# Spot the difference: Brain changes that enable fine visual discrimination learning

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Our visual perception of the world is often thought of as relatively stable. However, like all of our cognitive functions, visual processing is shaped by our experiences. During both development and adulthood, learning can alter visual perception. For example, improved visual discrimination of similar patterns is a learned skill critical for reading. In a new research study published in *Current Biology,* scientists have now discovered the neuronal changes that occur during learning to improve discrimination of closely related visual images.

This study, led by first author Dr. Joseph Schumacher and senior author Dr. David Fitzpatrick at the Max Planck Florida Institute for Neuroscience, establishes a transformative approach to studying perceptual learning in the brain. Researchers imaged the activity of large numbers of single neurons over days to track the changes that occur while a visual discrimination task is learned, performing these experiments in a novel animal model, the tree shrew.

The tree shrew is a small mammal with visual properties akin to the human, including a high degree of visual acuity and a similar orderly spatial arrangement of visually responsive neurons in the brain. As the researchers show, these animals can also learn complex behavioral tasks, making them ideal for understanding how experience shapes visual perception. In this study, tree shrews were trained to discriminate between highly similar visual images: identical black lines that differed only by a small change in orientation (22.5 degrees). In the task, the presentation of the lines at one orientation was rewarded with a drop of juice. Over days, tree shrews learned to discriminate between the two similar visual images, licking only in response to the lines at the rewarded orientation and withholding licking to the lines at the non-rewarded orientation.

The scientists combined this behavioral task with measurements of neural activity in V1, an area of the brain essential for visual processing. The neurons in this area are activated by specific features of visual input, such as the orientation of light-dark edges. Individual neurons show 'preference' for specific edge orientations, responding with the highest activity to these orientations and with progressively lower activity or no activity to edges orientated further from the preferred orientation. In this way, a visual scene that has edges with different orientations activates particular subsets of neurons to generate a neural activity pattern that encodes the information needed for visual perception.

Schumacher and colleagues found that visual discrimination learning in the tree shrew was accompanied by enhancement of the difference in the patterns of neural activity evoked by the two visual images. This was primarily due to an increase in the amount of neural activity in response to the presentation of the rewarded stimulus orientation relative to the non-rewarded orientation. But this was not just a general increase in neuronal responses to the rewarded stimulus. When the scientists examined the changes more closely, they found that this was mediated by changes in the activity of a remarkably specific subset of neurons: those whose orientation preference was optimal for distinguishing the orientation of the rewarded stimulus from the non-rewarded stimulus.

To fully understand the effect of learning on visual perception, the authors next investigated whether the changes in neuronal activity that improved visual discrimination persisted outside of the learned task context. Interestingly, they found that the neuronal changes not only persisted but were accompanied by changes in the trained tree shrew's abilities to perform other discriminations. This included both enhancements for some stimulus orientations and impairments for others—behavioral changes that were exactly what would be expected given the changes in the responses of this specific subset of neurons.

"This work demonstrates specific experience-driven changes in the activity of neurons that impact the perception of visual stimuli, enhancing discriminations relevant to task performance at the expense of other related discriminations," explains first author Joe Schumacher.

Now the lab has set its sights on combining this approach with new technologies to unlock the sequence and changes that occur in multiple types of neurons in order to mediate perceptual learning. By probing these questions in the visual system of the tree shrew, scientists in the Fitzpatrick lab are discovering fundamental new insights about perceptual learning that could impact our understanding of a broad range of learning disorders.

**More information:** Joseph W. Schumacher et al, Selective enhancement of neural coding in V1 underlies fine-discrimination learning in tree shrew, *Current Biology* (2022). DOI: 10.1016/j.cub.2022.06.009

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