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Do Plants Feel Pain?

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Abstract
Many people are attracted to the idea that plants experience phenomenal conscious states like pain, sensory awareness, or emotions like fear. If true, this would have wide-ranging moral implications for human behavior, including land development, farming, vegetarianism, and more. Determining whether plants have minds relies on the work of both empirical disciplines and philosophy. Epistemology should settle the standards for evidence of other minds, and science should inform our judgment about whether any plants meet those standards. We argue that evidence for other minds comes either from testimony, behavior, anatomy/physiology, or phylogeny. However, none of these provide evidence that plants have conscious mental states. Therefore, we conclude that there is no evidence that plants have minds in the sense relevant for morality.

Keywords
Plants, pain, moral patient, phenomenal consciousness, qualia.

1 Introduction

Do plants have minds and experience things like pain? A surprising number of people are attracted to the idea that plants have minds and experience conscious states like pain, fear, and other basic emotions (Reggia et al 2015). Some of the interest in this topic likely stems from discredited scientific studies,[1] new age productions amounting

[1] Like the boondoggle by Peter Tomkins and Christopher Bird, *The Secret Life*

to nothing more than pseudoscience,[2] and articles aimed at a general readership that conflate communication with phenomenal awareness.[3]

However, not all the evidence for plant minds is that bad. There are at least some contemporary academics involved in the search for plant minds, and certain studies published by reputable academics appear to lend some measure of credence to the idea that plants have minds. For example, according to one recent study, plants "hear" caterpillars eating their leaves and respond with various chemical defenses (Appel and Cocroft 2014). Additionally, the University of Murcia in Spain has recently opened a Minimal Intelligence Lab advertising itself as the first lab in the world to study the ecological and philosophical basis of plant intelligence.[4] And a recent volume entitled *Plant Minds: A Philosophical Defense* (Maher 2017) offers a careful and extended treatment of the idea that plants have minds, at least in some sense of the concept.[5]

Despite these explorations, the philosophical consensus seems to be that plants are not conscious. However, the experts offer little to no argument for this conclusion.[6] It's taken as obvious. Yet finding out that plants are conscious would have wide-ranging moral implications for human behavior, including land development, farming, vegetarianism, and more. If plants feel pain, then we owe them moral consideration. Descartes is widely vilified for his justification of practices like animal vivisection (e.g. Smith 1963). His views on

of Plants (Harper & Row 1989).

[2] Like this: http://www.plantconsciousness.com/index.html

[3] For example, https://science.howstuffworks.com/life/botany/plants-feel-pain.htm

[4] https://www.um.es/web/minimal-intelligence-lab/

[5] Although even Maher concedes much of the ground we argue for here: "We will find that if we accept currently dominant ideas about these facets of mind, we must conclude that plants don't have minds. However, I will contend that we need not accept those dominant ideas. There is instead a relatively new, minority view of the mind that supports thinking that plants do have minds, or at least, proto-minds," (p. 22).

[6] For two examples on this score, see Gennaro 2019 and Tye 2018.

consciousness allowed him to rationalize away the barks and yelps of living dogs as they were cut open for experiments (Descartes 1985). We should think about whether we are making similar mistakes with regard to plants.

This paper remedies this lacuna by setting out a methodology for identifying evidence for plant consciousness and arguing that the current evidence falls short. Determining whether plants have minds relies on the work of both empirical disciplines and philosophy. Our best philosophy of mind should inform the epistemic standards that must be met to make belief in another mind reasonable. Our best science should inform our judgment about whether plants meet those standards. Hence, this paper proceeds by first looking at the epistemology of other minds and then to the empirical evidence for plant minds.

Our conclusion is that there is no good reason to think that plants experience things like pain or pleasure. That is because there is no good reason to think that plants feel anything at all; there is no evidence that there is anything it is like to be a plant. Hence, our conclusion undermines arguments for moral obligations to plants that appeal to premises about plant mental states or conscious awareness. Those premises are unjustified since there is little evidence that plants have minds in the sense relevant for morality.

1.1 The concepts of mind and moral patiency

Before setting out a procedure for whether something can feel pain, there are three concepts that stand in need of clarification. The first is the concept of a mind. Before we can ask whether plants have minds, we should have a clear sense of what would count as a mind. For example, if any system capable of responding to a stimulus is a mind, then many plants obviously have minds. But then, so does a thermostat. Or if any system capable of altering the behavior of a larger system counts as a mind, then many plants obviously have minds. But then, so does a thermostat. This conception of a mind is too broad.

On the other hand, if being a mind requires the ability to entertain abstract thoughts (e.g. all cats are mammals) or higher-order desires (e.g. the desire to not have the desire to smoke), then no plants have minds. But then, neither do young humans or many animals. Or if having a mind requires the ability to employ reason and logic to determine proper beliefs or actions, then again, plants will fail the test. But then, so will many humans, some of which have even been elected to public office. This conception of a mind is too narrow.

Saying that a conception is too broad or too narrow indicates that our refining of the concept 'mind' answers to certain background goals that we have yet to make explicit. Too broad or too narrow, *for what*? Why do we care about the possibility that plants have minds? There is no, one, univocal sense of 'mind', and we should identify the concept of mind that is relevant for our goals in any given scenario. As made clear in the previous section, at least one of the central reasons is a moral one: if plants can suffer, then they matter, morally-speaking.

