Consciousness

Twenty seconds ago, how did it feel in your right big toe? To answer this question, you probably direct your attention to that toe and become conscious of how it feels now. Then you guess that, twenty seconds ago, it probably felt the same. But, did you really have a conscious experience of that toe twenty seconds ago? Or did you have an unconscious experience which only became conscious after you attended? Or was there no toe experience—conscious or unconscious—before you attended? We are all so familiar with conscious experiences that we take them for granted. But even a simple question about the conscious feeling of a toe can raise perplexing issues. Indeed, consciousness is among the most controversial topics in science and philosophy.

What is consciousness?

There is no widely accepted definition of consciousness. It is widely agreed, however, that consciousness is not synonymous with *mind*, because there appear to be many unconscious mental states and processes. Consider, for instance, the visual processes that underlie stereovision—our ability to see depth using both eyes. The processes involve sophisticated computations of small differences (called disparities) between the images at the left and right eyes, followed by computations of depth and shape from these disparities; we are conscious of the depth and shape, but not of the processes that compute disparities, depth and shape. The auditory processes that underlie our ability to localize the position of a sound source require sophisticated computations involving differences in phase and intensity of the acoustic signals at the two ears; we are conscious

of the location of the sound source, but not of the processes that compute this location. Examples like these suggest that, in fact, *most* mental states and processes are unconscious.

A mental state or process is conscious if there is something it is like to be in that state or engage in that process. For instance, what it is like to see a flat plate differs from what it is like to see a round cup, and both are conscious states. What it is like to hear a plane overhead differs from what it is like to hear a mosquito buzz your ear, and again both are conscious states. What it is like to consider a logical argument differs from what it is like to hesitate between pizza or sushi, and both are conscious processes. There is something it is like to see a ruby red grapefruit, endure a pounding headache, enjoy a promising idea, imagine the canals of Venice, feel elated or depressed, or dream that you are flying. Each is conscious or, as it is sometimes put, each has a *phenomenal character* with *phenomenal qualities*, i.e., *qualia.*

It is helpful in the study of consciousness to classify conscious states at three levels of detail: boot, general, and specific. The *boot* level simply describes whether or not a person is conscious at all. Examples of a boot-level transition from the unconscious to the conscious include being awakened from a dreamless sleep, revived with smelling salts after a concussion, or brought up from general anesthesia. The *general* level describes a global quality of consciousness, such as being drowsy, alert, sober, drunk, in a dream, or under hypnosis. The specific level describes particular conscious experiences (particular qualia), such as the chirp of a sparrow, the smell of frying bacon, the feel of velvet, or the glisten of dew on a blade of grass.

Approaches to the study of consciousness

There are two broad approaches to the study of consciousness: philosophical and scientific. The two approaches interact profitably, but their methods are substantially different.

Philosophical approaches focus on conceptual issues raised by consciousness. These issues are primarily, though not exclusively, ontological and epistemological. The central *ontological* issue is the nature of consciousness and its place in the world. What is consciousness? How is it related to space, time and matter? The central *epistemological* issue is how we can know if something is conscious. I think I am conscious, and I believe you are as well. But how can I know for sure that you are conscious? And how do I know that I am conscious? How do I know that a rock is not conscious? These central issues spawn a variety of related issues and philosophical theories.

Scientific approaches construct theories that make specific empirical predictions, and test these predictions in controlled experiments. The theories address several key questions: Why, and how, are some mental states conscious or unconscious? How are the three levels of consciousness related to activity in the brain? These questions are studied from the perspectives of several fields, including cognitive neuroscience, computer science, and physics.

Scientific Approaches

What is the biological basis of consciousness? In 2005 the journal *Science* placed this question second in a list of the top 125 questions that are as yet unsolved. Most scientists

who study consciousness are trying to answer this question. The reason for their confidence that there is, in fact, a biological basis for consciousness is the large number of correlations between neural activity and conscious experience.

There is, for instance, in the occipital lobes of the brain a tight correlation between activity in primary visual cortex (called area V1) and conscious visual experiences. If area V1 of the left hemisphere is destroyed, then conscious visual experience in the right half of the visual world is also destroyed; the person is blind in this half of the visual world. If smaller portions of V1 are destroyed, then conscious visual experiences in correspondingly smaller portions of the visual world are destroyed. Electrical stimulation of V1 is correlated with anomalous visual experiences.

Activity in visual cortical area V5 is correlated with the conscious experience of visual motion. If area V5 in the right hemisphere is damaged, then the conscious experience of motion in the left visual field is destroyed, a condition called hemi-akinetopsia. Activity in area V5 can be inhibited by appropriate magnetic fields generated by transcranial magnetic stimulation (TMS); this leads to temporary hemi-akinetopsia.

