191 Presentations

By: Bernardo Hernandez, Javier Escareno, and Wyatt Bender

Sex as an Algorithm: The Theory of Evolution under the lens of computation

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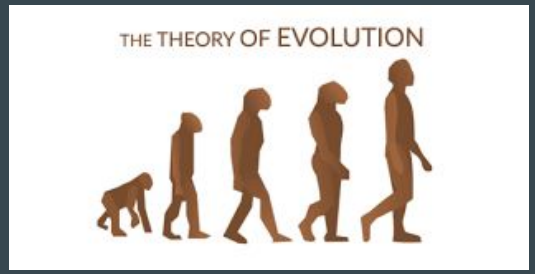
Present by: Javier Escareno



Motivations

- To prove that sexual reproduction can be viewed as an algorithmic process that increases the efficiency of evolution.
- To explore how sexual reproduction can facilitate the evolution of cooperative behaviors and increase the fitness of the offsprings.

Background Information

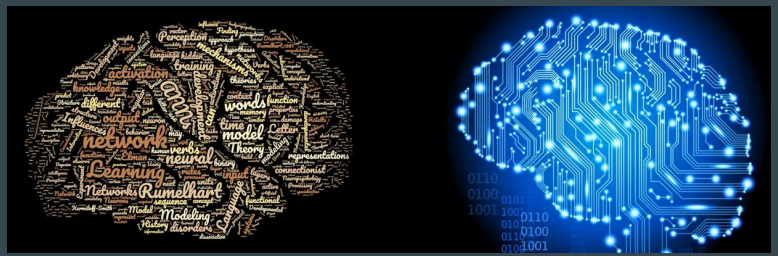
1. Written by Adi Livnat and Yoav Ram and Published in "Frontiers in Ecology and Evolution."
2. The authors review and condense previous research from a range of fields, including evolutionary biology, computer science, and optimization theory to develop a framework for understanding the role of sex and mutation in evolution, based on the principles of algorithmic optimization.

Problem Statements/ Questions to Answer

1. What is the role of Sex in Evolution?
2. What exactly is evolution optimizing towards if anything?
3. The paradox of variation?
4. Are mutations completely random?

Approach

1. By Applying computational concepts and techniques to biological systems it was able to shed some light on the mechanisms driving the evolution of sexual reproduction.
2. Using computational theory as a tool for understanding the evolution of sex and other complex biological systems.

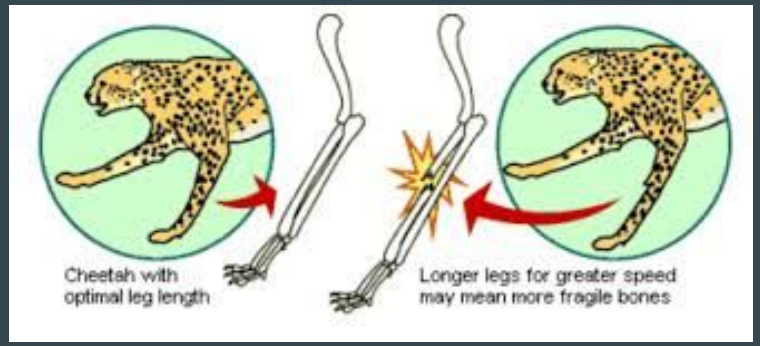


What Is The Role Of Sex In Evolution?

1) Genetic Diversity
    a) Sexual reproduction generates genetic diversity by shuffling and recombining genetic material from two parents, increasing the potential for adaptive evolution by generating novel genetic combinations.
2) Efficient Search Algorithm
    a) As an efficient search algorithm, sexual reproduction explores a larger search space of genetic combinations, allowing for more rapid adaptation to changing environments compared to other reproductive methods such as asexual reproduction.

What Is The Role Of Sex In Evolution? (Cont.)

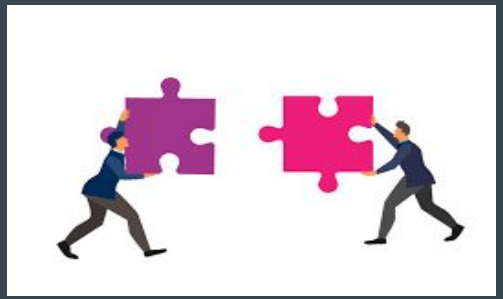
1) Trade-Offs
   a) There are trade-offs associated with sexual reproduction, such as the cost of producing only half of the offspring's genetic material in each generation, which is offset by the benefits of increased genetic diversity and adaptation to changing environments.



What Exactly is Evolution Optimizing towards if anything?

1. Reproductive success and fitness

2. Resolving sexual conflicts and balancing cooperation and conflict

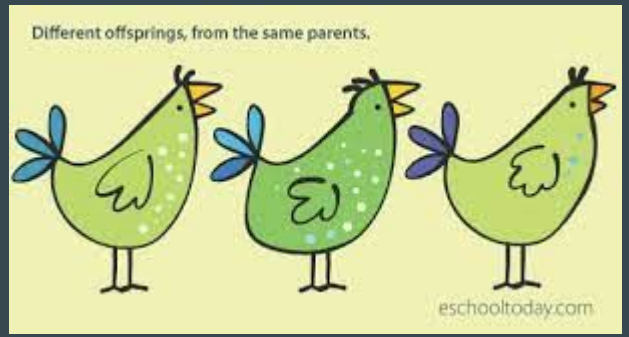


- Sexual reproduction is optimized to increase the efficiency of evolution by promoting genetic diversity, helping individuals in a population with adapting to changing environments, and ultimately leading to increased reproductive success and fitness.

- Sexual reproduction may balance cooperation and conflict by enabling mechanisms such as sexual selection, where individuals with specific traits are chosen as mates based on their reproductive fitness.

The Paradox of Variation

1. Sexual reproduction generates genetic variation through recombination and mutation, allowing for rapid adaptation to changing environments and increased potential for evolutionary success.
2. Sexual reproduction may also erode genetic variation through various mechanisms such as selection against certain mutations, purification of genetic variation, and the loss of advantageous traits due to recombination of genes.
3. The paradox of variation in sexual reproduction is that while it generates genetic diversity, it also has the potential to reduce genetic variation through selection and other evolutionary forces.



