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

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Abstract: Plants may produce fascinating behavioural phenomena for which the label 'cognitive process' may be applicable, at least by some definitions. Segundo-Ortin & Calvo (2023) base their hypothesis that plants might be sentient on the premise of demonstrated presence of cognitive complexity. However, the way phenomena are ascribed, and how the term 'cognitive' is used by Segundo-Ortin & Calvo, deviates from the common practice in studies of animal cognition, implying greater complexity than seems justified. It thus provides a questionable basis for attributing sentience to plants.

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1. Introduction

In their thought-provoking article, Segundo-Ortin & Calvo (S-O & C) (2023) argue that science should seriously consider the possibility that plants are sentient, i.e. they may have felt states. Their main argument is that *'current empirical findings strongly suggest that plants can perform many putatively cognitive abilities once thought unique to animals'*. These abilities include, they argue, the capacity to communicate; to distinguish kin from non-kin and modify behaviour accordingly; to make flexible decisions about multiple trade-offs; and to learn from and remember experiences. Combined with what S-O & C consider to be striking functional analogies between the nervous system of animals and the vascular system of higher plants, these abilities provide the basis for hypothesising that plants may possess felt states.

Provocative and challenging hypotheses are the fuel of scientific progress. They may force us to reflect on, and reconsider the evidence for, ideas long taken for granted. This target article certainly provides food for thought. It reviews a number of intriguing phenomena that show that plants can detect and respond adaptively to subtle variations in their environment in sometimes unexpected ways. However, to convince readers to accept an extraordinary hypothesis one might expect this to be based on solid evidence. In this respect I fail to be convinced. This is not because I have a problem in accepting that non-human animals, including those with a highly different nervous system, may have some form of sentience, however different this might be from ours. But—whereas others focus in their comments on whether plants possess a system that is functionally similar to the nervous system of animals and whether that is a requirement for attributing sentience to plants (e.g. Pessoa, 2023; Robinson *et al.,* 2023), or whether the question of sentience can be examined in a meaningful

way at all (Gutfreund, 2023)—my own doubts concern the premises underlying the attribution of sentience to plants: the presence of sophisticated cognitive processes.

2. What is cognition?

When defining cognition, most researchers of animal cognition relate to the definition provided by Shettleworth (2010) that '*cognition refers to the mechanisms by which animals acquire, process, store, and act on information provided by the environment'*. This broad definition includes perception, learning, memory and decision-making, processes that, as argued and demonstrated by Shettleworth and others (e.g. ten Cate & Healy, 2017), can be analyzed without making any assumptions about what the animal's private experiences are like. Accepting the above broad definition and replacing 'animals' by 'organisms' one can argue that plants too may show cognitive abilities. Note that the definition does not take into account the complexity of the mechanisms and processes involved; even the mechanism underlying a simple response to a single stimulus may be considered a cognitive one. Shettleworth's definition, however, differs in an interesting and significant way from how S-O & C use the concept of cognition. They state that plant cognition involves '*the manipulation of the environment in order to enable metabolic functioning*' and that '*cognition is inferred from behavioral patterns that are adaptive, flexible, anticipatory and goal-directed'*. This phrasing shifts the definition of cognition away from the causal one by Shettleworth—i.e., away from what proximate processes and mechanisms underlie a particular behaviour, to its consequences: to whether plant behaviour contributes to some beneficial outcome. This may result in teleological reasoning, explaining the proximate causation of phenomena in terms of the purpose they serve, the beneficial outcome. An example is their description of the growth pattern of bean shoots, which, according to a study by Raja *et al.* (2023), is influenced by the presence of a nearby climbable pole. S-O & C write: '*If the vine's attempt to reach the pole fails, it straightens out and tries again*', which (according to S-O & C) suggests that the behaviour is '*endogenously controlled by the plant to attain a specific goal'*. If this were presented as a causal explanation and evidence of cognition then it would almost inevitably entail attributing sentience to plants.

3. Being adaptive is not a criterion for the presence of complex cognitive processes

One of the first things students of animal behaviour are taught is to distinguish the question of function ('what is the behaviour for', its adaptive value) from the questions of proximate causation ('how is it executed?'). Consider, for example, the observation that after their chicks hatch, black-headed gulls remove the egg shells from their nest. In a series of classic text book experiments, Tinbergen *et al.* (1962) demonstrated that this behaviour is highly adaptive: the inside of egg shells is white and Tinbergen *et al.* showed that the presence of white eggs and eggshells in a nest results in predation, which is strongly reduced by removal of the shells. What made the birds perform this behaviour? Rather than interpreting the function (reduced predation) as the proximate cause for the behaviour, Tinbergen examined the mechanisms underlying the behaviour, analyzing which observable features of an egg shell, such as its colour, size, and shape produced the behaviour, and how. In present day terms we would say he was analyzing the cognitive mechanism.

Like any other genetic trait present in any organism, cognitive mechanisms evolved because they increase the fitness of their bearers, in other words, they are adaptive. However, as

Shettleworth (2010) emphasizes: '*such mechanisms need not – and seldom, if ever do – include foresight into the effects of behavior on fitness*'. Using adaptiveness as criterion for calling a process cognitive hence does not make much sense: it is hard to imagine the evolution (and persistence) of a cognitive mechanism that is not adaptive. Returning to the vine's behavior: a 'cognitive' explanation should be about what stimuli in its environment cause it to move in particular ways, and how these stimuli are perceived and translated into those movements. Explaining the seeming complexity of the vine's behavior in terms of '*controlled … to attain a .. goal*', S-O & C attribute purposeful foresight to the vine, thereby taking this to be indicative of the presence of sentience.

4. A plea for caution and careful study

As in the case of the vine behavior, other examples presented of the plant's responses to certain environmental triggers also seem to be labelled as 'cognitive' mainly because they are beneficial, adaptive. The phenomena are described in terms of complex decision-making, strategic responding, selecting responses, attempts to mimic phenotypes and to anticipate the future. Like others before them (e.g. Gagliano *et al.*, 2012), S-O & C also interpret the fact that plants can produce and respond to sounds (vibrations) as evidence of communication, although this still remains to be demonstrated (e.g. ten Cate, 2012). Despite S-O & C's statement that we should '*be cautious and critical with metaphors and analogies*' it is hard to avoid the impression that they themselves regard the terms they use as more than metaphors describing the outcome of a process in anthropomorphic terms, but as actual parts of the proximate mechanisms producing the observed phenomena. I agree that the examples of behavior to which such terms are applied are often fascinating. Yet, as S-O & C acknowledge, we often still lack insight in the proximate factors and physiological mechanisms involved. Words do matter (Harnad, 2023; Brooks Pribac, 2023; Booth, 2023), and labelling something a decision, choice or anticipatory behavior suggests that much more is going on than when labelling it 'response' when that word may often be at least as applicable. If one wants to call the perception of environmental stimuli and regulation of responses by plants 'cognitive', within a broad definition of the cognition, that is fine with me. (Whether this provides any more insight into the underlying mechanism is a different matter.) In any case, as long as we do not yet understand the proximate causation of the phenomena, I cannot see any reason why processes that result in adaptive outcomes that look complex and goal oriented—and are interpretable *as if* they were accompanied by some kind of mental process—as a sufficient basis for attributing sentience.

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