Most of the empirical work on consciousness involves careful study of such correlations, seeking to find, for a specific kind of conscious experience, a specific neural correlate of consciousness (NCC). An NCC for a specific kind of conscious experience is a minimal system within the brain whose activity is normally sufficient for the presence of that conscious experience.

Much of the theoretical work on consciousness involves proposing specific candidates for NCCs. Some proposals point to microscopic properties of individual neurons, such as coherent and incoherent quantum states in neuronal microtubules.

Others point to certain brain areas, such as the claustrum, a thin layer of gray matter that lies below and parallel to the cortex. Still others point to patterns of neural activity that loop between the brain's cortex and a subcortical structure called the thalamus. The brain is a complex organ with many levels of organization, from the submicroscopic, to the synaptic, to the neuronal, to local neural networks, to more global interacting neural systems. Theoretical work on NCCs tries to specify not only where in the brain an NCC is located, but also at what level of brain organization it operates. There is at yet no consensus about location and level for any NCC.

Proposing candidates for the NCCs is only half of the theoretical enterprise for scientists studying consciousness. The other half is explaining why there are such correlations. If, for instance, an NCC is found for the conscious experience of the taste of dark chocolate, then the next step is to explain why the brain activity in the NCC is correlated with that taste. Does the brain activity *cause* the taste? If so, precisely how? Why does this brain activity cause the taste of chocolate and not, say, the smell of lemon? Why does this brain activity cause any conscious experience at all? There are as yet no scientific theories that try to answer such questions (indeed this is sometimes called, for good reason, the *hard problem* of consciousness). The focus, for now, is on constructing descriptive theories of *what* the NCCs are, not explanatory theories of *how* the NCCs actually work.

Brain Imaging Experiments

The empirical search for NCCs often employs brain-imaging technologies, such as electroencephalography (EEG) and functional magnetic resonance imaging (fMRI). EEG

measurements of brain activity give excellent temporal resolution, on the order of 1 millisecond, but poor spatial resolution, since each electrode reports the summed electrical activity of millions of neurons. fMRI measures brain activity indirectly, through changes in blood flow that are correlated with changes in brain activity; it provides better spatial resolution than EEG, but poorer temporal resolution.

These techniques can be used, for instance, to search for NCCs associated with shifts in conscious experience during "binocular rivalry." Suppose one presents, say, a homogeneous green field to the left eye and a homogeneous red field to the right eye. A subject will report that they consciously experience the whole visual world as green for a few seconds, then they report that red starts to invade and eventually spreads until they consciously experience the whole visual world as red. The green and red experiences continue to alternate in an apparent competition for perceptual dominance, hence the name binocular rivalry. This is an ideal situation for studying the NCCs associated with a conscious shift in perceived color, because the stimuli to the two eyes remain constant even at the moment that the conscious perception shifts. Thus any brain activity correlated with the shift in conscious perception cannot be dismissed as due to a change in the visual stimuli.

Using fMRI, one can determine which brain areas have changes in activation that are temporally correlated with the subject's report of a perceptual shift. EEG can do the same job, but with an interesting twist. One can constantly flash the green stimulus at a certain temporal frequency, say 7 flashes per second (7 Hertz), and at the same time flash the red stimulus at a different frequency, say 14 Hertz. The neural systems that process the green stimulus will have activity at many different temporal frequencies, but they will

have considerable activity at 7 Hertz; similarly, the neural systems that process the red stimulus will have considerable activity at 14 Hertz. Thus this frequency serves as a tag, to let the experimenter know what color a particular neural subsystem is processing. When the subject reports a shift in perceived color, one can then look for brain areas in which there is, at the time of report, a shift in the frequency tag. These areas are candidates for the NCC of the shifts in color experience.

Philosophical Approaches

Is there a relationship between biology and consciousness? This is a key question asked by many philosophers who study consciousness. Notice that this question differs from the question asked by the journal *Science*, namely, What is the biological basis of consciousness? The *Science* question assumes that there is a biological basis of consciousness. The philosopher questions this assumption, and asks whether there is, in fact, a biological basis of consciousness. Maybe consciousness arises not from biology, but from physics. Or perhaps consciousness and biology exist side by side, neither arising from the other. Or perhaps physics and biology arise from consciousness. There are many possibilities, and philosophers debate their relative merits using logical arguments, thought experiments and appeals to the best current evidence from science.

One thought experiment that is widely discussed concerns the possibility of philosophical zombies: Is it possible that there could be a person who is atom-for-atom identical to you, who walks, talks and, in every way, behaves just as you would, but who is utterly without conscious experiences? If this zombie were pinched, it would wince and cry just as you would, yet it would experience no feelings of pain.

Some philosophers claim that such zombies are logically possible. This would mean that consciousness is not determined by the physical facts or functional properties of an organism, since these facts and properties are shared by the original and its zombie. Instead, consciousness would be something extra beyond the physical and functional. It would also mean that consciousness could not be shaped by natural selection, since natural selection can only select among options that make a functional difference to the organism's reproductive fitness; if zombies are possible, then consciousness makes no functional difference, and hence no functional difference in reproductive fitness.

