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Stress: An adaptive problem common to plant and animal science

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

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Abstract: It is very hard to determine whether plants have "felt states," but they do have specific states, such as stress, that depend on sensory input from their environment. Plants do not have neurons or brains, but they do have xylem and phloem, as well as many signalling molecules that are dynamically distributed in their bodies, enabling them to produce systemic responses to environmental stimuli. One common topic in plant and animal science that may or may not prove to involve sentience but that does involve the same molecules is stress.

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Segundo-Ortin & Calvo (2023) argue for taking the "plants might be sentient" hypothesis seriously and testing it rigorously. Their target article is rich and important, pointing out an interesting and controversial topic and highlighting the need for its rigorous investigation. It describes many thought-provoking experimental findings and their underlying plant biological processes.

The debate and controversy on plant cognition and sentience are productive. They contribute to plant science in developing and rethinking concepts and methods and in providing new knowledge about plant life. There is much for researchers on animal cognition and sentience to learn from plant science. Scientific concepts often change, and there are many debates and developments within animal cognition and sentience research, including debates on the criteria for sentience (e.g., Crump et al. 2022).

Segundo-Ortin & Calvo point out that "[t]he interest in plant sentience emerges from observations of cognitive capacities in plants." This is true, but considering whether plants are sentient is not a new question; it is connected with many other evolving ideas about organisms, science, ethics, and ecosystems. The thesis that "all biological organisms are machines" has been addressed directly in the context of plant sentience (Gerber & Hiernaux 2022).

One can think of "cognition" as a basic capacity of all organisms, including single cell organisms such as *E. coli* (Duijin et al. 2006). Organisms have evolved various kinds of cognitive capacities through evolutionary processes, and plants have their own ways of cognizing. There is no centre in a plant cognitive system. It is distributed -- "a coordinated set of semiautonomous processes running over the organism and items in its environment" (Sims & Yilmaz 2023).

Biology is a broad discipline, with many areas of specialization, in which comparing and sharing concepts has always been important. Different branches of biology sometimes share methods, tools, ideas, and concepts. One such concept is "stress." Its history is

particularly interesting: Plant diseases have been recorded since as early as 1700 BCE and there was research on microorganisms causing diseases in plants even before the development of the germ theory in the late nineteenth century (Somerville 2000). Plant researchers did not use the term "stress" for such conditions until after the term had become established for organisms in general by the 1930s (Lichtenthaler 1996).

There may be a connection between the "stressed state" and "sentience". The target article describes sentience as "the capacity of an individual to have felt states, including sensory experiences, external or internal." It is hard to determine whether plants have "felt states." but they do have *specific* states depending on sensory information from their environment. Physiological processes occurring during stress responses in plants are examples of such specific states. Plants do not have neurons or brains as animals do, but they have xylem and phloem as well as many signalling molecules dynamically distributed in their bodies and enabling them to produce systemic responses.

The affinities between animal and plant science in the context of "stress" is illustrated by GABA (gamma-aminobutryric acid), a molecule that accumulates in sesame plants under various stress conditions (Bor et al. 2009). This same molecule is also a neurotransmitter-inhibitor in animals. As Pessoa (2023) notes in his commentary, "[e]xplicit comparisons between plants and animals may be useful in many respects."

The responses of plants to conditions such as stress tolerance, stress avoidance, stress resistance, and stress escape are extremely complex (e.g., Blum 2016; Mickelbart 2015). They involve intricate physiological processes that depend on diverse genetic, epigenetic, environmental, and developmental factors. Terms like "avoidance" and "escape" that are used to explain plant behaviour under stress conditions clearly have some connection with the way they are used in studying animal behaviour. It is only natural for plant biologists to inform themselves on animal research from time to time and vice versa. These interactions can occur in various ways: reading each other's work; thinking through analogies or homologies; drawing inspiration from each other's methods, tools and findings; conducting collaborative research – and engaging in open multiple-specialty peer dialogue as we are doing here.

Summary:

1. Sentience (feeling) is hard to determine (in both animals and plants).

2. Sentience is a state.

3. Stress, like sentience, is a state.

4. Stress occurs in both plants and animals.

5. Stress may or may not be a sentient state (in animals or plants or both).

6. The same molecule (GABA) is involved in both animal and plant stress.

7. Hence, comparative as well as collaborative study, between plant and animal scientists, of stress, sentience, and behavior ("cognition"), is likely to be useful and informative for both plant and animal science.

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