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Transcranial direct current stimulation can boost language comprehension

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How the human brain processes the words we hear and constructs complex concepts is still somewhat of a mystery to the neuroscience community. Transcranial direct current stimulation (tDCS) can alter our language processing, allowing for faster comprehension of meaningful word combinations, according to new research from the department of Neurology the Perelman School of Medicine at the University of Pennsylvania. The work is published in the *Journal of Neuroscience*.

"Integrating conceptual knowledge is one of the neural functions fundamental to human intelligence," said the study's first author Amy Price, a neuroscience graduate student at Penn. "For example, when we read or listen to a sentence, we need to combine, or integrate, the meaning of the words to understand the full idea of the sentence. We perform this process effortlessly on a daily basis but it is quite a complex process and little is known about the brain regions that support this ability."

Semantic memory is our stored knowledge about the world, such as the meaning of words and objects. "We sought to understand how and in what part of the brain semantic representations are integrated into more complex ideas" said senior author Roy Hamilton, MD, MS, an assistant professor in the departments of Neurology and Physical Medicine & Rehabilitation, and director of the Laboratory for Cognition and Neural Stimulation at Penn. Recent findings from functional MRI scans (fMRI) and magnetoencephalography (MEG) have suggested the angular gyrus, a region of the brain known to be involved in language, number

processing and spatial cognition, memory retrieval and attention, as a potential hub for semantic memory integration, specifically the left angular gyrus.

Hamilton and team, which also included Jonathan Peelle PhD, an assistant professor in the Department of Otolaryngology at the Washington University School of Medicine, Michael Bonner, PhD, a postdoctoral fellow in the Department of Psychology at Penn, and Murray Grossman, MD, EdD, professor of Neurology and director of the Penn Frontotemporal Dementia Center, looked at the role of the left angular gyrus in semantic memory by applying high definition tDCS in healthy adults to modulate neural activity and determine its effect on semantic integration. This was done using three separate brain stimulation sessions in 18 healthy adults. Subjects donned the tDCS stimulation cap equipped with electrodes that stimulated the left angular gyrus or the right angular gyrus, as well as applied a fake form of stimulation known as sham stimulation as a control. After each stimulation session, subjects were presented with word pairs that could to be semantically integrated into coherent, or meaningful, combinations—such as "plaid jacket" and another set of word pairs that formed non-coherent, or non-meaningful combinations- such as "fast blueberry."

This was followed by a letter task that served as a control for brain stimulation affects on vision and attention, in which subjects looked at non-pronounceable strings of letters - such as vsbsl vsbql - and were asked to indicate whether or not the letter strings matched.

Results showed that stimulation to the left angular gyrus resulted in a faster comprehension of meaningful relative to non-meaningful word pairs when compared with both sham and right angular gyrus stimulation. This same effect was not produced in the letter-string task, showing that these findings cannot be easily attributed to non-specific

effects on attention, motor control or low-level visual processing.

"Our findings extend our knowledge about the angular gyrus as a center wherein the brain constructs higher-level meaning from individual words during semantic comprehension and plays an important role in the fluent composition of meaning in language," Hamilton said. "They are also consistent with the broader claim that the angular gyrus is a cortical semantic hub."

More information: A. R. Price et al. Causal Evidence for a Mechanism of Semantic Integration in the Angular Gyrus as Revealed by High-Definition Transcranial Direct Current Stimulation, *Journal of Neuroscience* (2016). DOI: 10.1523/JNEUROSCI.3120-15.2016

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