their eyes are closed and their faces expressionless. They look totally absorbed in something – as well they might, for they are attempting to get to grips with one of the most profound mysteries in all science: the nature of consciousness.

As practitioners of Buddhist meditation, they are using techniques of mind-watching developed over 2500 years ago by the Indian philosopher Siddhartha Gautama, better known as the Buddha. The aim of these techniques is to turn the conscious mind in on itself and to watch it in action.

According to Buddhists, such introspection can give insights into the nature of mind, reality and the mystery of consciousness. Such claims have traditionally cut little ice with scientists, with their insistence on objective evidence. Yet now highly trained Buddhist monks are joining with scientists to probe the nature of consciousness. By summoning up mental states while undergoing brain scanning, the monks are opening up a new approach to what consciousness researchers call The Hard Problem: how does brain activity produce the experience of being conscious?

For something most of us are sure we possess, consciousness has proved amazingly hard to pin down. The seventeenth-century French philosopher René Descartes thought he had made a major advance by using a

TIMELINE

528 BC Indian philosopher Siddhartha Gautama makes study and control of consciousness the basis of a movement now known as Buddhism.

401 AD The philosopher and Catholic saint Augustine of Hippo identifies self-awareness as a key aspect of consciousness, declaring "I understand that I understand".

1637 French philosopher René Descartes puts forward his "dualistic" view of mind and body, arguing that the mind is not merely the actions of the brain.

1690 In his "Essay Concerning Human Understanding", the English philosopher John Locke defines consciousness as "the perception of what passes in a man's own mind".

1874 German psychologist Wilhelm Wundt moves consciousness out of purely philosophical inquiry, and advocates its study via introspection.

1890 Pioneering psychologist William James of Harvard University rejects Cartesian dualism, and concludes that consciousness is just a product of brain activity.

1913 American psychologist John B. Watson criticises attempts to study consciousness as hopelessly subjective, turning the field into a backwater for decades.

1929 Austrian psychiatrist Hans Berger invents electroencephalography (EEG), by showing that brain activity can be measured using electrodes placed on the skull.

1979 American brain scientist Benjamin Libet discovers the 0.5 second delay between brain activity and the conscious sense of deciding to act.

1988 Dutch-born psychologist Bernard Baars puts forward Global Workspace Theory, according to which consciousness is the process by which normally unconscious processes are brought together on a mental "stage".

1990s–present Advent of brain-scanning methods such as fMRI prompts huge increase of interest in consciousness by revealing brain activity in unprecedented detail.

logical argument to conclude that the conscious mind must be made of different stuff from brains and bodies, a distinction now known as Cartesian dualism. Yet even at the time, critics such as Baruch Spinoza pointed out that such a distinction raises profound problems about how mind and brain interact.

By 1690, the English philosopher John Locke had put forward the first working definition of consciousness as "the perception of what passes in a man's own mind". While this implied that consciousness was not so much a thing as an outcome of certain processes, what these were Locke could not say.

Not until the middle of the nineteenth century were scientists able to attempt an assault on the mystery of consciousness. The discovery of anaesthetics had revealed an intimate connection between body and mind – in flat contradiction of Descartes' claim. Researchers then set about tackling The Hard Problem, seeking ways of bridging the gulf between the subjective experiences of the mind and the objective study of brain activity.

In the 1860s, Wilhelm Wundt of Heidelberg University – now regarded as the father of experimental psychology – took the first tentative steps. Impressed by Spinoza's view that the conscious mind is a direct creation of bodily effects, Wundt set about trying to find out more about these effects. The technique he used was introspection, in which he trained students to note and describe their conscious response to outside stimuli.

Wundt's research highlighted the importance of understanding "qualia", the subjective experiences we have of the world around us – the "redness" of

red, or the "sweetness" of sugar. Yet while Wundt worked hard to make his work objective, it was hard to gauge if one person's experience was the same every time, or matched anyone else's experience. He also lacked ways of making reliable objective measurements of brain activity that he could correlate with the subjective experience.

