Medical Xpress

Echolocation learning process involves close coordination between sensory and motor cortex

January 26 2017

Credit: Axel Kock / fotolia.com

Humans can be trained to use echolocation to estimate the sizes of enclosed spaces. LMU researchers now show that the learning process involves close coordination between sensory and motor cortex.

In principle, humans need not rely solely on vision for orientation. Some blind persons make use of self-generated sounds to estimate their position and orientation in an enclosed space relative to reflecting surfaces. They may tap the ground with a cane or produce clicks with their tongue, as some bat species do, and analyze the echoes to determine their distance to the surrounding walls. Now a team led by Lutz Wiegrebe, a professor in the Department of Biology at LMU, has shown that sighted people can be taught to estimate room size with the help of self-generated clicks. In collaboration with Dr. Virginia L. Flanagin from the German Center for Vertigo and Balance Disorders at the LMU Medical Center, the researchers monitored the activity in different regions of the brains of eleven sighted subjects and one blind person as they executed an echolocation task. The results enabled the team to analyze the neuronal mechanisms involved in echolocation in humans, and appear in the new issue of the *Journal of Neuroscience*.

Wiegrebe and his colleagues have developed a technique based on functional magnetic resonance imaging (fMRI), which makes it possible, for the first time, to monitor the process of echolocation by means of self-generated tongue clicks. In the study, this set-up was used to train sighted subjects in echolocation. The researchers first characterized the acoustic properties of a real building – a small chapel with highly reflective surfaces and a long reverberation time. "In effect, we took an acoustic photograph of the chapel, and we were then able to computationally alter the scale of this sound image, which allowed us to compress it or expand the size of the virtual space at will," Wiegrebe explains. The experimental subjects, fitted with a headset consisting of headphones and a microphone, were placed in the MRI scanner. They were then positioned within the virtual space by means of the signals fed to the headphones. The subjects produced tongue clicks, and the echoes corresponding to virtual spaces of different sizes – derived from the acoustic image – were played to them over the headphones. "All participants learned to perceive even small differences in the size of the space," Wiegrebe says. Moreover, they were better able to assess the size of the virtual space when they actively produced the tongue clicks than when these were played back to them. In fact, one of the experimental subjects learned to estimate the size of the virtual space to within 4% of its actual size.

The set-up used for the experiment also allowed the neuronal mechanisms involved in echolocation to be characterized with the aid of the MRI scanner. "Echolocation requires a high degree of coupling between the sensory and the motor cortex," Virginia Flanagin says. The sound waves generated by the tongue clicks are reflected by the surroundings and picked up by both ears, thus activating the sensory (auditory) cortex. In sighted subjects, this is followed shortly afterwards by activation of the motor cortex, which stimulates the tongue and the vocal cords to emit new clicking sounds. Experiments carried out with the congenitally blind participant, on the other hand, revealed that reception of the reflected sounds resulted in the activation of the visual cortex. "That the primary visual cortex can execute auditory tasks is a remarkable testimony to the plasticity of the human brain," says Wiegrebe. Sighted subjects, on the other hand, exhibited only a relatively weak activation of the visual cortex during the echolocation task.

The researchers now plan to develop a dedicated training program, which enables blind persons to learn how to use tongue clicks for the purpose of echolocation.

More information: Virginia L. Flanagin et al. Human exploration of enclosed spaces through echolocation, *The Journal of Neuroscience* (2017). DOI: 10.1523/JNEUROSCI.1566-12.2016

Provided by Ludwig Maximilian University of Munich