Are mutations completely random?

Yes

- Mutations can arise spontaneously during DNA replication due to errors in the DNA. These mutations can be classified as either point mutations or structural mutations.

No

- Mutations can also be induced by various environmental factors, such as radiation or exposure to certain chemicals. Similarly, exposure to certain mutagenic chemicals can also increase the rate of mutations.

Related Work

- "Evolutionary Computation: A Unified Approach", by Kenneth De Jong, published in the Proceedings of the 1st IEEE Conference on Evolutionary Computation in 1994. This paper delves into evolutionary computation, which is a family of optimization algorithms that are inspired by biological evolution.
- "Computational Evolution: A Survey and Roadmap", by Carola Doerr and Pietro S. Oliveto, published in the Journal of Computer Science and Technology in 2021. This paper gives an overview of recent advances in computational evolution, including genetic algorithms, evolutionary strategies, and evolutionary programming.

Conclusion

1. The theory of evolution can be understood in terms of algorithms that optimize fitness by generating and selecting for different types of variations.
2. Mutations are not entirely random, as they can be caused by environmental factors and may be more or less likely to occur in certain regions of the genome.
3. The paradox of variation highlights the tension between the need for variation as a piece of material for evolution and the need for stability in important traits.
4. Ultimately, the role of sex and mutation in evolution reflects the trade-off between exploration and exploitation which is the continuous search for new possibilities while exploiting existing solutions.

Play and its role in the mental development of the child

Bernardo Hernandez

Motivation

- Vygotsky wanted to show how play is the source of development in a child's life and show the importance of it.

- To show that, imagination, is a critical part of play

Problem Statement

- How play arises during the development?

- Is play the leading form of activity for a child of this age, or is it simply the most frequently encountered form?

Play in a child's life

- Vygotsky mentioned that play is important in a child's mental development
- Play in a child's life dealt with not only physical activities but also using their imagination
    - It helps break children from situational constraints

Play and Cognitive development

- During play a child can separate meaning from an Object
  - The child does not realize the they are separating meaning from the Object
  - Sticks becoming Swords/horse
- Although objects lose their meaning in play, all objects are specific to what role it must have:
  - Sticks must be swords/ horse not matter what (does not matter what stick)
  - This helps a child create a mental structure that allows them to connect the object with a meaning

How Play influences cognitive development

- Play helps children understand their environment
  - They set up rules for a game, and follow these rules until the game is finished.
  - They understand not stray away from these rules
- The rules that children make are influenced by an adult
  - Such as not being able to touch other people's things
- With the rules that children form during play, the behavior of a child is formed

Play on Behavioral Development

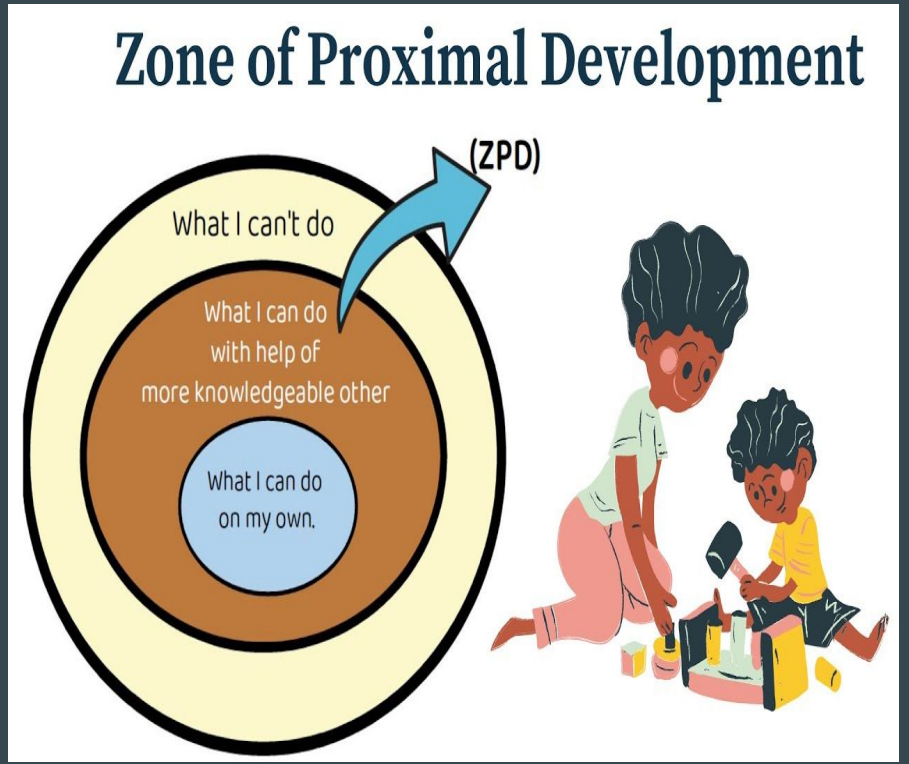
- The conditions that a child might place during play influences their behavior based on any rules that might exists
- Play prevents children from acting on impulse
- A child not in play, will always act on impulse
  - A door being shut and open
- Why do they act on impulse?
  - Objects excerpt a motivating force on children , in a way they are told what to do by the objects
- Why not in Play?
  - A child feels a greater sense of accomplishment when winning knowing he followed the rules

Play and Speech Development

- Play eventually changes once has the child has entered school
  - Becomes an internal process.
- Child begins to think on how to form a proper sentence
  - eventually , they form what they want to say and say it out loud

