Brain localization of consciousness? Neurological considerations

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This paper is based, to a large part, on the review by Zeman [1]. It gives a short overview on investigations, which try to demonstrate that, in the eyes of some authors, local neural correlates of conscious brain activity do likely exist which supports a materialistic view of consciousness. Simultaneously, the paper tries to elucidate why these hints should be seen with caution and scepticism in order to justify the view of a non-materialistic dimension of consciousness. The paper serves as an introduction to the other talks of the seminar. We use the term "consciousness" as synonymous with "awareness". The "contents of consciousness" encompass all that we are conscious of, aware of, or experience [2].

The conscious state in my opinion best corresponds to the wake state, in which we can act adequately according to the contents we are aware of. However, when sleeping, for example, one can still have visual and auditory experiences in the form of dreams. Conversely, when awake there are many things at any given moment that one does not experience. Dreams, in some respect, may therefore probably be conscious, however "adequate responses" with regard to their contents are normally not possible. Depending on the context used it thus seems to be justified to distinguish "consciousness" in the sense of "awareness" from wakefulness and other states of arousal.

The "problem of consciousness" has been identified as an outstanding intellectual challenge for many disciplines. The current fascination with consciousness is explained by the availability of new techniques in neuroscience which –as many scientists believe – would be able to "visualize" correlations between neural processes and features of conscious experience. Moreover, experiments have been undertaken which were thought to be suitable to demonstrate conscious and unconscious processes in the brain and make them distinguishable (e.g. the blindsight experiment [3]).

If a neural correlate for conscious (NCC) does really exist and could properly be made visible, the content of consciousness would then in principle be accessible – in the opinion of some neuroscientists. In other words, the neuroscientist’s faith is that every distinction drawn in experience and behaviour will be reflected by distinctions between patterns of neuronal
activity. But does brain activity of “thinking of the word sky” for instance, as shown by functional imaging techniques, which might indeed be very similar in person #1 and person #2 really mean that both individuals think the same content? This does not seem to be a true problem for the group of neuroscientists mentioned above. Their main goal for the future research is just to find the precise definition of the neural correlate of consciousness, while to think about the non-materialistic dimension of consciousness seems to be of minor interest to them. Moreover, this view brings one close to determinism, which many scientists and philosophers already claim, saying that everything in the physical world (including all our own actions) is predetermined. In this view, no one is responsible for anything they do, so punishment is an inappropriate response to crime. In this context Benjamin Libet’s experiment in 1985 [4] which apparently showed that the brain *unconsciously* prepares to act a measurable length of time before a person consciously decides to act (Fig. 1) seems to support this view. However, since it is unclear in this experiment what the “readiness potential” indeed means (whether it is really the “brain’s decision to act”) the interpretation of Libet’s experiment as a clue to determinism is thus questionable.

![Diagram of Libet's experiment](image)

The meanings of consciousness are multiple. In neurological practice consciousness is generally equated with *the waking state*. In this sense consciousness is a matter of degree and extends from waking through sleep into coma (see Glasgow Coma Scale [5]). Consciousness furthermore can be seen as *experience*. In this respect it is personal,
involving a conscious subject with memory. Lastly, consciousness can be understood as 

mind.

Regarding the biological account of consciousness, the knowledge of the neural basis of 
sleep and wakefulness and the understanding of the neural processes which underlie the 
contents of awareness, particularly visual awareness, are important. The anatomical 
structure which controls the conscious states is the ascending reticular activating system in 
the upper brain stem. This structure is not monolithic, but rather complex, and involves 
different neurotransmitter systems. Some pathways of neocortical activation through the 
recticular system involve the thalamus ("gate to consciousness"), others bypass the 
thalamus.

Activation of special parts of the neocortex is the prerequisite that something is conscious to 
us. In this context the study of vision has completed our knowledge on the cerebral events 
which underlie conscious phenomena, i.e., vision. Explicit neural processes, which directly 
give rise to conscious awareness, and implicit neural processes that allow visuomotor 
performance in the absence of awareness (e.g., blindsight) have been discovered. Explicit 
minus implicit neural processes may thus represent the key neural substrates of awareness. 
Further insights in cerebral processes underlying a conscious phenomenon stem from the 
study of memory and action.

