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Essay Review

Octopuses as conscious exotica

Other Minds: The Octopus and the Evolution of Intelligent Life, Peter Godfrey-Smith. William Collins, London (2017). pp. 255, Price £14.99 paperback, ISBN 978-0-00-822631-2

In one of his short stories, author Ted Chiang describes Lisa—an expert linguist—attempting to decipher the written language of an alien species (Chiang, 2002). Lisa is finally able to decode the intricate semagrams, and as she grows fluent in the language, she finds herself thinking in it too. It is then that she fully realises that the experiences of these aliens differ dramatically from human thought. Rather than seeing the world causally and sequentially, as humans do, the aliens experience the world "all at once". Rather than moving through time, they experience the world integrated over time, with the past, present, and future occurring simultaneously.

The problem of understanding alien minds is not limited to fiction. It has occupied philosophers and scientists for millennia. For as long as we have tried to grasp the mysteries of human consciousness, we have tried to understand nonhuman consciousness and, crucially, how to identify it when we see it. Contemporary research in cognitive science is no different. Cognitive scientists have asked whether scrub jays have vivid memories of the past, whether chimpanzees infer the experiences of others, and whether mice experience fear. Our desire to understand nonhuman consciousness, however, does not end with those animals with which we share an evolutionary history. Indeed, today the question of alien thought is attracting more attention, as artificial agents not only succeed in tasks historically achieved by humans alone, but also exceed humans in those tasks. DeepMind's program AlphaGo, for example, surprised the world last year by defeating world-leading Go champions. As Co-Founder and CEO of DeepMind, Demis Hassabis notes, this was "an order of magnitude better than anyone's ever imagined" (Burton-Hill, 2016). Go—a game so complex that evaluating all potential moves is not possible—has been played and studied by humans for over 3000 years. Go professionals often begin training as children. In May 2017, AlphaGo beat the top world ranked player, Ke Jie, who described AlphaGo as godlike in its abilities (Metz, 2017). As I write this (October 2017), DeepMind has released AlphaGo Zero, a program that has taught itself to play Go without being trained on human play (unlike AlphaGo, which was trained on human play). It beat the unbeatable AlphaGo 100 to 0.

As we learn more about the cognitive capacities of nonhuman organisms and as machines become more intelligent, the question of nonhuman consciousness moves to the forefront. Peter Godfrey-Smith's book, "Other Minds", is timely. The book investigates alien intelligence, focusing on cephalopods. Cephalopods, like snails and slugs, are molluscs—a phylum of invertebrate animals. Unlike other molluscs, however, cephalopods such as the octopus and cuttlefish are neurologically and behaviourally very complex. Invertebrate minds like these are alien in the sense of being unlike human minds on a variety of dimensions. Other cognitively sophisticated animals like chimpanzees diverged from humans 5–7 million years ago and share the same basic neural structure. In contrast, cephalopods and humans diverged 600 million years ago. Our last common ancestor with the cephalopod was likely a simple sea-dwelling creature with the body of a flat worm less than a centimetre long (5–7).[1] Both humans and cephalopods have come a long way since diverging. And, remarkably, both have ended up with what looks like intelligence. As Godfrey-Smith writes, "cephalopods are an independent experiment in the evolution of large brains and complex behaviour" (9). By examining cephalopod minds, we gain insight into the possible forms that intelligence and consciousness take.

In this essay, I draw on Godfrey-Smith's analysis in order to sketch the ways we might learn about what Murray Shanahan calls "conscious exotica" (Shanahan, 2016). Conscious exotica are creatures or systems that have a rich inner conscious life, but whose structure and behaviour is radically unlike humans. These are creatures that are so unlike humans that we may lack the vocabulary to describe their states. Conscious exotica represent an important case study in our scientific understanding of consciousness. Consciousness is typically identified in nonhuman organisms on the basis of similarities to humans. Given this, is it possible to identify consciousness in creatures that are radically different from us? If so, how can this be accomplished? Cephalopods provide an example of how this might be achieved.