With morality as a conceptual anchor, we can home in on the concept of mind relevant for the present discussion. How are minds relevant to morality? It is plausible (though not uncontroversial) that having a certain kind of mind—being able to entertain qualitative mental states—is a sufficient condition for moral patiency.[7] A moral patient is any being who is owed some sort of moral consideration from the rest of us. I morally ought to consider how my actions will affect my dog, but I have no corresponding obligation to consider how my actions will affect a rock in my yard. Rocks are not moral patients. Dogs are.

What is it about the dog that renders him a moral patient whereas the rock is not? The difference is that dogs are able to experience pain, pleasure, and other qualitative mental states whereas rocks cannot. Philosophers have various ways of describing this difference. Some put it in terms of sentience: dogs are sentient whereas

[7] Whether qualitative mental states are <u>necessary</u> for moral patiency is a more controversial question. We take no stand on that issue here. Furthermore, we grant that there are reasonable philosophers who deny that having qualitative mental states are <u>sufficient</u> for moral patiency. These philosophers defend a more restrictive least upper bound to the moral community (e.g. contract theorists who think only rational and conscious beings count as moral patients). Those philosophers may still find the case in this paper convincing, but they won't see the point since even if plants experience qualitative mental states, that won't be enough to show that we owe them anything, morally speaking.

rocks are not. Some put it in terms of qualia: dogs have mental states with qualitative aspects (qualia) whereas rocks do not. Some put it in terms of a subjective point of view: there is something it is like to be a dog but nothing it is like to be a rock.[8]

We will describe this difference as one of phenomenology: some minds allow for phenomenally conscious states and others do not. For example, there is something that it is like to see a red firetruck, hit your thumb with a hammer, hear a human voice, or smell a pineapple. Those phenomenal aspects are what make a mental state conscious in the phenomenal sense. Indeed, unconscious mental states are unconscious precisely because there is nothing that it feels like to have those mental states, and so we cannot tell by introspection whether we are in those states or not. To put it simply: there is something that it is like to *be* a being with a mind in this phenomenal sense (Nagel 1974).

We can now re-frame the question of this essay. The relevant question is not whether plants have minds in some very broad sense of the term. They obviously do. If having a mind is nothing more than displaying goal-directed behavior (Artistotle), having a capacity to respond to an environment (Darwin), or being disposed to behave in particular ways (Skinner), then plants have minds. Instead, the question is whether plants have minds in the phenomenal sense.[9] Is

[8] In this paragraph, we note that philosophers often conflate phenomenal mental states with mental states that include qualia or mental states that provide a subjective point of view. On that view, sentience is a property of a mind that indicates the possibility for such mental states. There are philosophers who deny that these terms are coextensive. In particular, there are philosophers who think that minds can have a subjective point of view even without a kind of subjectivity or phenomenal awareness (see van Gulick 1985 or Lycan 1987). For example, Lycan 1996 argues for a representational view in which consciousness is the monitoring of first-order bodily states where the latter have qualia but the former do not. We take no stand here on whether that is so or whether these terms are coextensive. The motivating question of the paper is whether plants feel pain. That's a question about the existence of a particular type of phenomenal state. If it turns out that plants have a kind of non-phenomenal subjectivity, that will not be a reason to think that they experience pain.

[9] Maher 2017 takes up this more focused version of the question in chapter 3. He concedes that most experts in the field think that plants lack phenomenal mental states, but he also thinks that they do not have sufficient evidence to draw

there anything it is like to *be* a plant? Do plants have subjective experiences? Are plants sentient?

1.2 The epistemology of minds

How do we know when a being has phenomenal mental states? Answering this question requires an epistemology of minds (from here on, 'mind' will be taken in the narrow sense described in the last section as capable of hosting phenomenal mental states). When it comes to the epistemology of our own minds, the answer is easy: we know that we have phenomenal states by introspection alone. We are intimately acquainted with our own pains, thrills, and experiences of the world around us.[10]

But how do we know that other beings experience things at all, much less experience things as we do? At first this question seems perverse: we all naturally form beliefs that there are other beings in the world with minds like ours. And that's true. Cognitive psychologists have impressive models describing a hard-wired "theory of mind" that allows even young children to naturally attribute minds and phenomenal points of view to agents in their environment (Baron-Cohen 2001). But that explains *how* we form such beliefs. The present concern is not how we do this but whether it's reasonable to do so.

The knowledge that other people have phenomenal experiences is not available by introspection. Instead, if challenged to defend the belief that others have minds, there are a few things we might say. First, we often know about the phenomenal experiences of others via testimony. Your brother tells you that his head hurts or your

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this conclusion (see pp. 73–4). The goal of this paper is to show that Maher is mistaken on this evidential point.

[10] Although perhaps our knowledge of our own phenomenal experiences is not as easy as we've made it out here. Some philosophers have argued that our knowledge of our own subjectivity depends on the same sorts of inferences that we make about the subjectivity of others (e.g. Carruthers 2011). It is not necessary to settle this question for current purposes. If it turns out that there is no unique epistemic access to first-person phenomenal states, then the methodology for establishing plant consciousness is on a par with the methodology for establishing animal consciousness, including ourselves.

boyfriend exclaims that the sunset is beautiful. If we think that testimony is a source of evidence for everyday claims, then it surely counts as evidence for a mental life as well.