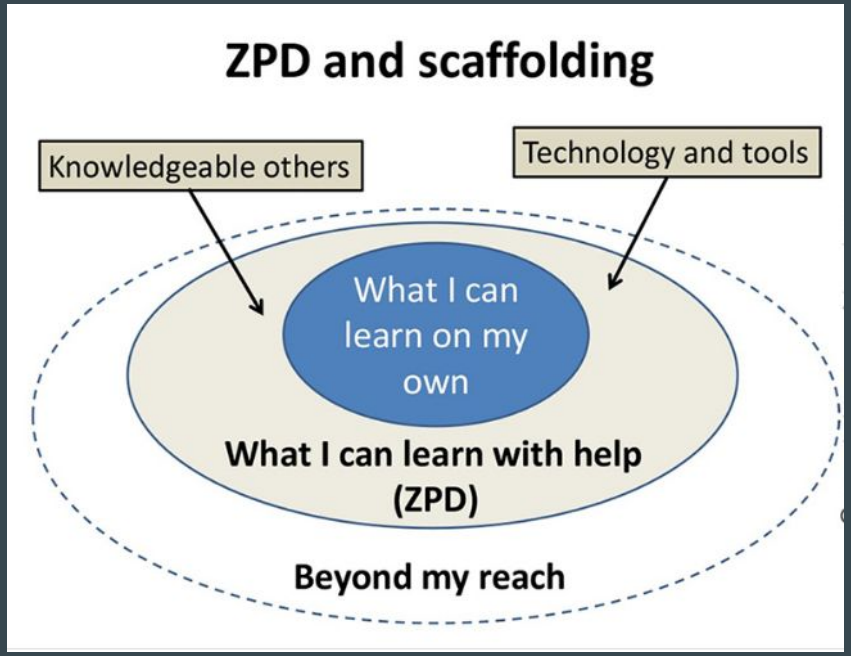
Vygotsky's Zone of Proximal Development (ZPD)

- A theory of learning and development
- ZPD is defined as what learner can do without assistance and what a learner can do with adult guidance or with capable peers
- Vygotsky believed that when a student is in the **Zone of Proximal Development** for a new skill/task, an appropriate amount of assistance can help so can they achieve it themselves



Scaffolding

- Technique that is used with ZPD
- Relies on children taking small steps to reach their goal
  - E.g when they are in ZPD for learning a new task
- This technique is used in schools



Social Cultural Theory

- Vygotsky's theory that parents, adults , and culture helped develop a child's brain
    - The higher- order functions
- Higher order function are are cognitive skills that are developed.
    - They are useful for self-control
- Vygotsky viewed human development to be reliant on social interaction
    - Which could be different if it came from a different culture.
    - This is different from Piaget's view.
    -

Social Cultural Theory

- Vygotsky believed that children could break away from their biological constraints , as long as culture was involved they would have the tools in order to adapt.
  - Culture heavily influences our lives, and the way we do things, since it is something that is done and passed on without noticing since of young age
  -

Different views on social cultural theory

Vygotsky's Theory

- Social factors influence development
- Development can differ between cultures

Piaget's Theory

- Childhood interactions and explorations influence development
- Development is largely universal

Related Work

- Vygotsky LS. Thought and Language. Kozulin A, trans. Cambridge, MA: The MIT Press; 1986. (Original work published in 1934)

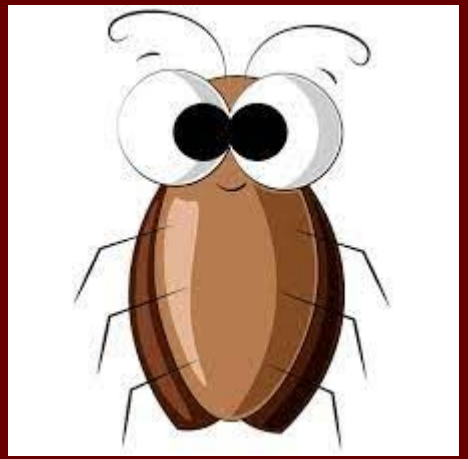
- Vygotsky LS. Thinking and Speech. Minick N, trans. New York: Plenum Press; 1987. (Original work published in 1934)

Conclusion

- How play arises during the development:
  - Play arises during a child's development when they start desiring things that can't be obtained, this is usually during preschool age
- Vygotsky considered play the essential in a child's development, and for play to have purpose: **source of a child's development**

Explanation of “Pavlov’s Cockroach: Classical Conditioning of Salivation in an Insect”

by Wyatt Bender



Motivation

- Is Classical Conditioning in salivation is fundamental for all organisms applicable?
  - “Ubiquitous among different phyla”?

- Proving that all phyla, evolutionary related animals, grow with the same survival abilities (this case being evolutionary saliva glands)

- Learned neural control exists elsewhere (insects such as cockroaches), other than humans and dogs learned by Pavlov.

Related Works

https://www.simplypsychology.org/pavlov.html

“Pavlov’s Dog Study and Pavlovonian Conditioning Explained”

- Simple and concise explanation of the Pavlov experiment

https://www.frontiersin.org/articles/10.3389/fphys.2019.01539/full

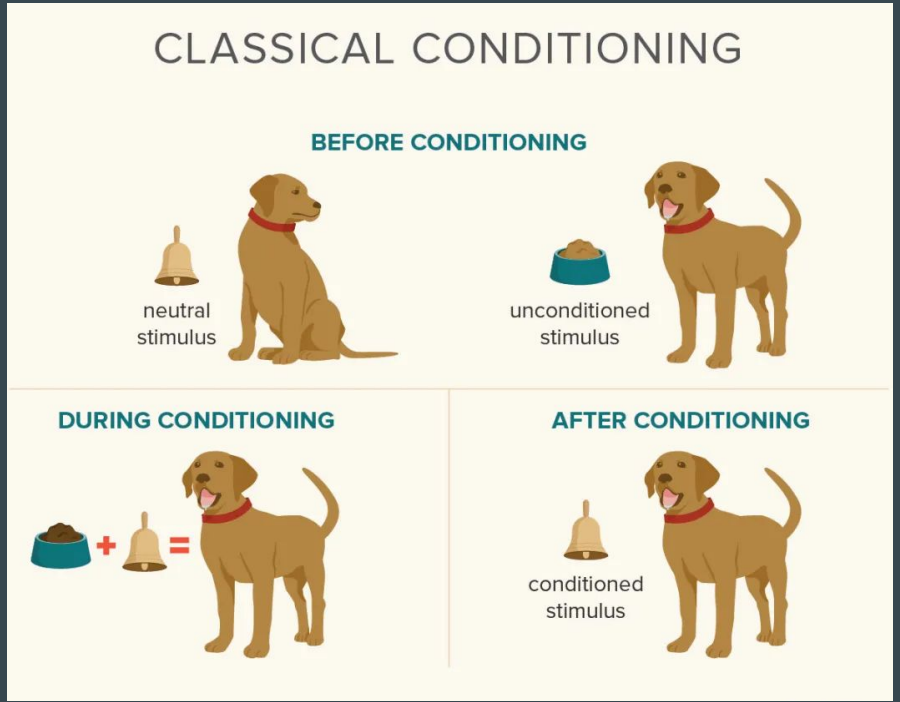
“Cockroaches Show Individuality in Learning and Memory During Classical and Operant Conditioning”

