Effects of preceding exposure on distance perception in varying and fixed virtual environments

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Background: Previous research showed that listeners calibrate to the acoustic environment when judging distance in real reverberant rooms, resulting in gradually improving performance even without explicit training. In contrast, similar enhancements are not observed in anechoic environments, suggesting that the improvements are due to tuning to specific reverberation-related cues in a given room. The mechanisms underlying this "room learning" are not well understood. A previous study [Schoolmaster, Kopčo, & Shinn-Cunningham, J Acoust Soc Am 113, 2285, 2003], examined 1) how consistency in simulated room presentation affects performance, and 2) whether previous exposure to consistent vs. inconsistent simulation influences the ability to interpret the distance cues in different rooms. It showed that distance perception is more accurate when the simulated environment is consistent than randomly chosen from trial to trial. Here, we further analyze the data to examine how they depend on type of simulated room (anechoic vs. reverberant) and the direction of stimulus presentation (frontal vs. lateral). And, we develop a model that proposes how subjects combine available distance cues in different contexts.

Methods: Three environments were simulated in the experiment, anechoic, center of a classroom and corner of a classroom. Participants were divided into two groups. The first group started with 6 sessions in a fixed environment (each session maintaining a consistent room condition in a random order) and then proceeded to 6 sessions in a mixed environment (room conditions randomly selected from trial to trial). The second group proceeded in the reverse order. Each session comprised eight runs, each consisting of 45 trials. Nine distances ranging from 15 to 170 cm were presented randomly within each run. Each run kept the direction of simulation (frontal vs. lateral) fixed.

Results: Overall performance, evaluated using the correlation coefficient, showed a complex pattern of results. The group that started with inconsistent room generally performed poorly, and even when later exposed to consistent simulation only improved performance slightly. On the other hand, the group starting with consistent simulation performed very accurately in each room and, when switched to inconsistent simulation, its performance deteriorated differentially depending on simulated room and direction. Analysis of response biases showed that these results are consistent with a model that assumes that 1) the listeners use room-specific weighting parameter values to combine the distance cues in consistent simulation, but that 2) they use one non-specific weighting parameter set when simulation is inconsistent.

Conclusions: These results show that listeners use past experience when calibrating to specific environments and that they might not be able to use an optimal room-specific tuning even for dramatically different environments (like anechoic vs. reverberant) when the environments switch rapidly.

[Work supported by Horizon Europe HORIZON-MSCA-2022-SE-01 grant N° 101129903 and VEGA 1/0350/22]