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A book review of Chauncey Maher, *Plant minds: A philosophical defense*, New York, Routledge, 2017

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These are exciting times for those interested in the sciences of the mind. Scientists begin to pay attention to a series of organisms that have traditionally been deemed cognitively un-interesting, and plants are among these organisms. For many, the idea that plants may be intelligent (or 'minded') is simply non-sense. And yet, the current scientific evidence seems to show that plants are not merely reactive organisms, and that the way they interact with the environment is far more complex than we initially assumed. This scientific evidence has called the attention of theorists, initiating the debate about whether plants can be considered intelligent in a proper, non-metaphorical way (Trewavas 2014; Adams 2018; Segundo-Ortin and Calvo 2019; Calvo et al. 2019).

In *Plant minds*, Chauncey Maher argues for the possibility that plants have minds. He does so from an openly philosophical standpoint, linking the current discussion about plant intelligence with other, ever-going discussions in the philosophy of mind. As the author tells us, the book aims to put in question some of the most longstanding and seemingly unquestionable assumptions about what having a mind implies.

Relying on the current mainstream consensus in the philosophy of mind, Maher presents what he considers to be "the best case for thinking that plants do *not* have minds" (p. 3). This case is grounded on the assumption that being intelligent requires having representations. According to this reasoning, because plants do not have representations, they cannot be intelligent (see Aizawa 2014 and Adams 2018 for recent versions of this argument). Against this argument, Maher proposes to see plant behaviour through the lens of the enactive theory of mind (Varela et al. 1991; Thompson 2007). Since the enactive school of thought is well-known for rejecting the assumption that being minded requires having representations, it can offer "support for thinking that plants have minds—or if you want to be cautious, proto-minds or minimal minds" (p. 115). Hence, to the question of whether plants have minds Maher offers a conditional yes: plants can be said to have minds, but only *if* we understand 'mind' along the lines of enactivism.

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The book is organized into six chapters. The goal of the first chapter ('Do Plants Have Minds?') is to set up the theoretical basis for the rest of the book, motivating the quest for plant intelligence. To do so, Maher analyzes a variety of philosophical frameworks about what a mind is, including Aristotelianism—or the idea that to have a mind is "to display a distinctive type of orderliness: orderliness directed toward a goal" (p. 5)—, Mechanism, Cartesian Dualism, Darwinism, Behaviorism, and the Computational Theory of Mind. According to Maher, contrary to what we may think, only Cartesian Dualism and Identity Theory rule out the possibility that plants have minds, whilst all the other frameworks remain consistent with this possibility.

Chapters 2 to 5 focus on different cognitive abilities. The aim of these chapters is to evaluate how plants perform with respect to them. The second chapter ('Perceiving') looks at plants' capacity to sense and discriminate environmental cues, producing responses to maximize their fitness. Multiple experiments show that plants can monitor and integrate over 20 diverse biotic and abiotic parameters, including, but not only, gravity, water, nutrient availability and distribution, competition, and so on, and that they can produce 'on the fly' adaptive changes at the level of their physiology, morphology, and phenotype (see, e.g., Baluška and Mancuso 2009; Cahill et al. 2010; Dener et al. 2016; Li and Zhang 2008).

The question is nonetheless whether this suffices to conclude that plants perceive. Since, according to the author, "scientists and philosophers think that perception necessarily involves *representation*" (p. 44), knowing whether plants perceive requires discovering whether plants form representations of these environmental cues.[1]

After analyzing different options, the author finds no convincing reasons to think that plants have such representations (but see Trewavas 2003; Sims 2019). But, if it is true that perception necessarily involves representation, it follows that plants do not perceive. Remarkably, even though Maher claims to be unsatisfied with this conclusion, he nonetheless accepts it, and suggests that there may be some other way to describe the capacity of plants to respond to different environmental cues without thinking of it as a form of perception (pp. 49–50).

