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Difficulties with the Electromagnetic Field Theory of Consciousness

Abstract: *The author's version of the electromagnetic field theory of consciousness is stated briefly and then three difficulties with the theory are discussed. The first is a purely technical problem: how to measure accurately enough the spatial properties of the fields which are proposed to be conscious and then how to generate these artificially, so that the theory can be tested. The second difficulty might also be merely technical, or it might be substantive and fatal to the theory. This is that present measurements seem to show a non-constant relationship between brain-generated electromagnetic fields and sensation. The third difficulty involves the basic question of whether consciousness per se has any direct effect on the brain. As an afterword, the disproportionate contribution of synchronously firing neurons to conscious percepts is simply explained in terms of the electromagnetic field theory of consciousness.*

Introduction

Since the present paper basically constitutes a very brief critique of the electromagnetic field theory of consciousness, I would like to state at the outset that I do not think this theory is wrong — far from it. Indeed, I would go so far as to say that I am quite emotionally wedded to the idea that conscious experience is identical with certain electromagnetic fields. In one sense, the idea and I could be said to have grown up together. My very first foray into the area of consciousness studies was an attempt to publish an early version of the the electromagnetic field theory of consciousness in the Hard Problem issues of *JCS*, which appeared in 1995/96. That paper was stonewalled by a series of referees and ultimately rejected. A second version, which I then submitted to a non-special issue of the same journal, suffered the same fate. In 1999 I included the name 'the electromagnetic field theory of consciousness' and a very brief outline of the theory as a footnote in a paper about something else (Pockett, 1999). Finally in 2000 I published a greatly expanded version of the original rejected papers in book form (Pockett, 2000).

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During all of that period, I was largely concerned to see the theory established and therefore to defend it against a string of objections. Answers to a number of these can be found in Pockett (2000). However, now that the theory has become well enough accepted for *JCS* to publish the paper by McFadden (2002), I feel free to set aside my attachment to it long enough to explore three difficulties which I have not so far been able to resolve.

What is the Electromagnetic Field Theory of Conscious Experience?

First let me make a brief statement of the theory as I see it. This is somewhat different from the version independently produced by McFadden (2000; 2002). My version of the electromagnetic field theory of consciousness is presently quite restricted in scope. It is that qualia are identical with certain yet-undefined spatio-temporal patterns in the electromagnetic field. At present, the only objects in the universe that generate such patterns are biological brains, but in principle there is no reason why the patterns should not be generated by artificial means.

The defining feature of conscious electromagnetic patterns in my view is not intensity, not ability to couple with brain tissue, and certainly not ability to fire motor neurons, all as suggested by McFadden (2002). Any number of gross, artificially-generated electromagnetic fields which we presently have the capacity to produce possess those properties, but are not conscious. Rather, I think the defining feature of conscious electromagnetic patterns is probably going to be some feature of their spatial constitution. I think this mainly because Walter Freeman's classic experiments show that the information which allowed him to classify the electromagnetic patterns he measured at the surface of rabbit brains as coming from a rabbit which was or was not experiencing a particular odour resided entirely in the spatial features of the patterns, and not at all in their overall amplitude, frequency or phase properties (Freeman & Baird, 1987; Freeman & Grajski, 1987; Freeman & Viana Di Prisco, 1986).

Freeman's papers do not reveal exactly what the defining spatial feature of conscious electromagnetic patterns is and it is not possible to predict this. The nature of the defining feature is something that will have to be discovered empirically. Making the necessary measurements to delineate the defining feature of conscious patterns calls for technical abilities that I do not presently possess: (a) the ability to make very high-resolution EEG or ECoG measurements correlated with the presence or absence of particular qualia, then (b) the ability to solve the inverse problem and thus reconstitute the EEG patterns that covary with qualia as they were at their site of generation, before the spatial smearing caused by passage through the meninges, skull and scalp.

Difficulties with the Electromagnetic Field Theory of Consciousness

Difficulty 1

Thus, the first difficulty I presently experience in connection with the electromagnetic field theory of consciousness is technical. In order for a theory to count

as scientific, it must be testable. At present we (or at least I) cannot measure the properties of the proposed conscious electromagnetic patterns, so I cannot even begin to proceed to the next technical hurdle, which is finding a method of reproducing the patterns artificially. Only when this second obstacle has been surmounted will the consciousness studies community be in a position actually to test the electromagnetic field theory of consciousness, by seeing if the artificially produced patterns can be reintegrated into the conscious field of the brain which originally produced them, to allow a re-experience of the original sensation.

This is by no means a disabling problem, however. Technical difficulties are made to be surmounted.

Difficulty 2

The second difficulty I would like to consider might also be merely a methodological one — or it might actually be fatal to the theory. This is that it seems on existing evidence as though there actually is no one-to-one correspondence between electromagnetic patterns measurable at the scalp or the surface of the brain and the conscious sensations experienced by the 'owner' of the brain.

Walter Freeman comments, both in the papers cited above and in his book *How Brains Make Up Their Minds* (Freeman, 1999), that the spatial patterns he measured lacked invariance with respect to unvarying stimuli. It is a little hard to know how to relate this to the information that the patterns can be classified as coming from a subject which is or is not experiencing a particular stimulus, but on a much lower level I have also now made similar observations. For example, the so-called auditory steady state responses which can be measured using scalp EEG electrodes sometimes disappear for a period, even when the (human) subject later reports having been clearly aware of the clicks that evoke these waveforms (Pockett & Tan, 2002). The question is, why? Is this apparent lack of correlation between electromagnetic patterns and sensation to be explained simply by the fact that minds are inclined to wander, so that at any given moment the subject may actually not be experiencing the supposed sensation, but rather daydreaming about food, sex, or any of the other multitude of topics which occasionally claim the attention of a healthy animal? Or is it an indication that the electromagnetic field theory of consciousness is completely wrong; that the electromagnetic fields generated by the brain really are merely epiphenomena, the noise of the engine, the smoke from the fire? Freeman thinks the latter. I am more inclined to the former view. It seems to me that the question can only be resolved empirically, by taking measurements from human subjects experienced in concentration meditation.

