P052

SINGLE SIDED DEAFNESS & ASYMMETRIC HEARING LOSS

Changes in auditory cortical activity contralateral to the stimulation related to improved auditory spatial ability after VR-based training

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OBJECTIVES

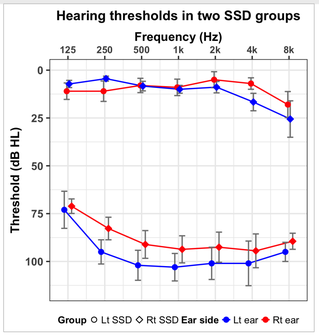
Patients with single-sided deafness (SSD) often struggle with sound localization, and there is an emerging need for intervention. While restoring hearing sensitivity in the deaf ear is challenging, auditory training for sound localization has shown its behavioral benefit. Previously, auditory cortical activity contralateral to the intact ear has been related to better localization behavior in SSD. In this fMRI study, we measured changes in auditory neural responses after auditory training pertaining to improving auditory spatial ability after virtual reality(VR)- based training for auditory localization.

METHODS

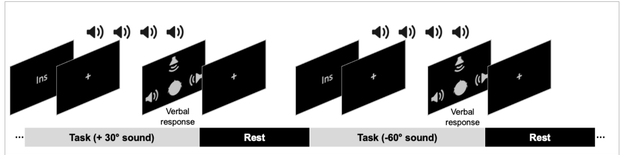
❖ **Participants**
- 14 patients with single-sided deafness (5 left-, 9 right-sided; mean age ± SD: 46.8 ± 13.4)

❖ **VR training protocol**
- Auditory stimuli were individually recorded, presented binaurally, and aligned with virtual speakers (Shim et al., 2023).
- 45-minute session x 3 sessions/week x 6 weeks = total18 sessions
- Four difficulty levels were adapted to individual performance.
- Training effects were evaluated using Root Mean Square Error (RMSE).

❖ **fMRI protocol**
- Block design: 14 blocks x 3 sessions with TR delay protocol
- MRI scanner: Siemens Magnetom Skyra (3T), TR=3s, TE=30ms
- Active noise cancellation using OptoACTIVE headphones with FOMRI-III microphone (Optoacoustics Ltd, Israel)



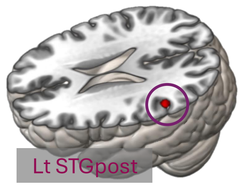
❖ **Sound localization task in MRI scanner**
- Stimuli presented in 5 directions:
  (Lt.) -60°, -30°, (center) 0°, (Rt) 30°, 60° at MCL (of better ear)
- Stimuli: speech sound (1-9 digit in Korean),
  binaural recordings for each subject (Callan et al., 2015)
- Verbal responses were asked per block (choice: Left, Front, and Right)

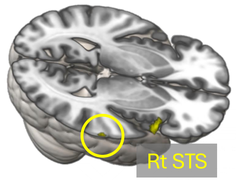


<fMRI experimental paradigm>

❖ **Data analyses**
- SPM12 and R packages used for data processing
- Signal intensity from two regions of interest with significant group differences was extracted and linked to training effects

❖ **Region of Interests (ROIs)**
- Our previous study (Shim et al., under review) in 35 SSD patients with sound localization tasks has shown a correlation between neural activity and behavioral performance in two key regions:
1) Left posterior Superior Temporal Gyrus Area (Lt STGpost): The LSSD group revealed increased neural activity in this region, which contributed to improved sound localization performance.
2) Right Superior Temporal Sulcus (Rt STS): The RSSD group noted increased activity in this region, which was significantly correlated with enhanced localization accuracy.
- The current study investigated changes in neural activity and performed a correlation analysis with behavioral measures within two regions of interest (ROIs).

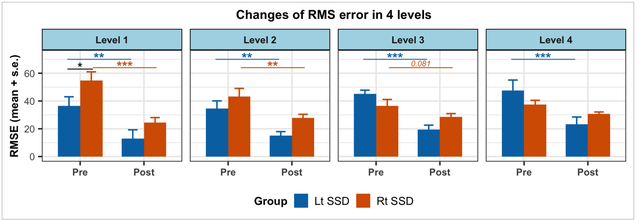


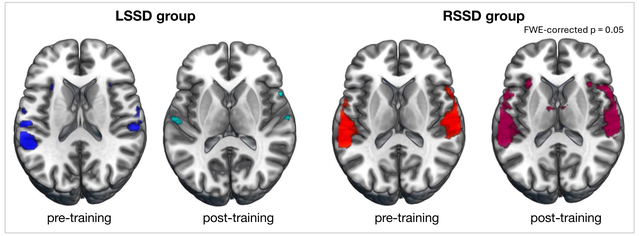


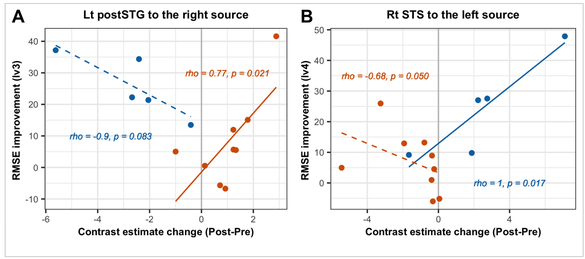
RESULTS

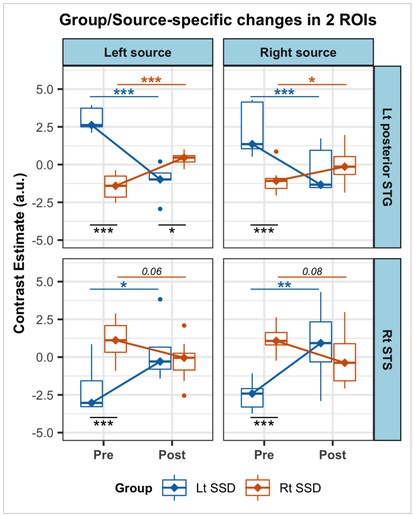
❖ After six weeks of VR training, both RSSD and LSSD groups showed improved auditory localization ability

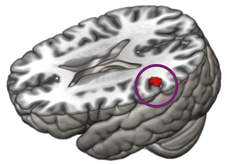
❖ Pre- and post-training fMRI revealed significant neural responses in **bilateral auditory cortices** and the **cingulo-opercular network (CON)**, with no within-group differences but observed group differences in auditory regions.











❖ The increased activity in the cortex contralateral to the intact ear decreased after training
❖ Changes in signal intensity in these regions correlated with improved auditory localization
• More increased activity in the cortex ipsilateral to the intact ear was related to better improvement in behavior after training
❖ We are cautious to be conclusive because of the small number of subjects.

CONCLUSION

VR-based auditory training for sound localization led to improved auditory spatial ability in patients with single-sided deafness (SSD). The fMRI results revealed increased neural activity in auditory regions contralateral to the intact ear, with changes in these regions correlating with behavioral improvements in localization. These findings suggest that auditory training induces cortical adaptations that enhance spatial hearing, offering a different mechanism than monaural hearing experience.

REFERENCES

• Shim, L., Lee, J., Han, J.H., Jeon, H., Hong, S.-K., Lee, H.-J., 2023. Feasibility of virtual reality-based auditory localization training with binaurally recorded auditory stimuli for patients with single-sided deafness. Clin Exp Otorhinolaryngol.
• L Shim, J Kim, G Kim, HJ Lee. Ear-specific neuroplasticity for sound localization in individuals with single-sided deafness. *Under review*