- Another experiment on cockroaches using Pavlov’s method (uses different scents) (2020)
- Uses isoamyl acetate, butyric acid, & trans-cinnamaldehyde as odors

Classical Conditioning

The learned behavior to know that something positive comes from a neutral stimulus

Ex: Dogs know there may be food made when you are in the kitchen.



Why Cockroaches?

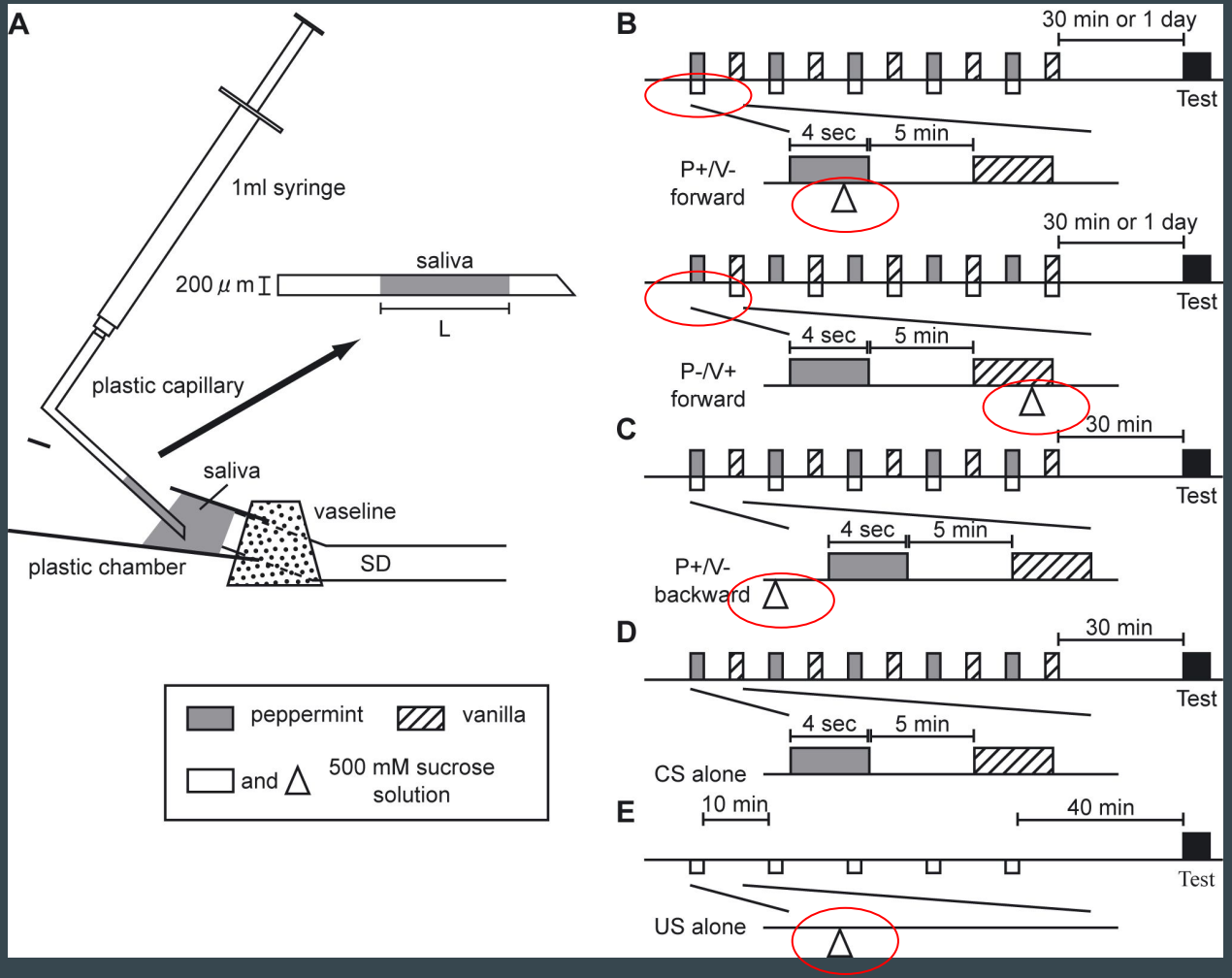
- Cockroaches can learn and remember individually like humans and dogs

- Cockroaches have neurons that trigger their saliva, and due to their physiology, scientists can tell the neurons apart

Experiment Preparation

- 20-30 adult cockroaches
- Fed sugar free yeast extract and as much water needed
- Maintained in a light-dark cycle (12:12) and 26-28 degree Celsius habitat

