Plant Philosophy and Interpretation: Making Sense of Contemporary Plant Intelligence Debates

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ABSTRACT

Plant biologists widely accept plants demonstrate capacities for intelligence. However, they disagree over the interpretive, ethical and nomenclatural questions arising from these findings: how to frame the issue and how to signify the implications. Through the trope of 'plant neurobiology' describing plant root systems as analogous to animal brains and nervous systems, plant intelligence is mobilised to raise the status of plants. In doing so, however, plant neurobiology accepts an anthropocentric moral extensionist framework requiring plants to anthropomorphically meet animal standards to be deserving of moral respect. I argue this strategy is misguided because moral extensionism is an erroneous ontological foundation for ethics.

KEYWORDS

Plant ethics, hermeneutics of biology, plant biology, anthropomorphism, moral extensionism

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Certainly, plants do not have neurons. But that does not prevent them from recognising and responding to subtle changes in their terrestrial, atmospheric, aquatic and subterranean environments (Garzon 2007; Calvo and Trewavas 2020b). Plants signal with each other via airborne chemical aromatics as well as root systems, in the latter often through microbial intermediaries and mycorrhizal networks (Furstenburg and van Hoven 1994; Selosse et al. 2006; Singh 2006). Recent advances in plant signalling research have discovered that, internally, plants achieve much faster information dissemination from one part of the organism to another than previously thought possible, via 'fast relay'

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calcium ion (Ca^{2+}) chemical signalling pathways, akin to myelinated nerves in mammals like ourselves (Choi et al. 2014). Continued discovery of new plant abilities, overturning previous plant biology frameworks that modelled plants as little more than biotic machines, are traditionally described with reluctant if ineluctable analogies to human and animal biology, attempting to respect – however unsuccessfully – professional conventions keeping plant behaviour at arm's length from anthropomorphisms.

However, the longstanding tensions between mechanistic and vitalistic metaphors to describe plant behaviour and communication (Ingensiep 2001) have reached a breaking point in the past couple of decades as plant science has matured. Perhaps ironically, the technoscientific apparatuses of plant biology have revealed uncanny (to many plant biologists) similarities between plants and animals along various dimensions (Cahill, Ljubotina and Mahal 2019). The most controversial of these similarities is the hypothesis that plant root systems function as a sort of 'brain', an idea that has launched a cottage industry in 'plant neurobiology' studies, noting that plants are replete with neurotransmitter analogues and hormones shared with humans (Brenner et al. 2006; Stahlberg 2006; Baluška and Mancuso 2007; Baluška and Mancuso 2009; Trewavas 2014). Plant neurobiology research, in particular, has brought to a head what plant studies anthropologist Natasha Myers (2015: 39) calls the 'fraught politics of anthropomorphism in the plant sciences'.

Marder and Hendlin have argued:

> To human knowledge, it seems that the better our technology, the more intelligent and communicative plants become. But, surely, there hasn't been a sudden surge in plant intelligence in the last thirty years; it was our perception of plants that has been growing and, to some extent, we ourselves have grown. (Marder and Hendlin 2016: 93).

Since the bulwark of human exceptionalism as the null hypothesis has waned, new notions of what a plant *is* (taking the ontological 'is' as a temporal, processual concept), coupled with more delicate and precise technologies and experimentation have wilted *a priori* Western conceptions of plant behaviour and plant intelligence as entertaining but with no bearing on cognitive science (Mazzolai et al. 2010; Gagliano 2015; Calvo 2016; Calvo and Friston 2017; Mancuso 2018).

Fundamentally, I argue that these contentious debates surrounding portrayals of plant intelligence are questions of interpretation, not description. The actual *behaviour* of plants over which these debates volley is largely uncontested even by sceptical plant biologists (Chamovitz 2018). The relevant scientific questions of fact – whether plant hormones work in certain ways, for example – share a high degree of consensus in plant biology, allowing researchers to forage further into the wonders of plants (Gagliano et al. 2012; Gagliano, Mancuso and Robert 2012). Controversy erupts, however, over *interpreting* these observations: their meaning in our larger sociocultural and

scientific context. Interpretation is an area, thankfully, where philosophy can contribute (Calvo 2016). Far from trivial discussions, the lenses through which we understand plant behaviour impact how human polities impart or withdraw attending ethical and legal frameworks regarding plants (Koechlin 2009).

I argue that plant neurobiology analogy-making is a well-meaning effort *strategically* to raise plants from the soil of ethical disregard, granting them moral considerability similar to that enjoyed by animals with brains by virtue of high animals' physiological and cognitive proximity to us. Nonetheless, I find this approach fundamentally misguided, as it reproduces the structural inequalities inherent in anthropocentrism. Plant neurobiology's extensionist approach, I claim, reinforces and buys into the very framework it wishes to depose. I analyse this dilemma in plant biology as attempting to translate plant processes into the pre-set legible form of contemporary ethical recognition, yet criticise this move for guilelessly entrenching rather than superseding the prevailing ethics of consideration based in sameness. Instead of honouring the wondrous discoveries of plant intelligence according to plants' particular differences on their own merits – the epistemologically and ethically preferred path – plant neurobiologists capitalise on *neuro*-hype and truck in the misapplied animal biological categories of brains and neurons appealing to moral extensionism. I call out moral extensional bioethics as a fundamentally erroneous ontological ground for ethics. Extensionism is narcissistically recursive, revealed by limit cases in animal ethics (Mikhalevich and Powell 2020). However, the sheer anatomically inescapable and unrationalisable difference between humans and plants productively forces the hand of this sort of ethical framework.

