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Researchers show there's more than one way to read - with implications for reading disorders

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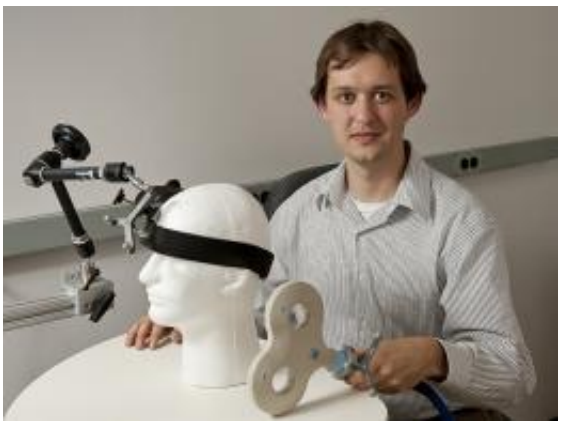

Andreas Rauschecker with the transcranial magnetic stimulation apparatus. The model's headgear is used to precisely target the procedure's disruptive currents. Credit: L.A. Cicero

(Medical Xpress) -- With specificity and precision, the brain's Visual Word Form Area, or VWFA, does exactly what its name implies. Every time we see something that looks like a word, it activates. The VWFA is so adept at packaging visual input for the brain's language centers that the task of word-recognition only takes a few tens of milliseconds.

Still, the problem of picking out words from a visual scene is strikingly complex –complex enough that it is currently used to distinguish human Internet users from automated software programs. If you've ever been

asked to type out a distorted word before gaining access to your email – a security test known as a CAPTCHA - you've proven that you're a better reader than your computer.

In a research paper appearing in last week's *Neuron*, neuroscientists from the Stanford Vision Imaging Science and Technology Lab demonstrate that one key to VWFA function is its ability to recognize words through more than one visual pathway. The finding not only demonstrates the flexibility of the human visual system, but may also have implications for our understanding of dyslexia and other reading disorders.

When the VWFA was first identified in 2000, the very existence of a brain region devoted specifically to word recognition was considered surprising. Reading is an activity that has only become widespread in recent human history.

"It didn't originally evolve for reading," explained Andreas Rauschecker, the primary author of the Neuron paper and an MD/PhD candidate in Stanford's Medical Scientist Training Program. "We likely invented reading to give the VWFA what it likes to see."

Located in the ventral occipitotemporal cortex at the back of the brain, the VWFA appears to act as a relay station between the primary visual cortex and the brain regions dedicated to language recognition and production. As an individual's reading ability improves, her VWFA has been shown to expand into neighboring brain regions, including the region devoted to facial recognition.

But what does the VWFA find "appealing" about words? Traditionally, researchers have thought of words as defined by "luminance contrast" – black letters on white paper, for instance. Rauschecker, however, was interested in a potential alternate pathway.

Instead of being "luminance-defined," words can be "motion-defined" – distinguishable from their background not by color or contrast, but by their apparent direction of movement. Against a field of dots moving one way, words made up of dots moving in the other direction will "pop out" to most viewers, even if the word and background dots are the same shade.

"In some ways, this is an especially extreme version of a CAPTCHA," said Rauschecker.

Participants in the study were asked to read while their brains were scanned by a functional MRI (fMRI) machine. The researchers presented the participants with various types of words – defined by either motion or luminance contrast – and watched for activation of the VWFA (Video example of the motion-defined words viewed by study participants.)

The researchers reasoned that, if the VWFA were only looking for a basic visual feature, such as the shapes of black-on-white letters, it shouldn't activate in the presence of motion-defined words. But scans showed that the VWFA responded equally to all legible words.

The result implied that the VWFA can receive information from the human MT complex, or hMT+: a region of the visual cortex necessary for motion perception.

The fMRI scans showed that the hMT+ did activate in the presence of motion-defined words, although it was unresponsive to other types of words. This finding suggested the existence of two separate visual pathways to the VWFA.

The researchers also precisely targeted transcranial magnetic stimulation to each individual's hMT+. The technique, which applies a rapidly

changing magnetic field to induce an electric current in the brain, can be used to briefly inject noise into specific brain regions, temporarily disrupting function. Stimulation dramatically reduced reading performance of motion-defined words while leaving luminance contrast-defined words unaffected.

"How exactly the information ends up in the VWFA depends on the specific visual features," Rauschecker said. "There's very flexible routing."

And the pathways seem to be partially additive. A word that is defined by both motion and color inspires a stronger VWFA response than a word defined by one or the other.

This feature offers the possibility of compensating for specific reading disabilities by designing electronic typefaces that could re-route visual information through undamaged areas of the brain. A digital font with a movement component could potentially increase legibility for some of those who have difficult reading.

The participation of hMT+ in the pathway is particularly interesting, as previous studies have shown that the region is less responsive to motion in dyslexics.

"That was something of a random finding," said Rauschecker. "There was no reason to think that, by showing people a moving stimulus, you should be able to predict their reading ability."

The research raises as many questions as it answers. Motion-defined words are an unusual stimulus, and the role of hMT+ in normal reading is still unclear. It may be involved in a reader's ability to switch rapidly from one word to the next in a sentence, though this remains only a theory.

Even the VWFA itself isn't the end of the word-recognition story. Participants also performed a decision task during their fMRIs, identifying words as either real words or nonsense words. VWFA activation was necessary for correct identification – but not sufficient.

The paper's senior author was Brian Wandell, a professor of psychology at Stanford. Funding for the research was provided by the Bio-X Graduate Student Fellowship to Rauschecker and a National Institutes of Health grant to Wandell.

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