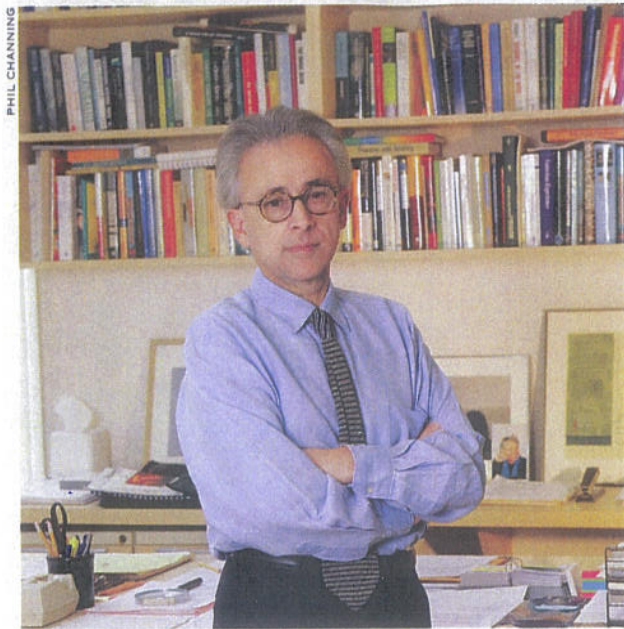


WHAT IS CONSCIOUSNESS?



A STORY WE TELL OURSELVES

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SOME PHILOSOPHERS maintain that solving the problem of consciousness is beyond the reach of human intelligence. This is very odd and, I believe, untrue. It fits a sensible intuition that the mind is something special and different, separable from the brain, but the fact that the intuition is sensible does not make it right.

All the natural history required to understand consciousness is now readily available in evolutionary biology and psychology. Gene networks organize themselves to produce complex organisms whose brains permit behavior; further evolution enriches the complexity of those brains so that they can create sensory and motor maps that represent the environments they interact with; additional evolutionary complexity allows parts of the brain to talk to each other (figuratively speaking) and generate maps of the organism interacting with its environment. Within the

frame of those interactions, the conversation among the maps spontaneously and continuously tells the "story" of our organism responding to and being modified by the environment. (The story is first told without words and is later translated into language when language becomes available, both in biological evolution and in every one of us.)

This natural knowledge amounts to the emergence of a basic self, and its presence changes the status of the brain's sensorimotor maps from nonconscious mental patterns to that of conscious mental images. Constructed knowledge is a solution to the problem of consciousness. It does not require a homunculus in the control room of the mind and is not scientifically harder to imagine than the long march from genes to culture.

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might have been shaped to keep compromising data away from the conscious processes that govern our interaction with other people. At the same time, it keeps the data around in unconscious processes to prevent the person from getting too far out of touch with reality.

What about the brain itself? You might wonder how scientists could even begin to find the seat of awareness in the cacophony of a hundred billion jabbering neurons. The trick is to see what parts of the brain change when a person's consciousness flips from one experience to another. In one technique, called binocular rivalry, vertical stripes are presented to the left eye, horizontal stripes to the right. The eyes compete for consciousness, and the person sees vertical stripes for a few seconds, then horizontal stripes, and so on.

A low-tech way to experience the effect yourself is to look through a paper tube at a white wall with your right eye and hold your left hand in front of your left eye. After a few seconds, a white hole in your hand should appear, then disappear, then reappear.

Monkeys experience binocular rivalry. They can learn to press a button every time their perception flips, while their brains are impaled with electrodes that record any change in activity. Neuroscientist Nikos Logothetis found that the earliest way stations for visual input in the back of the brain barely budged as the monkeys' consciousness flipped from one state to another. Instead, it was a region that sits further down the information stream and that registers coherent shapes and objects that tracks the monkeys' awareness. Now this doesn't mean that this place on the underside of the brain is the TV screen of consciousness. What it means, according to a theory by Crick and his collaborator Christof Koch, is that consciousness resides only in the "higher" parts of the brain that are connected to circuits for emotion and decision making, just what one would expect from the blackboard metaphor.

WAVES OF BRAIN

CONSCIOUSNESS IN THE BRAIN CAN BE TRACKED NOT JUST IN SPACE but also in time. Neuroscientists have long known that consciousness depends on certain frequencies of oscillation in the electroencephalograph (EEG). These brain waves consist of loops of activation between the cortex (the wrinkled surface of the brain) and the thalamus (the cluster of hubs at the center that serve as input-output relay stations). Large, slow, regular waves signal a coma, anesthesia or a dreamless sleep; smaller, faster, spikier ones correspond to being awake and alert. These waves are not like the useless hum from a noisy appliance but may allow consciousness to do its job in the brain. They may bind the activity in far-flung regions (one for color, another for shape, a third for motion) into a coherent conscious experience, a bit like radio transmitters and receivers tuned to the same frequency. Sure enough, when two patterns compete for awareness in a binocular-rivalry display, the neurons representing the eye that is "winning" the competition oscillate in synchrony, while the ones representing the eye that is suppressed fall out of synchrony.

So neuroscientists are well on the way to identifying the neural correlates of consciousness, a part of the Easy Problem. But what about explaining how these events actually *cause* consciousness in the sense of inner experience—the Hard Problem?

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Number (in millions) of visual receptors in each eye. Optical illusions show that the eyes compete for the brain's attention