Can the blind 'hear' colors and shapes? Yes, show Hebrew University researchers

Jerusalem, March 9, 2014 -- What if you could 'hear' colors? Or shapes? These features are normally perceived visually, but using sensory substitution devices (SSDs) they can now be conveyed to the brain noninvasively through other senses.

In the Center for Human Perception and Cognition, headed by Prof. Amir Amedi of the Edmond and Lily Safra Center for Brain Sciences and the Institute for Medical Research Israel-Canada at the Hebrew University of Jerusalem, the blind and visually impaired are being offered tools, via training with SSDs, to receive environmental visual information and interact with it in ways previously unimaginable (demo on how to listen to colors and shapes via music is in this link: http://www.youtube.com/watch?v=jVBp2nDmg7E).

SSDs are non-invasive sensory aids that provide visual information to the blind via their existing senses. For example, using a visual-to-auditory SSD in a clinical or everyday setting, users wear a miniature camera connected to a small computer (or smart phone) and stereo headphones. The images are converted into "soundscapes," using a predictable algorithm, allowing the user to listen to and then interpret the visual information coming from the camera.

With the EyeMusic SSD (available free at the Apple App store at http://tinyurl.com/oe8d4p4), pleasant musical notes convey information about colors, shapes and the location of objects. A unique training program has been developed to teach the blind to extract and interpret visual information. Twenty short lessons come with the app and additional free training and games are available on the group website (http://brain.huji.ac.il/site/em.html).

After training in use of the SSD equipment, the blind achieve various complex visual-linked abilities. In recent articles in *Restorative Neurology and Neuroscience* and *Scientific Reports,* blind and blindfolded-sighted users of the EyeMusic software correctly perceived and interacted with objects, recognizing different shapes and colors, or reaching for a beverage (A live demonstration can be seen at http://youtu.be/r6bz1pOEJWg). The EyeMusic combined with visuo-motor learning could also guide fast and accurate movements.

Other studies, published in two prestigious scientific journals, *Neuron* and *Current Biology*, demonstrated that the blind could interpret complex images such as faces, everyday objects, houses, and outdoor scenes, conveyed by soundscapes (using the grayscale vOICe algorithm). They could also locate people's positions, identify facial expressions and read letters and words, (See YouTube channel http://www.youtube.com/amiramedilab for demonstrations)

Available on the App Store

Despite these encouraging behavioral demonstrations, SSDs are currently not widely used by the blind population. However, a recent publication earlier this year in *Neuroscience & Behavioral Reviews* indicated that the reasons that have prevented their adoption have changed for the better over the past few years. For instance, new technological advances enable compact, light, inexpensive SSDs to be run from smart phone apps. Additionally, new computerized training methods and environments boost training and performance.

New research findings over the past decade at the Hebrew University has shown that contrary to the long-held conception of the cortex being divided into separate processing areas for vision or hearing, many brain areas are characterized by their computational task. These brain regions can be activated by senses other than the one commonly used for the given task. Thus, even people who have never been exposed to the "original" sensory information (such as a person born blind who has never seen a single photon of light in his lifetime, are able to reconstruct an image when trained to decipher a soundscape. The researchers found that congenitally blind people who read by touch using Braille or by sound through the SSD use the same areas in the visual cortex to process the information as those used by sighted readers. A further example of sensory substitution was recently published in *Current Biology* by Ella Striem-Amit & Dr. Amir Amedi, showing that blind subjects "see" body shapes via their ears using SSD equipment and training.

There is a whole network of regions in the human brain dedicated to processing and perceiving body shapes, starting from the areas processing vision in the cortex, leading to the “Extrastriate Body Area,” or EBA, and further connecting to multiple brain areas that decipher people’s motion in space, their feelings and intents.

In tests with the blind, it was found that their EBA was functionally connected to the whole network of body-processing found in the sighted. This lends strength to the researchers’ new theory of the brain as a sensory-independent task machine, rather than as a pure sensory (vision, audition, touch) machine.

However, not only the view of the brain as a sensory machine is being challenged, but also the dynamics of sensory processes. While it has previously been thought that sensory information is processed in the brain initially in sensory cortices and then integrated in associative areas, new evidence shows multisensory responses even in primary sensory cortices, known as crossmodal effects. A recent examined the hypothesis that crossmodal effects are determined by the context in which the sensory inputs are delivered. Sighted participants were presented with both soundscapes derived from the vOICe SSD and their corresponding visual images. After learning to use the vOICe, the auditory soundscapes attenuated activation in the visual cortex. Moreover, while before learning using the vOICe, areas considered as "crossmodal" showed strongest activation in relation to visual stimuli, while after learning the activation was greater for auditory soundscapes. These results show that plastic changes due to SSD learning occur also in higher order associative areas.

“The human brain is more flexible than we thought,” says Prof. Amedi. “These results give a lot of hope for the successful regaining of visual functions using inexpensive non-invasive SSDs or other invasive sight restoration approaches. They suggest that in the blind, brain areas have the potential to be ‘awakened’ to process visual properties and tasks even after years or maybe lifelong blindness through use of the appropriate technologies and training approaches.”

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Link to a drop box folder with movies & images for press/media use:

https://www.dropbox.com/sh/r4by5tdz806m0oe/NBVIMK1Ra6

The Eye-Music app can be downloaded at https://itunes.apple.com/en/app/id805461054
Further information on how to listen to colors and shapes via music is on TEDx:
http://www.youtube.com/watch?v=jVBp2nDmg7E .