Title: Neural Correlates of Auditory Distance Perception and of Auditory Distance Cues

Keerthi Doreswamy[1], Jyrki Ahveninen[2], Samantha Huang[2], Stephanie Rossi[2], Norbert Kopco[1]

[1]Institute of Computer Science, P. J. Safarik University, Kosice, 04001, Slovakia, [2]Athinoula A. Martinos Center for Biomedical Imaging, Department of Radiology, Harvard Medical School/Massachusetts General Hospital, Charlestown, MA, 02129, USA

Background:

Perceiving the sound source distance is of key value in many everyday activities. The psychoacoustics of distance perception and its neuronal correlates are poorly understood. Previous studies identified planum temporale (PT) and superior temporal gyrus (STG) as auditory cortical areas important for intensity-independent auditory distance processing based on the direct-to-reverberant energy ratio (DRR) and the interaural level difference (ILD) cues. However, it is not clear whether the area represents the distance percept per se and/or one of the intensity independent acoustic cues ILD and/or DRR. In a previous study [Doreswamy et al. (2021) ARO Abstract #M7], we conducted behavioral and neuroimaging experiments in a virtual reverberant environment. Here, we perform advanced computational analyses to identify the cortical areas encoding the distance cues and distance percepts.

Methods:

The auditory distance stimuli were simulated using a single set of non-individualized binaural room impulse responses (BRIR) measured on a listener that did not participate in this study. The auditory stimuli were broadband noise bursts varying in distance (15–100 cm) on the left-hand side along the interaural axis while the ILD/DRR cue availability was manipulated such that the cues varied with distance either congruently or incongruently. The behavioral experiment involved a distance discrimination task for various stimulus pairs. The discrimination performance was used to confirm that distance perception with congruent cues is better than with incongruent cues.

The imaging experiment was a sparse-sampling adaptation fMRI in which the stimuli were random sequences of noise bursts presented from various distances either with congruent or with incongruent cues. Univariate and split-half correlation multivariate pattern analysis (MVPA) were performed on the previously identified ROIs in volume space and compared to the previous surface-based results.

Results:

Behavioral results showed that subjects performed better when cues varied with distance congruently. There were no significant effects in fMRI univariate contrast between congruent vs incongruent stimuli, while significant contrasts were observed between stimuli containing DRR and ILD-only stimuli. On the other hand, MVPA found a significant difference between congruent and incongruent conditions. All these effects were observed in the right hemisphere, contralateral to the stimulus azimuth.

Conclusions:

These results suggest that the auditory cortex ROI encompassing the PT and STG encodes both the auditory distance cues and the distance percepts. And, while the cue encoding is non-distributed, detectable by univariate analysis, the percepts are encoded in a distributed network detectable only by multivariate analysis. However, the extent to which the encoding of cues and percepts is overlapping cannot be determined by the current analysis.

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