

HPS208 – How we think about life

Mid-Term Details

- ▶ February 27th, during regular class time
- ▶ You'll have all of regular class time to write if you want it
- ▶ There is no lecture or readings for that week

Mid-Term Details

- ▶ 10 multiple choice questions, based on lectures and readings (1 point each, 10 points total)
- ▶ Then, you'll answer four out of six short-answer questions, based on key course terms provided at the end of each lecture (5 points each, 20 points total)
- ▶ Let's look at examples of each type of question

Multiple Choice

- ▶ The Last Man thought experiment is meant to show:
 - a) that people are not ethically important
 - b) that human extinction would be a net ethical good
 - c) that animals are sentient
 - d) that we intuitively attribute moral status to non-human living things

Multiple Choice

- ▶ The following is not mentioned in the ASENT criteria for sentience:
 - a) possession of a neo-cortex
 - b) motivational trade-offs balancing costs and benefits
 - c) possession of nociceptors
 - d) associative learning beyond just habituation and sensitization

Short Answer

- ▶ “Explain Interconnection Interpretations of Hindu environmental ethics, and Framarin’s response to them.”
- ▶ Answers should be between 100 and 300 words
- ▶ Explain any technical terms
- ▶ We will be looking for an understanding of both the ideas and their context in the course (why were we talking about these ideas?)
- ▶ Focus on course content – offering your own novel interpretations is a very risky strategy and not necessary

Why is it ok to eat plants?

- ▶ We finished off last week talking briefly about the question of why, in Hinduism and Jainism, it's considered ok (or at least better) to eat plants rather than animals
- ▶ The Jain suggestion was that plants have less of a sensory world, and therefore suffer less



Plant Sentience

- ▶ But note that both the Hindu and Jain traditions regard plants as sentient!
- ▶ This is not at all an uncommon view in the broad scope of how people have thought about plants
- ▶ E.g., the vegetalistas of the Amazon report that they learn the art of healing from plants themselves

