Beyond the Mark of the Cognitive: An Explanation-Centred Heuristic for Plant Cognition

While humans are typically regarded as the paradigmatic cognitive agents, growing empirical evidence suggests that cognitive processes may extend far beyond the animal kingdom. Recent advances in plant biology indicate that plants exhibit complex and flexible behaviours that, when observed in mammals, are often taken to warrant cognitive attribution (e.g., Segundo-Ortin et al., 2026; Segundo-Ortin & Calvo, 2023; Trewavas, 2015). Reported examples include decision-making at both root (Hodge, 2009) and shoot levels (Gruntman et al., 2017), anticipatory responses (Novoplansky, 2016), communication (Runyon et al., 2006), kin and species recognition (Bilas et al., 2024), memory (Vyse et al., 2022), and various forms of learning (Gagliano et al., 2014, 2016). This expanding body of work, frequently discussed under the label "Plant Neurobiology" (Baluška & Mancuso, 2007; Calvo, 2016), has prompted many philosophers, biologists, and cognitive scientists to reconsider whether cognition might extend to organisms lacking nervous systems (Lyon et al., 2021; Lyon & Cheng, 2023). The resulting debate is both conceptual and methodological, concerning how cognition should be characterised, which theoretical principles ought to guide its investigation, and how experimental practices might support meaningful comparisons across taxa. More broadly, these questions bear directly on attempts to reconstruct and understand the evolution of cognition across the tree of life.

A common rationale for interpreting plant behaviour as cognitive appeals to complex forms of information processing (e.g., Novoplansky et al., 2024; Shoot et al., 2025). The guiding intuition is that plants detect, integrate, store, and exploit information to regulate adaptive responses to changing environments, and that such capacities plausibly support cognitive ascriptions. However, this strategy faces two fundamental challenges. First, the concept of "information" remains underspecified in these contexts: different philosophical accounts of information carry distinct theoretical commitments and explanatory consequences (Fresco, 2022; Piccinini & Scarantino, 2011). Second, the nature of cognition itself remains deeply contested: there is no consensus that information processing is either necessary or sufficient for cognition (e.g., Adams, 2018; Di Paolo et al., 2017; Varela et al., 2016), and no resolution in sight. As a result, debates over plant cognition often stall at the level of competing conceptual frameworks, rather than generating cumulative epistemic progress (Colaço, 2023; Lee, 2023).

This paper addresses these difficulties in two stages. First, it clarifies and critically assesses prominent philosophical conceptions of information under which plants might be said to process information, focusing on Dretske's (1986) natural information, Floridi's (2011) environmental information, and Bateson's (1979) difference-making account. While plausible cases can be made

that plants process information in each of these senses, the analysis shows that none of these conceptions, taken in isolation, suffices to ground claims about cognitive status. Whether such information-processing capacities warrant cognitive attribution ultimately depends on how cognition itself is characterised, and on resolving the broader impasse surrounding the mark of the cognitive (Rowlands, 2010).

In response, the paper advances a methodological shift from metaphysical boundary-drawing to explanatory practice in cognitive science by introducing the Explanatory Parity Heuristic (EPH). According to the EPH, when a paradigmatic cognitive phenomenon is best explained by positing a certain class of informational relations or organisational structures, and when an explanation of plant behaviour likewise invokes structurally similar relations playing similar explanatory roles, these explanatory similarities provide defeasible but non-trivial support for extending analogous explanatory inferences to the plant system with respect to the targeted capacity. The EPH thus reframes the question of plant cognition as an explanation-centred inquiry, focusing on the roles that informational posits actually play in successful scientific explanations rather on metaphysical criteria.

The EPH does not attempt to redefine cognition or to establish information processing as either necessary or sufficient for cognitive status, thereby sidestepping the longstanding impasse over the mark of the cognitive. Instead, it articulates a general methodological principle: similar explanatory roles warrant similar explanatory inferences, unless independently motivated asymmetries can be identified. On this way, the central question becomes not whether plants satisfy pre-theoretical intuitions about cognition, but whether the best explanations of their behaviours rely on organisational structures that perform the same kind of explanatory work as those invoked in paradigmatic cognitive systems. Furthermore, the support delivered by the EPH is explicitly defeasible and capacity-relative. It targets specific explananda rather than global claims about the cognitive status of plants. Resulting inferences remain provisional, since apparent explanatory parity may be undermined by alternative accounts that explain the same behavioural patterns without invoking information-processing organisation in an indispensable way and without corresponding explanatory loss. Accordingly, the EPH serves as a pragmatic methodological guide, bolstering confidence in extending cognitive-style explanatory inferences precisely when informational organisation proves explanatorily indispensable in the same manner as in established cognitive domains.

Thus, the paper makes two primary contributions. First, it clarifies the explanatory implications of leading conceptions of information as applied to plant systems. Second, it develops and motivates the Explanatory Parity Heuristic as a principled tool for distinguishing cases in which informational talk is merely rhetorical and dispensable from cases in which it contributes substantively to explanation. Applied to representative examples from contemporary plant science, such as root risk

sensitivity under temporally variable nutrient conditions (Dener et al., 2016), the EPH provides a framework for strengthening (or weakening) confidence in attributing specific cognitive capacities to plants, while avoiding reliance on contested a priori definitions of cognition. More broadly, the proposed approach provides a general template for evaluating cognitive attributions in non-neural organisms by grounding them in comparative explanatory practice, helping to move the debate on plant cognition from conceptual deadlock toward empirically testable progress.

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