Godfrey-Smith describes cephalopods as "probably the closest we will come to meeting an intelligent alien" (9). If cephalopods are conscious, then they may be the best example we have of alien consciousness. Cephalopods are not entirely different from humans in that both groups evolved on the same planet and were shaped by relatively similar environmental and evolutionary constraints. Both humans and cephalopods are carbon-based biological creatures that consume nutrients, reproduce, and die. The exotica Shanahan has in mind are more divergent—they might be extra terrestrial beings or machines built on principles opaque to humans. However, if we want to understand how to infer consciousness in alien and artificial beings, cephalopods are a good starting point. These are creatures with three hearts and a large distributed nervous system with multiple centralised "brains". As Godfrey-Smith writes, "If we want to understand *other* minds, the minds of cephalopods are the most other of all" (10).

Before beginning, two clarifications are in order. First, we must define what we mean by "consciousness" as this term is used to refer to a multitude of things, such as wakefulness, subjective experience, and self-awareness (Allen & Trestman, 2016). The form of consciousness Godfrey-Smith is most interested in is subjective experience (92), which is what we will focus on here. The question Godfrey-Smith asks is, "does it feel like

[1] Unless otherwise specified, citations refer to the page numbers of "Other Minds".

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something to *be* one of the large-brained cephalopods, or are they just biochemical machines for which all is dark inside?" (12). Subjective experience or "sentience" can be understood here as the ability to have experiences, such as emotions, seeing colours and shapes, and hearing sounds (see Van Gulick, 2017). Subjective experience is what leads to the Hard Problem of consciousness, something we will revisit below. It is the element that defies capture by physical theories and seems unknowable unless one is the experiencing subject.

The second important thing to note is that there are two distinct questions we can ask about consciousness. The *distribution question* asks, "can we know which animals beside humans are conscious?" while the *phenomenological question* asks, "can we know what, if anything, the experiences of animals are like?" (Allen & Trestman, 2016). We may agree that cephalopods are conscious (an answer to the distribution question) without knowing what their experiences are like (an answer to the phenomenological question). In order to identify conscious exotica, one need only answer the distribution question. However, we will often want to go further and identify the varieties of experiences that a nonhuman organism or artificial system is capable of—can it see or hear, can it feel pain, does it understand itself as a self that persists through time?

Starting with the distribution question then, are cephalopods conscious at all? For Godfrey-Smith, the answer is "yes." Octopuses have large nervous systems with around 500 million neurons, a size comparable to other mammals (50). They also have large brains relative to their body size. Brain size alone is a poor proxy for specific cognitive functions, however (Logan et al., 2017); thus, in order to infer something about the subjective experience of an organism from its brain, we must look more closely at the brain's structure and function.

The nervous system can be understood as having two general functions: to coordinate actions (to ensure all parts of an organism work together to enable a macro action like locomotion) and to link sensory input to actions (to provide sufficient communication between sensory input and motor control so that the former can guide the latter) (24–27). While both functions are crucial, it is the latter that likely gives rise to subjective experience, according to Godfrey-Smith: "subjective experience does not arise from the mere running of the system, but from the modulation of its state, from registering things that matter" (96).

Godfrey-Smith locates the evolutionary emergence of consciousness in the Cambrian period, which began about 542 million years ago. It is then that organisms began responding to a complex world populated with predators and prey—a world in which fast communication between sensory and motor systems was likely crucial to survival. There are several ways that sentience could emerge from a brain that evolved in such an environment. In addition to developing the capacity to obtain and manage rich sensory information, Godfrey-Smith discusses two new modes of processing, both of which he thinks plausibly played a role in shaping subjective experience (Godfrey-Smith, 2016a, 2016b, in press). First, in order to survive in a complex environment, an organism should be able to distinguish good stimuli from bad—that is, have an affective system. Such "primordial emotions" or "feelings that must be acted on" would allow an individual to successfully identify conditions harmful to it, such as lack of food, water, or air, as well as beneficial conditions, like food sources (96). Second, it is important for mobile organisms to be informed or aware of the motor actions that they are engaging in. Such awareness can be achieved through the production of efference copies or internal messages that inform the nervous system of the organism's actions. The nervous system can then compare these copies with sensory input in order to distinguish between stimuli that are a result of the world (an object coming towards the organism, for example) and stimuli that are a result of one's own actions (the organism moving towards an object). This would result in a rudimentary sense of self or "the beginning of an internal registration of the self/other divide" (Godfrey-Smith, 2016b).