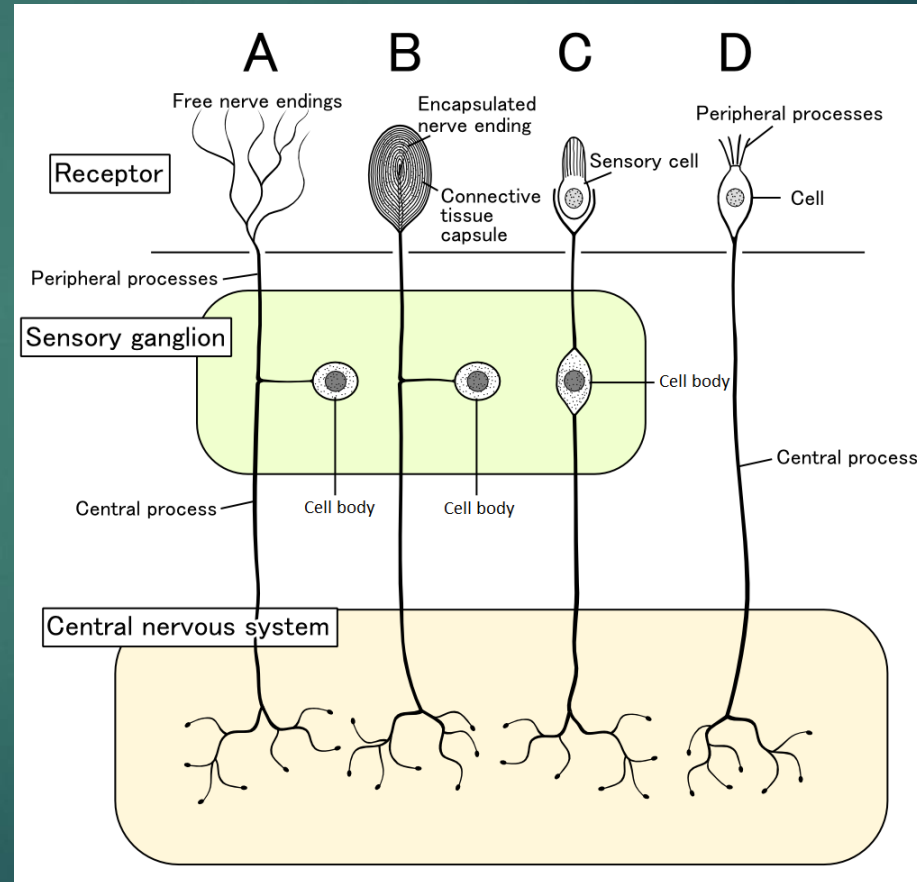


ASENT Criteria for Sentience

- 1) possession of nociceptors;
- 2) possession of integrative brain regions;
- 3) connections between nociceptors and integrative brain regions;
- 4) responses affected by potential local anaesthetics or analgesics;
- 5) motivational trade-offs that show a balancing of threat against opportunity for reward;
- 6) flexible self-protective behaviours in response to injury and threat;
- 7) associative learning that goes beyond habituation and sensitisation;
- 8) behaviour that shows the animal values local anaesthetics or analgesics when injured.

Nociceptors and Nervous Systems

- ▶ Nociceptors are by definition a type of neuron
- ▶ And while there is some debate about what counts as a 'brain', no one as far as I know thinks plants have one, much less integrative brain regions
- ▶ So on the neurological criteria, plants are going to automatically fail the ASENT test for sentience



Can Plants Behave?

- ▶ In our main reading for this week, Segundo-Ortin and Calvo (2020) say this: “Overall we hold that plant cognition encompasses behavioral patterns that are adaptive, flexible, anticipatory, and goal-directed.” (p.3)



Can Plants Behave?

- ▶ But in what sense can plants behave at all?
- ▶ What could count as plant behaviour, such that we can even ask if it's adaptive, flexible, etc.?



Movement

- ▶ Some plants do indeed move on time-scales we can perceive
- ▶ This is Mimosa Pudica, the “sensitive plant”
- ▶ If you touch the little leaves, they will fold up for a while
- ▶ We can also think of heliotropism, following the sun (lots of flowers do this)
- ▶ Or faster movements like the Venus Fly Trap
- ▶ (also, both the sensitive plant and Venus Fly Trap reduce their movements in response to general anaesthetics)



Darwin(s) on Plant Movement

- ▶ This 1880 book by one extremely famous Darwin and his somewhat less famous son describes various forms of movement in plants
- ▶ They save the punch-line of the book for the very last sentence:
- ▶ “It is hardly an exaggeration to say that the tip of the radicle thus endowed [with sensitivity] and having the power of directing the movements of the adjoining parts, acts like the brain of one of the lower animals; the brain being seated within the anterior end of the body, receiving impressions from the sense-organs, and directing the several movements.”



Growth as Movement

- ▶ Modern researchers in this area also treat growth as a type of movement
- ▶ That's obviously not how we think of 'movement' in animals
- ▶ But if plant growth is adaptive, flexible, etc., it's hard to see why it matters much whether we call it movement



Defense Mechanisms

- ▶ When maple and beech saplings are being eaten by deer, specific compounds in the deer saliva cause the plant to ramp up tannin production, above the levels you would see from just cutting the tree with a knife
- ▶ Ohse, Bettina; Hammerbacher, Almuth; Seele, Carolin; Meldau, Stefan; Reichelt, Michael; Ortmann, Sylvia; Wirth, Christian (February 2017). Koricheva, Julia (ed.). "Salivary cues: simulated roe deer browsing induces systemic changes in phytohormones and defence chemistry in wild-grown maple and beech saplings". *Functional Ecology*. 31 (2): 340–349.