By the end of the nineteenth century, Wundt's research had convinced leading figures such as the influential American psychologist William James that consciousness was a direct outcome of brain activity, and thus worthy of scientific study. Yet many scientists sensed the existing techniques were simply not up to the task. Frustrated by the lack of hard results, most switched to more concrete problems, and the study of consciousness became an academic backwater.

It did not dry up completely, however, and over the next half-century scientists developed a variety of methods for tackling The Hard Problem. In 1929, the Austrian psychiatrist Hans Berger made the first breakthrough by finding a way of detecting electrical activity within the brain. Called the Electroencephalogram (EEG), it allowed Berger to discover two types of electrical activity, known as alpha and beta waves, that seemed to be linked with key aspects of consciousness. Alpha waves, oscillating around 10 times a second, appeared to reflect the state of consciousness, becoming fainter during sleep or anaesthesia. Beta waves, on the other hand, were about three times faster, and reflected concentration levels and non-conscious responses like the startle reflex.

Berger's discovery began the study of what are now called neural correlates of consciousness (NCCs): types of brain activity associated with conscious experience. These are now a

JARGON BUSTER

The Hard Problem: According to many, this is the central problem any theory of consciousness must solve: how to link the objective, physical structure of the brain to the subjective feeling of being conscious. The term was first coined in 1994 by the Australian philosopher David Chalmers at the University of Arizona.

Dualism: A view of the conscious mind as something fundamentally different from the living, working brain. Originally put forward by the seventeenth-century French philosopher René Descartes – and still called Cartesian dualism – the idea that the mind is more than mere brain activity is not widely accepted today.

Quale: The subjective experience of, say, redness or the softness of wool or the taste of lemons. Impossible to describe, yet regarded as essential to the concept of being conscious, some philosophers contend there is no such thing as a quale (or, in the plural, "qualia").

Global Workspace Theory: A proposal for how the brain works, according to which consciousness exists as a kind of mental "stage" – the workspace – where the inputs from other independent parts of the brain which work unconsciously are brought together. GWT was put forward in 1988 by the Dutch-born psychologist Bernard Baars of the Neurosciences Institute, San Diego.

Neural correlates: Actual parts of the brain and nervous system whose function can be directly linked to aspects of consciousness. Using brain-scans and laboratory experiments, some scientists claim that key features of consciousness lie in primitive parts of the brain such as the thalamus and brain stem.

Nerve impulses

The brain consists of around 100 billion neurons, each one receiving electrical impulses from many others via connections called dendrites, and transmitting its response to its neighbours via a single thread called an axon. The connections aren't seamless, however, and to bridge these gaps, nerve-endings are equipped with so-called synapses. These turn electrical signals into molecules called neurotransmitters that flow across the gap, triggering fresh electric impulses on the other side.

major focus of research by scientists, many of whom think that understanding consciousness involves understanding how the brain binds together a host of NCCs into a single, unified whole.

It is a belief spurred on by a surprising discovery made in the 1960s: that our consciousness involves only a tiny fraction of all the activity in our brains. A team led by the American neurologist Benjamin Libet applied very weak stimuli to the skin of patients whose brains had been exposed for neurosurgery. EEG measurements revealed that their brains had detected the stimuli – yet the patients themselves said they could feel nothing. It was the same story with stronger stimuli which lasted less than 0.5 seconds: while the brains of the patients detected it, the patients consciously felt nothing.

Similar findings have since emerged from studies of NCCs such as vision and the resulting qualia like the "redness" of red. Our eyes take in a torrent of information at the rate of around a megabyte per second, yet our consciousness seems to ignore all but a tiny percentage of it.

This huge disparity suggests that the brain performs a huge amount of unconscious processing of sensory input, distilling it down before we become conscious of it. Such processing must take time to perform – suggesting there must be a time delay between our brains detecting a stimulus, and our mind consciously registering it. Attempts to measure this delay have led to perhaps the most startling discoveries yet made into the nature of consciousness.