However, neural events with conscious processes do not prove a causal relationship. 
Moreover, how can the presence or absence of consciousness be determined? One possible 
experiment is that of blindsight (see above). It gives some evidence that unacknowledged 
and presumably unperceived stimuli can exert detectable effects on neural activity and 
subsequent behaviour. Other experimental settings or neuronal states indicate that stimuli 
which are too faint or brief for conscious perception may be capable of eliciting neural 
activity. Nevertheless all these experiments and descriptions of brain activation processes do 
not explain how neural activity is the cause for consciousness. Likewise, all attempts which 
have been undertaken to specify the neurological mechanisms of consciousness in terms of 
neurobiological, information processing and even social theories of consciousness have 
failed to prove this causal relationship. Certainly, some of these theories sound rather 
attractive, in particular those of the neural correlate of consciousness (NCC) as a neuronal 
cell-assembly. Various NCC models have been proposed. Tononi and Edelman (1998) 
described a model of a constantly shifting "dynamic core" of neural elements [6]. This model 
plays down the role of particular neuronal types and cortical regions, but stresses the 
importance of the complex integration of thalamocortical subsystems. The NCC in the model 
by Crick (1994) and Koch (1998) is composed of sparse but spatially distributed networks of 
neurons which must stand above the background of neuronal firing [7,8]. Other models
assume dynamics of coalition of neurons ("winning coalitions"). All models have in common that they state that a certain "kind" of pattern of activity is crucial for consciousness, e.g. synchronized frequency or even selective synchronization (reviewed in [1]). There are still many open questions for all these investigators who support the existence of NCC: How large must the cell assembly be? Need it incorporate particular neuronal types or specific cortical layers? Need it involve given cortical regions and/or connections with regions elsewhere? Is there indeed a particular pattern? What is the duration of the NCC activity? What is the degree of complexity of interactions? In the eyes of these researchers it is just a matter of time to find the answers to all of these questions. Once they have been answered, it is assumed that the understanding of what constitutes consciousness will have been reached.

In my opinion, this purely biological approach to consciousness will not be satisfactory. Furthermore, the brain’s complexity is overwhelming: its connections are so immense that NCC defining seems to be impossible – the brain contains 2,500 – 5,000 cell types, each innervating 10 – 20 cell types; brain circuitry has at least about 25,000 – 100,000 macroconnections, which is roughly comparable to the number of mammalian genes; among 5,000 cell types even 25,000,000 possible macroconnections have to be supposed [9]).

For sure, thoughts cannot be evolved without a brain. However, the brain does not "produce" thoughts. Likewise neural events in the brain do correlate with the phenomenon of consciousness without any doubt, but they do not cause consciousness as already mentioned above. How could the experience of the redness of red, for instance, arise from actions in the brain? And moreover, how does a vital brain activity generate a mental element with rich subjective content? Whether scientific approaches will provide a completely satisfying explanation of consciousness seems to be a vexed philosophical problem and not a problem of natural sciences.

References and Notes


[3] Blindsight is defined as the ability to respond appropriately to visual inputs while lacking the feeling of having seen them. Following certain kinds of brain lesions (partial damage of their primary visual cortex), patients report an inability to see objects, but if pressed to guess at their location they display a capacity to point at them with reasonable accuracy. In the patient originally described by Sanders et al. (1974), D.B., excision of the right calcaneal cortex had been performed as part of the surgical treatment of an arteriovenous malformation. The patient was "urged to guess" the nature or location of stimuli in his blind field. His guesses, despite his insistence, that he saw "nothing except in his intact visual field", proved to be substantially correct (Sanders, M.D., Warrington, E.K., Marshall, J., Weiskrantz, L. "Blindsight": vision in a field defect. Lancet 1 (1974) 707-708).
Blindsight is one of the more dramatic of a number of lines of evidence suggesting that being aware of doing something is distinguishable from doing something, that areas of the brain underlying the experience of doing at least some things are distinct from those needed to actually do those things. Such a dissociation has a number of interesting implications. In a general sense, it provides evidence for the existence and significance of an “unconscious” element as a contributor to human behavior (and hence for “consciousness” as distinctive part rather than synonymous with the totality of brain function). Blindsight also provides a possible explanation for some experiences of “magical” or “transcendent” abilities, at least insofar as these relate to performance characteristics of individuals for which the individuals themselves cannot account. A dissociation between unconscious and conscious processing is also of significance in an educational context, since the two sorts of processing may acquire, process, and make use of experiences in different ways. Blindsight might be something which only occurs in cases of brain damage, but seems much more likely to be a significant phenomenon of intact brain function as well. Indeed, it seems likely that blindsight (and similar phenomena in other spheres) is an important ingredient of a variety of activities where one wants to move quickly and appropriately, without “thinking about it”. Thus blindsight is interpreted to show that visual qualia are epiphenomenal with regard to the information-processing of visual perception (see Paul Grobstein and Bogdan Butoi, http://serendip.brynmawr.edu/bb/blindsight.html). However, against the view outlined above, criticism has been made insofar as it was stated that blindsight cannot be adequately described as a special case of seeing (Ralf Schumacher, Institute of Philosophy, HU Berlin, Germany. http://www.bu.edu/wcp/Papers/Mind/MindSchu.htm).


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