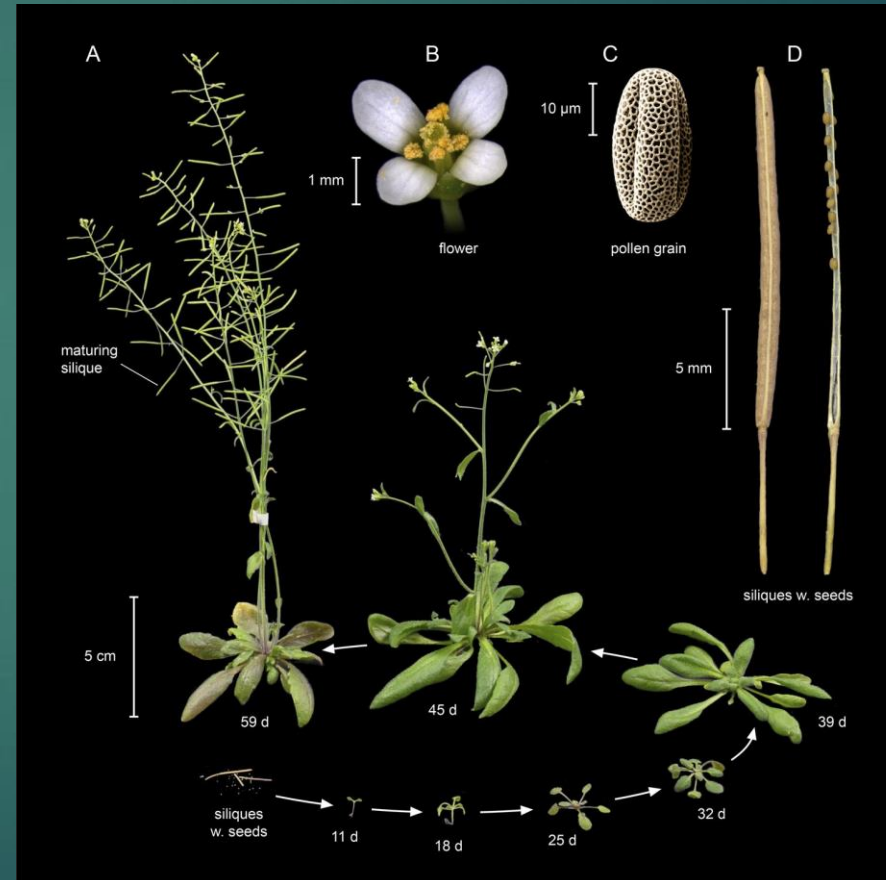
Communication

- ▶ We should be cautious here in using the word 'communication', since that has a lot of connotations we don't necessarily endorse
- ▶ What is clear is that plants release various Volatile Organic Compounds in response to stimuli like damage, which triggers responses in both kin and non-kin
- ▶ E.g., the smell of freshly cut grass triggers defensive responses in other blades of grass