A second avenue of knowledge is an inference to the best explanation based on the behavior of others (Singer 2002). This sort of inference is an extension from our introspective knowledge of our own phenomenal states. We know introspectively that when our hand goes into a flame that our phenomenal state of pain gives rise to certain behavior.[11] And so when we see similar behavior in others, we have evidence that there is a similar phenomenal state in others. Putting your sister's hand into the flame results in similar behavior on her part. Putting your pliers into the flame does not. So, it's reasonable to think that your sister has phenomenal mental states and your pliers do not.[12]

A third avenue for knowledge of other minds comes from anatomy and physiology (Singer 2002). Our best science shows without a doubt that certain physical structures are correlated with the ability to have phenomenal experiences. Now this is not to say that we've solved what philosophers call 'the hard problem of consciousness' (Weisburg 2017). We don't know why certain physical structures give rise to conscious mental states rather than none at all. But we do know *that* certain physical structures are correlated with phenomenal experiences such that if the underlying physical structure is altered, the conscious states are altered, too.

A couple of examples should make this clear. Consider first the famous case of Phineas Gage. In 1848, Gage survived an accident where a metal rod, 1¼ inches in diameter, was launched upward

[11] Well, epiphenomenalists will deny this link is causal. But it's unlikely that an epiphenomenalist would be reading this paper anyway. And even if she were, her displeasure of reading this claim won't give rise to any negative effects. Further, we don't need the claim that the qualitative state causes the resulting behavior. As long as the two are correlated, the IBE will go through: where there is the behavior there is the mental state regardless of whether the latter caused the former.

[12] Tye 2017 offers the best defense of the behavior-to-consciousness argument. However, we grant that this inference has come under increasing pressure as we learn more and more about how behavior and even choices can be triggered subconsciously. See Carruthers 2018 for a helpful overview of this sort of objection.

through his skull severely damaging his left frontal lobe. After his accident, Phineas Gage's personality changed so dramatically that his friends and family claimed that he was "no longer Gage" (Harlow 1868). Or consider physical traumas such as a lobotomy, a surgical procedure which alters the physical structure of the brain by purposefully damaging the connections between the prefrontal cortex and the rest of the brain. Surgeries like this exploit the fact that there is a connection between the underlying circuitry and conscious experiences. So, our best evidence suggests that structures like neurons, organs like brains, and systems like the central nervous system are requirements for phenomenal consciousness.

Finally, our last bit of evidence for other minds comes from evolutionary biology. It is reasonable to conclude that beings with similar evolutionary trajectories (phylogeny) have similar mental capacities. Once again, the idea is to leverage our introspective knowledge of our own minds into a kind of argument by analogy to beings with a similar evolutionary trajectory. For example, humans are closely related to chimpanzees (de Waal 2005). This is inductive evidence that the two species will have evolved similar strategies for survival, so if a human mind gives rise to phenomenal experiences, this is evidence that the chimp mind will as well (Singer 2002). If two beings occupy similar places on the evolutionary tree, then there is a plausible argument from analogy from the one to the other. While this is arguably the weakest of these four sources of the knowledge of others, it is still a source of evidence.

In sum, all but solipsists agree that there are other minds besides one's own. And if this belief in the minds of others is supported by evidence, then the evidence must come from one of the following four sources:

1. Testimony
2. Behavior
3. Anatomy and physiology
4. Evolutionary history (phylogeny)

If you can identify one or more of these sources as your justification for your belief in other minds, then that belief is based on the evidence.[13] If you can't, then your belief is not based on evidence. For example, in the case of other, non-human animals, the case that fellow humans are conscious and experience pain is isomorphic to the case that many non-human animals are conscious and experience pain. In particular, many non-human animals share similar nervous systems which respond physiologically similarly to ours when put in a circumstance that would elicit pain in humans, share similar evolutionary trajectories, and behave in ways similar to humans (Singer 2002). To make such an argument for plants, we must ask whether such evidence of consciousness exists for them, too.

2 The empirical evidence of plant minds

Is there evidence that plants have minds? If so, then it comes from one of the four sources of evidence described in the previous section. And the first is easily dispatched: despite flashy headlines to the contrary, plants don't talk (Krulwich 2014). That is NOT to say that plants don't communicate. They likely do so. But they don't offer testimony. What's the difference?

Testifying requires language, where a language is a rule-governed, symbolic system in which one could convey a potentially unlimited amount of propositional content. In that sense, command of a language requires more than a command of certain signals. It requires a grasp of the rules by which different signals can be arranged to communicate innumerably different things. As such, language is a one-of-a-kind evolutionary anomaly: humans are the only beings with a language. As biological anthropologist Terrence Deacon (1997) puts it:

> Animal calls and displays have nothing that corresponds to noun parts or verb parts of sentences, no grammatical versus ungrammatical strings, no markings of singular or plural, no indications of tense, and not even any elements that easily map onto words….these differences [between non-human animal communication and human language] are not a matter of incommensurate kinds of language, but rather that these nonhuman forms of communication are something quite different from language. (32–3)

[13] A disjunctive methodology similar to this is implicit in Singer 2002: 9–17 and explicit in Harrison 1991.