But, why should we accept this assumption in the first place? Why should we assume that perception *necessarily* involves representations? I take it to be a major flaw in Maher's argument that he offers no justification for this. Instead, I surmise that we ought to be cautious on this matter. On the one hand, we have the question of whether plants perceive their environment. The issue here is whether the empirical evidence we have robustly supports this view. On the other hand, we have the question about the processes that underlie such perception. This is a completely different issue, for it pertains to what best explains plant perception (if it exists). Only after having assessed against the empirical evidence the hypothesis that plants perceive we can ask whether such perception is best explained by positing representations. By mixing up both issues, and by merely assuming that because plants do not represent their environment what they are doing does not qualify as perception, Maher is conflating the *explanandum* with the *explanans*, thereby begging the question

[1] Even though the notion of representation admits different interpretations, Maher is clear that for something, *x*, to count as a representation, it must portray something else, *y*, as being a certain way so that *x* can misrepresent *y* (p. 46, 94).

against non-representational theories of perception (see Ramsey 2017; Segundo-Ortin and Calvo 2019, for different versions of this argument).

Chapter 3 ('Feeling') focuses on phenomenal consciousness. Whether or not plants are conscious in this sense is under debate among philosophers and scientists (see Calvo 2017; Taiz et al. 2019). Maher chooses to frame this question in terms of 'qualia,' and looks at plant neurobiology as a promising way to start.

The field of 'plant neurobiology' has emerged in recent years with the specific aim of investigating plant intelligence by integrating signalling and adaptive behaviour (see Calvo 2016). Remarkably, even though plants do not have neurons that could give rise to a brain or a nervous system, they have cells capable of electrical and chemical transmission. Moreover, the chemical and electrical activity of these cells underlies the ability of plants to respond in a fast and yet coordinated manner to the different environmental contingencies (Trewavas 2014).

Having a substrate that is functionally equivalent to a nervous system of animals, Maher asks whether this is enough to think that plants might feel. To answer this question, the author goes on to consider (he does it this time!) different possible theories about what it is required to have phenomenal consciousness, including different representational theories. Nevertheless, since he argued in the previous chapter that there are no convincing reasons to think that plants have representations, the only remaining option for thinking that plants are conscious is, according to him, enactivism:

> Enactivism holds that qualia (and consciousness more generally) are rooted in the ways in which things matter to an organism, which is rooted in its being an autopoietic and adaptive system. Given all of this, Enactivism implies that for any organism, there is at least a proto-feel to its encounters with things. That includes a Venus flytrap trapping a fly on a warm, humid morning in July. (p. 73).

Chapter 4 ('Remembering') touches upon the question of whether plants can learn in their lifetime, adjusting their behaviour on the basis of past experiences and interactions. The hypothesis that (at least some) plants are capable of learning is gaining traction in light of recent scientific evidence. Consider, for example, the studies of Gagliano and colleagues, some of which are mentioned by Maher himself. In a series of experiments conducted in 2014, Gagliano et al. studied habituation in *Mimosa pudica*, a species that is known for folding its leaves when subjected to mechanical disturbance. Gagliano and colleagues (2014) subjected exemplars of *Mimosa* to repeated 15 cm falls. Although harmless, these falls suffice to elicit the leaf-folding reflex in the plant. The researchers discovered a series of striking facts about *Mimosa* plants. First, that they can identify when a repeated stimulus is harmless, ignoring it in subsequent interactions. After a series of trials, *Mimosa* plants ceased to respond to this particular stimulus while remained reactive to other disturbances. Second, that the leaf-folding reflex habituates more rapidly in conditions where light is scarce. This suggests that *Mimosa* plants can develop different adaptive responses for the sake of energy efficiency and light foraging. Finally, that this habituated reflex can last up to 28 days.[2] Subsequent experiments also by Gagliano et al. (2016) have tested associative learning on exemplars of *Pisum sativum* (garden pea) successfully.

[2] For a critical analysis of Gagliano et al.'s experiment see Biegler (2018).

In light of this empirical evidence, the author asks whether plants can be said to learn and remember. According to Maher, even though it is clear that plants encode, store, and retrieve information, knowing whether plants remember requires that we look more closely at the nature of this information: "That plants encode, store, and retrieve weak [covariant] information does not give us a good reason for saying that they remember. More interesting is whether they encode, store, and retrieve *strong* information, whether they form *representations*" (p. 88). For him, the only theory that can justify us in thinking that plants encode such strong, representational information is the Functional Theory of Representation. Nonetheless, this theory is deemed unacceptable by the author, which implies that we have no reason to think that plants remember (pp. 93–94).