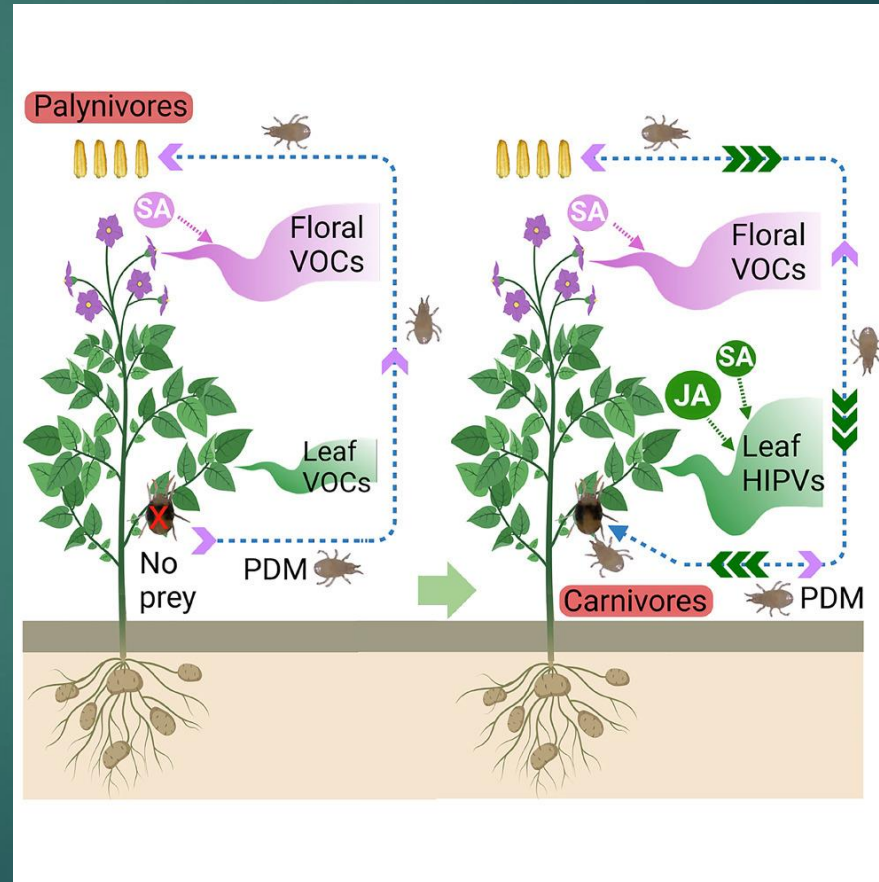
Sensing Vibrations

- ▶ “For instance, the model plant *Arabidopsis thaliana* can detect, through epidermal outgrowths (hairs called “trichomes”), the specific vibrations produced by the munching of caterpillars and respond to them by synthesizing toxins (Appel & Cocroft, 2014)”
- ▶ - Segundo-Ortin and Calvo (2020) p. 63)



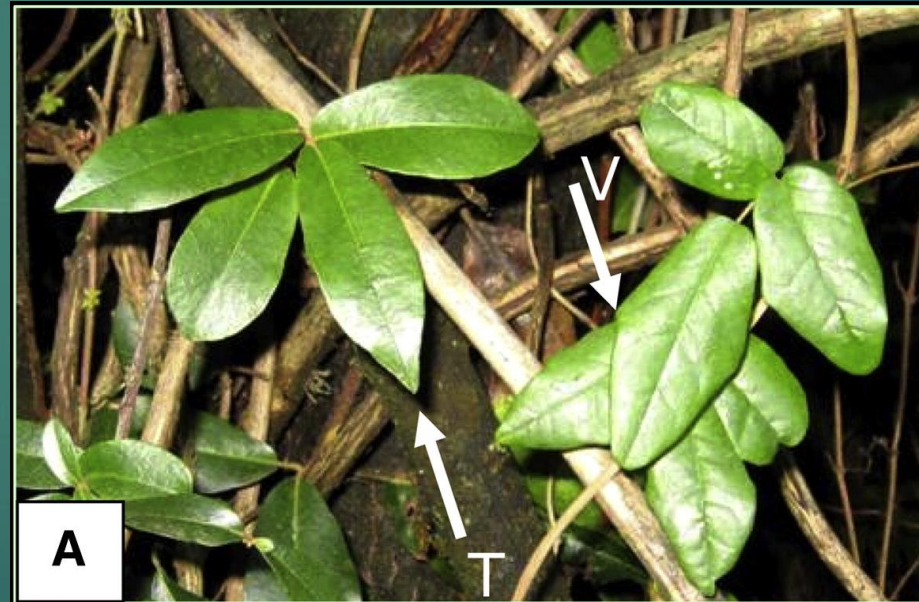
Mutualism between plants and invertebrates

- ▶ In wild potatoes, this study found that predatory mites will usually hang out on top of the flowers, eating pollen
- ▶ But when herbivorous spider mites attack the leaves, the plant will change the VOCs it releases, attracting the predatory mites down to eat the herbivorous ones
- ▶ Munawar, A., Xu, Y., Abou El-El, A. S., Zhang, Y., Zhong, J., Mao, Z., ... & Zhou, W. (2023). Tissue-specific regulation of volatile emissions moves predators from flowers to attacked leaves. *Current Biology*, 33(11), 2321-2329.