This article proceeds by outlining the contours of the plant neurobiology debate in popular, scientific and philosophical literature, to address the pressures that led plant biologists to make parallels between plant processes and animal processes to legitimate plants as consideration-worthy subjects. Critically analysing the plant intelligence debates and how they expose the self-undermining hegemonic ethics of moral extensionism allows us to examine whether plant ethics and the productive tensions in plant – rather than animal – comparisons might help environmental ethics more generally overcome unitary models of intelligence and worthiness.

PLANT INTELLIGENCE IN POPULAR DISCOURSE

According to Michael Pollan and others, scientific notions of plant intelligence lost whatever credibility they had in plant biology and philosophy after the publication of Peter Tompkins and Christopher Bird's 1973 exegetic *The Secret Life of Plants* (see Pollan 2013). While the book captured the public imagination, its combination of haphazard, panpsychist metaphysical speculations and unmethodical citizen science stigmatised legitimate progressive plant research,

casting disciplined research alongside the era's new-age pseudoscience (Nagel 1997), tarring the discipline's serious inquiry. Anthropomorphic ideas reproducing Western values such as the salutary effects of playing classical music to plants,[1] or speaking to one's plants soothingly to stimulate plant growth and wellbeing (Tompkins and Bird 1973), imposed cultural ideas of care for humans onto plants as pets-like-us, without any appreciation for their distinctive physiology, evolutionarily adapted sensing or contrastive sense organs.

At the time, the book, its methods and premises were excoriated by plant biologists, whom ecologist Rick Karban has typified as 'incredibly conservative' in the types of claims they are willing to entertain regarding their research subjects (quoted in Pollan 2013). Galston and Slayman (1979: 337) indicted the book as indicative of the 'wave of antiintellectualism [sic]' that was sweeping through the 1960s, culminating in the 1970s with *The Secret Life of Plants*. These critics also shunned citizen science and scoffed at 'one-man laboratories', suggesting that scientific information could only be generated in large institutional settings. The book's popular yet 'uncritical acclaim' created 'damage' to the discipline through its 'bizarre' claims, traumatising a generation of plant scientists (Ibid.).

More recently, plant biologist Daniel Chamovitz, creator of a massive open online course (MOOC) about plant biology and author of the popular *What a Plant Knows* (introducing a new generation to plant physiology's marvels without the esotericism of *The Secret Life of Plants*), wrote in a 2018 article titled 'Plants are intelligent; now what?' in *Nature Plants* about *The Secret Life of Plants* era:

> Like many of my colleagues over the past decades, I am scarred by the fallout of pseudo-science reports on plant intelligence that discredited any approach that viewed plants as anything more than an automaton, and may have stymied important research into plant behavior. (Chamovitz 2018: 622)

That plant biologists are 'scarred' by the bastardisation of science that almost inevitably follows any sort of popularisation, is telling of the precarious position of the discipline. Plant science could be regarded as a gatekeeping discipline – much like traditional animal science was before the advent of ethological methods in the 1940s and 50s – utilising biology to buttress the myth of human exceptionalism (cf. de Waal 2006; Marder 2013; Cahill, Ljubotina and Mahal 2019; Myers 2020).

After 30 years of this unofficial embargo on plant intelligence studies, however, spring finally came for the dormant discipline. After exploratory publications of careful research couched in conservative terms, prominent plant biologist Anthony Trewavas (2002) published an article in *Nature* re-establishing 'plant intelligence' as a viable topic for scientific research. This was

1. Plants don't have any special preference, but just grow better in response to vibrations of stereos versus controlled silence no matter the music style.

followed up by a flurry of other plant biology publications in similar keys that had been patiently waiting in the wings. Previously couched in obfuscatory language to interpret plant behaviours evincing signs of learning, such as episodic memory and intergenerational environmental learning (Calvo and Trewavas 2020b), many plant biologists began to formulate their claims more boldly in active and agentive terms, rather than the previously employed passive, mechanistic designations. This raucous visibility coalesced the already incipient field of plant neurobiology, and in 2006 led to a break-away group of plant scientists forming the new scientific journal *Plant Signaling & Behavior*, following the first meeting of the Society for Plant Neurobiology in 2005. Also in 2006, top phytologists Brenner, Stahlberg, Mancuso, Vivanco, Baluška and Volkenburgh published their landmark paper 'Plant neurobiology: An integrated view of plant signaling' in *Trends in Plant Science* (plant science's leading journal), assembling the major extant accepted research on plant signalling and interpreting it through the lens of plant intelligence. Trewavas followed this scientific off-shoot with the magisterial book *Plant Behavior and Intelligence*, Chapter 10 of which exhaustively compares the intelligence of plants to that of self-organising swarm intelligences found in animals such as ants and bees (Trewavas 2014: 93–104).

However, these events superseded the confines of a novel position. Problematic for other plant scientists not adhering to this new paradigm, was the tacit equation of plant intelligence with plant consciousness, and the open field of interpretation of what this might mean both epistemologically and ethically. Plant neurobiologists were making claims for plants' *neuro*biology based primarily on analogies between plant hormone excretions such as auxin, and root properties such as comparing sub-apex meristems to animal brains and nervous systems. Both the scientific experiments and the analogies used to make these novel claims are strongly disputed (Alpi et al. 2007; Taiz et al. 2019; Calvo and Trewavas 2020a; Taiz et al. 2020; Trewavas et al. 2020). If the plant neurobiology scientific revolution (in the Kuhnian sense) and ensuing recent 'plant turn' in the humanities (Castro 2019) has occurred, then it has not been a continuous curve, but rather has orbited in elliptical circumnutations (Charles Darwin's ([1880] 2012) term for the spiral movement of plant growth).

