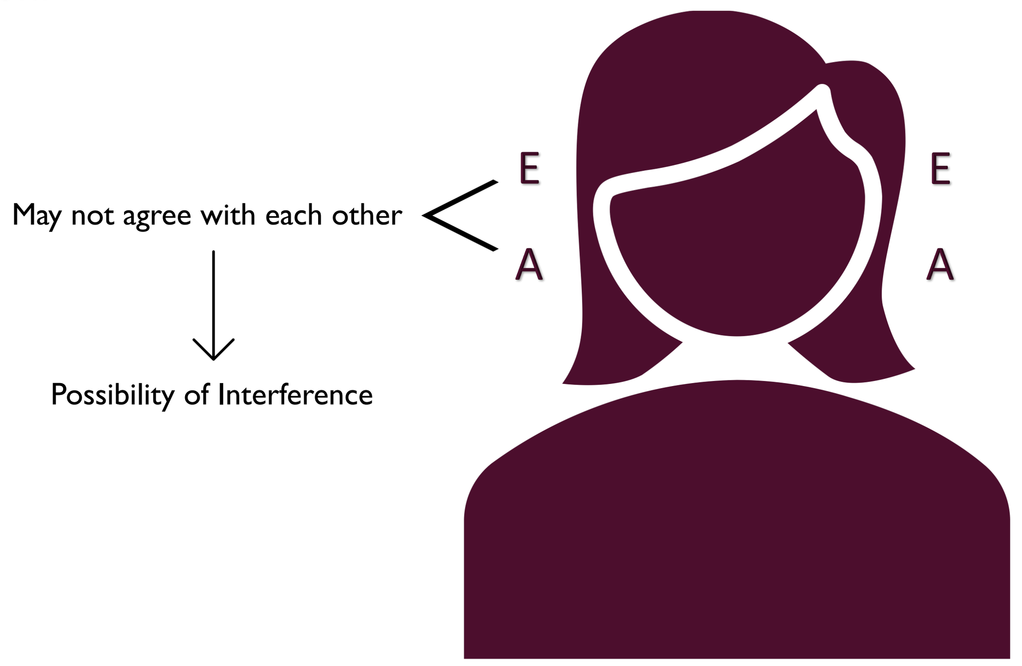
Spectral Weighting Analysis of Sound Localization with Simulated EAS Listeners

Jwala Rejimon, B.S.[1], G. Christopher Stecker, Ph.D.[2]

School of Medicine, The University of North Carolina at Chapel Hill[1], Spatial Hearing Lab, Boys Town National Research Hospital, Omaha, NE[2]

INTRODUCTION

Binaural interference refers to the reduction of binaural cue sensitivity in a target stimulus in the presence of a spectrally remote interferer. Binaural Interference is thought to especially impact hearing-impaired patients with electric-acoustic stimulation devices (EAS) due to the possibility of conflicting information.



- Van Ginkel et al. (2019) investigated this by measuring ITD/ILD thresholds in low-frequency noise bands with high-frequency Gabor click train (GCT) distractors.
- They found that interference effects were positively correlated with the degree of spectral overlap between the target and distractor.
- In this study, we followed up on Van Ginkel's experiment by investigating the specific contributions of the different frequency components in simulated EAS binaural hearing conditions.

AIMS

EXPERIMENT 1:

- To investigate the individual contributions of the different frequency bands in simulated EAS listening conditions
- To determine the dependence of perceptual weighting on the degree of spectral overlap

EXPERIMENT 2:

- To investigate if binaural interference reflects obligatory weighting of the spectral region of the interferer
- To determine if listeners can volitionally shift weight off the distractor and onto the target (ignore the centered click trains and localize the noise)

METHODS

PARTICIPANTS:

	N	Age Range	Gender (M/F)
Listeners	11	22—53	10 F, 1 M

All participants had self-reported normal hearing—no audiometric testing was performed due to the remote nature of the experiment.

METHODS

STIMULI:

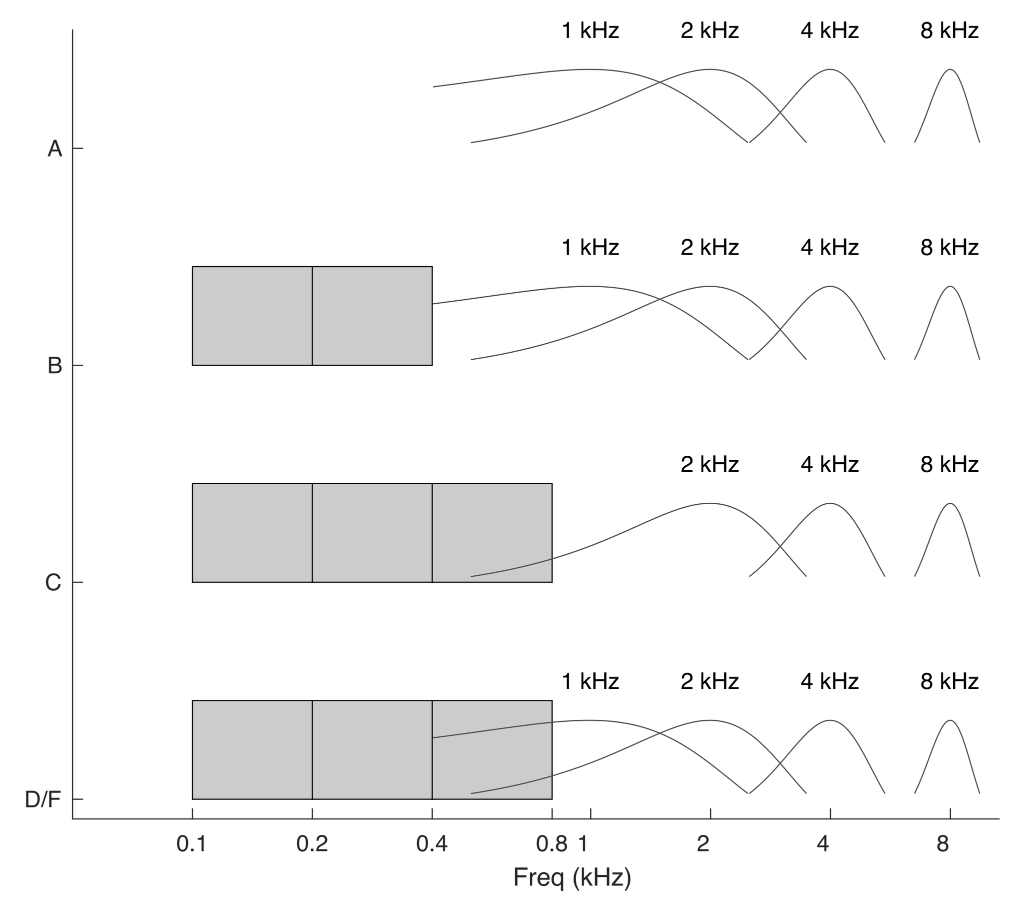


Figure 1: Stimuli consisted of 4 Gabor click trains and 3 low-frequency bands of noise. In conditions A—D, various components of the stimuli were silenced to observe how the perceptual weights would shift as the degree of spectral overlap was manipulated. The stimulus duration was set to 100 milliseconds and the presentation level was 60 dB SPL per component.

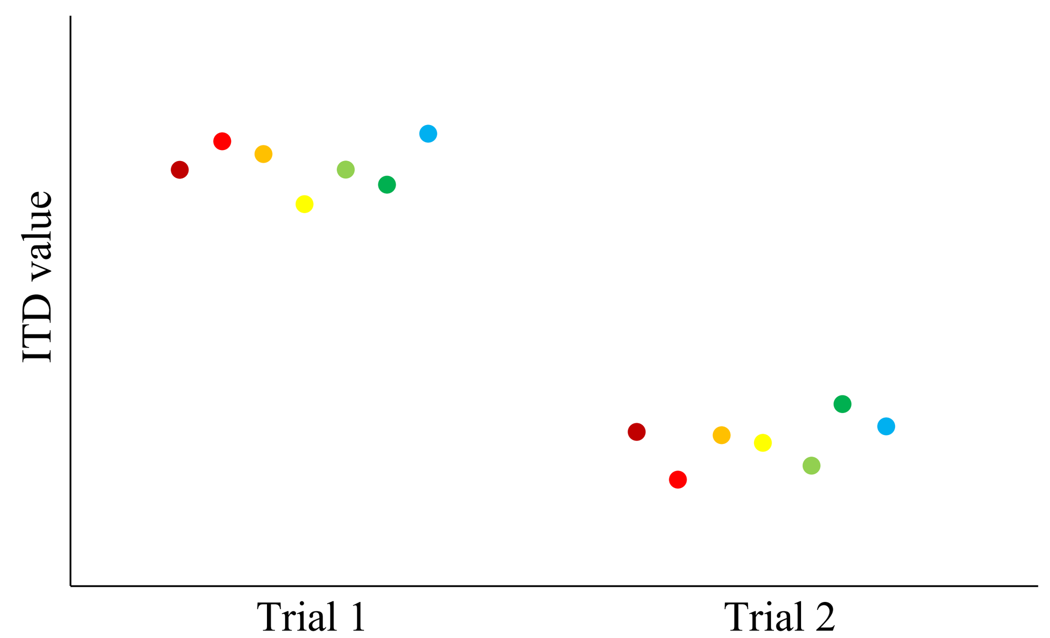


Figure 2: ITD and ILD values applied to each component were calculated as the sum of a shared "base" ITD and ILD (shared across all components) and a unique "jitter" ITD and ILD (assigned randomly and independently across components and trials). In Experiment 2, however, the click trains remained centered while the noise bands were to be localized.