Mimickry

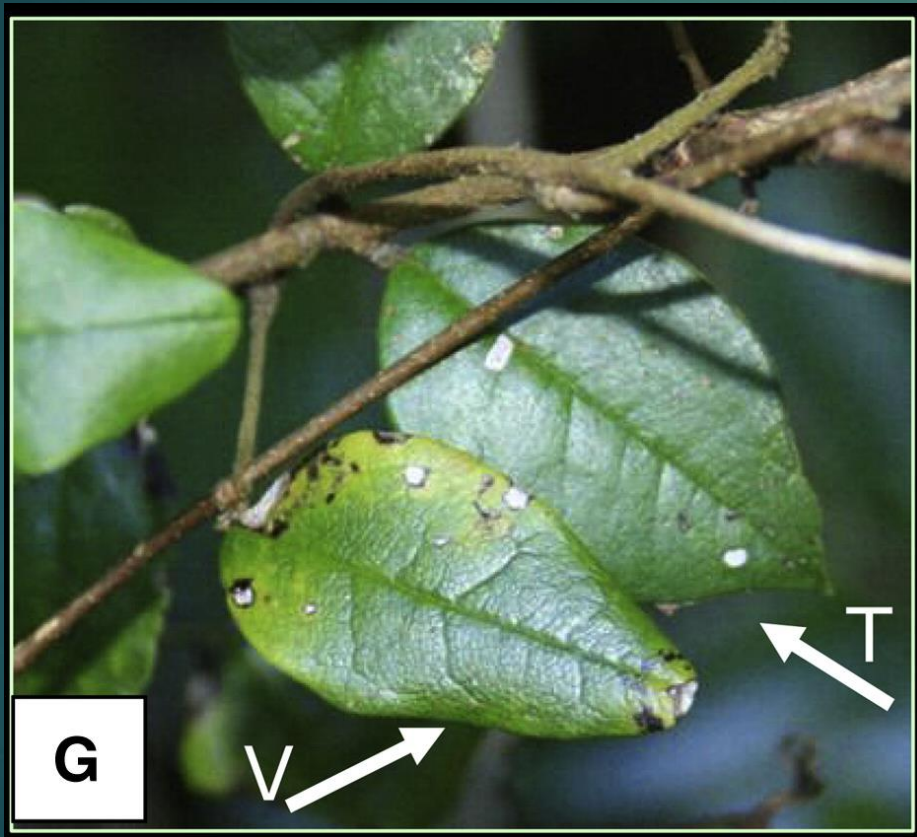
- ▶ Gianoli & Carrasco-Urra report that the climbing vine *Boquila trifoliolata* appears to mimic the leaves of the trees it climbs
- ▶ A single vine reaching multiple trees will grow different types of leaf
- ▶ Images from Gianoli, E., & Carrasco-Urra, F. (2014). Leaf mimicry in a climbing plant protects against herbivory. *Current Biology*, 24(9), 984-987.



Mimickry



Mimickry



Mimicry

- ▶ The authors say: “We currently lack a mechanistic explanation for this unique phenomenon.”
- ▶ VOCs are briefly considered
- ▶ So is horizontal gene transfer
- ▶ But the plants don't need to be touching for this mimicry to happen
- ▶ Baluška & Mancuso (2016, 2017) speculate that it could be a form of “proto-vision”



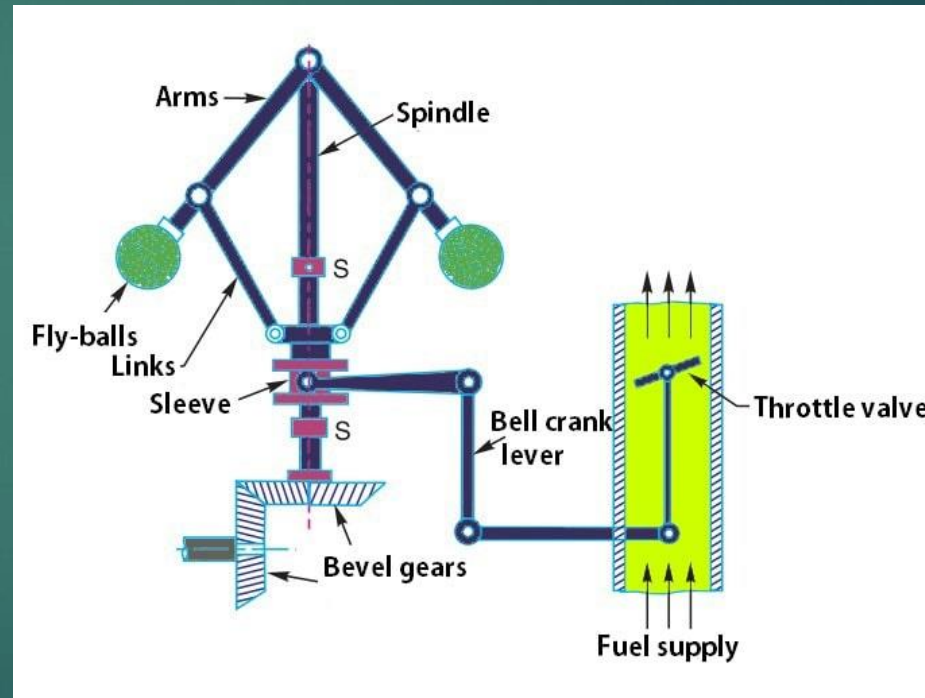
What does all that mean?

