Adaptations of the Brain

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In the complex studies of neurons and gray matter, cognitive psychologist Stephen Engel is sticking to the basics.

Engel, a professor at the University of California, Los Angeles, was able to characterize the way learning impacts the primary visual cortex — the first stop in the brain for information from the eyes — and the findings are beautifully fundamental.

“What’s most exciting is that it’s a pretty basic discovery that this part of the brain can change with learning, and it seems like something that could be fundamental to a lot of other stuff,” Engel said. “It’s not studying some particular phenomenon that only comes up in some cases; we use this part of our brain all the time and the fact that it can change seems pretty big.”

Engel presented the findings in an invited talk entitled, “Effects of Perceptual Learning on Early Visual Cortex” at the APS 17th Annual Convention in May.

Practiced and repeated stimulus leads to increased activity of neurons in the auditory cortex, but conclusions had not been made about stimulation in the visual sphere. The plasticity of this part of the brain was yet to be determined.

Engel and his team made the discovery with an experiment in the manner of an old-fashioned axiom: practice makes perfect.

Six human subjects completed a grueling 600 trials in 25 days by detecting a faint patch of light or determining the degree orientation of oblique or horizontal bars. Their brain activity was measured with functional magnetic resonance imaging before and after the training.

The more the subjects performed the tasks, the better they got at them — and this also was reflected as an increasing response in their visual cortex. Both empirical and qualitative data on performance reflect that learning occurred over time.

Engel hopes to determine, however, whether a large signal from the visual cortex means a few neurons are firing more loudly due to training, or more neurons are firing at a subdued state.

The findings suggest that detection of patterns depends directly upon the number of responsive neurons in the cortex, with larger responses producing better detection performance.

Readings from the fMRIs proved that training increased how strongly a stimulus was represented in the cortex, and that this representation was specific to the stimulus.

“The primary visual cortex adapts to the statistics of the environment we find ourselves in,” Engel said. “Statistics of the environment drive this plasticity.”

Follow-up experiments are currently being designed in the Engel Vision and Imaging lab at the University of California, Los Angeles. The researchers hope to extend findings to more complex tasks of the visual system, including the expertise acquired by radiologists as they become more adept at interpreting medical images.

“We understand really well how the neurons work back there, so if we want to understand how learning works, this is a great place to do it,” Engel said. “We know really well what the neurons are doing before learning, and so we can well characterize the changes due to learning.”

Engel believes that studying the visual cortex can serve as a model for the plasticity of the entire brain.

The study also found that the behavioral effects were long lasting, as subjects exhibited the effects of training in performing the same tasks several months later.

The findings in perceptual learning are already being used in the treatment of vision disorders, such as amblyopia or “lazy eye,” in which one eye is more strongly represented in the visual cortex than the other starting in childhood. Individuals with this condition suffer from poor vision through the weaker eye.

“Ultimately we’d like to understand the mechanism by which the brain can rewire itself,” Engel said. “Then we could tailor training programs to best take advantage of how the brain can change, and apply that to practical problems like disease and other non-health problems like reading or hearing.”