Wedged between animal biology, which treats its subjects more like autonomous subjects, and molecular biology, which treats its subjects more like determined objects, plant biologists (along with mycologists) have a narrow conceptual space in which to work. This often requires a degree of 'self-censorship' when exploring 'homologies between neurobiology and phytobiology', according to the original plant neurobiology exposition of Brenner et al. (2006: 415). This alleged 'self-censorship' stems directly (but not only) from the scientific backlash against the ideas presented in *The Secret Life of Plants*, and the multi-decade moratorium on plant intelligence research, leaving plant science

squarely inside an antiquated biochemical purgatory (Cahill, Castelli and Casper 2001). Although hardly any practising plant biologists then or now take the paranormal and human-empathic responses of plants in *The Secret Life of Plants* seriously, any whiff of the popular pseudoscience provoked by that book is deemed anathema to the actual scientific method and canon. Certainly, the book only represents synecdochally the larger perils of overstepping scientific boundaries, and the overarching siloing of information sacrosanct in the life sciences. Nonetheless, defences of this demarcation line arise even against scientists vetted via the most rigorous disciplinary peer-review, should they draw larger anthropomorphic or zoomorphic conclusions from novel plant experiments.

For example, on the podcast Radiolab's episode 'Smarty Plants' featuring plant (neuro)biologist Monica Gagliano,[2] her *descriptions* of her experiments (such as plant acoustic biology auditory perceptions of water) were received by the hosts with 'gee-whiz' fascination. But when she spoke of her *interpretations* of the observed behaviours as exhibiting 'plant intelligence', the interviewers became apoplectic (McEwen 2018). Lincoln Taiz, for example, author of the textbook *Plant Physiology* (now in its sixth edition) and one of the staunchest naysayers of plant neurobiology (Alpi et al. 2007; Taiz et al. 2019), describes on the podcast his scepticism of Gagliano's comparison of plants to animals, calling it 'a sort of romanticism', admonishing that 'if you get too wrapped up in your poetic metaphors, you're very likely to be misled and overinterpret your data' (McEwen 2018). Again, Taiz is not claiming that the experiment is falsely conducted (the description of the phenomenon), but rather that the plant neurobiologist's claim that the experiment proves or hints at plant intelligence is wrong (an 'overinterpretation').

For many scientists, the question of plant intelligence too often slides into plant consciousness (Calvo 2017). Consciousness, according to certain current scientific consensuses, requires a brain, which animals have uniquely evolved (Taiz et al. 2019). Even as he 'often draw[s] parallels and distinctions between plant and animal abilities to sense and respond to environmental signals', Chamovitz has 'generally shied away from the question of plant intelligence' (2018: 622). Such conceptual tightrope walking requires describing intelligent phenomena without recourse to the standard battery of terms and analogies we have developed to describe intelligence (Trewavas 2014). While plant intelligence is certainly not a psychological process (not consciousness, at least in the way we commonly conceive of it in mammals), it can be referred to as a type of *sign-action*, involving degrees of choice rather than inevitable reactions, according to phytosemiotics (Affifi 2013). So, Brenner et al.'s claim of 'self-censorship', restricting the application of plant abilities from the types of motivations, intentionality and other wilful activity routinely ascribed to so-called 'higher' animals, seems at least *prima facie* substantiated.

2. Gagliano is a plant neurobiologist in orientation, although she rejects the moniker.

THE 'NEURO'-CONTROVERSY IN PLANT BIOLOGY

Charles Darwin, who first tracked circumnutations, the spiral movements of plant growth, concludes in the final paragraph of his late work *The Power of Movement in Plants*:

> We believe that there is no structure in plants more wonderful, as far as its functions are concerned, than the tip of the radicle [the meristem section of plant roots] ... it has acquired such diverse kinds of sensitivities. It is hardly an exaggeration to say that the tip of the radicle thus endowed, and having the power of directing the movements of the adjoining parts, acts like the brain of one of the lower animals. (Darwin [1880] 2012: 572)

From such a propitious founding thesis from the originator of the theory of evolution, it is easy to see the enthusiasm plant neurobiologists might have for homologous thinking about plant roots and animal brains.

Since Darwin's ([1880] 2012) experiments demonstrating that plants 'remember' their orientation and adjust heliotropic and geotropic growth despite being temporarily tipped over, cooled in a fridge and brought back to room temperature days later, plant biologists have widely accepted that plants have certain basic capacities of episodic memory (Chamovitz 2012). Other plant memory demonstrations include their induced sleep or blooming according to different lengths of exposure to red or blue spectrum light, abilities to remember what colour of light ('sunset' or 'sunrise') they last 'saw' (Chamovitz 2012). Humans and alloanimals share this biological response with plants: blue light wakes us up, and red light induces melatonin required for REM sleep. These displays of memory certainly show some sort of intelligent processes are at work; but what does it mean to say that plants are intelligent or for Darwin to suggest that roots behave analogously to animal brains?

