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Fish sentience: A hypothesis worth pursuing

Commentary on **Woodruff** on *Fish Feel*

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Abstract: Woodruff's case for fish sentience is intriguing. Though far from ready for final acceptance, it is worth pursuing. The case is philosophically uncontroversial under functionalism and reductive materialism. It is also highly heuristic, as it raises interesting issues for further investigation, such as the neural causation of behavior, the role of Mauthner cells in conditioned avoidance, and whether operant conditioning is constitutive of fish sentience.

Keywords: fish, sentience, pursuit, acceptance, Mauthner cells, neural causation of behavior, C-start reflex, Pavlovian conditioning, operant conditioning, functionalism, reductive materialism

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Woodruff (2017) makes a case for the hypothesis (a term he repeatedly uses, to the benefit of his case) that certain fish (the *Actinopterygii* class, which includes the *Teleostei* infraclass and forms over 90% of living fish) could have phenomenal consciousness (subjective qualitative experiences), or "sentience" for short. Woodruff joins forces with others he cites to reject the claim that fish lack sentience. This negative claim has been made on two grounds. (1) Fish lack the kind of complex neuroanatomical organization presumably "necessary" (more on this seemingly innocent word below) for sentience (viz., a layered neocortex that receives substantial projections from the thalamus, or something near enough or "homologous"). (2) Fish also lack the kinds of complex behaviors often linked to sentience. Against both (1) and (2), Woodruff reviews evidence that fish have neuroanatomical structures (optic tectum, pallium) with the required organization, physiology, and sensory and behavioral correlates (e.g., conditioned avoidance) to meet the requirements for at least one kind of sentience, namely, visual phenomenal consciousness.

I find Woodruff's case scientifically intriguing — at least no less so than other cases of evidential support for hypotheses in science. He follows the tried-and-true scientific strategy of mustering as much evidential support as available for a tentative, preliminary, suggestive, but scientifically educated supposition. The evidence he presents strikes me as clear and diverse enough to treat the hypothesis at least as worthy of further scientific inquiry.

I missed a discussion of Mauthner (M) cells (a pair of readily identifiable reticulospinal neurons in the hindbrain near the entry of cranial nerve VIII, just under the fourth ventricle in teleosts and some amphibians), as they are a much-investigated neural substrate of the

unconditioned C-start escape reflex in teleosts such as zebrafish (*Brachydanio reri*) and goldfish (*Carassius auratus*) (see Eaton, Lee, & Foreman, 2001, for a review). This reflex might underlie the kind of behavior Woodruff views as indicative of fish sentience, namely, conditioned avoidance. M cells were also at the center of a major conceptual debate in recent behavioral neuroscience: What is a command neuron? Eaton and colleagues' research showed, contrary to what some had hypothesized, that M cells are not command neurons, at least as Kupfermann and Weiss (1978) defined them [in the inaugural year of the journal on which *Animal Sentience* is modelled: *Behavioral and Brain Sciences* – ed.], as necessary and sufficient neurons for certain behaviors. Thanks to that research, it has become doubtful that command neurons thus defined exist.

I bring up M cells to ponder their possible role in conditioned avoidance in teleosts. Moreover, the likelihood that command neurons as defined by Kupfermann and Weiss (1978) do not exist suggests that to hypothesize certain neural substrates to be "necessary" for conditioned avoidance and hence for fish sentience, as Woodruff does, might be counterproductive. Woodruff uses the term "necessary" a bit too often, which I believe weakens his scientific case for fish sentience, vis-á-vis Eaton and colleagues' research. This research strongly suggests that even a seemingly basic neuron such as the M cell is not strictly necessary for a seemingly simpler behavior (C-start unconditioned escape reflex) that might underlie conditioned avoidance in teleosts.

All this points at the suggestion that the neural substrates and behavioral indicators of fish sentience might be a more complex affair than is apparent from Woodruff's case for it. More generally, there may be no such thing as necessary (let alone sufficient) conditions for sentience, even in humans. A revision of alternative views of causation other than the simplistic necessary-and-sufficient-condition view could clarify the philosophical discussion on fish sentience.

In particular, Mackie's (1965, 1974) influential (albeit controversial) view of causes as "INUS" conditions could be illuminating. The acronym stands for an "**I**nsufficient but **N**ecessary factor *A* in a conjunction of factors (*A* & *B* & *C* & ...), out of possibly several conjunctions, that is **U**nnecessary but **S**ufficient for a certain effect *E*." In the present case, *E* would be some behavior (e.g., the unconditioned C-start escape reflex, conditioned avoidance behavior in teleosts). This allows us to accord a necessary/sufficient causal role to the functioning of M cells while avoiding Kupfermann and Weiss's (1978) simplistic definition. Such functioning could thus be viewed as an INUS condition for the unconditioned C-start escape reflex in teleosts (and providing a more plausible definition of command neuron that is consistent with Eaton et al.'s research). The (functioning of the) optic tectum and pallium might also be more plausibly (and profitably) viewed as INUS conditions for conditioned avoidance in teleosts.

