Locusts provide insight into brain response to stimuli, senses

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Baranidharan Raman, PhD, and his team trained locusts to recognize odors to learn more about how the brain processes stimuli.

By training a type of grasshopper to recognize odors, a team of biomedical engineers at Washington University in St. Louis is learning more about the brain and how it processes information from its senses.

Baranidharan Raman, PhD, assistant professor of biomedical engineering in the School of Engineering & Applied Science, found that locusts trained to recognize certain odors reacted differently when the odors were presented overlapping with another. While the results of this research, published in the April 27 issue of *Nature Communications*, focus on the sense of smell, Raman and his team plan to use the results to determine if the brain processes signals similarly for other senses.

A locust has sensory neurons in its antennae that convert chemical cues, such as puffs of an odor, into electrical signals and transmit them to circuits of neurons in the brain. Raman and his team examined the change in how the neurons in the locust's brain responded to an odor depending on activity before the exposure to the odor. They were interested in understanding how the response to an odor changed depending on the stimulus that preceded it.

The team discovered a feature in the way the brain processes signals: When two puffs of a similar odor were given one after the other, the spiking neural activity generated by the first encountered odor interfered with processing the second odor. As a result, even though a conserved set of neurons responded to the newer odor, the spiking activity patterns that would normally be brought on were disturbed. However, when two different odor puffs were given in overlapping succession, there was less interference to the brain's response evoked by the second odor.

For this study, Raman and his team used Pavlovian conditioning to train hungry locusts to respond to a puff of an odor by rewarding them with a piece of grass. After being trained, the locusts moved their palps, small sensory appendages near their mouth parts, in response to an odor puff they had been trained to recognize.

William Padovano, a senior majoring in biomedical engineering and a researcher in Raman's lab, painted the tips of the locust palps with a green paint to make them more visible and distinct compared to the surrounding parts. After videotaping the locusts' response to the odor puff, Padovano was able to filter out the motion of the painted palps and track the locusts' behavior very precisely. He saw that when an odor puff was given, the locust moved its palps in anticipation of its reward.

"We found that the locusts recognize the odor and move their palps within roughly 500 milliseconds," Raman said. "Once trained, the locusts did not forget the learned association easily. Even when we presented the trained odorant multiple times without any reward and in different ways, alone or in sequence, there was always a response."

The team sought to compare the changes in the neural and behavioral response when the locusts were given an odor they had been trained to recognize but manipulated to follow another odor they had not been trained to recognize.

"The locusts robustly recognized and responded to the trained odor whether it was presented alone or after another odor, but their response time and behavior were less predictable when the trained odor followed a similar odor that evoked highly overlapping neural activity," Raman said.

But when two different odors were presented, the locusts' response was very predictable.

"When the two different odors were in a sequence, the locusts responded quickly and predictably to the trained odor, because it was novel," Raman said. "The more novel the stimulus, the more preserved the pattern of the spiking activity becomes and more predictable the behavioral responses were."

Raman says the change in the neural response patterns they observed with stimulus history presents a general phenomenon about neural networks in the brain.

"This has helped us to finalize that even though the pattern of spiking activity over time has changed, the odor identity has not changed," Raman said. "The odor identity is completely encoded by which combinations of neurons are activated. The temporal dimension is used to emphasize or de-emphasize odorants based on their novelty."

Raman and his team plan to continue investigating neural responses.

"Given that we know we have a paradigm where we can very finely track the behavior, we can make very fine calculations with neural activity to understand how each aspect of neural response is related to behavior," he said.

More information: "Behavioural correlates of combinatorial versus temporal features of odour codes." *Nature Communications*, April 27, 2015. DOI: 10.1038/ncomms7953

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