Plant intelligence is operationalised through the hypothesis that plants 'think' via auxin transfer, and that their decentralised brain exists in the millions of root subapices of a mature plant. In auxin transfer, Brenner et al. (2006) note that plants produce chemicals that are neuronal chemicals in animals, mirroring Plato's original uses of the word *neuron* connoting vegetal fibre. Baluška and Mancuso specify Darwin's insights, locating the seat of plant intelligence in 'the transition zone ... interpolated between the apical meristem and the subapical elongation zone' of roots and root hairs (2013: 2). This decentralised network of oscillating ion and auxin plasma produces what they call 'plant synapses' (Ibid.). Framing plant processes analogically to animal brain models defines these researchers' self-understanding and engagement in this project, as Darwin did, reasoning:

> the transition zone resembles the segmentation clock of vertebrate embryos ... new root primordia are formed deeply within root tissues, in a stark contrast to other examples of plant organogenesis [generation of organs in an organism] ...

> they also show other striking parallels to developing animals. (Cited in Baluška and Mancuso, 2013: 3)

The difference is that descriptive parallels to animal developmental biology have moved from peripheral observations to the core of plant neurobiology's research programme.

The classic article, 'Plant neurobiology: An integrated view of plant signaling', like much subsequent work in this area, enumerates the parallels:

> At the molecular level, plants have many if not all the components found in animal neuronal systems. There are action potentials, voltage-gated channels, a vesicular trafficking apparatus sensitive to calcium signals, including synaptotagmins [membrane trafficking proteins first found in mammals] and other components of the neuronal cell infrastructure. Plants use plasmodesmata for direct cell-cell transport; these cytoplasmic connections have a poorly described role in electrical coupling between adjacent polarized plant cells. (Brenner et al. 2006)

The emergent function of plasmodesmata – microscopic channels, unique to plants as a kingdom, that link the plant's cells together – and other plant physiology structures have not been rigorously explained. Crucially, however, by emphasising parallels between plant abilities and animal ontologies, Brenner et al. provoke the hierarchical subordination of plants to animals in both sentience and ethical frameworks to reconsider the foundations on which these hierarchies stand. As will be discussed below, resorting to the standing of animals as the touchstone for elevating plants is logical vis-à-vis current biases in biology, but ethically counter-productive to plant neurobiology's ambitions of valuing plants on their own terms.

Making comparisons between plant and animal functioning is often unavoidable. As philosophers of biology and scientists have noted, biologists cannot make sense of nor accurately describe their non-human research subjects without recourse to linguistic and communicative metaphors of intentionality, mind and meaning typically reserved in science only for humans and organisms phylogenically like us (Keller 1984; Bateson 2000; de Waal 2006; Barbieri 2008; Hoffmeyer 2008). For example, plants have an interconnected root and leaf network, with the stem being the least biologically interesting plant part from a scientific point of view. Animals generally have a differentiated nervous system and brain that is coordinated only over a given substructure of their body (Carruthers 2006; 2007). However, with recent research demonstrating the importance of the brain–gut microbiome connection, in which the gut functions as a second brain (e.g. Montiel-Castro et al. 2013), and the discovery that the brain interacts with the lymphatic (immune) system (Louveau et al. 2015), a far more nuanced assembly of organs working together 'as' the brain has arisen. Such scientific revelations have not yet systematically been integrated into previously established Western medical models of isolated systems; nor has the dominant Modern Synthesis in evolutionary biology

evolved to integrate with these and other findings of the Extended Evolutionary Synthesis (EES) in biology (Noble 2008; Laland et al. 2015). Despite delays in scientifically commensurating paradigms, current research in animals and plants holds far-reaching implications for rehabilitating standard assumptions regarding alloanimal and plant nervous systems as messier or more complex than we have realised (Calvo and Trewavas 2020b; Mikhalevich and Powell 2020). Interpolating such findings requires updating prior assumptions, suggesting mounting misreckonings between previous models and organism bodies, abstractions and life processes.

The agency of organisms beyond animals with central nervous systems is beginning to play a major role in information studies as well as in cognitive science. This involves dissolving brain-in-a-vat stories of human consciousness through recognising human subjectivity and consciousness as decentred, according to the affordance theory of James Gibson (1979), the embodied, embedded, extended, enactive, ecological and affective (5EA) cognitive science paradigms, and the EES holobiont theory of natural selection displacing human consciousness from being brain-centric (Roughgarden et al. 2018). From the other direction, non-human forms of consciousness are increasingly being found in other organisms, especially at the interface between organisms and species. Microbial and mycorrhizal fungi networks associating with plants, for example, are increasingly described metaphorically as the computers and internet of the plant organism's extended mind (Nadell, Foster and Xavier 2010; Tero et al. 2010; Barto et al. 2012). The discovery of 'fast relay' information transfer through calcium ion chemical signalling reveals that plants command much faster ways of disseminating information from one part to another than previously believed, with functions analogously to the animal nervous system (Bothwell and Ng 2005). While this kind of signal transfer can be seen (and dismissed, for plant intelligence naysayers) as automatic rather than intentional, teleosemantics (or biosemantics) maintains that such signalling takes place through cooperation between different parts of the plant or purposefully between plants and other species (Artiga 2014). For such cooperation to make sense nonmetaphorically, some sort of deliberate allowing, or permission, must undergird this cooperation (requiring the premise that as non-deterministic actions, such signalling could be cut short, or such cooperation could be stopped).

