A New Acoustic Space for Hemispheric Asymmetries
investigated by dichotic listening

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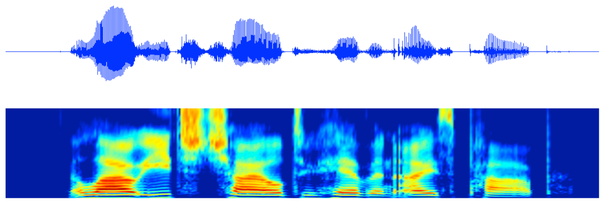
Introduction

- Speech contains a wide range of information
  e.g. speaker's identity, gender, tone, message, etc.
- This information varies across frequency (spectral dimension) and time (temporal dimension).
- Changes in frequency and time (spectrotemporal modulations) can capture unique characteristics of speech.

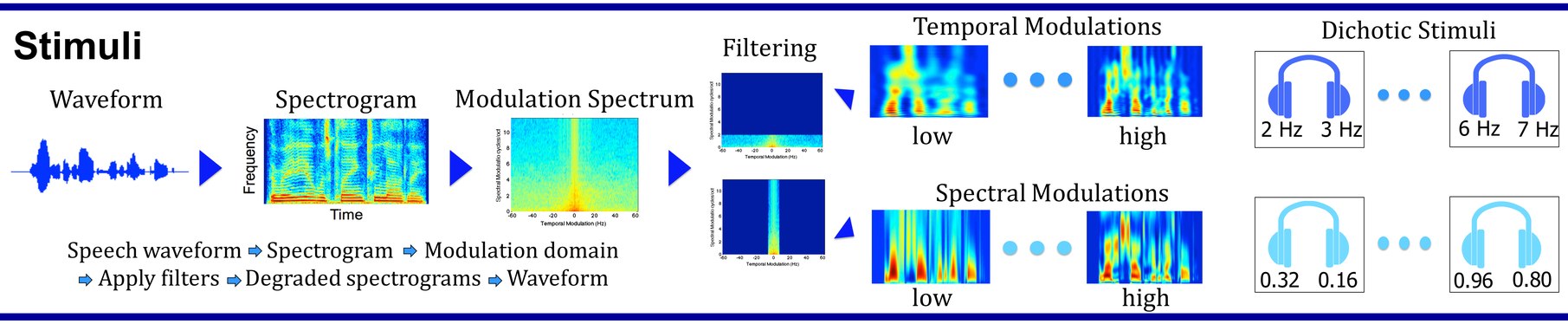


- To characterize these spectrotemporal modulations, we use a novel speech filtering technique.
- The modulation transfer function of speech (Elliott & Theunissen, 2007; Chi et al. 1999) enables us to parametrically examine this acoustic space.
- Here, we investigate the left and the right hemispheres' different sensitivities to spectrotemporal auditory cues (Poeppel, 2003; Zatorre, Belin, & Penhune, 2002)

Aim

- Map behavioral responses along the spectrotemporal axes using a novel filtering approach.
- Specifically, how these two axes contribute to affect intelligibility and gender identification.
- Investigate the hemispheric asymmetry in processing speech through dichotic listening tasks.

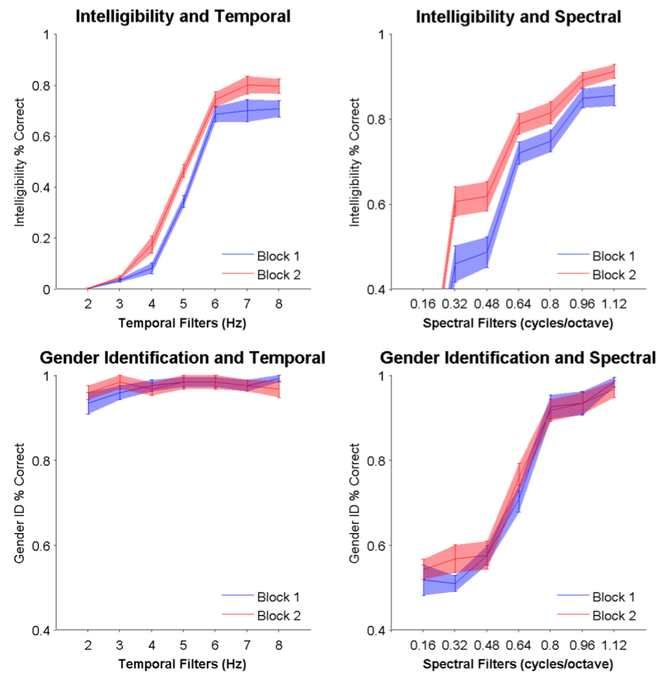
Stimuli



Speech waveform ➡ Spectrogram ➡ Modulation domain ➡ Apply filters ➡ Degraded spectrograms ➡ Waveform

