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Super Powers for the Blind and Deaf

The brain rewires itself to boost the remaining senses

By Mary Bates


It's a bird, it's a plane... Image: iStock/ Kriss Russell

It's an oft-repeated idea that blind people can compensate for their lack of sight with enhanced hearing or other abilities. The musical talents of Stevie Wonder and Ray Charles, both blinded at an early age, are cited as examples of blindness conferring an advantage in other areas. Then there's the superhero Daredevil, who is blind but uses his heightened remaining senses to fight crime.

It is commonly assumed that the improvement in the remaining senses is a result of learned behavior; in the absence of vision, blind people pay attention to auditory cues and learn how to use them more efficiently. But there is mounting evidence that people missing one sense don't just learn to use the others better. The brain adapts to the loss by giving itself a makeover. If one sense is lost, the areas of the brain normally devoted to handling that sensory information do not go unused — they get rewired and put to work processing other senses.

A new study provides evidence of this rewiring in the brains of deaf people. The study, published in *The Journal of Neuroscience*, shows people who are born deaf use areas of the brain typically devoted to processing sound to instead process touch and vision. Perhaps more interestingly, the researchers found this neural reorganization affects how deaf individuals perceive sensory stimuli, making them susceptible to a perceptual illusion that hearing people do not experience.

These new findings are part of the growing research on neuroplasticity, the ability of our brains to change with experience. A large body of evidence shows when the brain is deprived of input in one sensory modality, it is capable of reorganizing itself to support and augment other senses, a phenomenon known as cross-modal neuroplasticity.

Understanding how the brain rewires itself when a sense is lost has implications for the rehabilitation of deaf and blind individuals, but also for understanding when and how the brain is able to transform itself. Researchers look to the brains of the deaf and blind for clues about the limits of brain plasticity and the mechanisms underlying it. So far, it appears that some brain systems are not very plastic and cannot be changed with experience. Other systems can be modified by experience but only during particular sensitive periods (as is the case with language acquisition). Finally, some neural systems remain plastic and can be changed by experience throughout life. Discovering factors that promote brain plasticity will impact several areas: how we educate normally developing as well as blind and deaf children; rehabilitation after brain injury; and the treatment (and possible reversal) of neurodegenerative diseases and age-related decline.

Most of the research on cross-modal neuroplasticity has focused on blind individuals, who often have enhanced auditory abilities. Brain imaging studies show the visual cortex in the blind is taken over by other senses, such as hearing or touch, and contributes to language processing. However, researchers do not know as much about how deafness changes the auditory cortex. Helen Neville, one of the authors of the new study, previously showed people born deaf are better at processing peripheral vision and motion. Some animal studies indicate both vision and touch play a role in altered cross-modal organization of auditory cortex, but until now, the evidence in humans has been limited.

In the new study, Christina Karns, Neville, and Mark Dow of the University of Oregon asked how the early loss of hearing affected neuroplasticity in the deaf brain, and if that reorganization translated to altered perceptual abilities in deaf people. They were especially interested to see if deafness would affect how the brain processes touch and vision together, a question that had not been answered before now because it required precise tactile stimuli. Karns and her co-authors designed a unique device worn like headphones by the study's participants while inside an fMRI scanner. Flexible tubing, connected to a compressor in an adjacent room, delivered puffs of air to precise locations on participants' faces. These served as the tactile stimuli. Visual stimuli — brief pulses of light — were delivered through fiber optic cables mounted directly below the air-puff nozzle.

The researchers used the fMRI scanner to monitor changes in blood flow to different areas of the brain, with increased blood flow indicating an increase in brain activity. They paid special attention to an area known as Heschl's gyrus, which is the site of the primary auditory cortex in the human brain.

The participants included 13 congenitally deaf adults and 12 hearing adults for comparison. The deaf participants had more activation in the auditory cortex in response to touch and visual stimuli than did the hearing participants. Karns and her colleagues were surprised to find the primary auditory cortex in deaf people responded even more to touch than to vision.

The researchers took advantage of a known perceptual illusion in hearing people to look at how deaf brains processed both touch and vision together. The auditory-induced double-flash is a phenomenon in which a single flash of light, paired with two or more brief sounds, is perceived as multiple flashes of light. The researchers modified the illusion for their experiment by using a double puff of air as a tactile stimulus to replace the auditory stimulus. Deaf people were susceptible to the illusion of a double flash of light when a single flash was paired with double air puffs; hearing people were not.

The deaf participants all showed greater activity in Heschl's gyrus in response to the air puffs and light, but their responses differed in degree. Those with the highest level of auditory cortex activity in response to touch also had the strongest response to the illusion. This supports the interpretation that the double-flash illusion is a functional consequence of the altered cross-modal organization in the deaf brain.

Cross-modal plasticity can cause problems. If the brain has reorganized itself to compensate for the loss of hearing, what happens when hearing is restored? Stephen Lomber, a psychologist who studies cross-modal plasticity at the University of Western Ontario, compares it to a cottage you aren't using, so you let a friend stay there. The friend gets comfortable, rearranges the furniture, and settles in. If you come back, they may not want to leave. This could be why older people who are partially deaf find hearing aids confusing or unhelpful.

Cross-modal reorganization may also interfere with the success of cochlear implants. Incomplete reversal of deafness-induced brain reorganization might limit the benefit from cochlear implants, especially in children born deaf who receive implants after the age of four. These children, who have lacked auditory input since birth, may struggle with language comprehension and speech because the auditory areas of their brain have taken on the processing of other senses. Karns and other researchers studying cross-modal plasticity hope a better understanding of how the brain reorganizes will ultimately help deaf people. The ability to measure how much the auditory cortex has been repurposed for other sensory processing could help in designing intervention programs to retrain the auditory cortex to process sounds again. This research will not produce a real-life Daredevil, but it is a reminder that our brains have some hidden superpowers.

ABOUT THE AUTHOR(S)

Mary Bates earned her PhD in psychology from Brown University and is a science writer and blogger based in the Boston area. She has contributed to online and print publications including *Psychology Today*, the Howard Hughes Medical Institute News website, *Acoustics Today*, and the American Association for the Advancement of Science's Member Central blogs.