The Oxford Companion TO THE Mind

consciousness, communication, civilization. Trying to understand the physical relation between the brain and the mind has led many to believe that subjective conscious processes do not really control our behaviour, but are a minor manifestation of neural activity having little importance. For instance T. H. Huxley suggested that each of us is a 'conscious automaton' whose subjective awareness is like the sound of the steam whistle on a locomotive and not like the force of its pistons driving behaviour onwards.

I think this conclusion results from asking an *unproductive question* about an *incomplete system*, and it is not a conclusion one is forced to draw from the belief that neural mechanisms obey normal physical laws.

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4. Conscious awareness may occur with, and only with, such translation
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1. The unproductive question

When puzzled by something, we tend to ask 'What *is* it?', but it would almost always be more productive to ask 'What *does it do*?' This is the case with conscious awareness, whose nature causes more puzzlement to a modern scientific mind than almost any other question. If one asks 'What can be *done* with conscious experience that cannot be done without it?' one is led to the view that it is indeed concerned with communication, like the sound of the whistle, but that the whole process has a crucial importance, far beyond that implied by Huxley's analogy. You will, however, fail to recognize this aspect of the problem unless you consider all of the relevant system, not just part of it.

2. The incomplete system

We have known for some time that conscious experience is likely to arise in the brain, so it is natural to assume that this is where we shall find the answers to our questions about its nature. But animals, and particularly humans, do not function in isolation, and, if conscious experience is concerned with the relations between a community of animals, confining one's attention to a single brain will prevent one getting the full picture about what consciousness *does*.

3. Neural activity can be translated into a shared format

Since most animals are social, parts of their brains are likely to be devoted to social communications. These can be quite simple and their mechanisms not difficult to understand, as with the alarm signals or mating calls of

birds; even a computer issues some messages that might be considered social, as when it tells you the printer is out of paper, and we can readily understand exactly how that is done.

Now for us social behaviour is very much more important and complicated. The overall evolutionary fitness of a person must depend greatly upon how he or she has managed social relations, for the community has a very large measure of control over the benefits an individual and its offspring receive. These relations are to a large extent managed by the verbal reports we make to other members of our community about the neural activity in certain regions of our brains, and by the similar messages we receive from others. We are consciously aware not only of making, but also of receiving, such reports and of their contents.

4. Conscious awareness may occur with, and only with, such translation

Perhaps conscious awareness occurs when, and only when, regions of the brain capable of dealing with such verbal reports are primed for activity. I shall not justify this in detail, but can anyone suggest any other action that is normally accompanied by conscious experience, and which would not be the same type of action if not so accompanied? An unconscious being could not make reports of this type, and they would not be accepted if they were thought to have been issued in a zombie-like fashion. Perhaps an analogy may clarify.

It is as if we suddenly had a gift-wrapped box of chocolates in our hands, either generated by our own brain, or received from another; the gift-wrapped box corresponds to the conscious awareness, while the contents are verbal translations of neural activity occurring in some region of the originator's brain. We can give a self-generated box to others if we wish, or open a box we have received. If we do so, the contents carry sufficient information to the recipient brain for it to reconstruct to some degree the neural activity in the originator's brain, and the recipient can then discover the implications that activity had about whatever originally caused it.

At first sight this may seem a simple suggestion that assigns a role to conscious experience not too far from the common-sense view. But it brings out the formidable neural computations required by the relevant parts of the brain, and it also clarifies the link between consciousness and language. Suppose you open the front door and are confronted by a lion, so you make one of the suggested reports by shouting up the stairs 'Hey, there's a big furry animal on the front lawn swishing its tail and roaring'. To do this requires effective recognition of objects and actions, together with the ability to express the results in a natural language. This is a horrendously difficult task, obviously very, very much more than hearing a steam whistle, and although computers are not yet good at doing it, they are good enough to assure us that the job can be done using only well-behaved physical mechanisms.

5. The role of consciously generated reports

Now reports such as that on the lion play a very much more important part in our lives than a simple warning like a bird's alarm call. Of course it does warn the person upstairs of danger, but then this person may shout back 'Sounds like a lion—shut the door at once', so the first report not only had potential survival value for the person upstairs, but the reply brings added information back to the initiator that promotes his survival too. This apparently simple faculty has extraordinary consequences: by translating the visual information received on opening the front door into the common format of a natural language it can create in the recipient's brain a representation in which the new visual information can be combined with stored knowledge about the danger of large furry animals. Furthermore the same faculty in the recipient can then transfer this combined knowledge back to the originator. By translating neural activity into verbal format consciousness has assisted in creating a forum for meaningful communal communication.

