

ANIMAL SENTIENCE

AN INTERDISCIPLINARY JOURNAL ON ANIMAL FEELING

Mallatt, Jon and Feinberg, Todd E, MD (2022) [Decapod sentience: Promising framework and evidence](#). *Animal Sentience* 32(24)

DOI: 10.51291/2377-7478.1750



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Decapod sentience: Promising framework and evidence

Commentary on [Crump et al.](#) on *Decapod Sentience*

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Abstract: Strong points of the target article by Crump et al. are that it offers clear criteria for judging whether decapods are sentient, an effective semi-quantitative grading system for this purpose, and an astute, critical review of the literature. It concludes plausibly that major subgroups of decapods are sentient. A minor problem is that it includes classical, Pavlovian learning as a marker of sentience along with the more valid marker of complex (e.g., operant) learning. Another minor problem is that it does not distinguish results that are negative because of likely absence of sentience from results that are negative because they have not yet been gathered. Future studies should explore how decapods are sentient with so few neurons in their nervous system (<100,000).

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The target article by Crump et al. (2022) on sentience in decapod crustaceans is well-researched, clearly organized, and well-written. In our view, it meets its goals of presenting a framework for recognizing sentience (pain) in animals and of showing that decapods meet the framework's criteria and are hence likely to be sentient. It also offers a blueprint for future studies by exposing the gaps in current knowledge.

We consider sentience to be the same thing as primary consciousness [having the capacity to feel, Mallatt & Feinberg, 2020] so we will use the terms “sentience” and “consciousness” interchangeably in this commentary. We should also point out that we are on record as hypothesizing that all the arthropods are sentient, based on various lines of reasoning and

evidence, many of which match those in the target article (Feinberg & Mallatt, 2018; Mallatt et al., 2021).

The eight criteria for sentience proposed by Crump et al. are nicely balanced between four neural criteria and four cognitive-behavioural criteria. Relatively small in number and condensed yet informative, these criteria are easy to use for judging whether animals have sentience (see also the similar, but less-succinct, list of criteria in Feinberg & Mallatt, 2020).

1. **Nociception**
2. **Sensory integration**
3. **Integrated nociception**
4. **Analgesia:** (a) endogenous (b) exogenous
5. **Motivational trade-offs**
6. **Flexible self-protection**
7. **Associative Learning**
8. **Analgesia preference:** (a) self-administer (b) location (c) prioritised

Eight criteria for pain sentience

(Crump et al., 2022, §2.2)

Crump et al. state many of their criteria in ways that provide new insights into recognizing and understanding sentience. Here are some examples: Criterion 4 (Analgesia) ties together the actions of neurotransmitter chemicals and anesthetic chemicals as modulators of behavioural responses indicating pain; previous authors had split these into confusing jumbles of diverse criteria. Criterion 5, the conscious ability to make behavioral trade-offs by weighing positive versus negative stimuli, is rightly described as *motivational* trade-offs. This emphasizes that consciousness can motivate specific behaviors as well as help to choose them. This in turn allows behavioral flexibility. The target article defines flexibility as implying “that the animal can respond to the same noxious stimulus in different ways, depending on its situation” (p. 7).

Like Crump et al., we have always viewed flexible wound-tending as evidence that an animal feels pain (Criterion 6, Flexible self-protection). However, we did not infer that this implied the animal has “an internal representation of the location of the aversive stimulus.” We are happy to embrace this connection because we view neural maps of one’s body regions in the brain as themselves a sign of consciousness (Feinberg & Mallatt, 2016).

According to Criterion 7, associative learning can indicate sentience. Crump et al. emphasize the importance of “yoked controls” in experiments that test for such learning (p. 21): “a ‘yoked control’ is an animal that receives the exact same aversive stimuli as an animal in the test group, but unpaired with any neutral stimulus.” The target article helpfully explains that a yoked control can rule out the possibility that the learning is just a non-associative sensitization or habituation to the aversive stimulus. It also rules out the possibility that the response is not

due to learning at all, but to exhaustion from repeatedly responding to that stimulus during training.

With Criterion 8 (Analgesia preference), Crump *et al.* provide a useful explanation of why an animal that accesses analgesics is likely to be an animal who can feel pain (p. 24): learning an “active preference for analgesics or anaesthetics may also indicate the animal’s subjectively perceived aversion to nociceptive inputs, whilst separating this from the other direct effects of physical injury itself (e.g., impaired functioning).”

Other commenters on the target article have been pointing out that many of the eight criteria share overlapping parts, so they have been proposing ways to combine, eliminate, or down-weight certain criteria (Irvine, 2022; Jablonka & Ginsburg, 2022; Walters, 2022). These commenters offer ways to whittle the number of criteria down to four or three. A shorter and more compact list may indeed have some advantages. However, eight criteria seem few enough. Crump *et al.*’s Table 1 conveys the target article’s findings aptly by using all eight. Another reason we support using all eight criteria is that they match the categories of published studies: nociceptor studies, studies on integrative neural networks, neurotransmitter studies, trade-off studies, associative-learning studies, analgesic-administering studies, etc. Combining the criteria could make these studies more difficult to find in the literature, hampering efforts to answer questions about animal sentience.

