Sentience, the final frontier….

Commentary on **Sneddon et al.** on *Sentience Denial*

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Abstract: Arguments for fish sentience have difficulty with the philosophical zombie problem. Progress in AI has shown that complex learning, pain behavior, and pain as a motivational drive can be emulated by robots without any internal subjective experience. Therefore, demonstrating these abilities in fish does not necessarily demonstrate that fish are sentient. Further evidence for fish sentience may come from optogenetic studies of neural networks in zebrafish. Such studies may show that zebrafish have neural network patterns similar to those that correlate with sentience in humans. Given the present uncertainty regarding sentience in fish, caution should be applied regarding the precautionary principle. Adopting this principle may cause distress to humans, who are certainly sentient, as they strive to protect animals that may not be.

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Whether an entity is sentient depends on the definition of sentience. Sneddon et al. (2018) use Broom's (2016) definition, which requires that sentient organisms have subjective experiences (e.g., perceptions and emotions). Sneddon et al. (2018) make the case that fish have this capacity. They note that nociceptive stimuli exert a motivational force on their behaviour, and that nociception can be mitigated by opioids. They then examine the positions of those who believe fish are not sentient.

Sneddon et al. identify two major objections to fish sentience. Critics argue that fish lack complex cognitive abilities and that their brains lack the necessary neuroanatomical structures for sentience. Sneddon et al. cite work that convincingly demonstrates that fish can learn complex tasks. They also make the reasonable point that although fish lack the cortical areas thought to underlie sentience in humans (e.g., see Storm, 2017), fish could have evolved analogous neural circuits to produce this capacity.

Unfortunately, a major problem in determining whether fish are sentient is that it is difficult to exclude the possibility that fish are merely 'philosophical zombies'. In other words, fish could have complex learning, pass the mirror test for self-recognition, have modifiable pain systems, and show motivational responses to nociception, all without subjective experience. We know that this is a possibility because present-day artificial intelligence (AI), which is not thought to be sentient (Reggia et al., 2014), can mimic all of these phenomena. AI can learn complex tasks, including the ability to understand human language well enough to beat human contestants at the game show Jeopardy (see Tononi and Koch, 2015). AI can also learn to beat people at Go (Silver et al., 2017) and poker (Bowling et al., 2015). Winning at poker requires AI to 'know' when and how to 'deceive' (i.e., bluff), and to recognize when it is being deceived (www.bluffbot.com); these are non-trivial tasks. Robots have also been designed that can pass the test of mirror self-recognition (Komatsu and Takeno, 2011; Takeno et al., 2005). Some robots are equipped with nociceptors (e.g., sensors that respond to potentially damaging stimuli, Stiehl et al., 2004) that are modifiable (Ames et al., 2012). It should be noted, however, that having modifiable nociception is a poor criterion for sentience – all sensory systems are modifiable, even in very simple animals (e.g., vision in horseshoe crabs, Barlow et al., 2001). It is unclear why nociception would be expected to be different. 'Pain' can also be motivating for robots (see review in Adamo, 2016). For example, a robotic rat can be programmed to 'feel discomfort' when wet, and this discomfort 'motivates' it to learn the solution to a Morris water maze (Ames et al., 2012). Artificial emotions such as 'fear', anger', 'surprise', 'happiness' and 'sadness' have been programmed into autonomous robots, allowing them to adapt their behaviour to current conditions (Lee-Johnston and Carnegie, 2010): "[A]rtificial emotions can motivate a robot to reprioritize its goals, modulate its behaviour parameters and provide learning rewards" (Lee-Johnston and Carnegie, 2010, p. 469).

The ability of today's AI to mimic sentience without any inner experience (as far as we know) suggests that behaviour that implies sentience in us may not provide evidence of sentience in animals. On the other hand, the ability of AI to emulate some aspects of sentience does not mean that fish are not sentient. It merely demonstrates that these abilities do not require sentience. Studying patterns of neural activity using optogenetics in zebrafish could be an important step forward. Using optogenetics, it may be possible to study whether zebrafish neural activity has many of the attributes thought to be key in producing sentience in humans (see Storm et al., 2017). For example, computers tend to use feedforward neural architecture (with some exceptions, e.g., Ames et al., 2012), which Tonini and Koch (2015) believe is unlikely to allow for subjective experiences. Examining the details of zebrafish neural networks will allow comparisons with metrics thought to be important for supporting sentience; some of these metrics (see Storm et al., 2017) can be computed even though fish neuroanatomy differs from that of humans.

The authors acknowledge that, at present, it is not possible to be certain about sentience in fish. However, weighing the evidence, they argue that there is enough information to invoke the precautionary principle (Birch 2017), that is, that fish should be given explicit protection against pain and suffering. As they demonstrate, fish could be sentient, and it would therefore seem prudent to assume that they are sentient for regulatory purposes. However, we should not invoke the precautionary principle without considering the impact on humans. For example, if fish farmers in the developing world are shut out of EU markets because of fish welfare regulations, this will produce distress in humans. I do not mean to suggest that the precautionary principle is not appropriate for fish in some circumstances: only that the welfare of humans, who we know are sentient, must also be considered.

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