This means that while all testimony is a form of communication, not all forms of communication amount to testimony. Screaming out loud, striking a suggestive pose, clapping hands, and giving someone the finger are all ways of communicating. But they are not ways of testifying. When your dog barks because you stepped on his tail, you know that he is in pain. But you know this not by testimony but by his communicative behavior. So, we should consider evidence of that sort (like plant signaling) as behavior rather than testimony.

This leaves three avenues of evidence for the conclusion that plants have phenomenal experiences: plant behavior, plant anatomy and physiology, and the evolutionary trajectory of plants.

2.1 The behavior of plants

Plant behavior includes movement, various forms of signaling (both chemical and electric), and even displays of intelligence. Start with movement. The difficulty in identifying and analyzing plant movement comes down to timescale. The fact that nature documentaries have to speed up the blossoming of flowers or the extension of plant tendrils illustrates the basic point: it is difficult for humans to appreciate plant movement because it is often spread out across time. Of course, plants are rooted in place, but there is ample evidence that many plants exhibit various forms of tropism (see Baluska 2006). For example, the common sunflower (*Helianthus annuus*) rotates its developing heads from east to west over the course of the day to remain facing the sun (Vandenbrink et al 2014). At night, the heads reorient themselves to once again face east. This sort of reaction to stimuli is rather common for plants but is often too slow to attract notice.

However not all plants move slowly. Sometimes plant movement is quite quick as in cases of thigmomorphism. For example, the well-known Venus flytrap (Dionaea muscipula) is a carnivorous plant which snaps shut on unsuspecting insects when they stimulate trigger hairs on the surface of its bi-lobed leaves (McCormack et al in Baluska 2006). Further touches are needed for the pant to secrete enzymes and other proteins to digest and absorb the nutrients (Trewavas 2016). Interestingly, Trewavas argues that such specificity in the number of times the hairs must be touched indicates that the flytrap can count, too (Trewavas 2016).

A more interesting example is the touch-me-not (*Mimosa pudica*). This plant's claim to fame is the immediate and quick folding of its leaves when touched or otherwise agitated. This action, being on par with the human timescale, makes the plant a focus for numerous studies about behavior in plants (Abramson and Chicas-Mosier 2016). In one recent study, touch-me-nots were found to display habituation to a dropping stimulus. Not only would they cease to fold their leaves after several cycles of non-harmful disruption, but they retained the habituation after a month without ongoing stimulus (Gagliano et al 2014). This indicates that some plants not only move but learn as well.

Signaling is another form of communicative plant behavior. Most plants are able to send a variety of signals throughout their plant bodies, including chemical signaling and at least three types of electrical signaling: sustained wound potentials, action potentials, and slow wave potentials (also known as variation potentials) (Stahlberg et al in Baluska 2006, Brenner et al 2006). Action potentials are the kind of electrical signals that neurons employ, and they occur in all plants (Baluska et al 2004). The plant action potential shares the characteristic features of animal neuronal action potentials (Baluska et al 2004). Through chemical and electrical signaling, plants can register and respond (sometimes even selectively) to a variety of stimuli, including rain, bending, wounding, burning, touch, gravity, and light/darkness (Stahlberg et al in Baluska 2006, and McCormack et al in Baluska 2006). Touching has also been found to affect expression of certain genes in plants (McCormack et al in Baluska 2006).

Interplant signaling is another important behavior. Rather than relying on the same method that animals use for signaling and communication with others (auditory, visual, etc.), plants emit chemical signals into the air or ground, usually for the purpose of signaling danger. For example, the common sagebrush (Artemisia tridentate) emits volatile compounds into the air when damaged. These chemicals serve to indicate to other plants that there is a source of danger nearby, like a hungry herbivore or a parasitic insect (Karban et al 2006). This is clear evidence that plants both send and receive signals from one another. Some plants can even go beyond sending a warning. They can send help, too.

One of the most interesting cases of non-animal behavior comes not from a plant but from a fungus. Mycorrhizal fungi form a symbiotic relationship with the roots of plants. The fungi bind to plant root tips and spread through the immediate area, connecting to roots of different plants. Over time this creates an interweaving network that connects entire forests. Mycorrhizal fungus helps to feed hard to find nutrients to saplings and facilitates the transfer of various resources from plants that have a surplus to those in need (Simard et al 1997, Selosse et al 2006).

Because plants exhibit such complex forms of movement and communication, one might wonder whether such behavior can be classified as intelligent. Trewavas (2003) defines plant intelligence as "adaptively variable growth and development during the lifetime of the individual" (compared to the major form of expression of animal intelligence which is in the form of movement) and argues that all plants exhibit intelligent behavior according to such a definition. He argues that plants learn and make decisions, exhibited by their avoidance behavior to phenomena like droughts, and the modifications to their responses due to other environmental factors (temperature, humidity, previous plant history, etc.), and express individuality. In all, Trewavas considers a summary of 70 different definitions of intelligence and argues plants meet most or all of these various conceptions (Trewavas 2016 and 2017).

In summary, most plants are able to respond in a basic way both to opportunities (e.g. sunflowers) and threats (e.g. sagebrush). They exhibit basic habituation behaviors, and some can retain the behavior for up to a month. Certain plants can send and receive chemical signals that indicate damage or the presence of a potential predator, and some can even donate unneeded resources to struggling neighbors. And at least some of this behavior is sophisticated enough to count as intelligence. These surprising behaviors help to explain why some people think that plants have minds in the phenomenal sense. After all, how could they do such amazing things without conscious awareness?

