# Neuron populations in the medial prefrontal cortex shown to code the learning of avoidant behaviors

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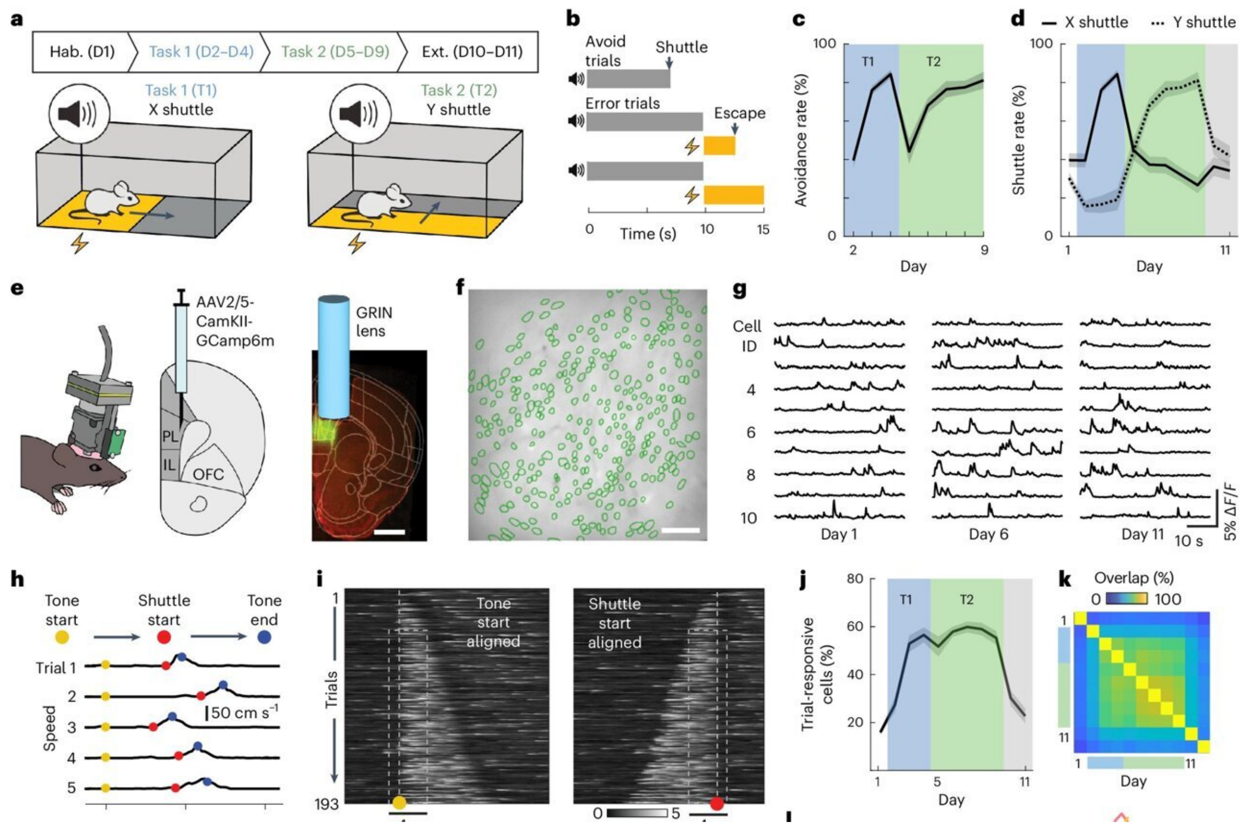


The two-dimensional active avoidance paradigm and recording of prefrontal population activity. Credit: *Nature Neuroscience* (2024). DOI: 10.1038/s41593-024-01704-5

Over the course of their lives, animals form associations between sensory stimuli and predicted threats or rewards. These associations can, in turn, shape the behaviors of animals, prompting them to engage in avoidant behaviors (e.g., avoiding specific stimuli and situations) or conversely, to engage with their surroundings in various ways.

Past neuroscience studies have found that this process of acquiring behavioral patterns via experience is supported by various brain regions. One of these regions is the medial prefrontal cortex (mPFC), a large segment of the frontal part of the brain known to contribute to decision-making, attention, learning and memory consolidation.

Researchers at the University of Zurich and ETH Zurich recently carried out a study investigating how the mPFC contributes to the learning of behavioral strategies over time, specifically focusing on the processes through which it connects sensory information to an animal's behavior. Their findings, published in *Nature Neuroscience*, suggest that the mPFC transforms sensory inputs into behavioral outputs by performing a series of computations at a neuron population-level.

"The medial prefrontal cortex (mPFC) has been proposed to link sensory inputs and behavioral outputs to mediate the execution of learned behaviors," Bejamin Ehret, Roman Boehringer and their colleagues wrote in their paper. "However, how such a link is implemented has remained unclear. To measure prefrontal neural correlates of sensory stimuli and learned behaviors, we performed population calcium imaging during a new tone-signaled active avoidance paradigm in mice."

In their experiments, which spanned a period of 11 days, Ehret, Boehringer and their colleagues recorded the activity of neurons in the brains of mice while the animals were engaged in a fear-conditioning task. The mice were placed in a chamber for learning sessions consisting of 50 trials each.

After they heard a tone, the mice received a mild but unpleasant electric shock to their feet. Half of the chamber they were in, however, was delineated as a "safe zone," meaning that if they were situated in this zone the mice would not receive any shock following the tone.

After repeated trials, the mice acquired avoidant behaviors and learned to rapidly move to the safe zone after they heard the tone. To examine the activity of neurons while the mice were learning to avoid the shock by escaping to the safe zone, the researchers used calcium-imaging techniques and fluorescence microscopy.

"We developed an analysis approach based on dimensionality reduction and decoding that allowed us to identify interpretable task-related population activity patterns," wrote Ehret, Boehringer and their colleagues.

"While a large fraction of tone-evoked activity was not informative about behavior execution, we identified an activity pattern that was predictive of tone-induced avoidance actions and did not occur for spontaneous actions with similar motion kinematics. Moreover, this avoidance-specific activity differed between distinct avoidance actions learned in two consecutive tasks."

When they analyzed the recordings they collected during experimental trials, the researchers observed a pattern in the activity of mPFC neurons that was linked to the execution of avoidant behaviors after hearing the tone and following previous fear-conditioning training. Overall, the team's observations suggest that the mPFC transforms sensory inputs into specific behavioral outputs via a series of distributed computations at a neuron population-level.

"These results highlight the complex interaction between sensory processing and behavior execution, and further work is needed to understand the temporal dynamics of sensory information flow through the network of involved brain areas," wrote Ehret, Boehringer and their colleagues.

The findings of this recent study could soon pave the way towards an even better understanding of the mPFC and its contribution to the learning of goal-directed behavior. Future studies could further examine the activity patterns identified by the team at ETH Zurich using other experimental methods and learning paradigms.

**More information:** Benjamin Ehret et al, Population-level coding of avoidance learning in medial prefrontal cortex, *Nature Neuroscience* (2024). DOI: 10.1038/s41593-024-01704-5