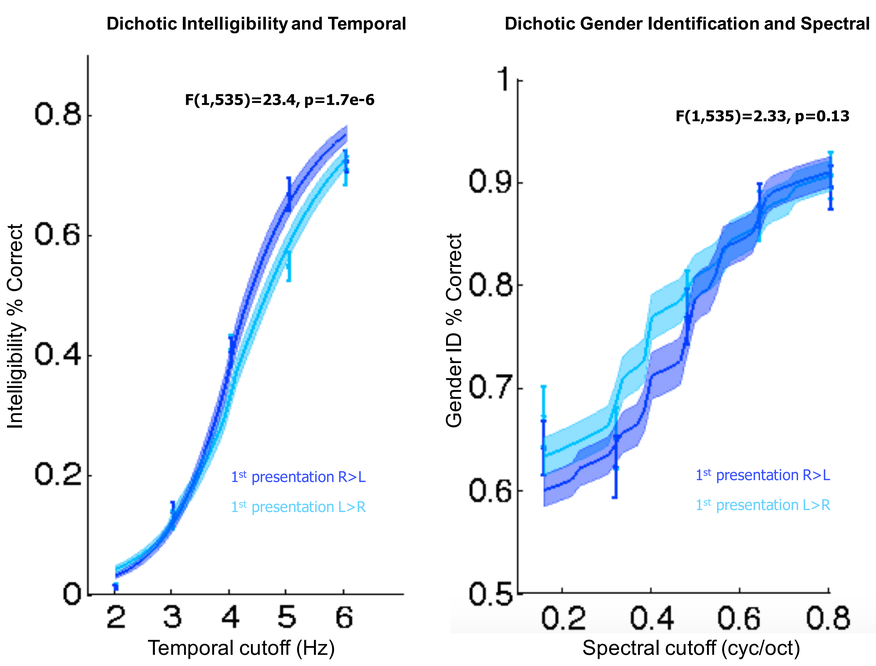
Results

Experiment 1: Spanning the space



Mean (line) and SEM (errorbar, shaded area)

Experiment 2,3: Dichotic



Mean and SEM of behavioral responses (dots) across subjects as well as within subject fitted psychometric curves (logistic regression, shaded area) when listening to the first presentation of dichotic stimuli with more modulation information in one ear or the other.

Design and Methods

- Sentences from the TIMIT database were filtered in the modulation domains at the critical lowpass modulations (temporal filters - 2 to 8 Hz, spectral filters - 0.16 to 1.12 cycles/octave)
- Exp 1. Participants (N=20) listened to 2 blocks (temporal and spectral filters) of 84 pseudorandomly ascending, parametrically degraded sentences. Reported gender and typed out what they heard as well as rated intelligibility (1~4 scale).
- Exp 2-3. A total of 60 participants were tested in a dichotic listening paradigm. The gender identification task (spectral filters) and the intelligibility task (temporal filters) were run separately. There were two blocks of 120 sentences (40 sentences, each played three times – right>left, left>right, diotic). See above headphones for a visualization of the right>left, left>right stimuli.

Conclusions

- **Using a novel speech filtering technique, we found that degradations across both temporal and spectral modulation axes significantly affect intelligibility. Moreover, only spectral modulations affect speaker's gender identification.**
- **Expanding on these findings, we found a significant right ear advantage for processing temporal modulations.**

References

Poeppel, D. (2003). The analysis of speech in different temporal integration windows: Cerebral lateralization as 'asymmetric sampling in time'. Speech Communication, 41(1), 245-255.

Zatorre, R. J., Belin, P., & Penhune, V. B. (2002). Structure and function of auditory cortex: Music and speech. Trends in Cognitive Sciences, 6(1), 37-46.

Elliott, T. M., & Theunissen, F. E. (2009). The modulation transfer function for speech intelligibility. PLoS Computational Biology, 5(3), e1000302.

Chi, T., Gao, Y., Guyton, M. C., Ru, P., & Shamma, S. (1999). Spectro-temporal modulation transfer functions and speech intelligibility. The Journal of the Acoustical Society of America, 106(5), 2719-32.