

Octopus experience

Commentary on [Mather](#) on *Octopus Mind*

Peter Godfrey-Smith

Faculty of Science
University of Sydney

Abstract: The first part of this commentary attempts to get "inside" the octopus mind a little further than Mather does, drawing on her description of octopus cognition in many places but diverging in others. The second part outlines other disagreements with her account of the animals, especially in the area of social behavior.

[Peter Godfrey-Smith](#) is Professor of History and Philosophy of Science at University of Sydney. His main research interests are philosophy of biology and philosophy of mind. His books include *Other Minds: The Octopus, the Sea, and the Deep Origins of Consciousness*. [Website](#)



Few people – perhaps no people – are as well qualified to try to get inside the mind of an octopus as Jennifer Mather. She has worked on these animals for many years and has done uniquely informative experiments that bear on the more cognitive side of their capacities and the most challenging questions about them. Her target article is a detailed survey of what is known about octopus cognition and how it might relate to their experience. Yet, for all the ecological and behavioral detail, she does not try to get *inside* them very much, except in a few passages, where she does try to work out what octopus experience might feel like from the animal's point of view. This itself is not a criticism. Her choice may reflect a reasonable belief about what can and can't be known at this stage (perhaps ever). But I am going to take this opportunity to try to get a bit further in, to ask some questions about what octopus experience might feel like to the animal. To do this involves a kind of imaginative leap, an attempt to place ourselves in something like their perspective. Doing that is not doing science, but it can be guided by science. Imaginative moves of this kind can be consistent with — or fail to be consistent with — what we know or have reason to believe about what the animals can do. So I will press forward a little on this, accepting Mather's account of the octopus and its capacities in many places but indicating disagreements in others. At the end of the commentary, leaving the imaginative exercise, I will list some other places where I don't agree with what Mather says about the animals.

If we want to work out what octopus experience feels like, a good place to start is with the sensory side. Philosophers overstate and overweight the role of sensing *per se* in subjective experience – as opposed, for example, to moods, feelings and urges. But sensing is certainly part of the picture. Octopuses are very visual animals; this they share with us. People sometimes claim that octopuses are extremely near-sighted, something that would affect their experience

of a world of objects around them, but this is certainly not true of some species. I have seen octopuses react to other octopuses coming in towards them from at least five meters or so in conditions of only moderate visibility and responding differently from how they respond to other incoming animals.

Mather says a couple of times that octopuses are color-blind. This is the standard view despite the puzzles it raises about their ability to match hue as well as brightness in camouflage. A number of proposals have been offered about how cephalopods might be able to discriminate colors by unusual means. Stubbs and Stubbs (2016) argue that cephalopods might use chromatic aberration caused by the shape of their lens to distinguish colors. Another proposal links the question about color to a more intriguing feature of octopus sensing, the fact that octopus skin (or the skin of *Octopus bimaculoides*, anyway) is sensitive to light (Ramirez and Oakley 2015). This finding opens the way to further possibilities concerning color sensing (as Mäthger et al. 2010 [sic] noted in an earlier discussion of light sensitivity in cephalopods), because there might be interactions between color production mechanisms, controlled by the brain, and color-sensing mechanisms. This also affects rather strikingly the question of what it might feel like to be one of these animals. It's not quite that an octopus can see with its skin – not in the sense of forming an image – but it may well be that not just the intensity of light, but changes, shadows, and perhaps hues can be detected with the whole body. Mather does not discuss any of this, perhaps because she is not convinced it is likely to be important. I am curious what she thinks, as it might change our view of their visual experience. (Incidentally, it may be that some Echinoderms really can see – picking out objects – with their whole bodies: see Yerramilli and Johnsen 2010).

Octopus arms, through their suckers, are very sensitive to touch and to chemical stimuli. A rubber glove and bare skin are immediately treated as entirely different by an octopus. So we have a body with good vision and eight very sensitive arms. When we imagine octopus experience, we should start with a sensory world intensely charged with these modalities. But then we should add another feature of the octopus's organization:

As discussed by Mather, octopuses have a rather decentralized, distributed nervous system, with more than half the neurons in the arms themselves. In addition, it is not clear how much awareness an octopus has of the location of its own arms much of the time. It is difficult to know whether they lack proprioception altogether and must use vision only to work out where their arms are, or they have hidden proprioceptive mechanisms. Let us assume that octopus proprioception is at least much reduced compared to ours. (Several people have made a speculative comparison between octopuses and Ian Waterman, a famous neurological patient who lost all proprioception due to an infection and must use vision to keep track of his body: Carls-Diamante 2017 and Keijzer, personal communication).