2.2 The anatomy and physiology of plants

In terms of similarities, plants share many basic features with other beings that we know have minds. For example, many plants have vascular systems that move liquids throughout their bodies, structures analogous to muscles that allow for basic movement, and pathways that allow for the dispersal of chemical signals throughout the plant. They also have reproductive structures, food and water processing structures, and exhaling-type structures for the elimination of wastes.

However, plants are also very dissimilar in other physiological aspects. Simply put, plants don't have brains, or nervous systems (at least in the way that many animals do—see below). This is important, because several physical structures are implicated in consciousness, most of which exist in the brain (Mashour and Alkire 2013). Note that we don't have to assume a sort of identity theory of the mind to raise this objection to plant minds: even if qualia or phenomenal states are not identical to brain states, the two are at the least intimately correlated. So, it makes sense to look for identical or similar structures in plants in order to find evidence for plant minds. But do plants have anything that could process stimuli and somehow bring about consciousness in a way similar to a central nervous system?

Despite a lack of neurons in plants, the field of 'plant neurobiology' is dedicated to explaining how goal-directed behavior of plants is possible. Researchers in this field have unearthed some interesting parallels between animal neurobiology and analogous signaling, signaling chemicals, and signaling-related structures found in plants (Stahlberg 2006). While plants may lack certain physical structures that undergird consciousness in animals (like neurons), they have other physical structures that perform relevantly similar functions (like action potentials that allow for electrical signaling). For example, it has been known for some time that Auxin (a plant hormone) is an important regulator of plant growth. Baluska et al (2003a, 2005) have described a model of Auxin transport that, in some ways, resembles cell-to-cell communication at neuronal synapses by neurotransmitters, and have argued Auxin itself is a neurotransmitter-like signaling molecule (Baluska et al 2004). Furthermore, Baluska et al (2003b) have noted that, like neurons, which are polarized cells with "output channels" (axons) and "entry ports" (dendrites), elongating plant cells are also polarized cells with opposite ends showing either efflux or influx of signaling molecules like auxin. The end-poles of elongating plant cells, Baluska et al argue, might be considered a sort of "plant synapse" serving to process and transmit information.

Furthermore, many neurotransmitters utilized by animal nervous systems have been found in high concentrations in plants (Brenner 2006, Baluska 2005). Plants receive, store, and process information, can learn, and plant roots even discriminate between self and non-self (Baluska 2005, Trewavas in Baluska 2006) and avoid contact with roots of other species (Trewavas 2003). Finally, Baluska et al (2004) proposes that highly specialized zones of root apices (transition zones) have groups of cells with "brain-like" tissue and might act as diffuse "'brain-like' command centres" and that vascular bundles could play roles similar to nerves. Taken together, these findings might make us wonder whether plants have the necessary physiological features for something like a nervous system that might allow for some sort of consciousness (Calvo et alia 2017).

Despite this, the consensus among experts suggests that plant physiology falls short of the physical correlates to consciousness that we have identified in other creatures. For example, over thirty scientists from several institutions around the globe recently cosigned a letter indicating that while plant cells share features and properties with other cells such as action potential propagation, use of neurotransmitter-like substances, and signal transduction and transmission over distance, "there is no evidence for structures such as neurons, synapses, or a brain in plants" (Alpi et al).

Furthermore, Peter Neumann argues that there are some very stark differences between root apices and brains. In most animals, a brain is necessary for life, and death follows decapitation or brain activation almost immediately. This is in contrast to plants which can withstand the excision of their roots (there are exceptions in "lower" animals which don't have centralized brains and instead have a diffuse nerve net) (Neumann in Baluska 2006). Cutting of an animal's nerves, can cause paralysis and be life-threatening; in contrast, phloem girdling has little adverse effect on fruit trees subjected to it. The parallel is this: both involve the disruption of signaling events, in animals by cutting nerves and in plants by cutting what, as we saw above might be considered "nerve-like tissue". Yet, we see acute differences between animals and plants in their response to such disruption (Neumann in Baluska 2006). In addition, there are many "lower" multicellular plants which can function without roots or vascular tissues. Finally, Neuman reviews findings that "do not indicate that root apices function as essential neurobiological command centers involved in regulating shoot growth responses to adverse changes in the root environment" and argues that behavior to environmental stimuli in plants could be accounted for via cell-cell signaling and hormone and other molecule transport (Neumann in Baluska 2006).

2.3 The evolutionary trajectory of plants

On the one hand, animals and plants are both eukaryotes with membrane-bounded organelles. In that sense, humans and plants have more in common than, say, humans and bacteria. But obviously, plants and humans are not closely related. An estimate of the divergence of plants, animals, and fungi put the separation of the kingdoms around 1,576 million years ago (Wang, Kumar and Hedges 1999). The early evolution of nervous systems, on the other hand, arose sometime during the Cryogenian, between 635 to 850 million years ago (Liebeskind et al 2017). So, while we share common ancestors with plants, we are very distant relations indeed, and our divergence happened before early nervous system evolution.

In contrast, humans diverged from chimpanzees roughly 6 million years ago (Patterson et al 2006). Thus, only a brief glance at a phylogenetic chart is enough to make the point that plants and animals evolved along very different avenues and likely pursued very different strategies for survival (more about this below). This concludes the brief survey of plant behavior, physiology, and phylogeny. What can this survey tell us about plant minds?