The relations between M cells and the optic tectum and pallium, as well as the C-start escape reflex and conditioned avoidance, to sentience in teleosts deserve closer scientific investigation. Conditioned avoidance, in particular, raises the issue of the relation between instrumental (operant) and Pavlovian (classical) conditioning, which adds to the complexity of the behavioral indicators of fish sentience. Conditioned avoidance in shuttle-boxes is a complex arrangement that involves two kinds of contingencies: An initial Pavlovian (light-shock) contingency and, later, a response-dependent reduction in shock frequency. Exactly how these two contingencies interact in associative learning remains an extensively investigated but as yet unresolved issue. A key question here is whether conditioning under operant contingencies is

constitutive of sentience — or is just Pavlovian conditioning enough? Why? All of this, of course, attests to the highly heuristic value of Woodruff's case.

In the meantime, and to continue waxing philosophical, I find Woodruff's case intriguing enough to warrant scientific *pursuit*, but not *acceptance* (see Laudan, 1977, for this important but overlooked distinction) of the hypothesis of fish sentience (and many others, to be sure, the contrary one included). Woodruff shows that the possibility of fish sentience deserves serious scientific consideration, at least as much as the contrary hypothesis. Acceptance of either hypothesis would require a much stronger, definitive commitment — one that very few hypotheses, if any, deserve. Even the best-supported hypotheses are corrigible, as is the evidence that supports them.

I thus see no fundamental difference between how Woodruff follows this strategy and how others do it to support other hypotheses in science (e.g., the existence of Higgs bosons, black holes, or an alien megastructure surrounding KIC 8462852). Perhaps, sentience has been a somewhat more contentious topic because, like intelligence and awareness (and thought), sentience supposedly bears directly on what makes us human. The controversies that surround sentience may thus be akin to those that once surrounded heliocentrism and evolutionism long ago, which questioned humanity's centrality in the universe.

To be sure, some philosophers' discussions have added to the aura of mystery about sentience (e.g., Chalmers, 1997; Jackson, 1982, 1986; McGinn, 1999; Nagel, 1974). A common denominator in these approaches is a rejection of reductive materialism, also known as mind-brain identity theory. According to the type-type version of this theory, all mental properties (and, hence, all particular mental states, events, and processes) are brain properties (and, hence, they are particular brain states, events, and processes; see Polger, 2004, for a recent defense of this theory). But it would be mistaken to imply that such a common denominator is incompatible with the hypothesis of fish sentience. Quite the contrary: Non-reductive materialism, especially functionalism, in at least some forms (e.g., the machine-state version propounded by Putnam, 1960, 1967; cf. 1988, Ch. 5), is entirely compatible with the hypothesis, and others that are perhaps less palatable to behavioral neuroscientists.

In particular, functionalism implies that even *inorganic systems* (e.g., silicon computers) *could in principle* be sentient, and literally (not metaphorically) so. To qualify as sentient, they would have to have internal states that serve as causal mediators between inputs and outputs of the same *kind* as those found in sentient beings. Under functionalism, then, the possibility of *inorganic machine* sentience is entirely coherent and unsurprising (my emphasis on "inorganic" here averts the rebuttal that animals too are machines; they are, but organic ones). If machine sentience is a coherent possibility under functionalism, the hypothesis of fish sentience becomes less puzzling.

But the possibility of machine sentience might strike behavioral neuroscientists, maybe Woodruff included, as too much of a stretch. They, like many others, might find functionalism too permissive and thus react similarly to another hypothesis, likewise possible under functionalism: *plant* sentience (Baluška & Mancuso, 2016; Smith, 2016, Ch. 2). Still, the possibility of plant sentience, too, makes the hypothesis of fish sentience entirely unsurprising, which makes Woodruff's case seem less radical. To functionalists, fish sentience is nothing to fret about: They are the least likely to be naysayers about Woodruff's hypothesis; but then again, Woodruff and other behavioral neuroscientists may well see functionalism as being overindulgent.

Woodruff's case would also seem less radical on the conjecture of some functionalists (Block, 1995, 2005; Burge, 1997; Dennett, 1996) that sentience might be basic and thus widespread across *Animalia*. This conjecture is consistent with the possibility that some insects (e.g., bees) could also be sentient (Smith, 1991; Klein & Barron, 2016; cf. Reber, 2016). If insects could be sentient and are neurobiologically and behaviorally simpler than fish, then fish sentience should not come as a surprise.

An alternative to functionalism is the mind-brain identity theory.* To be sure, this theory rules out machine and plant sentience, but not fish or insect sentience. Nothing in identity theory precludes the possibility of different kinds of brains and, hence, different kinds (or degrees) of sentience. Fish sentience is thus entirely possible in reductive materialism as well.

At last two philosophies of mind, then, functionalism and reductive materialism, render Woodruff's case philosophically uncontroversial, which facilitates taking it into consideration. Philosophy of mind is listed among Woodruff's interests in the target article. I would be very interested to know how he navigates through these philosophical choppy waters.

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*Yet another alternative is behaviorism, but the dominant form of behaviorism, radical Skinnerianism, rejects any causal explanations of behavior in terms of brain states.

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