Those in the plant intelligence debates doubting these capacities agree with Alpi et al. (2007) in resolutely rejecting the extension of plant signalling as an analogy or homologue to animal organs and abilities. Alpi et al.'s paper, co-authored (or at least signed) by 36 leading plant biologists, rejects overextending interpretations of plant intelligence to homologies with nervous systems found in animals as dangerous. Failing to see any positive value in comparisons to animal physiology models, such analogies are only metaphors, they claim. Such depictions are bound to incur misconceptions about plants and the entire

enterprise of plant biology. These biologists view plant neurobiologists' claims as 'founded on superficial analogies and questionable extrapolations', maintaining that 'there is no evidence for structures such as neurons, synapses or a brain in plants' (Alpi et al. 2007: 136). These sceptical scientists question: how could one have neurobiology of any kind, without the requisite animal organs and physiological properties that have come to define neuro?

While at first glance these disagreements revolve around literalism and semantic issues – asking how seriously the metaphor of brains and neurobiology should be taken – both promoters and detractors contend that something more fundamental is at issue in these debates. Plant purists (defenders against plant neurobiology) wish to defuse over-generalisations by referencing the physiological differences and scientific overstatements of plant neurobiologists. For example, neurophytologists claim that plasmodesmata are common throughout the plant body, not just located in the transition zone (Trewavas 2014), and that they, rather than some other mechanism, may act as the auxin transport system. Instead of hypothesising plant 'neurotransmitters', plant hormones could instead be transported through cell walls via symplasts, which pass between the cytoplasm that connects plant cells. This Occam's Razor for plant physiology suggests the most mechanistic interpretation of observations possible, with plant purists disagreeing over the biological accuracy of plant neurobiologists' accounts in minor (interpretive), not major (descriptive), ways (Hiernaux 2019).

From a different perspective, plant purists are making an epistemic claim that I think is correct: endosemiotic plant communication and hormone transfer do not look anything like the arrangement of animal hormone and neuronal functioning. Even if some of the same hormones present in plant root activity also occur in animal brains, and even if abundant analogues between plant organs and properties and animal ones exist, these organisms are so different in their functioning and orientation to their world and themselves that on some level it is not quite clear why these comparative claims of plant neurobiology are taken seriously. Certainly, the same chemical hormone in a plant does not work in the same way as in a mammal. When we make terms like 'nervous system' or 'brain' or 'neurobiology' too metaphorical, they lose their precision. After all, if plants have neurons, then we could call these neurons$_2$, distinct in meaning from animal brain-based neurons$_1$. However, such additional nuancing calls into question the utility of such descriptors in the first place. The extensive and intensive meanings of words can only be bent so far before they break. New words and concepts must be invented to take up the slack; but these too are freighted in value hierarchies.

Questions of plant consciousness, intelligence and agency, as fraught as they are, open up an even deeper misunderstanding in Western biological ontologies based on radiating declensions from the taxonomic Vitruvian Man.

The plural ontology of plants themselves drives us to investigate more deeply the assumptions of human exceptionalism and biological hierarchies.

VEGETAL EPISTEMOLOGIES

In their parries against plant neurobiology, plant purists draw on consciousness studies from other domains of science and philosophy that problematise consciousness or intelligence without brains. Some members of the original group of scientists contradicting plant neurobiology have recently published a damning paper based on a meta-analysis of evolutionary biologists cataloguing which species' brains are complex enough to exceed the threshold for the emergence of consciousness (Taiz et al. 2019, based on Feinberg and Mallatt 2016). This theory of neurobiological naturalism looks at the 'suite of neurobiological features' found in known conscious animals in attempts to close explanatory and experiential gaps in brain and consciousness correlates (Feinberg and Mallatt 2016: 113). Such modular approaches to consciousness (Carruthers 2006), one might think, favour pluralistic conceptions of consciousness; instead, they usually (including in this case) position consciousness as the independent variable based on plural forms of brains. Brain types can vary within a range to produce consciousness (for example, in cephalopods, arthropods and vertebrates), but the preconditions for consciousness are still taken to require a 'nervous system', 'a real brain', 'affective circuits' and 'neuro-hierarchical complexity' (Feinberg and Mallatt 2016: 119). Thus, for scientists, arguments current in the philosophy of mind impinge upon notions of plant biology and plant intelligence. Certain material substrates are still the metrics by which consciousness, and, by extension, intelligence, are judged possible.

Plant neurobiology proponents forward epistemic claims about science to accomplish the ontological work of drawing the analogy between plants and animals. But they are also making philosophical claims (Calvo 2016; Heras-Escribano and Calvo 2020). Plant neurobiologists argue that plant activity can no longer be tenably regarded as merely automatic biochemical reactions, but that plant chemical processes are agental, and mirror neuronal activity in animal brains in important ways. In making these comparisons, plant neurobiologists construct two claims. First, plant processes exhibit similarities to animal processes; second, *because of these similarities* plants should be regarded as more agental and intelligent. Whether emphasis rests on the analogy between plants and animals or whether plant 'neuro'biologists use the term not merely to catalogue similarity but principally to respect plants' abilities as wholly *different but nonetheless intelligent and thus intrinsically valuable processes*, makes all the difference in how seriously we should take them. These epistemic claims are intertwined with ethical ones. The language used to elevate the status of

plants as intelligent may serve to affirm the traditional intelligence hierarchy of animals to plants, or to transform and thus dismantle it.[3]

This paradox of comparing plants favourably to animals in order to raise their regard as undermining the particular abilities and hence types of intelligence plants display, has not been adequately theorised. One of the challenges of plant biology is how to recognise the current incompleteness of our knowledge of plant functioning without under- or overdetermining the data. If indeed a gap exists between plant ontologies and human epistemologies (cf. Serres 1995: 24–5), do we give plants the benefit of the doubt, or privilege the extant data scientists have collected on plants? Plant biologist and anthropologist Natasha Myers describes learning from plant molecular and cell biologists about plasmodesmata in plants:

> Could plasmodesmata be the cellular structure that enables such a widely distributed and multiply interested body to cohere, to hang together? Did plasmodesmata endow plants with a nerve-like network to propagate energies, intensities, and affects throughout its body? (Myers 2015: 37)

To critics of plant neurobiology, such questions amount to naked speculation: unsubstantiated, romantic and open to misinterpretation by a public more than willing to be misled into believing plants possess powers surpassing their physiological realities. To plant neurobiologists, however, awareness of networks such as plasmodesmata hint at the undiscovered or unresolved physical foundations of plant intelligence and physiology based on the mounting experimental data challenging the previous paradigm, which they take as their null hypothesis.

Beyond extremes such as 'plants can never be intelligent because they don't possess brains like animals' versus 'plants possess physiological properties analogous to animal nervous systems and brains, therefore they may/must be intelligent', Myers self-consciously is not searching for equivalencies. As a hybrid researcher, Myers is awed at the sophistication of plants to meet their environmental sensing needs according to patterns similar to the functions of nervous systems, without conflating animal nervous systems with the analogous but irreconcilably different 'nervous systems' of plants (again, nervous systems$_1$ versus nervous systems$_2$). Interviewing molecular biologists in 2014, Myers found them enflamed at the popular 'enchantment with an approach that so audaciously engaged human and animal models of intelligence and behaviour to structure inquiry into plants' (2015: 38). At the same time, these same scientists presented their concerns about the framing of plant neurobiology in ways sympathetic to plants: comparing plants to humans or animals undervalues the true marvels of plant behaviour on their own merits, which fails to value the evolutionary abilities they perform that animals and humans *cannot* (Ibid.: 39). Far from coming from a place of incredulity to

3. On the difference between affirmative and transformative values, see Fraser 1997.

gatekeep intelligence for the animal kingdom only, the plant biologists Myers interviewed sought to not set plants up to fail by requiring their status and recognition to be contingent on their proximal abilities and organs to animals. These mixed feelings of molecular plant biologists revealed how rejecting recourse to human or animal anatomical similarity can enable valuing plural intelligences including those of plants.

BECOMING-PLANT THROUGH PARTICIPATORY ACTION RESEARCH WITH PLANTS

The social science framework of participatory action research (PAR) is a useful method to allow research subjects to contribute to the process and outcomes of studies. PAR has already been extended to animal research (Merskin 2010), so further applying it to plant research to make better sense of the scientific debates over plant neurobiology seems at least *prima facie* conceivable.

Just as sustained proximity with any research subject can inoculate[4] the experimenter faithful to their research (as epitomised in the 2020 film *My Octopus Teacher*) into the world of the research subject, Myer observes that '[i]n the process of their careful work, plant scientists learn to pay attention to what it is that plants pay attention to' (2015: 42). In this process, plant scientists' perspectives of the world *become plantlike*, at least partially so. This is evident in Trewavas' *Plant Behavior and Intelligence* (2014), which is structured around the work of Nobel Prize-winning botanist Barbara McClintock. As much as any modern cytogeneticist, in her ground-breaking work with maize plants, McClintock's reasoning became plantlike. In her biography, *A Feeling for the Organism*, Evelyn Fox Keller relates how '[i]t was easy for McClintock herself to lose sight of the difference between what could be seen with the relatively uneducated eye and what could be seen only with the help of a long chain of logical inference that, to her, had become second nature' (Keller 1984: 126). Internalisation of this 'long chain of logical inference', mimicking the processes of plants, prompts Myers to give plant biologists the nickname 'vegetal epistemologists' (2015: 42).

Vegetal epistemologists must spelunk into the world of plants if they wish to understand them on their own terms, entering into what Jakob von Uexküll called their *Umwelt* (species-specific awareness of environmental features, enabled and constrained by species' sensory organs) (von Uexküll 2010). As a vegetal epistemologist, McClintock's methodology, as oblique as it may sound

4. The original late Middle English meaning of inoculate, coming from the Latin, means 'to graft a bud or shoot into a plant of a different type'. Inoculate means 'engrafted:' *in* (into) + *oculus*, 'eye' or 'bud'. See *OED* 1a: To set or insert (an 'eye', bud, or scion) in a plant for propagation; to subject (a plant) to the operation of budding; to propagate by inoculation; to bud (one plant) *into*, *on*, or *upon* (another).

to standard scientific protocols, is actually run-of-the-mill for scientists dealing with alive, responsive organisms. Indeed, this is how ethologists treat animals or sociologists humans (Merskin 2010; Mancuso, Viola and Pollan 2015; Mancuso 2018). What is bizarre, is not Stefano Mancuso's statement that 'a scientist needs to "love" his [sic] subject in order to do it justice' (quoted in Pollan 2013), but the Cartesian modus operandi of 'sado-dispassionate' objectivity, which conceals more than reveals biases (Seitz 2000; Plumwood 2002: 41). Plant neurobiologists aim not only to know and describe the intelligence of plants, but – whether they publicly attest or deny it – also to contribute to updating antiquated Western scientific practices by exploring ways of decolonising scientific methodologies (Smith 2012; Kimmerer 2015).