Chapter 5 ('Acting') focuses on agency or purposeful behaviour. As we saw before, plants do not simply "sit there." Instead, they respond to their ever-changing environment, sometimes by moving in the direction of a particular stimulus (tropisms). So, do plants *act*? As Maher insists, the common assumption is that voluntary actions differ from mere bodily movements (such as reflexes) because the former are caused by processes that involve representations. Since we have stated in previous chapters that plants do not have representations, we must conclude that plants cannot behave in a purposeful, voluntary way.

Yet, once again, an argument for why memory and agency *necessarily* involve representations must be forthcoming on Maher's behalf if we are to take this position seriously. To repeat, ruling out the hypothesis that plants act or remember on the basis of unjustified theoretical assumptions is a serious methodological flaw, and it is not acceptable from the point of view of a naturalistic philosophy of mind.

In the last chapter of the book ('Mind in Life'), Maher advances a positive argument for thinking that plants might have minds—or, at least, proto-minds. To do so, the author brings enactivism back to the fore, and presents it as a genuine alternative to the computational-cum-representational theory of mind.

Enactivists are well known for maintaining two main ideas. First, "that to have a mind is not necessarily to harbor representations—pictures, words, models, maps—of a world outside oneself, but is to disclose (bring forth or 'enact') a world of things that have significance (meaning or value)" (p. 114). Second, that there is a continuity between life and mind. This is so because all living creatures are autopoietic and adaptive. 'Autopoiesis,' also referred to as 'material self-production,' denotes the capacity of living systems to generate and maintain their own identity as something distinct from the environment. 'Adaptivity,' in turn, refers to the capability of living systems to regulate themselves with respect to the conditions of the environment and the boundaries of their own viability. To do so, systems must be able to actively monitor internal and external perturbations, recognizing in them the tendencies that can lead to the loss of their autopoiesis, thus enacting their own meaningful perspective of the environment.

Since, according to Maher, plants are autopoietic and adaptive, they can be said to have minds:

1. Autopoiesis-and-adaptivity suffice for having a mind.
2. Plants are autopoietic-and-adaptive.
3. So, plants have minds. (p. 120)

At this juncture, however, we might wonder whether the book succeeds in presenting a positive case for plant cognition or intelligence. For full disclosure, I agree with the author that the quest for plant intelligence is worth pursuing. Nevertheless, I cannot but find the positive argument of Maher wanting. Arguing for the thesis that enactivism can accommodate the possibility that plants have minds does not do a very convincing case for the possibility of plant intelligence (which is the primary aim of the book). Also, if the author aims to convince us that enactivism can shed new light upon the debate about whether plants have minds, it would have been better for him to have presented an extended version of the positive argument, detailing how an enactivist theory of cognition can explain what plants are able to do. What would an enactivist account of plant intelligence look like?

In addition, although most enactivists take autopoiesis and adaptivity as being sufficient for cognition, they do not stop there. Instead, enactivists are famous for advancing non-representational explanations for some of the cognitive abilities Maher discusses in his book—including, but not only, perception, memory, and agency (see, e.g., Di Paolo et al. 2017; Hutto and Myin 2013, 2017). So, why didn't the author engage with these alternative explanations? By merely surrendering the possibility that plants perceive, remember, and act based on the assumption that such cognitive abilities necessarily involve representations Maher is not only begging the question against these enactive, non-representational accounts; rather, he is also obviating much of the potential enactivism has as a genuine explanatory contender in the cognitive sciences, including the science about plant cognition. Both issues together raise the question of what *Plant minds* has to add to the existing literature on plant cognition and intelligence.

To close up, it is worth mentioning that *Plant minds* has been conceived as a short introductory book to the topic of plant cognition, and that it belongs to a series aimed to a wide audience (an audience that does not consist of philosophers and cognitive scientists only). The book does a good job in showing how much of what we think about plant minds comes from received views, but it fails in showing how these received views can be challenged. Therefore, while those uninitiated in the debate will appreciate the book as an accessible introduction to the topic, those who are looking for new arguments for the case that plants are intelligent may find this book unsatisfactory.

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