THE CONSCIOUSNESS OF WORMS

Elementary nerve circuits, organisms capable of movement. Some studies and solid observation lead to a radical hypothesis: Consciousness is a different phenomenon from thought.

Giorgio Vallortigara

Contro te povero verme
le lagnanze sono eterne

(Toti Scialoja)

When wondering about the presence of consciousness in other organisms, people usually refer to mental abilities—reasoning, problem solving, decision making—as inferred from behavior. The assumption seems to be that if an animal exhibits sophisticated mental abilities then it must be conscious, with the corollary that the ability to exhibit sophisticated mental abilities is related to possessing complex brains.

Many theories that enjoy wide acceptance in the scientific community seem to share the same assumption, namely, the idea that the complexity of the nervous system somehow explains the emergence of consciousness. It seems to me, however, that this idea is wrong.

Mental activity is not consubstantial with consciousness. One of the most important acquisitions of modern neuroscience has been precisely the realization that much of our mental life is unconscious. The cognitive unconscious is not limited, as one might believe, to automatic and instinctive responses, but operates in the more refined aspects of our mental life.

CONSCIOUS AND UNCONSCIOUS

The examples are countless. I will just briefly illustrate a couple of them. Cognitive psychologists employ a technique known as *Continuous Flash Suppression* (CFS) to investigate conscious and unconscious mental processes.

It works like this: one eye is shown an easily recognizable stimulus, say a well-known face, while simultaneously the other eye is presented in rapid sequence, say every 100 milliseconds, with a series of images, always different, consisting of variously colored rectangles inspired by those Mondrian painted. What happens under such conditions is that the face is not seen. Better said: it is not consciously seen, because it can be observed that cognitive processing, even deep processing, is nevertheless conducted in the presence of the suppression caused by the continuous succession of images *a là* Mondrian. This can be proved by measuring reaction times to perceived stimuli. Suppose you observe a simple subtraction with three numbers, 9 - 3 - 4. Since the stimulus was presented under CFS conditions you had no consciousness of seeing the three numbers and the symbols of the subtraction, much less therefore of


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having calculated the result of the equation, which is 2. Subsequently, however, you are asked to read numbers aloud, responding as quickly as possible: what you observe is that you are faster at reading 2 than, for example, at reading 3. Everything takes place as if an inner calculator of whose operation you are unaware has taken it upon itself to carry out the equation and make the correct answer readily available to your lips.

In this example, the dissociation concerns the performance of a high-level cognitive skill, such as solving an arithmetic equation, and the psychological reference to being aware or unaware of having perceived the stimuli. But the same dissociation can be observed between the execution of a skill and the neural correlates that are usually associated with the execution of that skill.

RECOGNIZE THE STIMULI

A couple of years ago the case was reported of a patient with corticobasal syndrome, a rare neurodegenerative disease, who showed an inability to read Arabic numerals 2 through 9, although he was able to read the letters of the alphabet normally. When shown a number, say 8, the patient was unable to recognize it and asked to draw what he was looking at he produced a jumble of graphic marks whose shape resembled a chaotic tangle of spaghetti. Curiously, the deficit did not manifest for 0 and 1 (perhaps because they resembled letters). But what is important to note here is that the inability to recognize stimuli also applied to what was shown in or at a dip of the numbers 2 to 9. For example, a face embedded in the graphic sign of the number 8, depicted prominently and recognizable under normal circumstances, was found to be non-experienced by the patient. And yet the electroencephalographic examination showed that the characteristic signature of face recognition, a negative signal known to specialists as N170 was observable in the electroencephalographic trace.

All this reveals that high-level mental processes are distinct from consciousness; one can observe the former

Artistic representation of brain cells.

in the absence of the latter. Conversely, consciousness can be observed in the absence of high-level mental processes. Intuitively, we know this very well because we have adjusted our consideration of those suffering from even major cognitive deficits to prudential criteria: we believe that being deprived of intelligence and reasoning is not the same as being devoid of sentience; one can feel something, for example pain, even when mental abilities are severely impaired.

CONSCIOUSNESS IS EXPERIENCE

In short, being conscious, in its primeval manifestation, that is, feeling something, experiencing something -- such as, for me right now, experiencing the hardness of computer keys, the black and white in the screen where I type, and the vague whiff of disinfectant in the freshly cleaned office -- is not identified with thinking, reasoning or paying attention. Consciousness is first and foremost experience.

Through studies of a variety of animals with miniaturized brains, we have learned in recent years that the most basic cognitive operations can be conducted with a handful of neurons. Bees, whose encephalic ganglion has less than a million neurons, are capable of discriminating human faces, abstractly categorizing the equal and the different, conducting approximate arithmetic operations, and recognizing after brief training on a limited number of specimens the graphic style of Picasso versus Monet in images never previously seen. The limitations of miniature brains relate, if anything, to memory stores or the ability to conduct perceptual analyses in parallel rather than sequentially (in fact, the latter is the mode by which usually moving insects actively explore visual scenes).

Bees have far greater cognitive skills than the modest amount of neurons would suggest.

Whether or not reasoning, deciding, or problem solving requires large, complex brains is, however, irrelevant to the issue of consciousness. The idea that consciousness emerges spontaneously as a result of the complexity of the nervous system, particularly the cortex, seems to me to be magical rather than scientific thinking, and above all, it collides with well-established facts.

