ANIMAL SENTIENCE
AN INTERDISCIPLINARY JOURNAL ON ANIMAL FEELING

Pessoa, Luiz (2023) What can plant science learn from animal nervous systems?. *Animal Sentience* 33(6)
DOI: 10.51291/2377-7478.1774
Date of submission: 2023-03-25
Date of acceptance: 2023-04-10

What can plant science learn from animal nervous systems?

Commentary on **Segundo-Ortin & Calvo** on *Plant Sentience*

Luiz Pessoa
Department of Psychology, University of Maryland

Abstract: I welcome Segundo-Ortin & Calvo's (2023) call for a rigorous science of plant behavior and physiology. My commentary addresses three points drawn from the literature on animal brains that could help elucidate the possibility of cognition and sentience in plants: (1) the presumed requirement of a centralized brain; (2) centralization of control versus heterarchical organization; and (3) connecting plant research with research on animal nervous systems.

Luiz Pessoa is a neuroscientist interested in how emotion, motivation, and cognition are integrated in the brain. He is the author of *The Cognitive-Emotional Brain* (2013) and *The Entangled Brain* (2022), both by MIT Press. **Website**

I applaud Segundo-Ortin & Calvo's (2023) call for a rigorous science of plant behavior and accompanying physiology. They provide an excellent summary of plant behaviors that have links to cognition, from communication to decision-making and learning and memory. As the authors state, the situation faced in the domain of plants is rather similar to the one animal researchers face. I agree with the authors that the possibility of plant cognition and sentience should not be excluded out of hand. As in animal research, rigorous science is needed to move forward.

1. **Brain basis**. An important point raised by the authors is that very different functional and anatomical structures can give rise to cognition and sentience in different species. A particularly informative example is provided by considering mammals and birds. Many of the "sophisticated" cognitive capacities of mammals have long been known to be produced by the highly differentiated gray matter of their cerebral cortex ("neocortex"). However, in the last 20 years, a number of bird species have also been found to have extremely sophisticated cognitive capacities, comparable to those of elephants, dolphins, and primates (including the great apes). Birds exhibit complex communication, memory, navigation, problem-solving skills (including tool-use), as well as complex social behaviors.

The avian and mammalian lineages diverged more than 300 million years ago. Although the brains of both these vertebrate taxonomic groups follows the "basic plan" of the vertebrate brain, the telencephalic organization of birds is very different from that of mammals. Birds have no layered cortex, yet their brain can support comparable cognitive capacities (Pessoa, Medina, and Desfillis, 2019). It remains an empirical question which physiological and anatomical organizations can support cognition and sentience.

2. **Centralization of control vs. heterarchical organization**. One the arguments against plant cognition discuss in the target article is that a "central controller" is necessary for complex cognition. A growing number of studies, however, have emphasized that there can be more

heterarchical (as opposed to hierarchical) brain organization in vertebrate brains (Pessoa, 2022).

It is usual to think that many of the brain's important functions depend on a centralized form of organization. For example, the prefrontal cortex can be viewed as an area where many types of information converge to allow it to *control* behavior. A different view is that brain organization is decentralized, with processing through interactions of many spatially distributed areas rather than a master "controller." Instead of flowing hierarchically to an "to one area where all the pieces are integrated, information flows in multiple directions without a strict hierarchy.

I believe Segundo-Ortin and Calvo are right that spatial centralization may not be necessary for cognition and sentience, although certain forms of *functional centralization* might still be important. Animals often have compact bodies that must move in an integrated manner, requiring some form of functional centralization. Having part of the animal approach an object while another part retreats would clearly be problematic. But functional centralization need not be implemented as anatomical centralization (although it might sometimes be helpful). Distributed processing can produce emergent, coherent patterns of organization without having to draw all components to the same spatial location.

3. Animal nervous systems. As the target article states, some problems in plant research are similar to those faced by animal researchers. Thus, it might be useful to adopt approaches that have been useful in the animal literature. For example, Mikhalevich et al. (2017) suggest that an "adaptive triadic model" consisting of behavioral flexibility, environmental heterogeneity, and functional-anatomical properties may be useful in studying comparative cognition.

Proponents of cognition and sentience in plants would benefit from analyzing "minimal nervous systems" with comparable properties. Ginsburg and Jablonka (2019), for example, emphasize associative learning in animal sentience, particularly the transition from nonassociative learning to limited associative learning to what they call "unlimited associative learning." Segundo-Ortin & Calvo might not favor this particular framework, but it might be useful to try to make more direct contact with the animal literature along such minimalist lines.

Explicit comparisons between plants and animals may be useful in many respects. Do some plants have capabilities that are comparable to those of sea anemones and corals, or perhaps *Hydra* with its distributed nerve net? How have less mobile animal species, similar in this respect to plants, evolved the physiological mechanisms to meet complex adaptive challenges that differ from those evolved in more mobile life forms?

Segundo-Ortin & Calvo raise several important points in their target article. If we are to address the questions they raise, I think we need to adopt a scientific stance that does not reject the possibility of "cognition" and "sentience" in plants. We need to develop ways to investigate these constructs rigorously, with all the empirical, computational, and theoretical tools available.

References

Ginsburg, S., & Jablonka, E. (2019). *The evolution of the sensitive soul: learning and the origins of consciousness*. MIT Press.

Mikhalevich, I., Powell, R., & Logan, C. (2017). Is behavioural flexibility evidence of cognitive complexity? How evolution can inform comparative cognition. *Interface focus*. *7*(3): 20160121.

Pessoa, L. (2022). *The entangled brain: How perception, cognition, and emotion are woven together*. MIT Press.

Pessoa, L., Medina, L., Hof, P. R., & Desfilis, E. (2019). Neural architecture of the vertebrate brain: implications for the interaction between emotion and cognition. *Neuroscience & Biobehavioral Reviews*. 107: 296-312.

Segundo-Ortin, M. & Calvo, P. (2023) Plant sentience? Between romanticism and denial: Science. *Animal Sentience* 33(1)