Learning Without a Brain: Habituation and Stimulus Discrimination in Mimosa pudica Explained by Mechanosensitive Channel Desensitization?

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Whether plants—which lack a nervous system—can exhibit "intelligent" behaviors such as learning and stimulus discrimination remains a fundamental question in biology. I addressed this question using the model plant Mimosa pudica, known for its leaf-closing movement (thigmonasty) in response to mechanical stimulation. Stimuli were delivered using a custom stimulation device, and changes in the plant's responses were quantitatively evaluated using a deep learning model. Repeated vertical vibration led to a gradual decrease in the response. Notably, even in this attenuated state, the plant exhibited a strong response when a different stimulus was applied from the horizontal direction. The same pattern held when stimulus directions were swapped. Spontaneous recovery—whereby the response recovered after extended rest—was also observed. These findings demonstrate that M. pudica can discriminate the directional properties of stimuli and modulate its responses accordingly, and together with the observed spontaneous recovery, meet the behavioral criteria of habituation. How is such sophisticated information processing achieved within the simple tissue architecture of M. pudica? Based on the observed responses and calcium signaling dynamics, I hypothesized that local desensitization of mechanosensitive (MS) ion channels on the cell membrane serves as the underlying mechanism. A mathematical model built on this hypothesis successfully reproduced the observed behavior. Moreover, a response predicted by the model was also observed in M. pudica. These results suggest that even without a centralized processing system such as a brain, plants may "retain" environmental information as physical states at the cellular level through MS channel desensitization, enabling adaptive behavior.

Awards Won:
Second Award of $2,400
The Scientific and Technological Research Council of Türkiye TUBITAK: 1st Prize Award
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