3 Why the evidence fails to show that plants have minds

Start with the evidence from phylogeny. This is the weakest evidence for plant minds. It is utterly clear that plants evolved along a different evolutionary trajectory than animals, their paths diverging long before nervous systems in animals evolved, and so a comparison between them is of little evidential value. This is not to say plants couldn't have evolved nervous systems separately (through convergent evolution), but it means that the evolution trajectory of plants *in relation to animals* isn't going to tell us much about whether plants are conscious. To see this, imagine you were new to earth and were simply handed a phylogenetic chart that illustrates the evolutionary pathways of all living things. You then learned that at least some individuals in the kingdom *Animalia* had minds in the phenomenal sense. Would this bit of information plus the chart of evolutionary history be enough to conclude that any other taxa represented on the chart had minds in that sense?

No. Instead, the only kind of inference you could draw from your knowledge of *Animalia* to other kingdoms would rely on basic principles of evolution that would apply to individuals in all kingdoms. For example, we know that living things must replicate or reproduce in order to survive. And so we can conclude that plants must have a way of replicating or reproducing. We know that all living things must have a way of taking in nutrition or sustenance of some sort. Therefore, plants do the same.

But the inference that we cannot make is that a particular survival strategy that was good for one kingdom is also good for the next. What is the same is that individuals in both kingdoms must survive. What is potentially different is how individuals in each kingdom survive. The development of conscious mind was an evolutionary advantage for some animals. But that doesn't mean that it's a strategy employed by all living things.

Here's another way to look at it. The anatomical basis for pain and pleasure is pretty expensive equipment as far as resources are concerned. For example, in humans, the brain takes up an inordinate share of the body's calories and oxygen. The central nervous system is one of our most fragile features, and as a result, both the brain and the spinal cord are encased in protective bone. It's theoretically unlikely that such a system would have survived the winnowing power of natural selection unless it conferred some sort of survival advantage. And clearly it does: humans are mobile creatures who travel through radically different environments and lead a complex social life. We need to be able to locate mates, enemies, food, shelter, and water. Conscious mental states, including pain and pleasure, help us to do so.

Compare this to plants. Plants are not mobile. They do not move through their environments, and they do not lead complex social lives. They do not leave their environments to locate mates, avoid enemies, or procure food and water. While animals respond to external stimuli by moving, plants respond by changing their phenotype (Trewavas in Baluska 2006). Given their immobile nature, conscious mental states like pain and pleasure wouldn't help a plant to survive one whit.[14] In fact, such mental states would likely be a hindrance: plants might suffer terribly despite being unable to move or avoid the painful stimulus, and they would have to dedicate a huge slice of natural resources to keeping the conscious mind equipment up and running.

The general lesson is that a strategy that is brilliant for a mobile creature might be worthless for an immobile one. That's why an inference from a strategy that works for humans to a strategy that works for plants is suspect. The evolutionary distance between humans and plants makes an inference from the former unlikely.

The evidence from plant anatomy and physiology is not much better. And here it's important to leave behavioral evidence to the side to think clearly about exactly what is shown by the physiology itself. Imagine again that you a newcomer to earth, and you were presented with dead specimens of plants or very detailed fossil remains of plants. What could an examination of their structure alone tell you about whether or not they were sentient?

Not much. And this is due largely to the hard problem of consciousness. If we had general principles that linked physical structures to mental correlates, we would be in a position to examine any physical entity and say conclusively whether that physical structure gave rise to mental phenomena or not. But we are nowhere even close to solving the hard problem of consciousness. Indeed, some philosophers think that current worldviews *cannot* solve it (Nagel 2012).

So we are left with a very thin physiological basis on which to make an inference. What we know is that our mental phenomena depend on a very careful arrangement of a handful of different types of structures like neurons and glial cells that make up our brain and central nervous system. And we know that plants have none of these. The conclusion is that—as far as physiology is concerned—we have little reason to think that plants have minds in the phenomenal sense.[15]

[14] Churchland 1986 makes this point forcefully.

[15] The most persuasive paper we know of that argues for the thesis that plants

This leaves one avenue as of yet unexplored: plant behavior. Let's start with the displays of plant intelligence reviewed above. Jeremy Bentham was right that intelligence isn't a necessary condition for moral patiency. But neither is it sufficient, at least given how 'intelligence' is typically construed. To see that this is true, consider Trewavas' claims that when a computer beat chess grandmaster Garry Kasparov at chess, such actions were intelligent (Trewavas 2003) or that cellular networks, bacteria, and single-celled eukaryotes all exhibit intelligence (Trewavas in Baluska 2006). It's clear that the computer that beat Kasparov was not conscious in the sense relevant for morality. It's also clear that cellular networks, bacteria, and single-celled eukaryotes, while exhibiting complex behavior, are likewise not conscious in the sense relevant for morality. Similarly, although plants may be able to be described as intelligent, such intelligence is not the same kind that is sufficient for phenomenal consciousness.

Let's consider the other surprisingly complex forms of behavior that plants exhibit. Here is how the argument from behavior to plant minds is supposed to go. Plant behavior is relevantly similar to human behavior. In at least some cases, both avoid noxious stimuli, both move to secure resources, and both signal surrounding lifeforms. Human behavior is at least sometimes guided by conscious mental states. Therefore, plant behavior is at least sometimes guided by conscious mental states.

