An Investigation into How Localisation of Virtual Sound Sources is Affected by Reverberation

Jack Miller | Q12889601 | BEng (Hons) Audio and Acoustic Engineering

Supervisor: Juan Battaner-Moro

1 Introduction

Virtual surround sound is found in many applications, from personal media consumption to virtual conferencing. In attempt to simulate a realistic sound environment, audio is processed with binaural cues and room reflections. Binaural cues are applied to audio via convolution of HRTFs measured in an anechoic chamber, in which only the direct sound is present. This may not include enough cues for accurate localisation *(Fukui & Nishio, 2013)*. However other studies *(Giguère & Abel, 1993)* find that sound localisation accuracy decreases with increasing reverberation time. The effect that reverberation has on sound localisation was investigated, with research and considerations into possible interactions, such as the precedence effect *(Litovsky, et al., 1999)* and ITD dominance.

2 Objectives

- Create a database of directional audio that has a mixture of dry and reverberant audio.
- Provide lossless method of sharing audio to participants online.
- Collect subjective data from participants, measuring accuracy of perceived direction.
- Compare subjective results with findings from similar experiments.

3 Methodology

A database of HRIRs, containing 187 angles of azimuth and elevation, was obtained online from the Fraunhofer Society LISTEN project. A dry mono audio sample recorded in an anechoic chamber was obtained online, consisting of multiple high frequency tones spanning a wide frequency range from 1.2-15kHz.

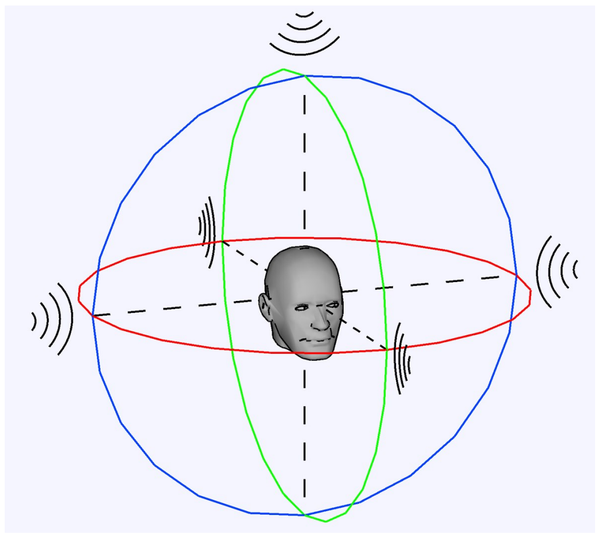

Figure 1 Visualisation of angles used

5 angles were chosen *(Fig.1)* from the database considering the cone of confusion effect *(Wallach, 1939)* and were convolved with the audio using MATLAB live script. The directional audio was then processed with 3 variants of artificial reverb using Audacity's 'Freeverb' Schroeder reverb algorithm. The 3 variants simulated a small, large and cathedral sized room to cover a full range of reverberant settings. A set of 20 audio files were created: 5 dry and 15 reverberant. Audio files were distributed (lossless) to subjects via Google Drive and their perception of direction was recorded via Google Forms questionnaire.

4 Results

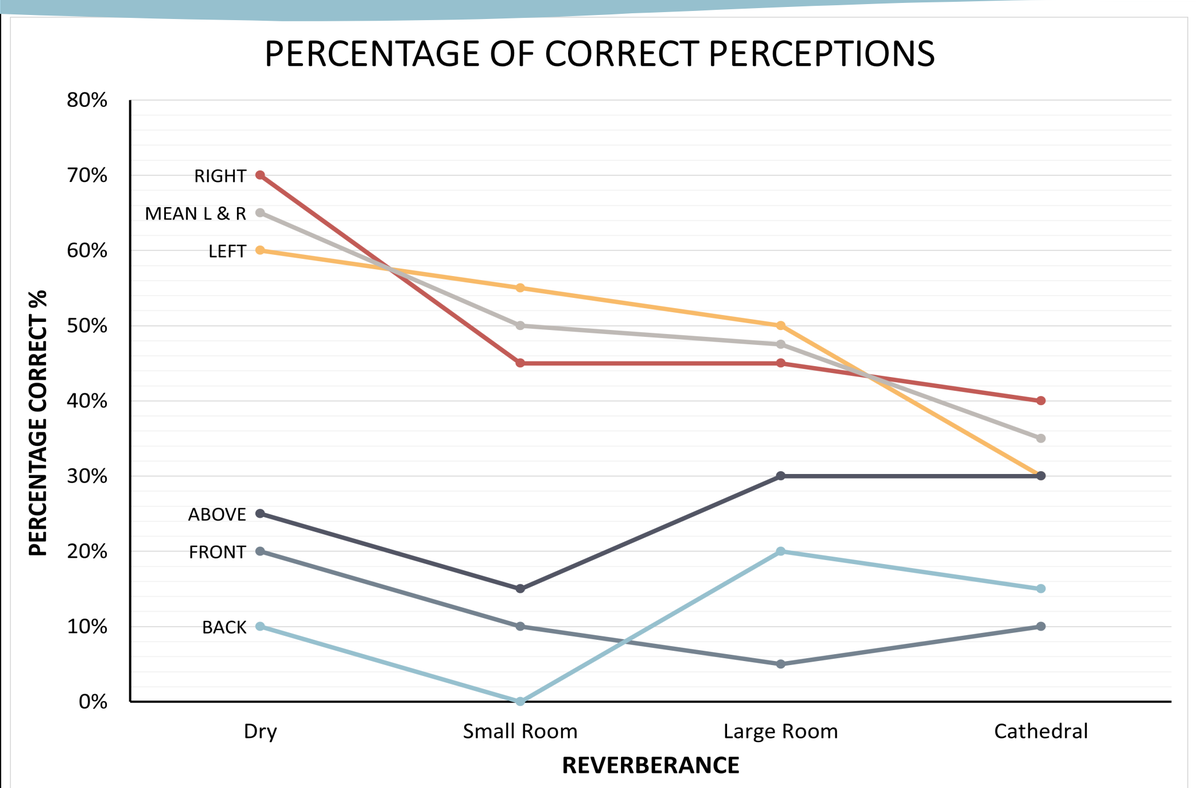

Figure 2 Subjective results of correctly perceived angles

Results for left and right azimuths showed a strong correlation between increasing reverb and decreasing correct perceptions. Dry audio had 60-70% accuracy that steadily decreased to 30-40% for the highest reverb setting. For front, back and above directions, no correlation was shown due to the front-back confusion effect *(Howard & Angus, 2017).*

5 Conclusion

The project was deemed successful as results for left and right angles reinforced previous studies that found localisation ability decreased with increasing reverberation. However, for front, back and above angles, the secondary binaural cues such as pinnae reflections were not strong enough to differentiate between angles with identical ITD and ILD. The front-back confusion effect was bolstered by non-individualised HRTFs and headphone sound reproduction *(Wightman & Kistler, 1989)*.

References

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