TASK AND APPARATUS:

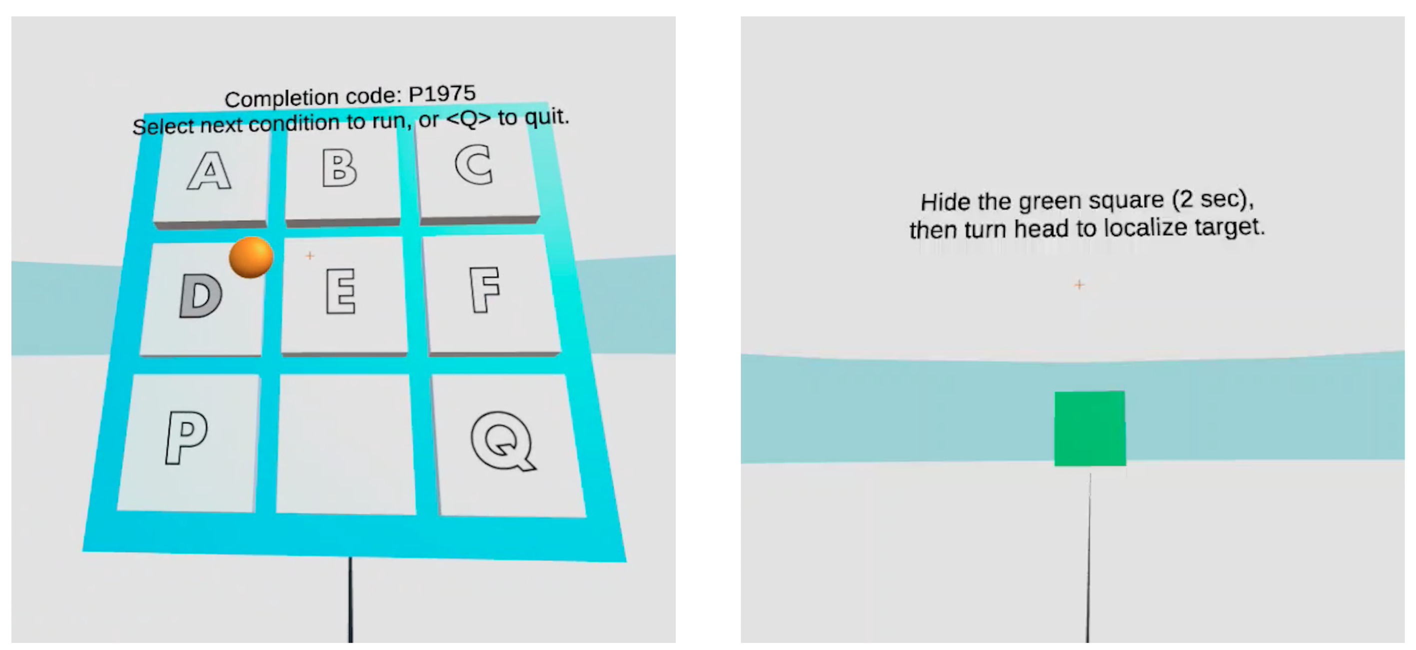


Figure 3: Stand-alone virtual reality (VR) headset and circumaural headphones (see Figure 5) were used in conjunction with a customized version of A-SPACE, a program developed by one of the authors (GCS) to control perceptual experiments in VR.

PROCEDURES AND ANALYSIS:

- All testing and consenting was done remotely
- Testing equipment was sanitized and delivered to participants' residences in a contactless manner
- Participants completed 6 runs of conditions A through D, presented in counterbalanced order, followed by 8 consecutive runs of condition F
- Multiple linear regression was used to relate the participants' rank-transformed responses onto the actual ILD and ITD values of each component (See Folkerts and Stecker, 2019)