In 1976, a team of researchers led by the German neurologist Hans Kornhuber set up an experiment to measure the time delay between the brain activity required to move a finger and actually making the movement. The speed of nerve impulses suggested the time delay would be around 200 milliseconds, similar to that of reflex actions. Yet the researchers found the delay was much longer. This was at least consistent with the idea that anything involving the conscious mind involves a lot of processing. The researchers found something else, however: the brain activity began around 800 ms before people finally got around to moving their finger. This was a startling discovery, with disturbing implications for the long-cherished notion of free will. For the sheer size of the delay hinted that our actions are not initiated by our conscious mind at all, but by the non-conscious brain activity taking place out of our perception.

An even more perplexing discovery was made in 1979 by Libet and his colleagues, during studies of the effect of applying direct stimuli to the brain.[1] Again, common sense suggested just a short delay between applying the stimulus and conscious detection – but again the researchers found a substantial delay, of around 500 ms. They also found something else: that the brain appears to "back-date" the conscious response, thus creating the

impression there was hardly any delay at all.

These two findings not only cast new light on the link between brain activity and consciousness, but also gave some hints about what consciousness is actually for. First, although our actions are not initiated by our conscious mind at all, our consciousness can at least veto any actions generated by our non-conscious brain that we deem unacceptable. Free will is thus not about consciously choosing to act in certain ways, but about consciously choosing *not* to act.

Second, Libet's experiments point towards a reason why the brain expends so much effort to create consciousness: it binds together sensory inputs from the outside world to produce a consistent and reliable model of what is happening "out there".

This notion of consciousness as a model of reality fits in well with the sense we have of our brains creating a kind of mental "theatre". In 1988, the Dutch-born psychologist Bernard Baars took this idea to create the so-called Global Workspace Theory of consciousness. According to this, conscious processes are those currently in the "spotlight" of mental attention, while others remain out of the spotlight, stored in the memory for immediate access. Meanwhile unconscious processes are at work behind the scenes – and also form the mental audience, responding to what is currently in the spotlight.

GWT appears to be more than just a metaphor: it is based on results now emerging from the biggest breakthrough yet in the objective study of conscious processes: brain-scanning. Techniques such as functional Magnetic Resonance Imaging (fMRI) give researchers detailed, real-time maps of brain activity, allowing it to be related to conscious processes. This has led to an explosion in studies of NCCs, with specific parts of the brain being identified as key players in conscious processes. For example, a central region known as the thalamus appears to be crucial in bringing sensory input into the "spotlight" of conscious attention, while the so-called ventro-medial cortex near the front of our brains seems to create our sense of life having purpose.

At the same time, researchers are beginning to look again at Wundt's methods for tackling the notoriously difficult subjective aspect of consciousness. They are recruiting people with decades of experience of examining their conscious states and reporting their experience: Buddhist monks. Early results from studies of monks undergoing brain-scans suggest that their years of intensive meditation allows them to produce stable mental states to order, giving researchers the consistency needed for reliable insights into the subjective experience of consciousness.

This meeting of cutting-edge technology and ancient spiritual practice

Electroencephalogram

The invention of the Electroencephalogram (EEG) by the Austrian psychiatrist Hans Berger in 1929 was a major breakthrough in consciousness research, as it gave scientists a painless, non-invasive means to study the brain in action. Conscious and unconscious brain activity is the result of electrical signals flowing between individual brain cells, or neurons. While the signals between individual neurons are very weak, Berger found that the activity within specific parts of the brain is relatively easy to detect using pairs of electrodes placed around the skull. An EEG detects the signals as voltage differences between the pairs of electrodes, amplifies it and passes the result to a recorder, which captures the ebb and flow of brain activity.