The dogma of the cortex (or its equivalents in other species) as the generator of consciousness is challenged by the classic findings of the Canadian neurosurgeon Wilder Penfield, who had noted how excision of even large portions of the cortex, performed under local anesthesia to treat intractable forms of epilepsy, left patients conscious and communicative (even while

GIORGIO VALLORTIGARA

Professor of Neuroscience at the Centre for Mind-Brain Sciences at the University of Trento, of which he was also director, he is the author of more than 300 scientific papers in international journals and of several popular books including *Born Knowing* (MIT Press 2021) and *Divided Brains* (with L.J.Rogers and R.J. Andrew /Cambridge University Press 2013).
In 2016 he received the Geoffroy Saint Hilaire International Prize for Ethology and an Honorary Degree from Ruhr University, Germany. He is a Fellow of the Royal Society of Biology. He writes for the cultural pages of newspaper such *Il Sole 24 Ore* and popular journals such as *Le Scienze*. He is part of the Scientific Direction of *Prometeo*.

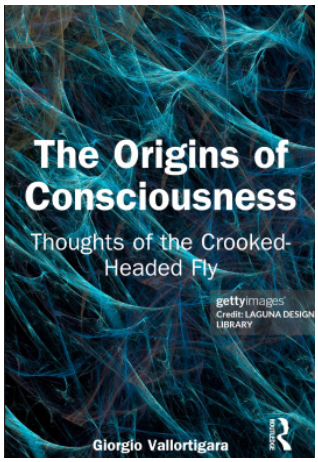
the surgery itself was being performed). Even a radical surgery such as a hemispherectomy (the complete removal of an entire cerebral hemisphere) does not cause consciousness to fail, but merely damages certain discriminative abilities and motor or language skills of the patient. Of course, we know that massive bilateral damage to the cortex gives rise to a persistent vegetative state condition but, as neuroscientist Bjorn Merker has noted, this does not prove that cortical function is essential for consciousness, because cortical damage inevitably destroys the many circuits in the brainstem that under normal conditions receive inputs from the cortex.

THE BRAIN STEM

Even more dramatic is the evidence gathered by Merker himself in favor of the fact that children with hydranencephaly, a rare condition in which the prosencephalic hemispheres are largely and in some cases completely missing and the corresponding cranial cavity is filled with cerebrospinal fluid, would be conscious (albeit severely damaged in terms of sensory, motor and intellectual abilities). Primary consciousness, the fact of feeling something, would be sustained according to Merker by structures in the brainstem.

But when and why in the evolutionary history of organisms did it happen that it was necessary to feel something? After all, we know that under various circumstances behavior would seem to be able to take place fully in the absence of conscious accompaniment. One can observe in this regard the impressive footage of subjects (both human and non-human) suffering from a condition called "blindsight" who move with ease in the environment without bumping into objects or even manipulating them correctly even though, as a result of a more or less extensive lesion to some portions of the primary visual cortex, they are cortically blind and declare (the human patients) or show in appropriate tests (the monkeys) that they

Possession of tiny brains does not prevent the faculty of feeling something.



The essay reproduced here summarized some of the content of the book *The Origin of Consciousness. Thoughts of the Crooked-Headed Fly* that will be available in English by Routledge, London.

do not experience anything.
Some videos on the behavior of subjects with "blindsight" can be seen at these links: https://www.youtube.com/watch?v=rDIsxwQHwt8
https://www.sciencedirect.com/science/article/pii/S0960982208014334
Little or nothing do we know at present about the specific contents of feeling of other organisms, which may be incommensurate with our own (as philosopher Thomas Nagel observed, what might a bat feel when it experiences the shape of an object with its sonar?). However, I believe that we can usefully address the question why experiencing something was necessary at a certain moment in evolutionary history. In particular, I believe that the important transitional moment occurred when organisms took to moving in the environment actively, and consequently faced the problem of recognizing in sensory stimulations what turns out to be happening as a byproduct of their own movements. To grasp the point, imagine stimulating a mole out of its burrow with a throw of soil to hit its flanks: the animal will respond with an appropriate defensive maneuver. However, the same defensive maneuver will not be enacted by the animal as it burrows underground, in spite of the fact that as a result of its movement it will happen that it is sensory stimulated by the topsoil.

THE CARBON COPY

The solution to the problem, which has had a long genesis both theoretically and experimentally, but which is related in particular to the research of the behavioral physiologist Erich von Holst, is based on the idea that each time the nervous system sends a signal to the motor system to generate a bodily action, a second carbon-copy signal (known as the "efferent copy" or "corollary discharge") is sent to a system that provides a comparison with the sensory signal that is about to occur, as if in a kind of prediction about the possible sensory outcomes of the action. I have argued recently that if, as theorists such as the evolutionary psychologist Nicholas Humphrey have argued, the initial response to sensory stimuli was to take the form of a bodily reaction, the carbon copy (the efferent copy) of this signal is precisely what gives authorship to the bodily reaction, that is, the fact that it is felt, that it is one's own, namely, that it is conscious.
The presence of circuits that carry out the kind of *feedforward* mechanism that underlies what von Holst labeled the "reafference principle," could thus represent a minimal but necessary condition for something to be felt to be a particular kind of creature, such as a worm. About the specific qualitative contents of this feeling something at the moment we can only say that we ignore them. But if we could faithfully reproduce the cellular circuitry that sustains them nothing would prohibit, in principle, making them our own, for example in a prosthesis, and knowing for the first time what it feels like to be a worm when the earth touches it or, if Maurice Merlau-Ponty was right when he noted that to see is to palpate with the gaze, to be a bee that feels the touch of ultraviolet light reflected from the petals of a flower. ■

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