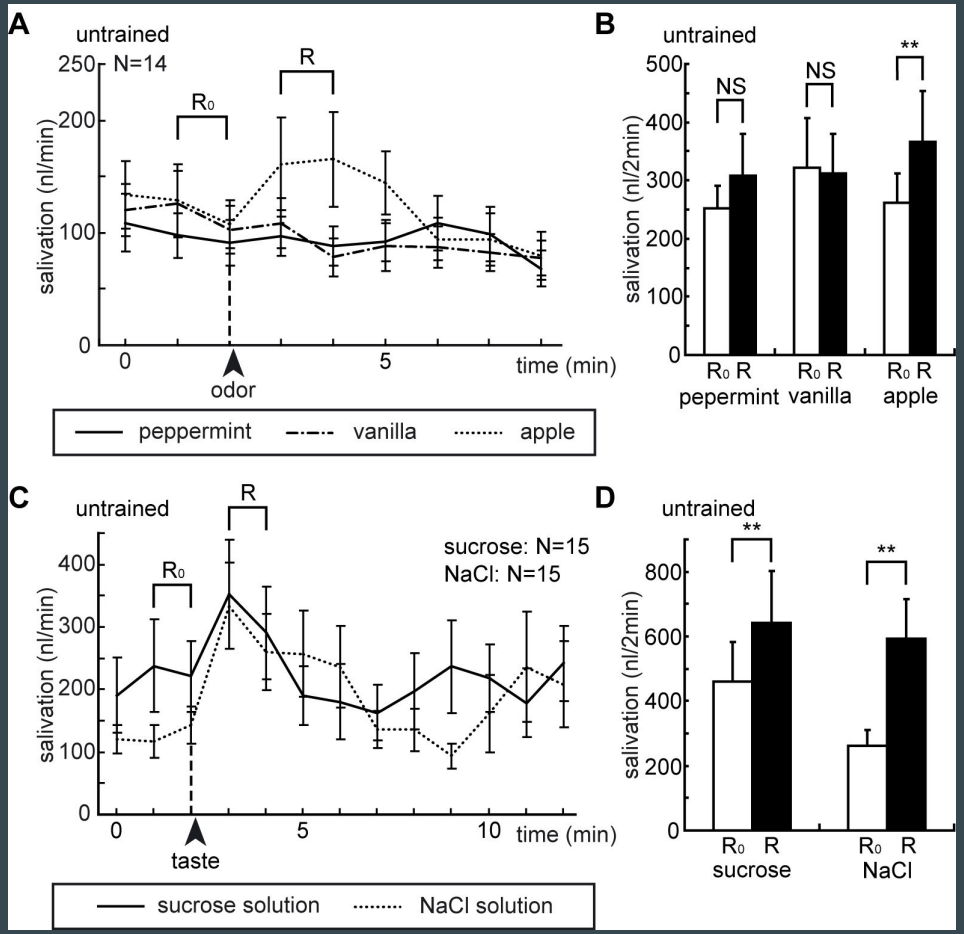
- Roaches were then restrained ventral side up on low melting wax
- Antennas immobile from staples (mouth moves freely)
- Cuticles and labium removed to expose the salivary ducts


A
1ml syringe
200 μ m
saliva
L
plastic capillary
saliva
vaseline
plastic chamber
SD
peppermint
vanilla
and
500 mM sucrose solution
B
30 min or 1 day
Test
4 sec
5 min
P+/V-
forward
30 min or 1 day
Test
4 sec
5 min
P-/V+
forward
C
30 min
Test
4 sec
5 min
P+/V-
backward
D
30 min
Test
4 sec
5 min
CS alone
E
10 min
40 min
Test
US alone

