Neural Mechanisms of Spatial Release from Masking in Vocoded and Non-Vocoded Environments

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Do broadband interaural level differences modulate hemodynamic activity in auditory-related areas for vocoded or broadband sound?

1. Introduction

- Hemodynamic response in auditory cortex (superior temporal gyrus, STG) increases during a spatial selective attention task when the masker is speech vs. noise [1].
- Zhang et al. used interaural time difference (ITD) cues to separate target and masker.

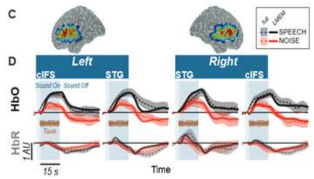


Fig. 1 from [1]. High-IM elicits stronger task-evoked responses than low-IM across STG and cIFS.

- Cochlear Implant (CI) users do not have robust access to ITD cues [2], but may benefit from magnified interaural level difference (ILD) cues ([3], Figure 2)

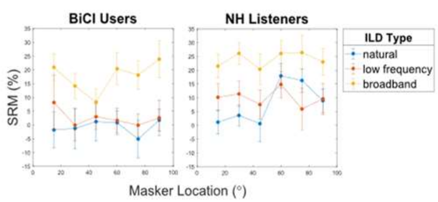
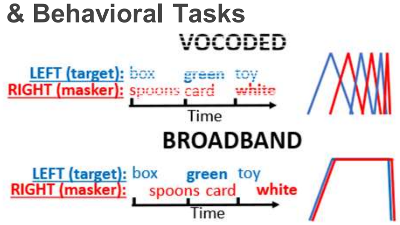


Fig. 2. Broadband ILD cues improve SRM over naturally-occurring ILD cues in both normal hearing (NH) and bilateral CI users (BiCI)

Hypotheses:

1. ILD cues can provide a similar amount of spatial release from masking (SRM) as do ITD cues, as indicated by hemodynamic response in STG and lateral prefrontal cortex (LPFC).
2. Hemodynamic response is relatively weak when target and masker are co-located and when target and masker are ideally separated.
3. Vocoding necessitates magnified ILD cues to elicit a similar hemodynamic response.

2. Stimuli & Behavioral Tasks



3. Methods

- Subjects were asked to attend to a target sound on the left and indicate the arrival of a color word with a button press.
- **Conditions**:
  - Target and Masker were separated using ITD cues (ITDSpeech, ITDNoise), or various ILD magnitudes (ILD0, ILD5, ILD10, ILD20, ILD30, ILDInf).
- **Subjects**:
  - Self-reported normal hearing listeners
  - 34 subjects Vocoded Experiment
  - 39 subjects Broadband Experiment

4. Data Collection and Analyses

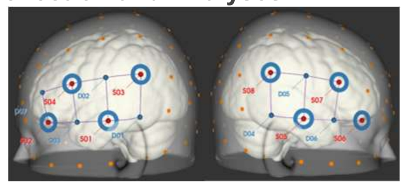
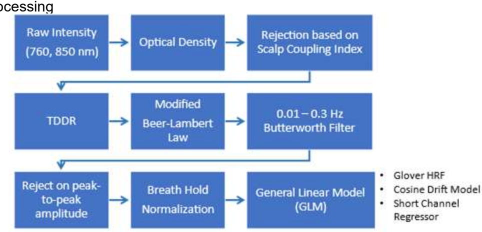


Fig. 3. Our optode montage covers superior temporal gyrus (STG) and lateral prefrontal cortex (LPFC).

- 8 source x 8 detector NIRSport2 fNIRS system (NIRx)
- fNIRS Data Processing



  - Select single channel in each region (STG, LPFC) with strongest ITDSpeech – ITDNoise difference.

5. Spatial cues do not modulate hemodynamic activation in STG.

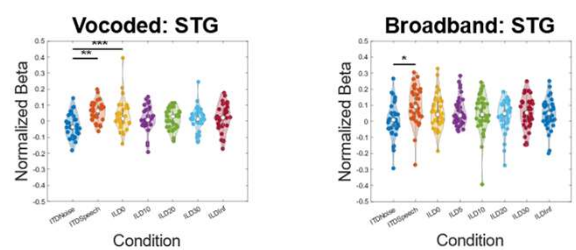


Fig. 4. Hemodynamic activation (Beta) values across condition in STG.

6. Spatial cues do not modulate hemodynamic activation in lateral PFC.

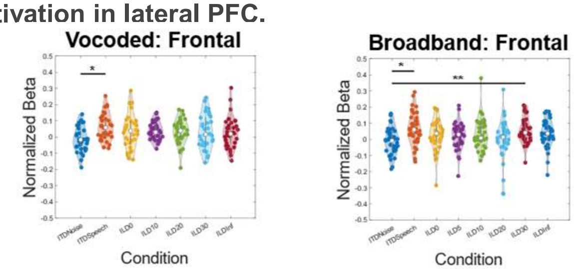


Fig. 5. Hemodynamic activation (Beta) values across condition in LPFC.

7. Behavioral sensititivy is consistent across condition and shows large intersubject variability.

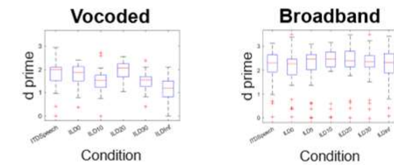


Fig. 6. Behavioral sensitivity (d-prime) across condition.

8. Hemodynamic activation is skewed to the right hemisphere with broadband stimuli, and bimodal with vocoded stimuli.

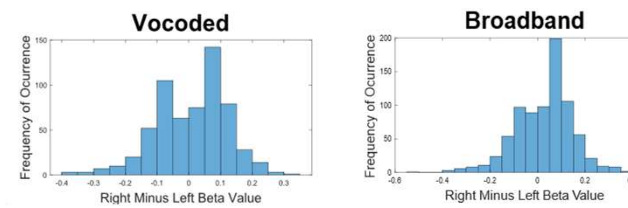


Fig. 7. Difference in activation between corresponding left and right channels.

9. Stronger activation is observed in broadband environments.

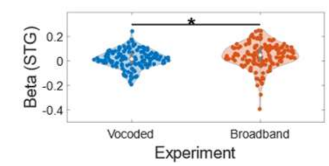


Fig. 8. Hemodynamic activation in STG in all ILD separated conditions (excluding co-located). Significantly larger activation is observed in broadband conditions

10. Summary and Next Steps

Summary

- Hemodynamic activity does not seem to be modulated by degree of broadband ILD cues.
- Lateralization of hemodynamic activity may provide insight into spatial auditory attention.
- Hemodynamic activity in this experiment may be driven mostly be properties of the stimuli, rather than attentional processes.

Next Steps

- Image more medially in prefrontal cortex on a similar task, and compare with effort and attention literature ([4], [5]).
- Include a more specific montage, and use 3D head imaging to register optical probes to the scalp.
- Compare the temporal and spatial aspects of the two experiments individually.
- Compare fNIRS with other neural measures of spatial attention (EEG, fMRI)

References

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Acknowledgements
This work is supported by: NIH RO1-DC019126, NIH R21-DC018408. Poster outline from Dr. Sahil Luthra.