As an argument by analogy, the argument's strength relies on the depth of the relative similarities between humans and plants. And if we examine behavior alone, the similarity is not very deep at all. Classifying human behavior and plant behavior on anything but the

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are conscious on the basis of anatomy and physiology is Calvo 2017. But the case is weak in two respects. First, the paper argues for a conditional thesis with a weak consequent: if insects are conscious, then plants *might* be conscious (211). The problem here is that establishing the antecedent is no small task, and argument from physiology that insects are conscious falls prey to many of the confusions we point out here. Second, the paper deploys the concept of consciousness in ambiguous ways, sometimes referring to goal-directed behavior (ex. 215), sometimes to mere awareness (ex. 208 and 223), and sometimes to phenomenal consciousness (ex. 207). One of the key points of this paper is that goal-directed behavior and awareness of one's environment need not require phenomenal awareness.

crudest categories would be enough to show that there is little overlap between the two. The best that we could say is that plants sometimes engage in very broad patterns of behavior that we could describe as signaling behavior, stimulant-avoidant behavior (e.g. withdrawing from a touch), sustenance-seeking behavior, etc.

But these broad categories won't be enough to ground an argument by analogy for mental states. For example, consider stimulant-avoidant behavior such as withdrawing from harmful contact. There is no necessary connection between stimulant-avoidant behavior and pain. Stimulant-avoidant behavior is not necessary for pain because a being could "hold it in" and not let the pain affect her behavior. And stimulant-avoidant behavior is not sufficient for pain, either, because it can be faked. And notice that from an evolutionary perspective, both moves are sometimes advantageous.

So the connection between stimulant-avoidant behavior and pain is merely contingent. That means that an argument by analogy that focuses on behavior alone will not be very strong. It's not enough to show that at least some plants have at least some behavior that can be broadly classified as stimulant-avoidant. And the reason it's not enough is because membership in that category is not a reliable indicator of pain—the mechanical arms of a standard carwash recoil when they touch the side of a vehicle, but the car wash isn't in pain. My space heater will turn off if you tip it over. This keeps the heater from baking the carpet and destroying itself. But my space heater doesn't experience pain.

Furthermore, merely switching to examples of living things rather than space heaters won't help. There are plenty of examples of detection, signaling, and behavior that occur in living things and yet are below the threshold of consciousness. Consider the human body. Our bodies routinely detect and signal in ways that are below the level of conscious awareness. There's no evidence that your pancreas experiences qualia when it detects high blood sugar and releases insulin in response. If there were, this evidence would come in the form of testimony, behavior, etc. But there is none. (Note that there are philosophers who think that all living things from a pancreas down to simple cells have minds in some sense or even phenomenal mental states. We address this line of thought in §4.3.)

However, an argument from behavior can be improved by bringing in additional points of relevant similarities, such as anatomy. This point can be seen clearly by examining the core of John Stuart Mill's argument against solipsism:

> I am conscious in myself of a series of facts connected by an [sic] uniform sequence, of which the beginning is modifications of my body, the middle is feelings, the end is outward demeanor. In the case of other human beings, I have the evidence of my senses for the first and last links of the series, but not for the intermediate link. (1979: 9)

Mill goes on to say that the "legitimate rules of experimental inquiry" demand that he posit similar intermediate states for his fellow man. He later uses this same argumentative framework to argue for non-human animal sentience.

But this strategy works only because of the deep similarities between humans and non-human animals at the first and third steps. The "modifications" of human bodies closely match the alterations that arise in the brains of non-human animals, and the "outward demeanor" of human bodies closely matches the behavior of non-human animals. But with plants, there is very little similarity in either the first or third steps.

We conclude that the arguments from behavior are ultimately parasitic on arguments from testimony, physiology, and evolutionary trajectory. If a robot exhibited stimulant-avoidant behavior, that alone would not be good evidence that the robot had a mind. Arguments from behavior to a mind are plausible only when the similarities go beyond the behavior itself.

4 Objections

The conclusion of the foregoing analysis is that there is no good evidence to conclude that plants experience pain or have minds in the phenomenal sense. But this conclusion shouldn't dampen our appraisal of plant abilities. The empirical evidence suggests that at least some plants are aware, communicative, and even intelligent in certain respects. The mistake is to assume that such properties require consciousness. There is a sense in which my car is aware that a door is ajar. But that doesn't mean that my car has a mind. Immune cells are made aware of foreign objects in the body, and even attack those objects, but immune cells don't have minds. So, too, we should freely grant and be amazed by the fact that plants can detect features of their surroundings and communicate with fellow plants without a conscious awareness of what is going on. Detection doesn't require a mind. Not all awareness is conscious awareness.

Still, this concession might not be enough to convince some readers of the mistake of positing plant minds. We close by anticipating three objections to either our argument or our thesis that there is no evidence of plant minds.

4.1 An argument from caution

First, some might offer a kind of argument from caution. Historically, humans have been reluctant to extend membership in the "mind club" to outsiders. Women were once considered feeble-minded or irrational (Denmark and Paludi 2008). Slavery was defended in part on the mental inferiority of the enslaved races (Winthrop 1968). The exploitation of non-human animals for food is often defended by neo-Cartesian claims that non-human animals are senseless or cannot suffer or feel pain (Carruthers 1989). Surely this track record provides us with a reason to be cautious when denying that plants have minds.