Gustatory and Olfactory Stimulation

R = rank by odor stimulation
(in Wilcox test)
N = roaches tested

$$W = \sum_{i=1}^{N_r} [\mathrm{sgn}(x_{2,i} - x_{1,i}) \cdot R_i]$$

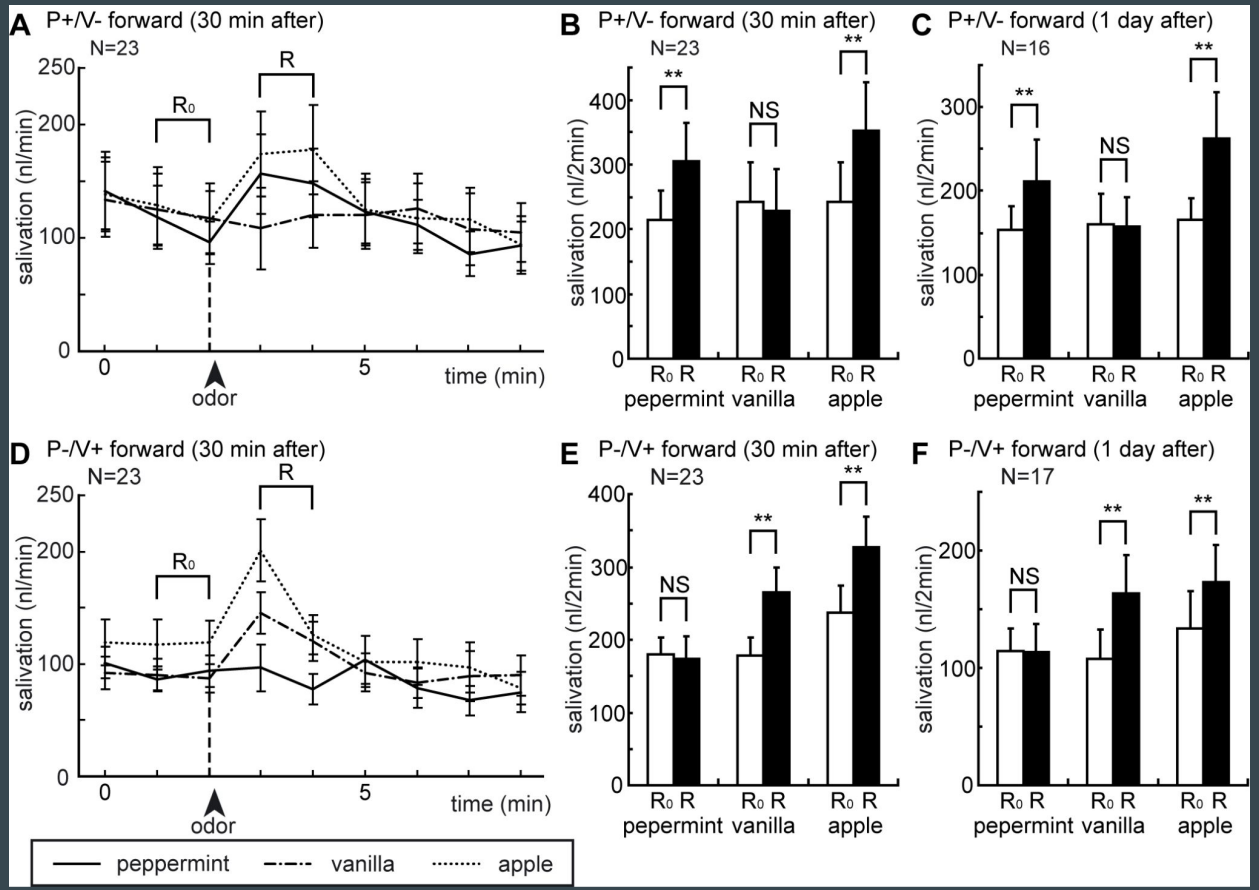


Results after First Gustatory and Olefactory stimulation

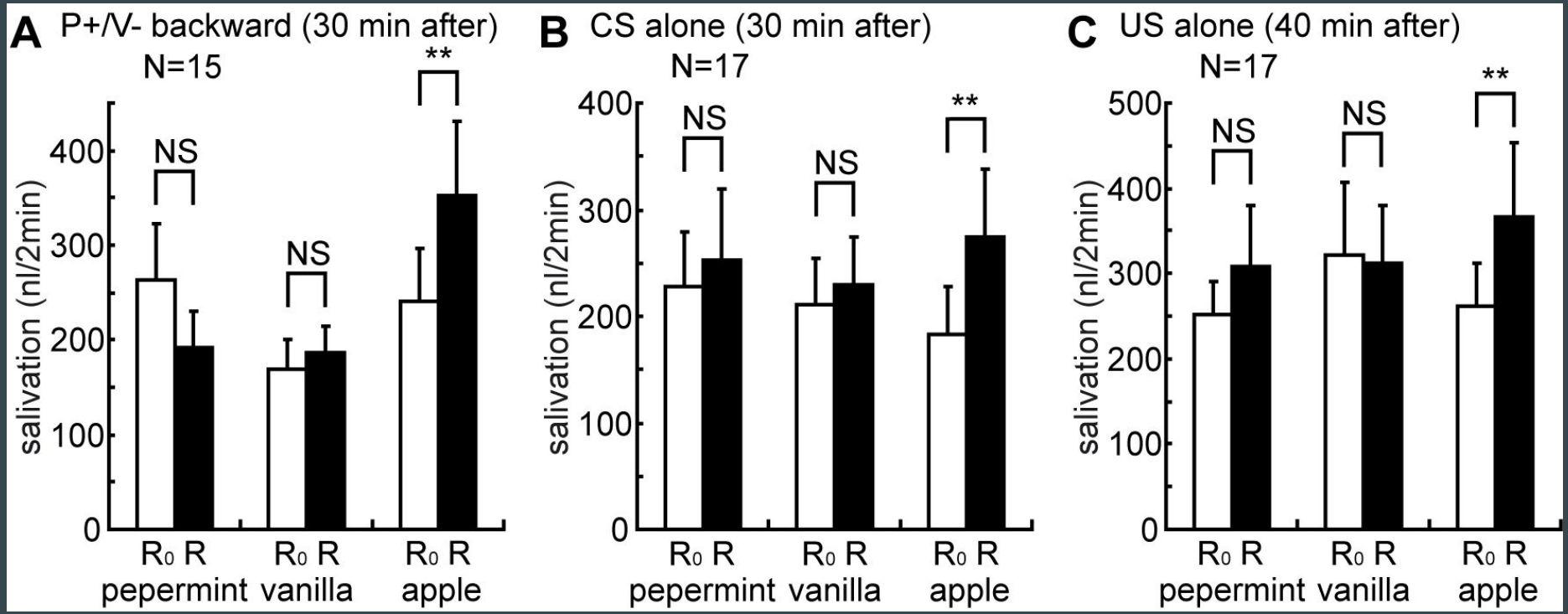
- Steady salivation of 100-200nl (nanoliters)
- Almost 600nl for NaCl and Sucrose
- Average of 300nl for peppermint and vanilla
- Apple odor and sodium chloride solution were heavily preferred more over vanilla or peppermint (shown in chart after) due to wilcoxon test, which compares two paired groups

$$W = \sum_{i=1}^{N_r} [\mathrm{sgn}(x_{2,i} - x_{1,i}) \cdot R_i]$$

Classical Conditioning at Work



Control Experiments (no change in salivation level)



Conclusion Stated

- Untrained cockroaches showed no salivation responses to vanilla or peppermint odor
- When odor was paired with sucrose solution and another odor was presented alone, cockroaches exhibited salivation response to sucrose paired odor but not to the odor by itself
- Conditioning effect maintained for 1 day after conditioning
- Backward-pairing: CS alone and US alone trials did not induce a conditioning effect.

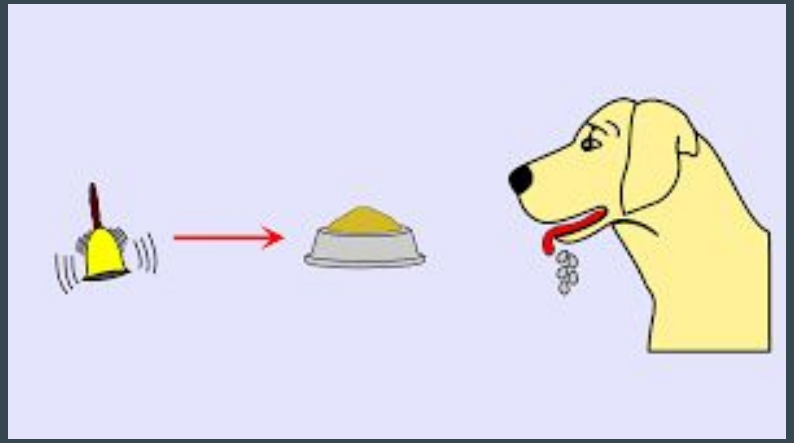
“The results demonstrate conditioning of salivation in cockroaches, for the first time in species other than dogs and humans, thereby demonstrating that conditioning of salivation is ubiquitous among different phyla”

