POSTER

Perceiving occlusion through auditory–visual substitution

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Background

Sensory-substitution prosthetic systems are based on the idea of substituting visual stimulation with stimulation from another intact sense such as audition or touch. Although such systems have been studied for almost 40 years (Bach-y-Rita 1968), they are still poorly understood. Here we ask whether we learn to perceive simple spatial properties using The vOICe (Meijer 1992), a system for visual-auditory substitution. The vOICe converts images to sounds according to a straightforward rule: images are scanned from left to righ, horizontal positions are converted to temporal position within 1s sound. Vertical pixel position is converted to frequency (lower frequencies meaning lower positions). Pixel intensity is converted to loudness. Thus each scan generates a complex sound signal having a regular mapping of sound features to image features.

Methods

We explored four properties of spatial layout : localization, orientation and occlusion. To study occlusion, we also needed to address grey value discrimination.Three participants were studied in four experiments. In all experiments participants had to attend daily sessions consisting of 100 trials over several weeks. Experiments ended when they answered correctly to more than 90% of the trials for three consecutive sessions. The first experiment tested the localization of a target rectangle among nine alternative locations. Blindfolded participants pointed to the location where they perceived the target rectangle. The second experiment tested the discrimination of a target color among two alternatives. We simultaneously showed two rectangles, one black and one white, and blindfolded participants had to point to the location where they perceived the white square. The third experiment tested the orientation of a target rectangle among two alternatives (horizontal or vertical). We showed rectangles with vertical or horizontal orientationss and different location. Participants had to point twice in the horizontal or in the vertical direction to signify the perceived orientation. The fourth experiment, finallly, tested the correct interpretation of the occlusion between two rectangles. We showed 32 occlusion patterns and participants had to point twice in the horizontal or vertical direction to identify the occluding rectangle.

Results

Participants learned to localize to a level close to 100% accuracy in about 30 days. Subsequently, they learned color discriminations in about 27 days. Finally, learning of orientation discriminations took only about 4 days. Thus learning was cumulative, color and orientation discrimination benefiting from having learned localization. However, the correct interpretation of occlusion between two rectangle remained more difficult . The percentage of correct responses remained less than 75% in each participant, even after extensive training (up to 43 sessions over a period of 2 months). The difficulty was related to specific occlusion patterns.

Conclusions

These problems may reflect specific limitations of auditory-visual substitution in prosthetic devices for the blind. Further research is needed to determine how they may be overcome.

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