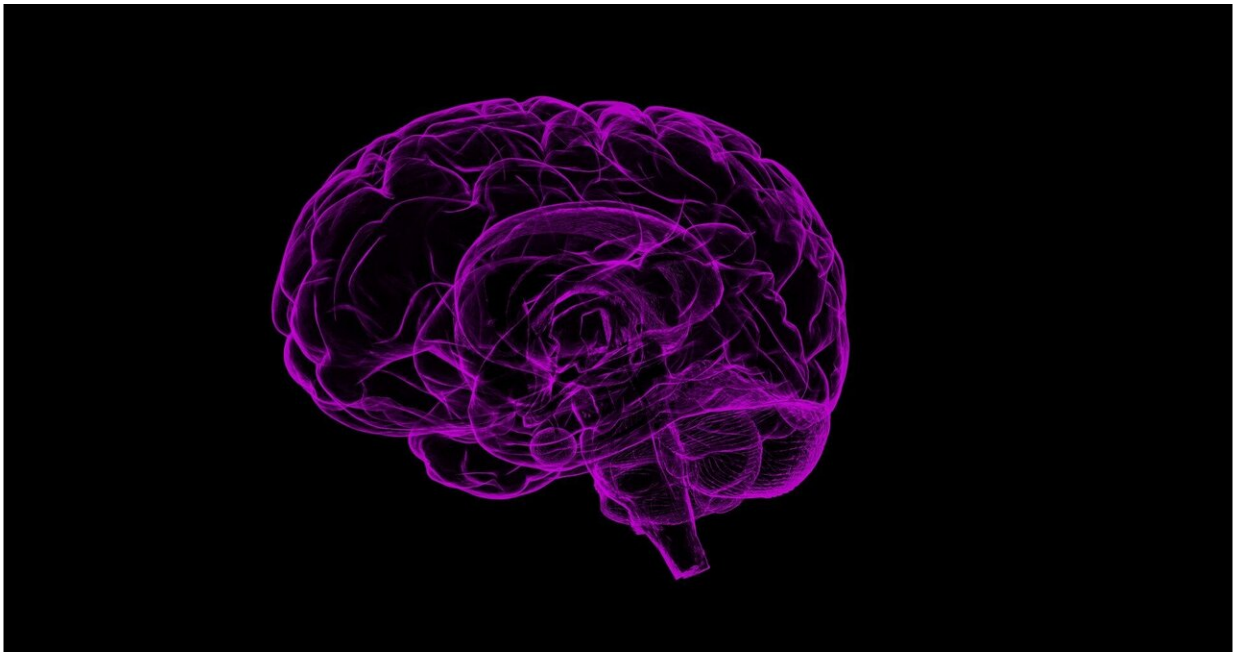
The mind of a blind 'Batman' reveals that novel maps can emerge in the adult brain

July 1 2021



Credit: Pixabay/CC0 Public Domain

The adult brain is more malleable than previously thought, according to researchers from the Interdisciplinary Center Herzliya. They trained a 50-year-old man, blind from birth, to 'see' by ear, and found that neural circuits in his brain formed so-called topographic maps—a type of brain organization previously thought to emerge only in infancy. This finding reported recently in *NeuroImage,* sheds new light on the brain's ability for change and holds promise for helping people restore lost function, for example, after a stroke.

"The human brain is indeed more plastic during infancy, but it maintains an enormous potential for reprogramming throughout a person's life," says Prof. Amir Amedi, head of the Baruch Ivcher Institute for Brain, Cognition & Technology at IDC Herzliya, whose team conducted the study.

This research is Amedi's latest challenge to the classic theory of brain organization, according to which the brain has specialized regions, each geared to processing a particular type of sensory information—visual, auditory and so on. The theory holds that for these regions to become organized properly, we must be exposed to the relevant stimuli early in life. This view stems from seminal studies by David H. Hubel and Torsten N. Wiesel—awarded the 1981 Nobel Prize in Physiology or Medicine for this research—showing that without exposure to such stimuli during a critical period in early life, the corresponding sensory system fails to develop. After the critical period, the brain is considered to experience a progressive loss of plasticity, that is, the ability to modify itself based on novel experiences.

But over the past decade, evidence has been accumulating that the brain's sensory regions can handle stimuli outside their 'specialization'. In a recent review in Neuroscience and Biobehavioral Reviews, Prof. Amedi and Dr. Benedetta Heimler bring together compelling findings in healthy as well as visually- and hearing-impaired individuals, showing that sensory regions deprived of their natural input can be activated by atypical senses—for example, the visual cortex can be activated by sound or touch.

Moreover, the researchers cite studies, including those in Amedi'a lab, in which such atypical activation was achieved in adults. They call for revising the classical concept of critical periods of development: instead of a fixed time window in early life, they suggest focusing on the brain's ability to acquire specialization throughout a person's lifetime, in other words, reversing the loss of plasticity.

In the new study in *NeuroImage*, Amedi's team trained a man, blind from birth—identified as MaMe, by the first syllables of his first and last name—to recognize objects using a sensory substitution algorithm the lab had developed. The method, EyeMusic, converts visual stimuli into "soundscapes," sound units that convey information about geometric shapes. They convey positions on the y axis by musical pitch, and those on the x axis by time. Thus, tones of a higher pitch denote higher locations, whereas their ordering in time corresponds to their respective positioning from left to right. The researchers scanned MaMe's brain using functional magnetic resonance imaging, before the training and after he had successfully learned to recognize soundscapes.

Hofstatter describe the intriguing results: "After MaMe had learned to interpret soundscapes, his neural circuits were shown to be activated not only in the auditory cortices, but also in the occipital cortex, which receives visual stimuli in sighted people and is not expected to be activated in a congenitally blind individual". Amedi adds: "Not only that, the activation followed a pattern of topographical maps—the highly ordered manner in which external stimuli are mapped in all the sensory systems of the human brain. For example, in the visual cortex of sighted people, neighboring locations are "mapped" onto adjacent neurons, whereas places at a great distance from one another are represented by neurons that are further apart.

MaMe's scans revealed topographic maps tuned to pitch and time—or even to both concurrently—that had not existed in his brain before he'd started the training. For instance, tones of a similar pitch were represented by adjacent neurons, whereas those of radically different pitches—by neurons that were distant from one another. This is the first time topographic maps have been shown to emerge in an adult human brain.

These findings suggest that the brain's sensory regions are primed for specific computations but not specific senses, and that they can be adapted to processing novel sensory experiences.

In fact, past studies by other researchers had shown in newborn laboratory animals that it's possible to "move" the vision function to the brain's hearing region by surgically guiding nerve fibers from the visual cortex to the auditory one. The new study by Hofstetter and colleagues supplies a proof of concept that a similar transition can be done in a noninvasive manner, and in an adult, rather than infant, brain.

"Critical periods are not permanent cut-off points for developing new sensory abilities—rather, in a way, we can give the brain a second chance at any point in life," Amedi says.

He points out that EyeMusic can teach people to develop an ability that is similar to that of bats and dolphins: extracting information about geometric shapes from complex sounds. A major difference, of course, is that the animals had developed this natural ability in the course of hundreds of thousands of years of evolution, whereas in the lab, it can be acquired after a relatively short training.

"With the right technology, one can induce a speeded-up evolution of sorts in the sensory brain," Amedi says.

More information: Shir Hofstetter et al, Topographic maps and neural tuning for sensory substitution dimensions learned in adulthood in a congenital blind subject, *NeuroImage* (2021). DOI: 10.1016/j.neuroimage.2021.118029