- ▶ But of course responding to external stimuli isn't enough to say that something is "perceiving" the world
- ▶ If our question is a moral one, this isn't enough evidence, surely
- ▶ Simply acting in a way that looks intelligent can be accounted for in several ways that don't involve sentience



Mechanical “Intelligence”

- ▶ Consider the Watt Governor
- ▶ Here is a clever bit of machinery that looks like it's doing something goal directed
- ▶ But we can be pretty confident this thing isn't sentient
- ▶ Natural selection has proven capable of producing mechanisms much more complicated than this!



Goal Directed Behaviour

- ▶ In a sense, the Watt Governor is goal-directed
- ▶ Its goal is to regulate the speed of trains!
- ▶ We can say that without committing to anything too strange, because it has an extrinsic goal, which we gave to it
- ▶ Humans have intrinsic goals, and it seems reasonable to say animals do to
- ▶ But how about plants?



Equilibrium vs. Goal Directedness

- ▶ There's a great big debate about what we should call "goal directed", if anything
- ▶ One thing people disagree about is whether a ball rolling towards the bottom of a bowl should be called a simple form of goal directed behaviour
- ▶ If this is goal directed, then any system with an equilibrium point is goal directed
- ▶ Perhaps we want something more stringent in our definition

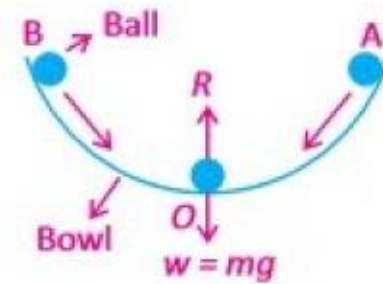


Fig. 10.2: When a ball is gently displaced from the centre of a bowl it starts oscillating about the centre due to force of gravity which acts as a restoring force

Equilibrium vs. Goal Directedness

- ▶ Later in the semester we'll read Walsh (2006), who argues that for something to be goal directed it should have three properties:
 1. Persistence
 2. Plasticity
 3. Repertoire
- ▶ So it should persistently pursue a goal, using flexible strategies drawn from a wide repertoire of possible behaviours

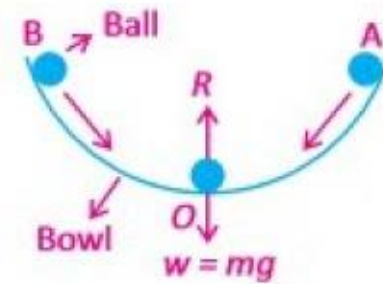


Fig. 10.2: When a ball is gently displaced from the centre of a bowl it starts oscillating about the centre due to force of gravity which acts as a restoring force

Decision Making

- ▶ “Trewavas (2014) reports that when exemplars of *Calamagrostis canadensis* are offered adjacent habitats to grow, they choose the habitat with the best conditions of competition, warmth, and light. However, *C. canadensis* can also “discriminate these conditions in combination [...] choosing light plus warm soil in preference to others” (p. 84).”

(p.4)



Learning and Memory?