One important message from research on sensation and perception over the last half-century is that the quality of decisions depends upon the amount of relevant information that is available for making them: the faculty of generating and receiving reports in a format that is understood by other members of one's community enormously increases the amount of information available for decision making, and if this is what conscious awareness brings to humanity it undoubtedly has the potential for greatly improving individual evolutionary survival. It should be added that it provides access not only to knowledge stored in other brains, but also to knowledge that has passed through other brains but is now stored in books, libraries, and the internet. Civilizations depend upon communal and stored knowledge, and mankind differs from the rest of the animal kingdom in the complexity of the cultures and civilizations it has created. Consciousness has brought the faculty of representing knowledge in a format that is shared among large communities, and it is tempting to suppose that its development was the main factor that led to the extraordinarily rapid evolution of our species.

6. Take-home messages

I started by saying that the physical understanding of the mind had been impeded by asking the *wrong question* about the *wrong system*. I think the *right question* is 'What can we *do* with conscious experience that we could not do without it?' and the important answer is 'It helps us to make reports on our sensory and other subjective experiences in

a common language, and to receive and understand such reports from others'. The *right system* is really the whole species that exhibits consciousness, together with its evolutionary history, but considering a community of brains rather than a single isolated brain is a large step in the right direction: only then does the selective advantage of using a common format become evident. Although the survival value of consciousness cannot be understood by considering an isolated brain, these ideas obviously point to the language centres and the parts that feed them as the regions of greatest interest for the neuroscientific analysis of the mechanisms of consciousness.

Several other conclusions have also been reached from this approach:

- Conscious experience is Nature's way of telling us that we have a potential communication to make—it is like the wrapping on a gift.
- Since these gifts can change a recipient's beliefs, and beliefs can modify actions, we need not doubt that conscious experience can be causally effective and has evolutionary survival value.
- Mechanisms associated with consciousness translate neural activity into the common format of a natural language, making possible communal decisions based on far greater knowledge. The improved quality of these decisions can explain why mankind now dominates the earth.

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consciousness, the neural correlates of. Consciousness is a puzzling state-dependent property of certain types of complex, adaptive systems. The best example is a healthy and attentive human brain. If the brain is anaesthetized, consciousness ceases. Small lesions in the midbrain and thalamus of patients can lead to a complete loss of consciousness, while destruction of circumscribed parts of the cerebral cortex of patients can eliminate very specific aspects of consciousness, such as the ability to be aware of motion or to recognize objects as faces, without a concomitant loss of vision in general. Given the similarity in brain structure and behaviour, biologists commonly assume that at least some animals, in particular non-human primates, share certain aspects of consciousness with humans.

The most mysterious aspect of consciousness concerns '*qualia'—the redness of red, or the painfulness of pain. Rather than trying to tackle it directly, it seems more sensible to discover the neural correlates of consciousness (the NCC), that is the minimal brain mechanisms causing any one specific conscious percept, memory, or action, as a preliminary to finding causal explanations, with the hope that when we understand how the brain produces consciousness the problem of qualia may be easier to solve.

Much of the activity of our brain seems to be unconscious. It seems probable that for neural activity to become fully conscious it must both persist for some length of time and interact with a substantial amount of the front of the cerebral cortex, a region that is involved in thinking, planning, and making wilful decisions.

To produce such a big effect a large coalition of active neurons must form. The members of this coalition must each express its own characteristic trigger feature, while at the same time giving support to the other coalition members. It is this widespread, sustained, highly specific activity that corresponds to what we are visually aware of.

In viewing the normal cluttered visual environment the brain must rapidly attend to some salient visual object and segment it from the general background—not an easy task. The visual information coming into the eyes is usually ambiguous, and could be interpreted in more than one way, depending somewhat on our previous experiences. So the winning coalition of active neurons, which represents that object, must compete with other coalitions representing both alternative interpretations and other, unattended parts of the visual scene. The firing of the neurons outside the dominant coalition may represent the unattended parts of the visual field by firing together more locally and more transiently, thus producing a very fleeting form of visual awareness.

The great amount of local mutual excitation between excitatory cortical neurons, and the activity of the many types of inhibitory neurons (which prevent the system going into uncontrolled oscillations, as it does in epilepsy), are all involved in this competition between rival coalitions. Each neuron in the coalition supports its 'friends' (those that support it) and attempts to suppress its 'enemies' (those that would inhibit it). Attention can be thought of as a neural mechanism which biases this competition. One cannot attend to two separate objects simultaneously if they produce strongly overlapping activation in the same local neural network.

The biggest, most powerful coalition will win, and then maintain itself for some time (at least for a few hundred milliseconds) while the unsuccessful neuronal activity, though not negligible, will be fragmented and repressed, at least for the time being.

One has the impression that the activity of the coalition may have to reach a threshold of some sort before it can sustain itself for a reasonable time, possibly with help from feedback loops of one sort or another. It is also possible that the system shows some hysteresis. That is, it will persist even if its support has diminished somewhat.

The activity in the coalition is bound to influence many neurons outside the coalition, but not sufficiently to co-opt them as members. The trigger features of these related neurons would represent the past associations of elements of the coalition, or possible future motor actions. It is these associations that express the meaning of the activity of the coalition members.

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