Other philosophers claim that zombies are not logically possible. Once you have specified the physical facts and functional properties of an organism, then all the facts about consciousness are also fixed. Many philosophers in this camp are reductive functionalists, who claim that consciousness is *identical* to certain functional properties. In organisms, these functional properties are most likely properties of the nervous system, but there could be other systems, perhaps sophisticated computers, having internal functional states that are conscious. According to the reductive functionalist, these functional states do not *cause* consciousness, they *are* consciousness; in the same way, twelve does not cause a dozen, it is a dozen. The reductive functionalist is thus exempt from the duty of explaining how functional properties cause consciousness. Instead, this functionalist must give a principled account for why certain functional states are conscious and others are not. There are as yet no such accounts that are widely accepted.

Still other philosophers claim that we are all zombies, and that none of us has any conscious experiences. Our belief that we are conscious is an illusion, perhaps caused by certain computational processes in the brain that monitor the states of other brain

processes. Few philosophers are willing to defend this view. Most admit that we are not infallible about our own conscious experiences, and that we can at times be wrong about what we think we are experiencing. But few are willing to make the stronger claim that we are so wrong that we are in fact zombies: If we are that wrong about conscious experiences, is there anything we can be reasonably sure about?

Historical Perspective

The modern philosophical study of consciousness is usually traced to the work of Rene´ Descartes (1596-1650), who proposed *substance dualism*, the doctrine that there are two kinds of substance in the universe: physical substance and mental substance. According to Descartes, each human being is a composite of both substances, and they interact in the brain at the pineal gland. Few professional philosophers or scientists now advocate substance dualism, although a version of it was defended by Karl Popper (1902-1994) and John Eccles (1903-1997) in their 1984 book *The self and its brain.*

George Berkeley (1685-1753) proposed a version of *idealism*, the doctrine that only consciousness exists, and that what we call the physical world is really the contents of conscious experience. Idealism was developed further by Immanuel Kant (1724-1804) and Georg Hegel (1770-1831), and enjoyed substantial popularity in the late 19th century.

Critiques of idealism by Bertrand Russell (1872-1970) and G.E. Moore (1873-1958) contributed to a decline in its influence. In its place, the dominant view became physicalism, the doctrine that all that exists is the physical world, and that consciousness is caused by, emerges from, or is a property of certain physical systems. This switch was

particularly striking in the field of psychology. The classic 1890 book *Principles of Psychology* by William James (1842-1910) freely discusses consciousness and the hard problem of its relationship to brain activity. But the behaviorist psychology of William Thorndike (1874-1949) and B.F. Skinner (1904-1990) restricted itself to the physical vocabulary of stimulus and response, and considered consciousness to be an unsuitable topic for scientific study. Behaviorism was superceded about 1960 by more cognitive approaches to psychology, and consciousness once again became a topic for active scientific study about 1990. Most of the current scientific and philosophical work on consciousness assumes that some version of physicalism is true, and takes seriously the hard problem of explaining how conscious experiences could arise in a purely physical world.

Future Research

Empirical investigation of the neural correlates of consciousness is currently the most active area of consciousness research. It promises to remain so, due largely to the complexity of the brain, with its billions of neurons and trillions of synapses, and due to the complexity and variety of conscious experiences.

This will continue to be complemented by theoretical work that tries to explain how neural activity can cause, or give rise to, conscious experiences. Progress on this problem has been remarkably slow, with no theory yet proposed that has the minimal explanatory power expected of a genuine scientific theory. The theories now on offer are sketches, serving primarily to suggest directions where a genuine theory might be found: perhaps quantum states of microtubules, or perhaps looping patterns of neural activity

between thalamus and cortex, or perhaps the informational complexity of neural activity. This promises to be an active area of research, with big new ideas needed for its solution.

The precise relationship between consciousness and attention is controversial and promises to be an active area of research. Are they in fact identical? If not, can there be attention without conscious experience, or conscious experience without attention? Is attending to your right big toe identical to having a conscious experience of that toe, or do you have a conscious experience of that toe even when you are not attending?

Also controversial is the relationship between the self and conscious experience. Does consciousness require a self? Can there be conscious experiences without an experiencer? Can there be an experience of the smell of garlic without a self that experiences that smell? If a self is required for consciousness, why is this the case and what is the nature of the self?

As these examples indicate, research into consciousness is highly multidisciplinary, spanning philosophy, neuroscience, cognitive science, computer science and physics. The insights that emerge will transform our understanding of human consciousness, and therefore of human nature and its place in the world.

Donald D. Hoffman

University of California, Irvine

See also: Mind and body, Unconscious processes, Attention, Attention and

Further readings

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