RESULTS

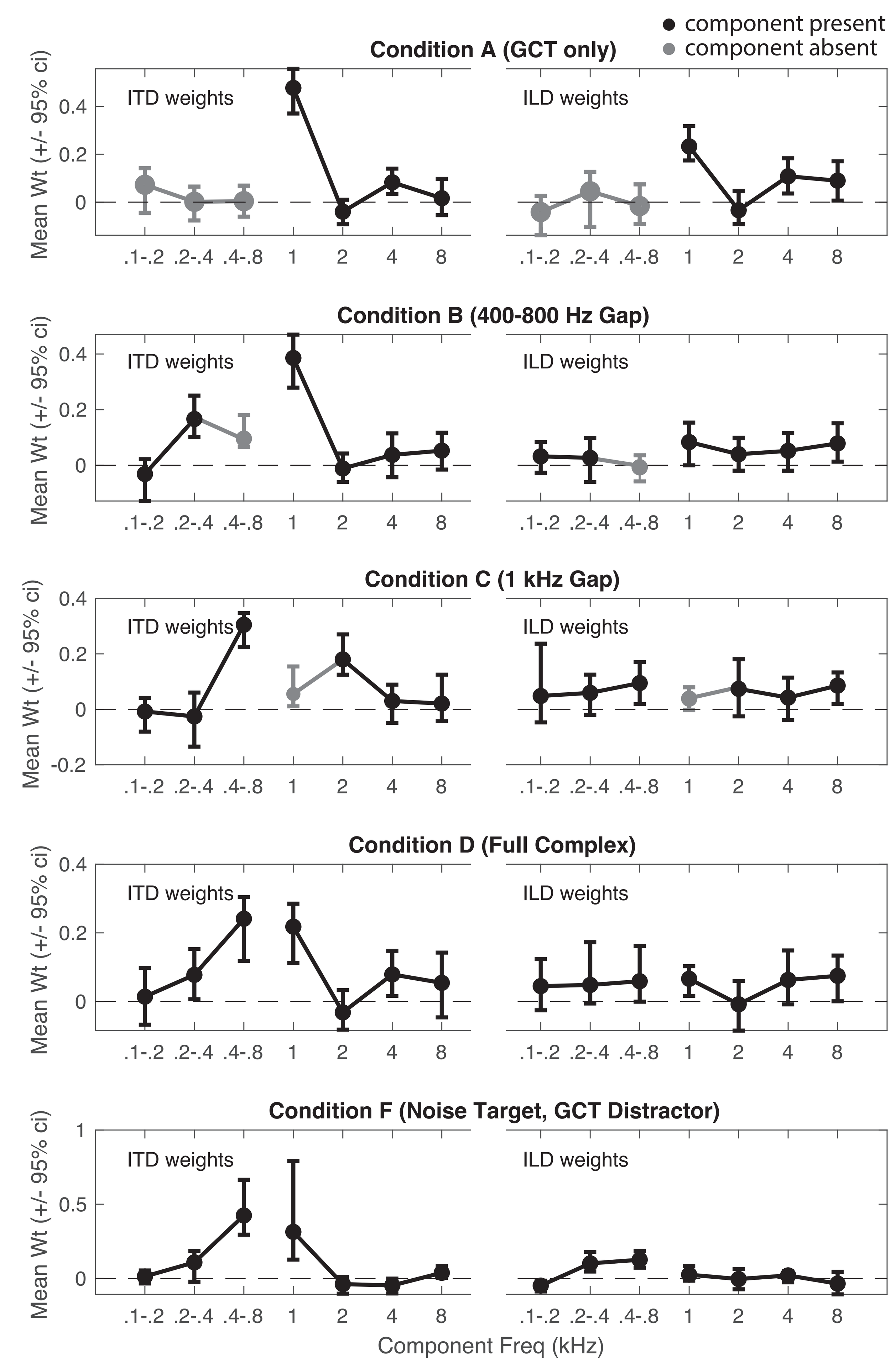


Figure 4: Spectral Weighting Functions are shown for conditions A through F. Findings suggest that ITD weights were consistently highest in the 400—1000Hz regions. In Experiment 2, where the click trains served as distractors and the task was to localize only the noise, the results were highly variable across subjects.

CONCLUSIONS

- Experiment 1 results exhibit a pattern of perceptual weight being highest between 400Hz and 1000Hz. This concurs with prior research in the lab (Folkerts and Stecker, 2019) and is consistent with previously established "ITD dominance region" (Bilsen and Raatgever, 1973).
- Experiment 2 results exhibit a slight pattern of volitional shifting of perceptual weight from the click trains to the noise bands, but there is high variability between subjects.
- Some subjects in Experiment 2 displayed improvement in their ability to shift perceptual weight—this indicated a possibility of learning.

IMPLICATIONS:

- Ability to reproduce booth testing using virtual reality (VR) headset opens up possibilities for remote binaural cue testing in future research
- Possibility of expanding VR testing into clinical settings

LIMITATIONS:

- Unable to audiometrically verify that participants had normal hearing
- Heterogeneity across subjects and high variability in Condition F
- Testing over headphones produces an internalized percept whereas a free-field set-up produces an externalized percept of the sound

Figure 5: A standalone VR headset (Oculus Quest 2) along with calibrated circumaural headphones (Sennheiser HD 280) were used to deliver auditory and visual stimuli.

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