These beings classified as outside of the rational community currently have no spokesperson through whom joining the communicative debate is possible (Latour 2004). By enminding plants, even if their 'minds' are very different from mammals', plant intelligence research brings the vegetal world inside the community of concern. Moving from defensive (debarring comparisons with human capabilities or brains) to offensive vegetal epistemological claims (positing strong claims for plant intelligence based not only on multiple intelligence theses but analogical processes and features to human mammal brains),[5] biosemiotics – the semiotics of biology examining how organisms make sense of their lives and environments – posits an alternative framework for recognising plant agency without collapsing these abilities and sense-making of their environment into animal analogues or inferiorities (Kull 2000; Krampen 1991). As a scientific example of engaging in and promoting practices that interject non-human concerns and 'wills' into the idealised-rational realm of discourse, the engaged methods –if not the ethical comparisons of plant neurobiological forays – are crucial for achieving a 'universal discourse' that recognises the existence of a responsive community larger than the solely human (Eckersley 1999; Plumwood 2002).

PHILOSOPHIES OF SAMENESS, SCIENCES OF DIFFERENCE

The type of moral extensionism at work aiming to legitimate plants as subjects or moral patients worthy of consideration is part of what I call 'first wave' animal philosophy studies, which I repudiate as undermining the intended project. First-generation animal studies (Singer 1991; Cavalieri and Singer 1994), despite using a utilitarian framework, follow a Kantian model of the person, granting inclusion and consideration based on proximity to the model abstract human. The closer an animal's physiology and behavioural capacities are to humans, the more moral consideration they deserve. This 'similar like us' moral extensionism thesis suggests that the further their biology and

5. Trewavas (2017) plays both sides of deconstructing 'brain chauvinism'.

ethological capacities are from us, the less likely they are to possess the *type* of intelligence or consciousness that we regard, and thus our dutiful treatment is commensurate with their standing in such rankings.

Plant neurobiology bases its strategy on the dominance of moral extensionist claims, I contend. Phytologists and scholars wishing to flag plants' exceptional attributes as capabilities that demand redesignating them as agental subjects understand that couching their claims according to dominant models of proximal moral inclusion provides one of few opportunities for plants to become legible according to those ethical frameworks currently politically effective.

Insofar as the plant neurobiology project is motivated to enhance the status of plants and reduce crass human instrumentalisation of them – genetically engineering plants for our ends, monoculturing and addicting them to fertilisers, micromanaging every aspect of their life and growth through human-directed regiments of water, soil nutrients and light exposure – this is a valuable environmental ethics project. If more people become aware of the ethics-carrying capacity of plants through the catchy metaphor 'neurobiology', such actions bring plants closer conceptually, increasing the chances of reconsidering our duties to them.

However, insofar as the project doggedly attempts to make direct comparisons between animals and plants, and to squeeze plant processes into the animal biological mould, environmental ethics must part ways with such thinking. Plant neurobiology is rhetorically useful, but unwittingly performs a certain type of ontological violence to plants. The interpretive question of undisputed empirical phenomena asks: why must we make plants animal analogues in order to respect them? Granting plants intelligence does not mean they must possess the kinds of minds animals do, nor that their sensory circuitry must look alike or similar to our own, to develop respect and regard for their ways of being in the world.

At the heart of this debate is the question: what is a brain? Which, in physicalist science entails the question: what is intelligence? Fundamentally, modern science has tended towards brain-centrism: rendering a given organism intelligent according to the similarity of its brain to ours. In reifying this monolithic notion of intelligence modelled on proximity to a standardised human brain, areas of Western science and philosophy have also adopted a parallel Vitruvian Man model of moral consideration.

According to this presupposition, we can choose from several models when we inquire into plant intelligence. One is the homologue model. Octopuses, for example, distribute two-thirds of their neurons in their tentacles, enjoying a decentralised brain (Godfrey-Smith 2016). Could it be that plant roots operate with a similar but more extreme decentralised brain, with auxin transfer acting as a surrogate neurotransmitter?

Another model might be to say that plant processes aren't real neuronal activity, but play for the plant the *function* of neural processes, with the root

subapical transition zone acting for plants as neurons function for animals. Perhaps unsatisfactorily, according to this analogy we must also grant that the plant's intelligence only analogically nears animal intelligence, and hence plant agency only analogically approximates animal agency, and so on for moral consideration purposes. But already, we find ourselves on a continuum of agency, intelligence and moral consideration, instead of a hard cut. How we regard the trope of analogy is the Archimedean point of the plant neurobiology debate.

If we look for similarity, then analogy works according to the Vitruvian Man model of an abstract model that exists nowhere but nonetheless is the standard for consideration. This is problematic for several reasons. Firstly, exclusionary practices that work on a basis of sameness themselves are not objective but subjective, normally biased towards reflecting values represented by the community performing the Vitruvian modelling. Exclusion is a product of self-identity, whether self-reflexive or not, although reflexivity moderates this greatly. Thus, the epistemic worth of such devaluations is suspect, as such estimations are self-referential.

A second problem with analogies based on sameness is perceiving otherness as a deviation from moral worth. The self-centrism of such ethical models is self-congratulatory, supporting blinkered and isolated rather than interdependent and networked self-notions. Permeability to the other has to do with how willing one is to be influenced in kind by the deemed to be different other. Once we essentialise either sameness or difference, we have already abstracted away from the phenomena at hand.

Basing moral consideration on acceptance of difference *as* difference without making difference *worse*, however, means that there are various ways of being not requiring hierarchical organisation. A non-anthropocentric moral designation means that we would not need to legitimate the lives of plants, secret or not, in terms of animals. Plants would be able to stand on their own legs (or stems, as it were) as justifiably intelligent or intentional beings, to the degree they are (and research can plausibly be so interpreted), without having to create equivalences between their very different processes and those of (higher) animals currently grandfathered into Vitruvian human models' expanding circles of diminishing moral consideration.

