If it looks like a duck: Fish fit the criteria for pain perception
Commentary on **Sneddon et al.** on *Sentience Denial*

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Abstract: Whereas we have denied the experience of pain to animals, including human babies, the evidence is becoming clearer that animals across a variety of species have the capacity to feel pain (Bellieni, 2012). As converging findings are collected from pain studies and the study of cognition, it is becoming harder to deny that fish are among the species that do feel pain.

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Until very recently, it was widely believed that infants and young babies were incapable of feeling pain (Bellieni, 2012). As with fish, the argument went that babies had the pain receptors but that they did not experience the pain due to an underdeveloped central nervous system and poor memory (Bellieni, 2012). However, the evidence is becoming clearer that babies have fully developed neurobiological systems to respond to pain (Fitzgerald & McIntosh, 1989) and that their behavioral responses are indicative of the experience of pain (Bellieni, 2012). The arguments for pain experiences in human babies are very similar to the criteria suggested by Bateson (1991) to test for pain in animals.

Specifically, Bateson (1991) and Smith and Boyd (1991) have three basic behavioral signals that indicate their perception of pain: (1) that they respond to painful stimuli in ways that reduce damage, (2) that these behaviors are altered by known analgesics, and (3) that animals engage in avoidance responses to minimize contact with noxious stimuli. In their target article, Sneddon et al. (2018) describe clear examples of increased motor behavior in fish experiencing acetic acid, which would normally be an adaptive response for removal from an environment. Further, they review support for the effectiveness of analgesics in suppressing this change in behavior. Other studies have shown extensive learning of avoidance responses to noxious stimuli in fish (e.g., Dunlop, Millsopp, & Laming, 2006; Overmier & Hollis, 1990; Overmier & Hollis, 1983).

Thus, with good evidence that fish meet the behavioral criteria for the experience of pain, the sticking point on whether fish feel pain seems to be primarily a question of fish sentience. As described by Sneddon et al., sentience includes both cognitive and emotional abilities in animals. Chandroo, Duncan, and Moccia (2004) argue fish show representations of both their internal and

external environments. For example, fish form cognitive representations of aversive stimulation and form expectancies about that stimulation (reviewed in Overmier & Hollis, 1990). Fish show the ability to represent simple categories in order to form basic concepts such as musical types (Chase, 2001). They even show evidence of complex social skills such as social learning, cooperation, and cheating (as reviewed in Bshary, Wickler, & Fricke, 2002).

It is not surprising that fish are capable of a variety of cognitively complex behaviors given the recent research suggesting that even many invertebrates show remarkable cognitive abilities. Bees show the ability to represent numbers (Gross et al., 2009). They also show evidence of problem solving in a string-pulling task and of the ability to transmit that learning socially (Alem et al., 2016). Similarly, jumping spiders show the ability to make decisions about the best routes to take to reach prey items (Tarsitano & Jackson, 1997) and show expectancy violations based on the number of prey species present (Cross & Jackson, 2017). Although it seems unlikely that we will ever find evidence of fish theory of mind or metacognition, it is hard to deny that a variety of animals across phyla seem to show the basic properties of what some authors call "primary sentience," the awareness of their internal and external environments (for review see Chandroo et al., 2004). As we once did with babies, we now seem to be making complex arguments to deny the experience of pain in fish. If a fish looks like she is in pain and acts like she is in pain, the likelihood is the fish is in pain.

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