Explanation of “Learning By Association in Plants”

by Wyatt Bender

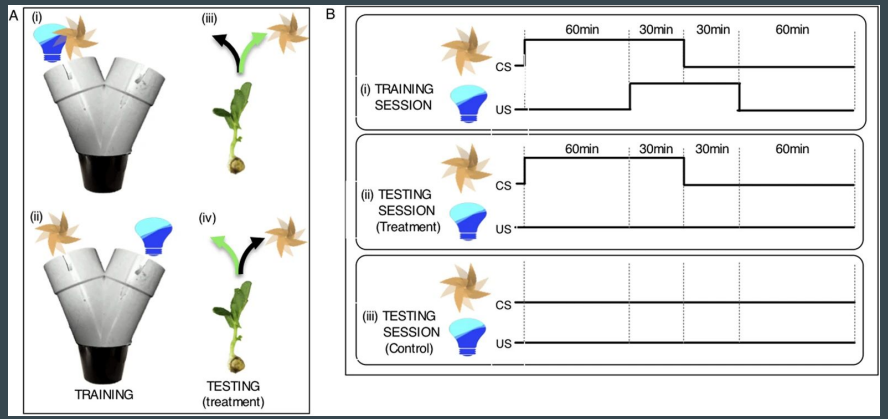
The Motivation

- Can associative learning be used by plants/pea seedlings?
  - Possibly affected by homeostatic needs like hunger, thirst, and sleep?
  - Recently found to learn non-associatively (single event exposure)
- Similar learning process to the Animal Kingdom?