Experiments from the Hochner lab in Jerusalem have shown that octopuses can direct their arms visually when they want to (Gutnick et al. 2011), and in *Other Minds* (2016) I discussed field observations where octopuses engaged in conflicts using a single arm like a cocked fist directed toward another octopus when advancing from some distance away (see **Figure 1**). There is top-down control of the arms in these contexts. Suppose we put these data together with the view that has been offered (sometimes impressionistically, sometimes based on observations after an arm has been severed) that arms can generate some basic movements, perhaps including exploration, in a self-guided way. This would suggest arm control that might

be mixed between central and local control, or alternating between them, or both. I conjecture (and this step is purely a conjecture) that an octopus uses attention to "pull itself together" on some occasions but also, when attentional focusing is absent, the arms are allowed to carry on some local exploration of their own.



Figure 1: An octopus (*O. tetricus*) attacking another with a single directed arm. Photo appears (BW) in Godfrey-Smith 2016, p. 68.

If this conjecture is right, and putting the previous paragraphs together, we reach an experiential situation rather far from our own. Assuming that sensory information from skin and suckers does get to the central brain and is not entirely local in its effects, we have an animal that has both a very expansive sensory surface – with respect to light, chemicals, and touch – and a sensory surface that has an unpredictable extent and shape. Arms can wander in ways that induce sensory events, doing so simultaneously at least with respect to a couple of arms, and will be very sensitive to what they encounter. When I try to imagine this, I find myself in a rather hallucinogenic place, and that is everyday life for an octopus.

Sensory experience interacts with aspects of experience that are evaluative, including mood-like and emotion-like states (Walters 2018, Feinberg and Mallatt 2016). I agree to some extent with Mather's soliloquized summary of the motivational side of octopus life: "Exploration: What might I do with this object?... Fear: Everyone is out to get me.... Flexibility: If at first you don't succeed, try another way." As David Scheel pointed out to me, Mather's soliloquy omits some other motivations that might figure in octopus life: rivalry and possessiveness, aggression rather than fear in response to a threat, along with comfort and familiarity. We might then imagine, as a first approximation, a sensory presentation that incorporates vision with centrally unpredictable effects of local arm actions and a motivational profile that includes those features.

I say "first approximation" especially, as this assumes the existence of a single experiencing *self* in the octopus. It may be that the distributed nature of the octopus nervous system precludes this, replacing it with something of a different shape. A conjecture that I think

makes some sense of observed behaviors is one related to what I said about central and peripheral control above. Attention can pull together the octopus and centralize its action, as seen in jetting, in whole-body displays, in directed reach, and some den-building behaviors. But the low-attention state for an octopus, when it is not entirely quiescent, could be one that includes semi-autonomous arm motions. These arm activities may be too simple and too far from having self-like properties to be centers of experience of their own. Instead, the situation might be one where there is a single subject of experience, but one that is more or less extensive at different times – one that incorporates more or less of the animal's body. When it is less extensive, this is because the arms are partially self-directed.

Another possibility that has been raised is a *two*-subject view of the octopus, where one experiencing subject is based in the central brain and one is based in the arm network as a whole. This possibility was raised for consideration (but not endorsed) by Carls-Diamante (2017), drawing on Grasso (2014). I am doubtful about this option because of the limited unity of the neural basis for the "second self." That system is perhaps large enough, but not integrated enough in its own right.

I will close by setting aside this attempt to get inside octopus experience and describing some disagreements with more minor points in Mather's target article, some related to my own work. Mather says: "Godfrey-Smith (2016) has suggested that cephalopod brains lack reafference copy of their actions (the internal feedback loops duplicating action commands that help vertebrate brains monitor their motor output)." But in *Other Minds* I did not make any claims about which octopus actions are associated with internal efference copies and which are not. She also describes some of our field work as follows:

“Recently, Scheel et al. (2016) found *O. tetricus* gathered in a mound of scallop shells. They observed many interactions and suggested that we should no longer consider octopuses to be solitary animals. However, the bulk of evidence, including their own study, still suggests that they are solitary.”

