Perceptual weighting of elevation localization cues across frequency

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Publication date:
2019

Document Version
Publisher's PDF, also known as Version of record

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Citation (APA):
Perceptual weighting of elevation localization cues across frequency

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Introduction

Much research has been conducted on the integration of information of binaural lateralization cues over frequency. Macpherson and Middlebrooks (2002) showed that listeners weight interaural time differences (ITDs) more strongly at low than at high frequencies, while interaural level differences (ILDs) are weighted more strongly at high frequencies. These findings were coherent with the proposed duplex theory of Lord Rayleigh (1907). Other studies have confirmed that binaural information is integrated over frequencies in the binaural system to lateralize sounds (Buell and Hafter, 1991; Woods and Colburn, 1992) using a spectral weighting function (Ahrens et al., 2015). While these studies investigated the weighting of information over frequency in horizontal plane, no such weighting exists for vertical (elevation) localization. In this study, we aimed to investigate if certain frequency areas are perceptually weighted higher than others. Furthermore, predictors of perceptual weights in the head-related transfer functions (HRTFs) were investigated.

Methods

Fig. 1 A) The listeners were instructed to rate if a test stimulus was perceived above/below a reference stimulus. B) The test stimulus contained seven 1 ERB wide noise bands with randomly permuted individual HRTFs from seven elevations. The reference stimulus contained the same frequency bands but all with an elevation of ϑ=0°. An example: test stimulus is shown in light grey and the reference stimulus in dark grey. Each stimulus was 300ms in duration. The procedure was repeated 445 times for each condition.

Fig. 2 Perceptual weights calculated from a multinomial regression analysis for the wide frequency range condition. The grey lines represent the individual results from the 11 listeners and the blue line the mean over the listeners. A) Azimuth angle of 15° to the left. B) Azimuth angle of 45° to the left.

Perceptual elevation weighting

Relation between perception and HRTF features

Discussion & Conclusions

- The frequency band of 6.4 kHz is perceptually weighted largest with respect to elevation, however the intra-subject variation is large.
- The magnitude variation predictability over the elevations of the individual HRTFs correlates with the perceptual weights.
- A narrow frequency range seems to lead to less reliable perceptual weighting results.
- Results are a perceptual extension to directional/boosted bands (Blauert, 1997).
- Step towards a weighting function for computational models (e.g. Zonooz et al., 2019)

We would like to thank the complete Audio Team from the Facebook Reality Labs, particularly Rasih Mehra, Philip Robinson and Henrik Hasager. Thank you to Isaac Engel for the headphone equalization software.

Acknowledgments

Icons: Head by Yorlmar Campos from the Noun Project, loudspeaker by Symbolon from the Noun Project, finger by Adrien Coquet from the Noun Project.