The catch is: why should plants be morally considerable in proportion to the progress of science? Respect for other beings, it turns out, has less to do with them, and more to do with us.

Perhaps we would be better off not viewing homologies between plants and animals as the holy grail of moral worth. Such an approach misattributes the proprioceptive capabilities of plants physiologically. Despite the tremendous strides philosophers have made in extending the demarcation line of moral considerability to sentient creatures in the past century (Glock 2000; Grandin and Johnson 2005; Bekoff and Pierce 2010), it would be a mistake to subsume

'higher plants' into the same category as animals or 'personhood'. After all, animal welfare has arguably hardly in aggregate benefited as a result of animal rights. Plant neurobiology teaches us most directly about our need to embrace pluralism, epistemically, ontologically and ethically. Realising such an ethics concretely still requires much work (Koechlin 2009; Hendlin 2015; Hiernaux 2019; Hendlin 2020). Nonetheless, instantiating an ethics of difference rather than sameness is precisely what is called for to move from a domination to a partnership relationship with the more-than-human world (Collard and Contrucci 1989; Plumwood 1993; Eisler and Fry 2019).

CONCLUSION

The very project of plant neurobiology, while well-meaning, attempts to argue in the master's language, instead of taking plant science on its own terms to be sufficient – based on respecting difference – to legitimate valuing plants as moral patients. In taking a moral extensionist framework based on equating plant roots with decentralised animal brains, I claim plant neurobiologists undermine their own programme of bringing plants into the moral community of concern. The framing of plants as possessing subapical root-brains based on animal models has been strategically important in expanding the standing of plants, even if such comparisons remain analogical. Yet we should not need to compare plants to animals in order to elevate their position as intelligent beings. While such claims make for good public relations, aspirations to animal models ultimately telegraph preordained defeat in valuing plants on their own merits. Recursion to animal – and fundamentally, human – monolithic taxonomies of intelligence undermines the pluralist promise of plant intelligence as different, not lesser.

The ways of communicating to which we attune ourselves depend on what we are looking for, our openness to surprise and how new meaningful patterns can emerge that ask for our interpretation (as in the work of McClintock). Awareness of such intelligent patterns of conduct, rather than glossing them as random or mechanical, calls us to respond intentionally and relationally without defaulting into untethered vitalism. Neither should we apply general rules of Vitruvian sameness to non-human beings, when the details of their actions betray a specificity of response, not of purely mechanised reaction, but closer to genuine communicative action worthy of moral consideration (Hendlin and Ott 2016). If plant communication and intelligence look nothing like the concentric circles of animal sentience, this betrays a *prima facie* lack of respect for intelligence showing up differently from our own proximate model. Intelligence may be a wild garden of exemplars, not a monoculture.

Historically, Western thought has reproduced categories of discrimination to substantiate threshold categories. But this need not be our way forward.

Difference may be both *conceptual* in pluralising notions (e.g., intelligence$_1$, intelligence$_2$, or intelligence$_3$) – *differentiating* without discriminating (e.g. without superordinate and subordinate) – or *epistemological*, acknowledging the fundamental non-exchangeability of beings, even beings of the same species (Bateson 2000; Hendlin 2020).

What would moral consideration not predicated on moral extensionism's unitary-unit proportioning look like for plants? One approach is conservation biology, eliminating harms to established plant communities (such as stands of old-growth trees) and minimising unnecessary harm and instrumentalisation vis-à-vis plants in meeting human needs (Koechlin 2009; Jordan 2012; Marder 2013). How do we establish moral consideration not based on some notion of proximity? By not treating plants as equals or unequals; nor generalising an oak tree with a strand of grass in terms of value or comparable considerations under the kingdom 'plants' (neither to quantify so many blades of grass as possibly 'equalling' an oak). When we start thinking about plants divorced from their environment, we are already doing them a conceptual and physical violence.

The intelligence of plants is its own sort of intelligence, incommensurable with other forms of intelligence. It does not automatically follow that this difference should necessarily demote it as an inferior, ancillary or truncated form of intelligence. Likewise, professional athletes or musicians exhibiting tremendous embodied skills that have become automatic (cognitively offloaded) responses and processes coming with ease – no longer requiring harrowed self-reflective or disciplined self-awareness – in no way diminishes the virtuosity of their performance; cognitive offloading may be the prerequisite. The superficiality of plants, as Marder (2013) indicates, may be their strength, revealing to ourselves how overly complicated we have made our own world of dissimulation, when we too are much more automatic or 'superficial' than autonomous in our everyday lives (whether we admit to it or not) (Bargh and Chartrand 1999; Appiah 2010; Barrett 2010; Sapolsky 2017).

Indeed, in ethics, serious work aiming to extend personhood to plants is already well underway (Puleo 2019). As plant intelligence as understood by science is contingent upon larger social understandings of who we are and our need to differentiate ourselves, plant neurobiologists are doing perhaps the best they can by appealing to already present values and models of intelligence. Perhaps plant neurobiologists would call themselves something else, if more favourable circumstances allowed. We would be wise to realise that the pluralist teachings of plants have much to offer the rest of our scientific and social measurements, and find traditional and innovative ways of integrating these lessons of plurality with dignity into our epistemologies, ontologies and ethics.

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