The octopus engages with its environment in sophisticated ways. Thus, we have good reason to think that a key function of the octopus's nervous system is to modulate sensory-motor activity. First, octopuses have "complex active bodies" or bodies that are built to engage with the world (38; Trestman, 2013). An octopus's eight arms are used not only for locomotion, but to explore, capture prey, and defend against predators. Each arm is controlled by a nervous system that can act relatively independently of the octopus's central nervous system. Each arm has millions of receptors for taking in tactile and chemical information (Hochner, 2008). However, octopuses can also visually direct their arms in the absence of chemical and tactile information, suggesting some multimodel sensory integration (Gutnick, Byrne, Hochner, & Kuba, 2011). Octopuses also have a camouflage system that includes tens of thousands of pigmented cells (chromatophores), each of which is controlled directly by the nervous system (Ramirez & Oakley, 2015). The octopus uses this system to hide from and confuse predators, as well as communicate to conspecifics. Godfrey-Smith writes, "If there is a form of subjective experience that comes along with sensing and acting in a living system, the octopus has plenty of that" (98).

The above suggests that octopuses should have some form of consciousness, but what kind of experiences do they have? What does it feel like to be an octopus? We turn to the phenomenological question. Based on the above, we can say that octopuses likely have basic subjective experiences, such as bodily awareness and primordial emotions such as hunger, thirst, and pain (Denton 2009).

In addition to recognizing continuities in human and octopus experience, we can identify discontinuities. Octopuses lack language and do not appear to engage in anything resembling speech. Given this, we can be fairly certain that octopuses lack subjective experiences analogous to human inner speech. This is an important difference as inner speech is a prominent player in the subjective experience of humans. As Godfrey-Smith writes, "the echoes and commentary, the chatter and cajoling, are as vivid as anything in our inner lives" (149). Octopuses do communicate, however. For example, they change the colour of their skin in order to signal to potential mates and competitors (125). Their skin also engages in what looks like a kind of "chromatic chatter" (128). Even when there is no one around, the skin of a cephalopod will display fluctuating colours. These colour changes are best interpreted not as a kind of talking to oneself, however, but as involuntary firings of the nervous system, the chromatic system on "idle" (127). Unlike speech and gestures, which a signaller can observe, octopuses are unable to observe their own skin patterns; thus, "there's probably not much role for the efferent copies that involve skin patterns" (156). Efferent copies of verbal speech are a hypothesized mechanism for our capacity for inner speech (143–148).

Although octopuses do not appear to experience anything resembling inner speech, we have reason to think that their subjective experiences go beyond primordial emotions and bodily awareness. Humans without the capacity for language or inner speech are sometimes capable of sophisticated functioning (142–143). What form of nonlinguistic consciousness might underpin such behaviour and what are its functions? Regarding function, there are several candidates, such as the integration of sensory input to form a coherent model of the world and the ability to solve novel problems in a deliberate, non-routinized way (87–92; see also chapter 6). Such abilities may lead to "an integrated perspective on the world" and "a more definite sense of self" (97). If this were the case, then identifying abilities like these in octopuses would suggest that they possess additional forms of consciousness. Although more research is needed in this area, octopuses are regularly described as curious, observant, innovative problem solvers, and as being able to use multimodal sensory information in sophisticated ways (98–105; Hochner, 2008). If future studies show this to be the case, and the above theories of consciousness are correct, then we would have good evidence that octopuses have conscious abilities beyond primordial emotions and bodily awareness.

Thus, it seems possible, to some degree, to get an answer to the phenomenological question with respect to octopuses. Some might feel unsatisfied with answers such as the above, however. Godfrey-Smith intends to make headway on the Hard Problem of consciousness. He asks, "how do