- ▶ How about this criterion from ASENT: “associative learning that goes beyond habituation and sensitization”?
- ▶ Our main reading mentions this briefly, but let's turn to this supplemental reading for more detail
- ▶ The short version is: there isn't much evidence for complex associative learning in plants at present

Perspectives on Behavior Science (2018) 41:431–446
<https://doi.org/10.1007/s40614-018-0173-6>

LEARNING: NO BRAIN REQUIRED

On the Conditioning of Plants: A Review of Experimental Evidence

Barry E. Adelman¹ 

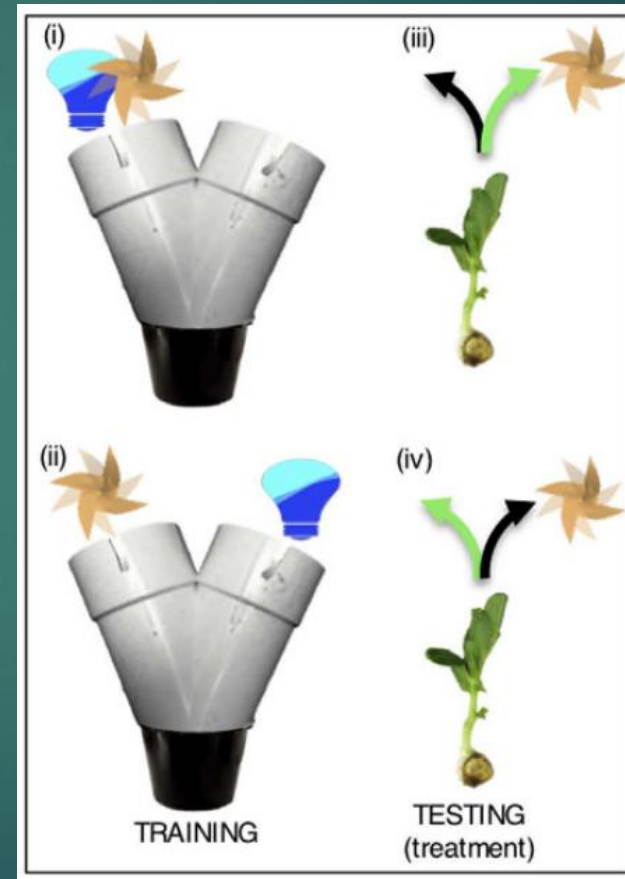
Habituation

- ▶ Mimosa Pudica does show stimulus-specific habituation
- ▶ Holmes and Gruenberg (1965) report that repeatedly dripping water on *M. Pudica*'s leaves causes it to slowly stop responding to water drops
- ▶ But touching it with a finger would still elicit the folding up response
- ▶ Holmes, E., & Gruenberg, G. (1965). Learning in plants? *Worm Runner's Digest*, 7(1), 9–12.



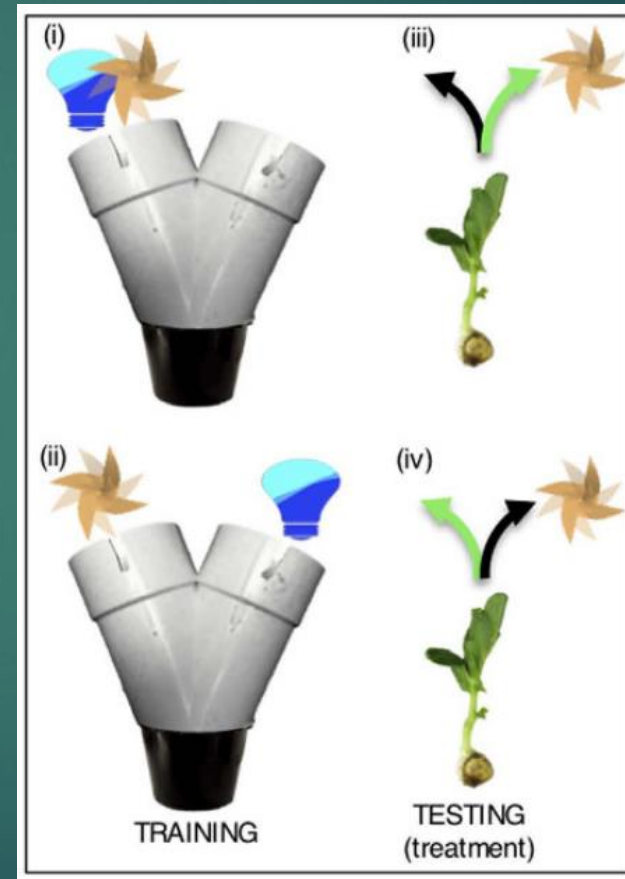
Gagliano et al. (2016)