Finally, woven through the target article’s presentation of the eight criteria is an underlying concept of the function of consciousness, characterized as follows:

“Sentience in humans plausibly facilitates flexible cognitive functions to maximise benefits and minimise harms. By integrating information across the animal’s whole nervous system to generate evaluations, sentience also plausibly facilitates flexible decision-making and new forms of associative learning... A related idea is that sentience may provide a ‘common currency’ for decision-making [this currency being a continuum of good to bad emotional feelings along which perceived stimuli are assigned]... allowing an animal to combine and compare information across different modalities and times. Sentience would thereby enable the animal to prioritise its most urgent needs, leading to beneficial motivational trade-offs in novel situations.” (p. 3)

For extended considerations of the functions (adaptive roles) of consciousness, see Feinberg & Mallatt (2019; 2020).

The semi-quantitative grading system the authors use to evaluate decapods for sentience (pp. 8-9) yields a good middle ground between making quantitative decisions that are too rigid and making qualitative decisions that are too uncertain. Crump *et al.* make effective use of confidence levels (very high, high, medium, and low), both in the way these levels are first applied to each criterion (p. 8 and Table 1) and then again in tallying multiple criteria to determine the probability of an *Infraorder* being sentient (p. 9).

Another strength of the target article is that it deeply and critically evaluates the literature. Rather than just accepting other authors’ conclusions, Crump *et al.* point out problems in some of the experimental designs--especially with the use of control groups. Their critical review reports many null or negative findings along with the positive ones, to evaluate all the evidence in forming its conclusions (in their Table 1). For example, on pp. 18-19, Crump *et al.* show that

the evidence for motivational trade-offs in decapods is weaker than is commonly believed. There is some better evidence for such trade-offs in an article by Herberholz & Marquart (2012) on crabs that the target article overlooks, although the aversive stimuli in that study were threatening rather than painful (Woodruff, 2022).

In an earlier target article in this journal, Birch (2017) suggested that every taxonomic Order of animals should be evaluated for sentience. We responded that testing so many low-level taxa would be a waste of effort because sentience is likely to characterize higher clades than an Order, such as all the amniote vertebrates (“reptiles,” birds, and mammals) or all the vertebrates, period (Mallatt, 2017). We now better understand Birch’s strategy and embrace it, as it is applied in the new target article. The fine-grained division into Suborders and Infraorders, as codified in Crump *et al.*’s Table 1, reveals important cross-taxon trends in the findings as well as highlighting the knowledge gaps to be filled by future research.

We would question Crump *et al.*’s decision to mix (1) the evidence against sentience (failures) with (2) evidence that is insufficient (due to having been understudied) into a single category of ‘low confidence’ (p. 8). The reason the authors do not separate these seems to be that they cannot prove that any decapod fails any criterion (p. 24). Although this is true in the extreme sense (because absence of evidence is not evidence of absence), we are all in the business of evaluating which organisms are sentient, and hence which organisms are not. Thus, Crump *et al.* should have analyzed the studies and weighed the odds that their decapods were truly failing a criterion or sub-criterion—a failure that seemed likely, for example, when repeated experiments found that decapods did not react to opioids (pp. 15-16; see also the commentary of Walters, 2022). This is not to imply that the mixed ‘low confidence’ category is useless; but parsing it into its two evidential subcategories would add valuable information to the target article’s analyses. Commentators Brown (2022) and Comstock (2022) offer the same sort of criticism and solution.

Another concern is that the framework includes simple types of associative learning in its associative-learning criterion (see the discussion of Criterion 7 on p. 7). The simple, classical, Pavlovian type of learning need not be conscious: when we humans hear the dinner bell, our ensuing salivation is not a conscious decision. More complex types of associative learning are needed to demonstrate sentience, such as the ‘global operant learning’ of Feinberg & Mallatt (2016: 152) and the ‘unlimited or open-ended associative learning’ of Ginsberg & Jablonka (2019) and Jablonka & Ginsburg (2022) (see also Birch *et al.*, 2020). In another commentary on the present target article, Woodruff (2022) raises this same issue. Crump *et al.* defend including simple types of associative learning because their list allows *partial* criteria (pp. 8, 6); but to us, such learning is not a marker of sentience and is hence incorrect.

Although we are suggesting that Crump *et al.* not use simple associative learning in their future analyses, its use in the target article does not invalidate their positive conclusions about decapod sentience because they do document many studies that showed advanced associative learning along with the simple, Pavlovian studies. For example, the long analysis of true crabs on pp. 21-22 abundantly documented avoidance learning, which is a type of operant learning. Furthermore, an uncited paper by Abramson & Feinman (1990) found that crabs easily pass the paradigmatic lever-pressing test for operant learning [but see also Abramson & Calvo’s 2022

current commentary]. Further support for Crump *et al.*'s argument is the evidence for operant learning in another important group of decapods, the lobsters and crayfish, as reviewed on p. 23.

In conclusion, we find that the target article makes a strong case for decapod sentience, within the criterial framework that it offers. It also raises an idea for further research on the subject based on the fact that crabs and lobsters have only about 100,000 neurons in their nervous systems ([Decapod Crustaceans, animalresearchinfo.org](#)). This is a startlingly small number, considering that it is fewer neurons than in most insects (Table 9.2 in Feinberg & Mallatt, 2016), even though insects have much smaller bodies. How could so few neurons provide these decapods with so advanced a process as sentience and its associated behaviors? The answer we propose is that their small nervous system has extremely efficient neural circuitry (Chittka & Niven, 2009) and that its individual neurons process much more information than does a neuron of vertebrates or even insects. This hypothesis can be tested neurobiologically in decapods.

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