On the one hand, the fact that we have gotten it so wrong, so many times in the past is surely a reason for caution. But the important point here is that such caution is not a reason to think that plants do, in fact, have minds. The thesis of this paper is that there is no good evidence that plants have minds. But to reason from the premise that we have been mistaken about mind-attribution in the past to the conclusion that plants *have* minds is an argument from ignorance. Instead, the best we can do is recognize that it's in our interest to think that plants don't have minds and review the evidence with due care.

4.2 An appeal to intuitions

Next, some might cite the widespread belief, intuition, or hunch that plants have minds as a reason to think that they do. On the one hand, we are sympathetic to the idea that widespread belief that P is at least some reason to think that P is true (McBrayer 2105). On the other hand, there are two problems with citing this fact as a reason to think plants have minds. First, it's not at all clear how widespread such a belief or intuition is. This is an empirical claim that would have to be established before the premise could be used in an argument.

Second, the evidence provided by widespread belief is defeasible evidence. And one way in which such evidence can be defeated is by offering a plausible account of why the belief is both widespread but mistaken. In this case, there is a ready explanation of just this sort, namely, the human tendency to anthropomorphize (Epley et alia 2008, Urquiza-Haas and Kotrschal 2015). We readily project our own mental states onto things around us with little regard for whether those things actually bear those mental states or not. For example, one recent study revealed that subjects were more likely to confer mental states on inanimate objects like cars and computers when they malfunction as compared to when they run normally (Morewedge et alia 2007). Each of us could relate similar experiences: We sympathize with cartoon characters who get hit in the head. We cheer for pinewood derby cars. And we talk to fish. Some scientists have suggested that the sorts of videos and memes likely to be shared on the internet compound the problem by portraying brief snippets of plant or animal life through rose-colored lenses.[16] When we see a plant manipulate itself or its environment—especially through time lapse photography—it's easy to project mental states onto plants that almost certainly lack them. But our tendency to attribute such states is little evidence that they are actually there.

4.3 An appeal to widespread psychism

Finally, one might object to the case presented here by noting that we don't rebut any of the various philosophical theories that make phenomenal consciousness a widespread feature of the world. Two examples of such views are panpsychism and biopsychism. According to panpsychism, everything has phenomenal mental states; qualia

[16] Anthropomorphism: how much humans and animals share is still contested, *The Guardian, January 15, 2016* https://www.theguardian.com/science/2016/jan/15/anthropomorphism-danger-humans-animals-science

are literally everywhere.[17] That means that things like rocks, landscapes, and even quarks are conscious in some sense. Slightly less radical, biopsychism is the view that every *living* thing is conscious or has phenomenal mental states.

These views are relevant for the debate over whether plants feel pain. On panpsychism, plants exist and hence have phenomenal mental states. On biopsychism, plants are alive and hence have phenomenal mental states. Biopsychism, in particular, has been invoked in recent attempts to argue that plants have phenomenal experiences (e.g. Godfrey-Smith 2016, Maher 2017, and Thompson 2007). Enactivism, as the view is called by Thompson 2007, is the view that being alive is sufficient for having a mind (in at least some sense). If having a mind requires some sort of qualia, then enactivism entails that plants have at least some qualia, and that point the question would be open whether that qualia includes states like pain.

The problem with all of this is that evidence is person-relative. In this case, your noticing the fact that X exists or that X is alive counts as evidence that X has a mind *only if* you also believe that one of these high-level theories about consciousness is correct. Absent a reason to think the theory is correct, merely existing or living won't count as evidence for a mind. By way of analogy, consider a case from political philosophy. The fact that a group of people would consent to a principle in the original position is evidence that the principle is fair only if one antecedently accepts a Rawlsian theory of justice. If you don't agree with the high-level ethical theory, then you won't be persuaded to accept the conclusion that a principle is fair merely by consulting facts about what people would agree on in the original position.

The goal of this paper is to show that we don't have any evidence that plants have minds in the sense relevant for morality. That is to

[17] There are more restrictive versions of panpsychism. For example, one version says that all fundamental objects in the natural world have phenomenal mental states. On this version, things like rocks won't have mental states since rocks are not fundamental objects, but the quarks, electrons or whatever counts as the fundamental constituents of the rock have mental states. We cite the more general view here because it's the version that would be relevant to showing that plants have minds. On the restricted view, the most that would follow is that the fundamental constitutive parts of plants have minds, and that's not relevant for the thesis of this paper.

say, we argue that there is no good evidence that plants have phenomenal mental states. Our argument rules out each of the main bodies of evidence that are widely shared and often cited as evidence for minds. However, our argument does not rule out things that become evidentially relevant once one accepts a controversial, high-level theory about widespread consciousness like panpsychism or biopsychism.

We obviously don't have the space to develop refutations to complicated, high-level views like panpsychism and biopsychism in a short paper. For that reason, we concede that our conclusion is a conditional one: provided that one does not already accept one of these high-level theories, there is no good evidence for the existence of phenomenal states like pain in plants. We grant that philosophers who have strong reasons to adopt one of these high-level theories will have evidence for plant minds that the rest of us lack. But the burden of proof shifts to the high-level theory: without a positive reason to endorse panpsychism or biopsychism, it remains true that there is no good evidence for the existence of plant minds in the phenomenal sense.[18]

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