- ▶ By far the strongest evidence they review for associative learning in plants comes from Gagliano et al (2016)
- ▶ This group took pea plants, and tested whether they could be conditioned to grow towards a gently blowing fan
- ▶ The fan was either paired (or not, in the control) with blue light which the pea plants with typically grow towards
- ▶ Image from: Gagliano, M., Vyazovskiy, V. V., Borbély, A. A., Grimonprez, M., & Depczynski, M. (2016). Learning by association in plants. *Scientific reports*, 6(1), 38427.



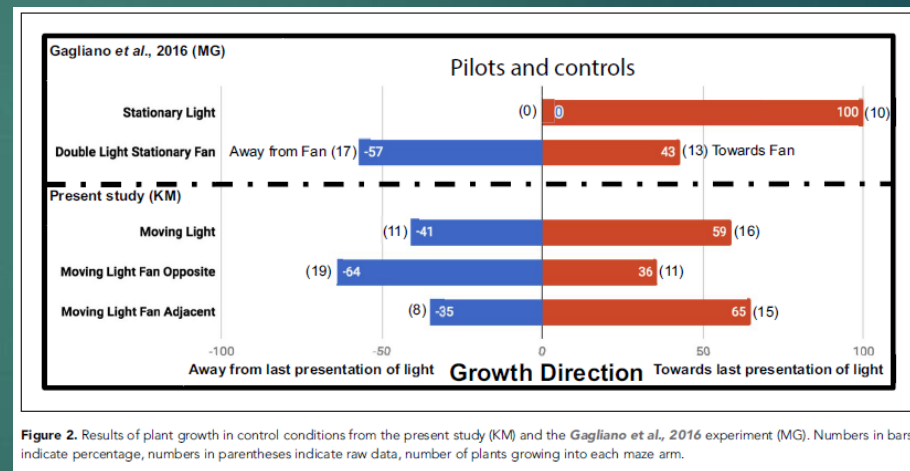
Gagliano et al. (2016)

- ▶ And indeed, Gagliano et al. did find a statistically significant tendency to grow towards the conditioned stimulus (the fan blowing)
- ▶ Unfortunately, this result failed to replicate in at least one follow up study



Markel's Replication

- ▶ Markel (2020) ran the experiment again, but this time found a null result
- ▶ Markel used a somewhat larger sample size, and “blinded” scoring
- ▶ Markel, K. (2020). Lack of evidence for associative learning in pea plants. *Elife*, 9, e57614.



Learning and Memory?

- ▶ So Adelman (2018) found the only really promising evidence for conditioning that goes beyond habituation in plants was Gagliano et al. (2016)
- ▶ But Markel (2020) was unable to replicate Gagliano et al.'s experimental results
- ▶ Absence of evidence is not necessarily evidence of absence, but as of five years ago plants do not seem to fulfill this ASENT criterion for sentience

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LEARNING: NO BRAIN REQUIRED

On the Conditioning of Plants: A Review of Experimental Evidence

Barry E. Adelman¹ 

Plant Consciousness?

- ▶ The final section of our main reading is on various proposals which support the idea that plants are conscious
- ▶ It's worth noting that the authors seem to treat 'sentience' and 'consciousness' interchangeably, though not everyone thinks that's a good idea
- ▶ E.g., the ASENT authors distinguish them because of phenomena like blind-sight and masked priming effects



Plant Consciousness?

- ▶ I would describe all of the proposals in this section as dauntingly technical
- ▶ I can try to answer any specific questions people have, but let's consider this section of the reading not testable on the mid-term
- ▶ We'll return to some of the broad themes here in the week on strange agents



Key Terms

- ▶ Plant Movement
- ▶ Plant Communication
- ▶ Plant Intelligence
- ▶ Goal Directed



Next time:
Animacy and Inanimacy