In the first stage of training in concentration meditation, the usual experience is that the novice can maintain attention to a particular object for only a few seconds at a time (Wallace, 1999). After a number of years of dedicated and directed practice, the adept can attend unwaveringly to a chosen sensation or perception for hours. For our purposes, use of a subject for whom one can be confident that the particular sensation one thinks one is studying really is the only content of

consciousness at the time one is making electromagnetic measurements would seem to be an essential feature of methodology, which has hitherto been neglected.

Difficulty 3

The third difficulty I presently have with the electromagnetic field theory of consciousness is in some senses the most basic. It can be boiled down to a simple question: should we expect consciousness (i.e. conscious electromagnetic fields) to be a direct cause of behaviour? At first sight this seems a very odd question, to which the intuitive answer is yes, of course we should. Thus McFadden (2002) presently is, and I (Pockett, 2000) previously have been at considerable pains to demonstrate that electromagnetic fields of the sort we variously suppose to be conscious can indeed influence the firing of neurons in brains. However, on further reflection, I am forced to confront two problems in this regard. These are that:

(1) I cannot presently conceive how spatial electromagnetic patterns, which by their very nature quickly become spread and smeared by volume conduction as they move through the brain, could maintain enough structure to affect neural activity patterns in far-flung regions of the central nervous system in the sort of delicate, non-gross fashion which would be necessary for them to control behavioural output. I can certainly see that spatial electromagnetic patterns which evolve in time could be identical with qualia, or sensations/perceptions. Sensations/perceptions occur in one place, evolve in time and then are gone, just like the electromagnetic patterns in question. But as soon as electromagnetic patterns are measured at some region of space other than where they were generated, the pattern is immediately different. It is less precise, has less delicate spatial structure. We may be able to reconstruct the original pattern by use of clever mathematics, but the brain does not have the capacity to do this in a direct and immediate fashion. Basically, by the time what was originally an intricate spatial pattern reaches some other part of the brain, it is no longer the same pattern. My problem is that I cannot see how such a smeared caricature of the original could be expected to influence behavioral output in any precise way

(2) Libet has shown (Libet *et al*., 1983), and his finding has been confirmed by Trevena and Miller (2002), that the brain-generated electromagnetic 'readiness potentials', which precede a so-called voluntary movement, actually begin of the order of a second before the subject is conscious of deciding to move. Because of the length of time involved, this finding stands up in the face of a plethora of possible measurement errors in relation to the time at which the subject actually does decide to make the movement (Pockett, 2002b). The relevance of the finding to our present discussion is that it seems to indicate the lack of a direct influence of consciousness on the brain. The brain apparently makes at least this kind of limited decision to move

independently of consciousness, which then becomes privy to the action only some time after the decision is taken.[1]

If these two observations are taken at face value, they seem to indicate that the anwer to the question 'Should we expect consciousness to be a direct cause of behaviour?' might well be 'No.' At the very least they show that McFadden's version of the electromagnetic field theory of consciousness (which includes the causative action of conscious electromagnetic fields on physical behaviour) may not be wholly tenable. My own version of the theory (which equates only sensations/perceptions with electromagnetic patterns and not volition or intentionality)[2] escapes essentially unscathed, if a little chastened by the knowledge that consciousness should not be allowed to overreach itself. We should definitely place most of the burden of the construction of minds squarely on the brain itself, not on the electromagnetic patterns it generates. Perhaps some of these electromagnetic patterns do confer on us the mingled benediction and curse of sensory experience — but perhaps that's all they do.

Afterword on the Relation of Synchrony to Conscious Patterns

As McFadden (2002) says, a growing number of experimental observations show that synchronously firing neurons seem to be involved in the generation of conscious percepts, while non-synchronously firing neurons don't (Eckhorn *et al.*, 1988; 1993; Eckhorn, 1994; Engel *et al.*, 1991a,b; Fries *et al.*, 1997; Gray *et al.*, 1989; Kreiter and Singer, 1996). McFadden makes a number of statements about this but, like everyone else so far, does not precisely grasp the point. The point is that synchronously firing neurons contribute disproportionately to meso- and macroscopic electromagnetic patterns. As pointed out in Pockett (2000), the relative contribution to a field potential of coherently firing neurons (M) to incoherently firing neurons (N) has been estimated to be $M / \sqrt{N}$ (Elul, 1971). About 10^7 neurons line up in parallel within a $1cm^2$ potion of cortical gyrus. If only 1% of these fire coherently, the relative contribution of these 1% of neurons to the overall electromagnetic pattern would be $10^5 / \sqrt{10^7}$, or about 30 times greater than that of the 99% of neurons which fire incoherently (Nunez, 1995). If conscious percepts are electromagnetic patterns, 1% of neurons firing coherently would be likely to contribute up to 30 times more to conscious percepts than the other 99% of neurons.

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[1] Others of Libet's data have been taken as indicating a similar lag of consciousness behind events in relation to sensory qualia, but these data are subject to alternative interpretations (e.g., Pockett, 2002a).

[2] I use the word intentionality here in the sense in which Thomas Aquinas and Walter Freeman use it, referring to directedness towards some future goal, not in the modern philosophical sense of meaning that consciousness is necessarily of or about something.

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