IMAGE OF THE MONTH

Estimates of the prevalence of the subtype of synesthesia in which the brain links graphemes and color range from 1 in 100 to 1 in 200, said Edward M. Hubbard, Ph.D, of the cognitive neuroimaging research unit of the l'Institut National de la Santé et de la Recherche Médicale (INSERM) near Paris.

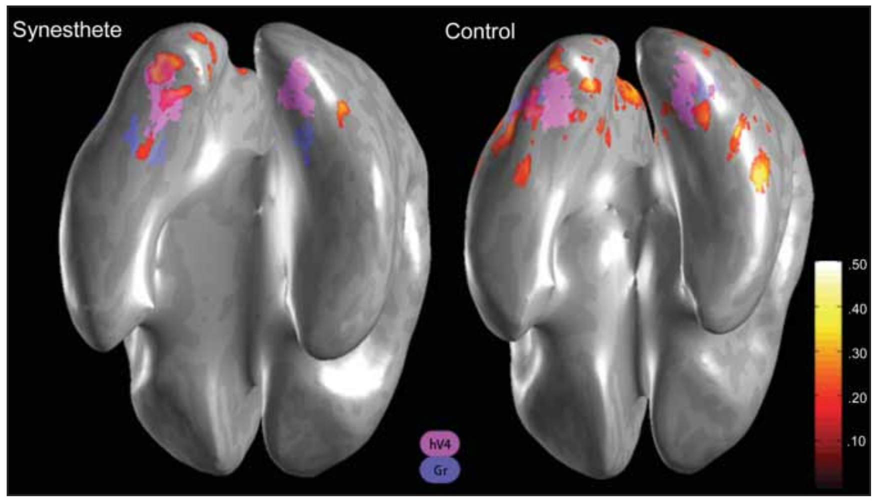
Dr. Hubbard and his associates at the University of California at San Diego and the Salk Institute, La Jolla, Calif., performed four 90-minute-long sessions of functional MRI (fMRI) in six people with grapheme-color synesthetes and in six nonsynesthetic controls. In the first session, the researchers used T1-weighted MRI to map the anatomy of the entire brain. This MRI provides an image of the brain's surface that the researchers can manipulate—inflating it or unfolding it as necessary to view the regions of interest.

In each of the four sessions, the researchers used T2-weighted MRI to collect 16 3-mm coronal slices covering the back portion of the brain—the back 4.5 cm—on a 1.5-T machine. The researchers next used retinotopic mapping to delineate each person's visual field on the cortical surface. Retinopic mapping is done while the subject views black and white contrast-reversing checkerboards. The result is a point-to-point map that "actually lays out—on a subject-by-subject basis—where the boundaries of the visual areas lie," he said.

The researchers were interested in cortical region human V4 (hV4) which is color sensitive, and the region that is grapheme selective. The two regions are adjacent, making it very important to be able to accurately distinguish them. The analysis of retinopic mapping requires virtual unfolding of the highly folded cortical gray matter.

They flattened the 3-D cortex in the high-resolution anatomic scan to a 2-D surface to better identify the areas of hV4 and grapheme-selective areas. However, geographic relations are lost in this view of the cortex.

In the second and third scan, the subjects were presented with either numbers or letters, alternating with nonlinguistic symbols. The images (at right) are a computer-generated amalgam of all of the scanning sessions. The anatomic scan has been inflated to preserve geographic relations in the brain. In the images of inflated cortices for a synesthetic subject (at left) and for a control subject (at right), the blue areas represent the grapheme regions of interest—the regions in which one would expect to see activation upon encountering a grapheme. The color-selective area hV4—where one would expect to see activation associated with seeing a color—is in light purple. The yellow-red areas indicate areas of brain activity upon seeing graphemes, with the intensity of activation increasing from yellow to red.



Functional MRI shows activation in both the grapheme (blue) and color (violet) regions of the cortex in the subject with synesthesia but not in the control.

"In early visual areas, like V1, there is a slight trend for more activity in the synesthetes than in the controls but it's not significant. The only place where there is a significant difference really is in this color-selective region (hV4)," said Dr. Hubbard. This difference in the hV4 region between synesthetes and controls "tells us that the part of the brain, which many previous studies have shown to be implicated in color processing, is active in synesthetes when they say that they see colors," he said.

The V1 region represents the first stage of visual processing—primary visual cortex. The V1 region both processes color and orientation and depth, among other things. The hV4 region is much more specialized for color processing. It all means that people with this type of synesthesia aren't imaging those colors. They really are processing color when they encounter graphemes.

—Kerri Wachter

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