may lead to new insights into the role of NCCs – and our ability to control them. Yet it fails to address some major mysteries about consciousness. Why do we possess it?[2] What advantages does it confer – and are humans alone in being fully conscious?[3]

One possible explanation lies in the view of consciousness as a means of creating a mental model of reality. Any organism possessing such a model can do more than merely react to stimuli, and pray the response is fast enough to escape predators. It can use the model to foresee threats and opportunities out there in the "real world" – thus freeing it of the speed limitations of non-conscious reflexes. A conscious creature, in other words, does not have to stumble around blindly, hoping its reflexes will keep it out of trouble. By binding together non-conscious responses to create even a simple model of reality, a creature possessing some degree of consciousness can avoid getting into tight corners in the first place – giving it a huge evolutionary advantage.

This in turn suggests that asking whether an organism is conscious or not may be the wrong question. Rather, consciousness may be a question of degree – with, say, an insect having a markedly less sophisticated model of reality than a human.

As with so many aspects of consciousness, definitive answers are still some way off. Even so, there is growing excitement that scientists are now closing in on the mystery of how 1,400 grams of squidgy tissue can endow us with our ineffable but unique sense of self.

Notes

1. In experiments performed on patients undergoing open-brain surgery, Benjmin Libet and his colleagues found that unless the brain is stimulated strongly enough for at least 500 ms, it fails to notice anything. In further tests, they stimulated the patients' brains, but this time followed it 250 ms later with a stimulus applied to their skin. As the 500 ms delay should apply in both cases, the patients were expected to report feeling the brain stimulus first, followed by the skin stimulus 250 ms later. Bizarrely, however, the patients reported feeling the skin stimulus first. Libet and his colleagues concluded that the brain "edits out" the 500 ms delay from the skin response to ensure that the actual time of the stimulus and the perception of it remain in sync. That, in turn, ensures that our mental model of reality – as constructed from our senses – isn't permanently 500 ms behind the times.
2. One of the most controversial theories of consciousness was put forward in 1989 by Professor Roger Penrose, an Oxford academic whose expertise lies in a field apparently unrelated to the mind: quantum mechanics, the laws of the sub-atomic world.

   In a best-selling book *The Emperor's New Mind*, Penrose argued that the ability of human minds to make intuitive leaps towards deep truths about the universe is the result of a special type of computation triggered by quantum effects in the brain. These effects, he suggested, might also be responsible for binding together the activity in the brain to create a sense of a single, coherent consciousness.

   In collaboration with the American anaesthetist Dr Stuart Hamerhoff, Penrose later argued that these quantum effects took place within tiny protein cylinders in nerve cells known as microtubules.

Despite attracting huge public interest, Penrose's theory has few adherents among consciousness researchers, who argue that it swaps one mystery for many more, and flies in the face of experimental evidence. Microtubules seem incapable of supporting the necessary quantum effects, and damage to them appears to have no effect on consciousness.

3. According to a survey published in 2001, around 1 in 10 people in Britain has experienced a so-called "out of body" experience (OBE), in which they felt as if their conscious being had separated from their body.

   Many scientists dismiss OBEs as some bizarre glitch in brain function that creates the illusion of separation. If true, however, OBEs would present a profound challenge to current ideas of consciousness, which are inextricably linked to the physical brain.

   To test the reality of OBEs, scientists have set up experiments to find out if people undergoing OBEs can see objects or numbers out of view of their physical bodies. Some of these have produced suggestive results, but nothing that has so far convinced mainstream scientists.

Further reading

Consciousness: an introduction by Susan Blackmore (Hodder & Stoughton, 2003)

The User Illusion by Torr Norretranders (Penguin, 1998)

Mapping the Mind by Rita Carter (Weidenfeld & Nicolson, 1998)

Understanding Consciousness by Max Velmans (Routledge, 2000)

How the Mind Works by Steven Pinker (Penguin, 1998)

The Astonishing Hypothesis by Francis Crick (Simon & Schuster, 1994)