The Influence of Prior Experience on Distance Perception in Fixed and Varying Environments

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Background: Auditory distance perception depends on listeners' ability to adapt to the surrounding acoustics. Prior studies have shown that accuracy improves with implicit calibration in reverberant rooms but not in anechoic conditions, suggesting that "room learning" relies on reverberation-specific cues, though the underlying processes remain unclear. In a previous study [Kopčo and Fedorenko, 2024, ARO PS8 Abstract], we examined how environmental consistency and preceding exposure shape performance, showing that initial exposure to consistent simulated environments supports accurate distance judgments, evaluated by using the stimulus-response correlation, whereas inconsistent exposure hinders them. In the present work, we extend this analysis by evaluating response biases and by examining the acoustic effects of the environments on the distance cues.

Methods: Three virtual environments were tested (anechoic, classroom center, classroom corner), with sources presented from medial and lateral directions. Stimuli were 5-burst pink noise sequences, level-roved to minimize loudness cues. On each trial, one of nine distances (15–170 cm, spaced approximately logarithmically) was presented. A run consisted of 45 trials in which the stimulus direction was fixed while the environment could be fixed or randomly chosen on each trial. A session consisted of 8 runs. Participants (N=8) were split into two groups: one began with 6 sessions in a fixed environment followed by 6 in mixed environment, while the other experienced the reverse order.

Results: Overall performance, measured by correlation coefficients, revealed a clear effect of exposure order. The group that began in consistent conditions achieved higher accuracy across all rooms, but their performance declined upon switching to variable conditions, with the magnitude of deterioration depending on room type and source direction. In contrast, the group starting with variable conditions performed significantly worse, and subsequent exposure to consistent conditions yielded only modest improvements. Bias analyses showed systematic underestimation of distances in the anechoic room and overestimation in reverberant rooms, consistent with the use of a single Direct-to-Reverberant Ratio (DRR) mapping across contexts. Performance was generally higher in reverberant environments than in anechoic, and for lateral sources compared to medial ones, indicating effective utilization of both DRR and Interaural Level Difference (ILD) cues when available. The acoustic analysis showed that the cues were considerably altered in the corner vs center of the room.

Conclusions: These findings demonstrate that listeners rely on prior experience to calibrate distance perception in specific environments. This room-specific tuning is disrupted when acoustic conditions vary rapidly, leading the auditory system to collapse multiple contexts into a single generalized mapping. Thus, auditory distance perception is a dynamic, experience-driven process, constantly tuned by the context of the preceding experience.

[Work supported by HORIZON-MSCA-2022-SE-01 Grant No. 101129903, APVV-23–0054]