The "Octopolis" site (discovered by Matt Lawrence in 2009 and first reported in Godfrey-Smith and Lawrence (2012)) was not used to claim that octopuses in general are not solitary. Many species, perhaps most, may well be rather solitary, or solitary in most circumstances. In our 2016 paper, we collected primary reports of social behaviors or displays to conspecifics among over a dozen different octopus species (2016, Table 1). That is a significant range of exceptions. I do think there is probably more variation in social tendencies than earlier literature acknowledged. Mather suggests that "*Abdopus* is clearly the most social of this solitary group" and "definitely the most social octopus known," drawing on Huffard et al. (2010). The Larger Pacific Striped Octopus would probably vie for this title, as pairs share dens (in captivity) and have even shared food (Caldwell et al. 2015).

Mather suggests that a dark mantle color in *O. tetricus* we interpreted as a display in our 2016 paper is "perhaps a general arousal leading to more chromatophore muscle tension and not a stereotyped display." However, octopuses attempting to return to a den under the eye of an aggressive individual did not produce a dark color, and that would appear to be a high-arousal situation. In addition, the dark coloration we described in that paper was associated

with several other distinctive behaviors with display-like features, including spreading of the web and arms, and "standing tall."

Lastly, in Mather's table summarizing "actions by octopuses that require the guidance of a mind" (Figure 7), several examples lend themselves to explanation in lower-level terms than the ones she gives. Avoidance of stinging sea anemones, even if learned, probably does not require "causal reasoning," unless every case of reinforcement learning should be interpreted in these terms. The same applies to her interpretation of wiggling of arm tips to lure prey in terms of planning and imagination. I do not endorse an Occamist view in this area – the idea that low-level explanations deserve the benefit of the doubt. (See Mikhalevich 2015 for arguments against over-use of Occamist principles in animal behavior studies.) But simpler options are still "live" in these cases, and more would have to be done to support the richer interpretations.

References

- Caldwell RL, Ross R, Rodaniche A, Huffard CL (2015). [Behavior and body patterns of the larger Pacific striped octopus](#). *PLoS ONE* 10(8): e0134152.
- Carls-Diamante, S. (2017). The octopus and the unity of consciousness. *Biology & Philosophy* 32: 1269-1287.
- Feinberg T, Mallatt J (2016). *The Ancient Origins of Consciousness*. Cambridge MA: MIT Press.
- Godfrey-Smith P (2016). *Other Minds: The Octopus, the Sea, and the Deep Origins of Consciousness*. New York: Farrar, Straus and Giroux.
- Godfrey-Smith P, Lawrence M (2012). Long-term high-density occupation of a site by *Octopus tetricus* and possible site modification due to foraging behavior. *Marine and Freshwater Behavior and Physiology* 45: 261–268.
- Grasso FW (2014). The octopus with two brains: How are distributed and central representations integrated in the octopus? In: A-S Darmaillacq, L Dickel, JA Mather (Eds.), *Cephalopod cognition* (pp. 94-112). Cambridge, UK: Cambridge University Press.
- Gutnick T, Byrne R, Hochner B, Kuba M (2011). *Octopus vulgaris* uses visual information to determine the location of its arm. *Current Biology* 21: 460–462.
- Huffard, CL, Caldwell, RL, Boneka, F (2010). Male-male and male-female aggression may influence mating association in wild octopuses (*Abdopus aculeatus*). *Journal of Comparative Psychology* 124: 38-46.
- Mather, J (2019) [What is in an octopus's mind?](#) *Animal Sentience* 26(1).
- Mäthger LM, Roberts SB, Hanlon RT (2010). [Evidence for distributed light sensing in the skin of cuttlefish, *Sepia officinalis*](#). *Biological Letters* 6: 600–603.
- Mikhalevich I (2015). Experiment and animal minds: Why the choice of the null hypothesis matters. *Philosophy of Science* 82: 1059-1069.
- Ramirez MD, Oakley TH (2015). [Eye-independent, light-activated chromatophore expansion \(LACE\) and expression of phototransduction genes in the skin of *Octopus bimaculoides*](#). *Journal of Experimental Biology* 218: 1513-1520.
- Scheel D, Godfrey-Smith P, Lawrence M. (2016). Octopus use signals during frequent conspecific interactions. *Current Biology* 26: 377–382.
- Stubbs AL, Stubbs CW (2016). [Spectral discrimination in color blind animals via chromatic aberration and pupil shape](#). *PNAS* 113: 8206-8211.
- Walters ET (2018). Nociceptive biology of molluscs and arthropods: Evolutionary clues about functions and mechanisms potentially related to pain. *Frontiers in Physiology* 9: 1049.
- Yerramilli D, Johnsen S (2010). Spatial vision in the purple sea urchin *Strongylocentrotus purpuratus* (Echinoidea). *Journal of Experimental Biology* 213: 249-255.