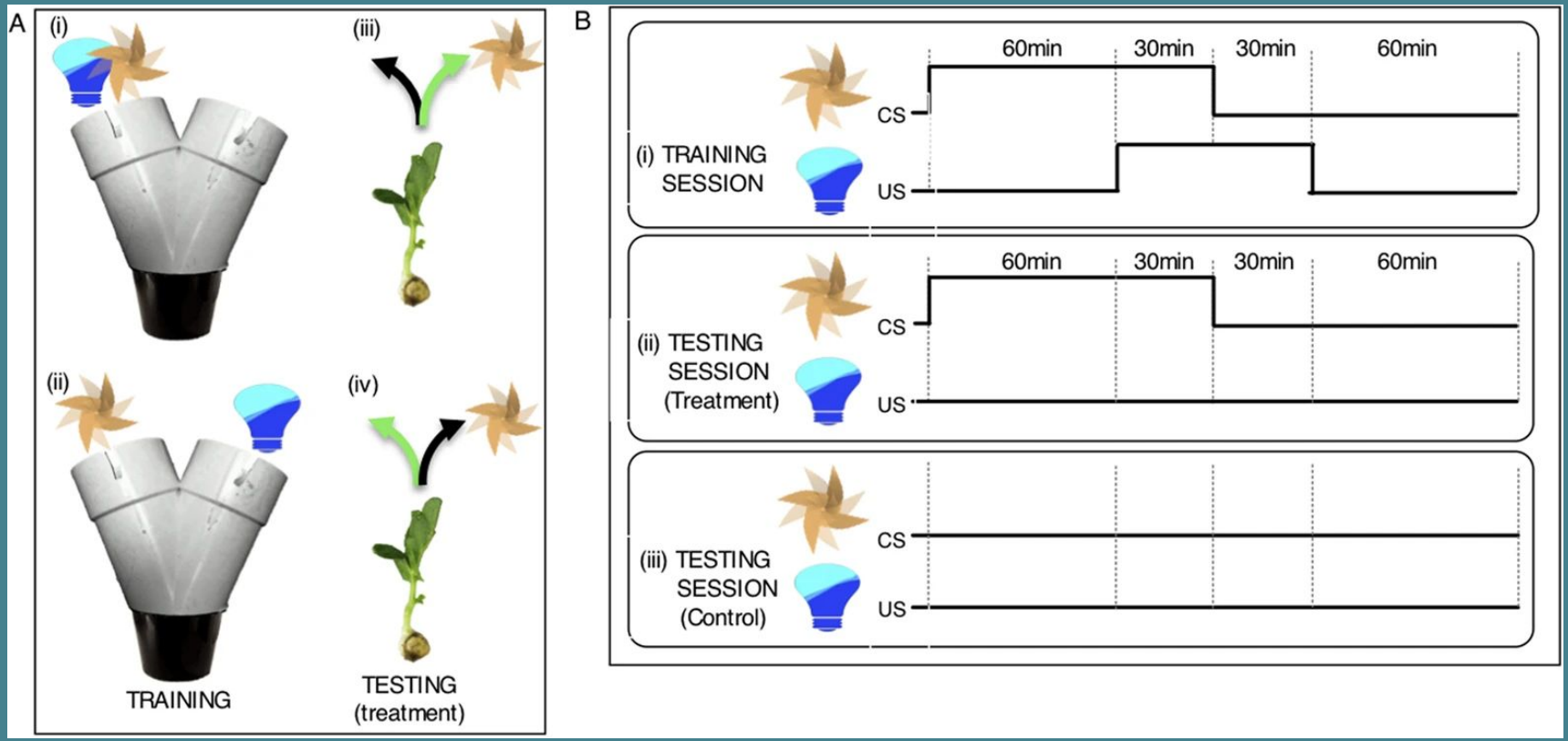


Germination and Growth Conditions

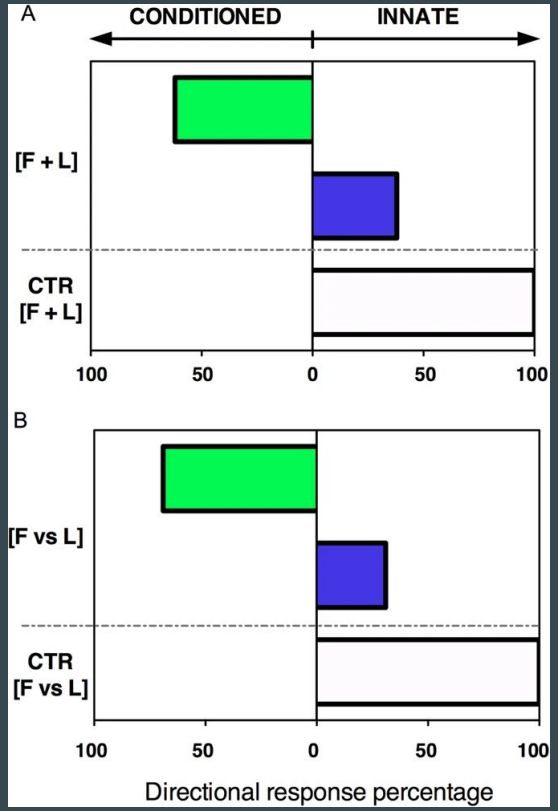
- Pea seedlings were germinated hydroponically in 250 mL round containers
- kept in the dark in a 5.3 m^2 Controlled Environment Room (CER)
- Seeds were soaked in water for 24 hours and then wrapped with clean, wet paper-towel surrounded by an external layer of aluminium foil.
- Placed in Y-maze (also in next slide)
- N = 45 pea seedlings
- Experiment 5-8 days long (light/dark cycles)



Conditioned (CS) & Unconditioned (CS) Stimulus



Associative Learning in Pea Seedlings

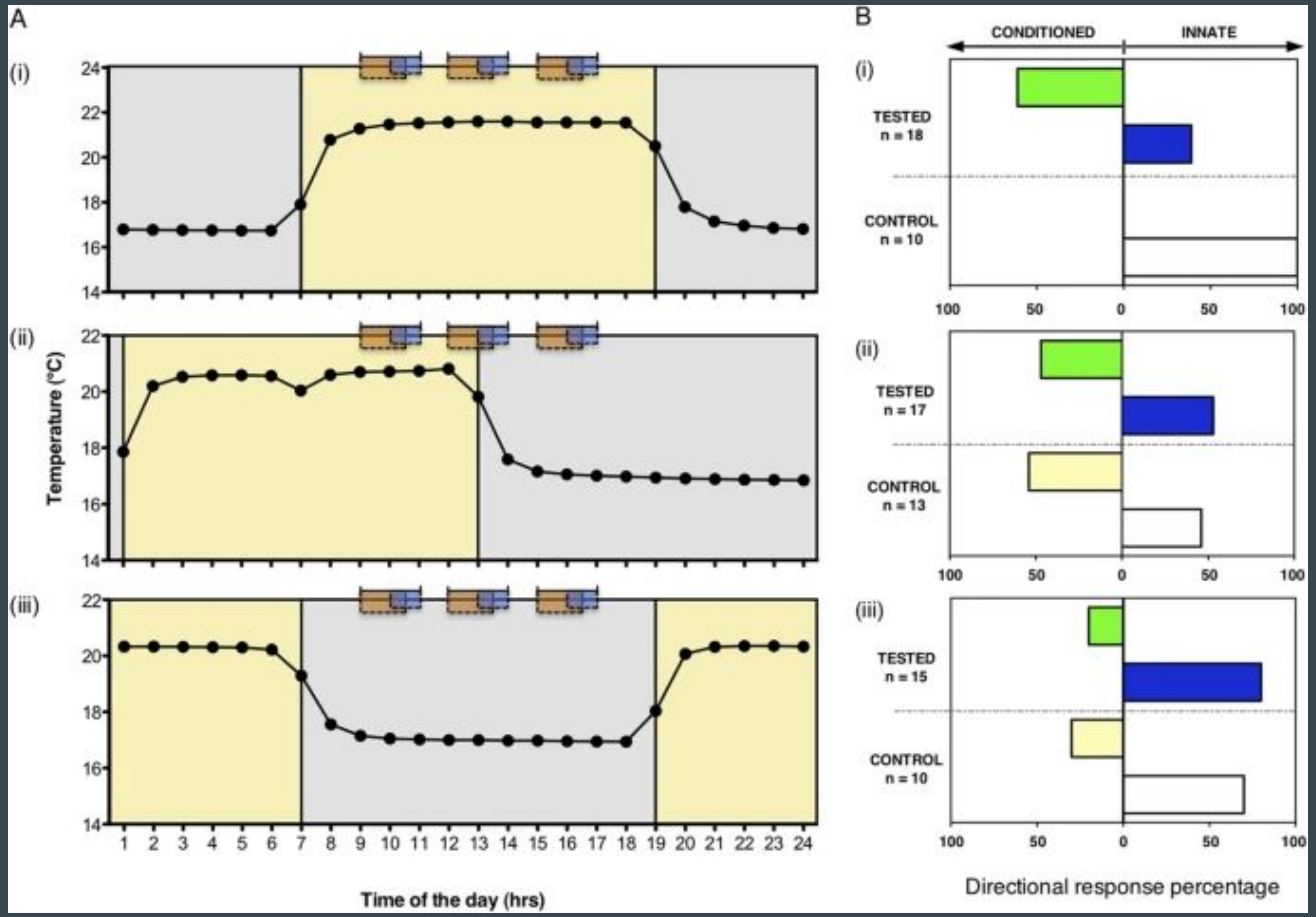


Test Group N = 16
Control Group (CTR) = 19
(due to technical reasons)

- 62% and 69%of seedlings showed learning (green bar) of following the light. The rest (blue bar) did not learn.

-- Control group followed blue light both times (white bar)

Circadian Effects on Behavioral Performance of Pea Seedlings



A:

- Blue and Orange rectangles represent Fan and Blue Light

Cycles:

- Dark /Light /Dark
- Light /Dark
- Light/Dark/Light

B:

- i: control seedlings grow towards last known light location
- ii & iii: Phase-shift disrupts phototropic sense

Conclusion

-Circadian rhythm in seedlings had deviated from Zeitgeber Cycle

-possible phase shifts from light pulses during training days

Shared by both animals and plants, associative learning is a mechanism that's universally adapted.