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Speech reception thresholds in various interference conditions

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Motivation:

Speech intelligibility is integral to human verbal communication; however, our understanding of the effects of competing noise, room reverberation, and frequency range restriction is incomplete. Hearing impaired listeners typically utilize a restricted frequency range, which handicaps intelligibility significantly, especially in complex environments. The goal of this study is to explore speech intelligibility performance in normal listeners when the frequency range of speech they can utilize is limited in different complex environments such as with noise and different degrees of room reverberation.

Methods:

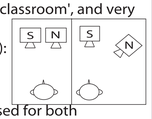
Subjects: 3 normal-hearing listeners, ages 18-21

Stimuli:

- Sentences from the IEEE speech corpus
- Speech-shaped masking noises generated by average long-term sentence spectra with three spectral ranges:
  - wideband
  - highpass above 2 kHz
  - lowpass below 2 kHz
- The sharp 2-kHz cutoff chosen to approximately bisect the range of frequencies most important in speech
- Highpass noise condition to simulate high-frequency hearing loss
- Sampling frequency is 20 kHz

Rooms:

- Pseudo-anechoic , moderately reverberant 'classroom', and very reverberant 'bathroom'
- Two configurations (head in center of room):
  - Sentence 0°noise 0°, 1 m away
  - Sentence 0°noise 45°, 1 m away



- Impulse responses recorded from KEMAR used for both sentence and masker
- Scaled to same rms for direct portion, reverberation adds energy
- All data reported as level of Sentence Level (see Figure 1) (For wideband case, Sentence Level corresponds to SNR in dB)

Adaptive Paradigm:

- Noise level held constant
- Sentences scaled to Speech Reception Threshold (SRT) of 50%
- SRT is mean level of last 10 of 15 sentences per list
- Each condition tested at least 3 times

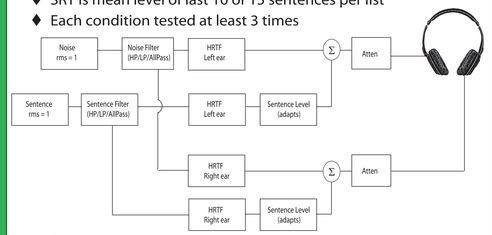
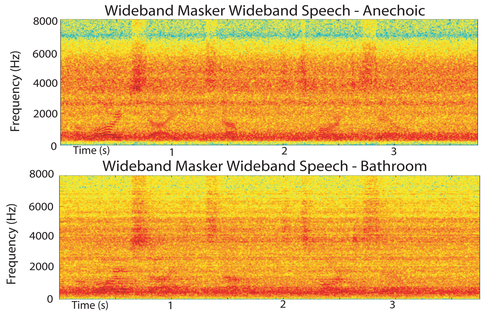
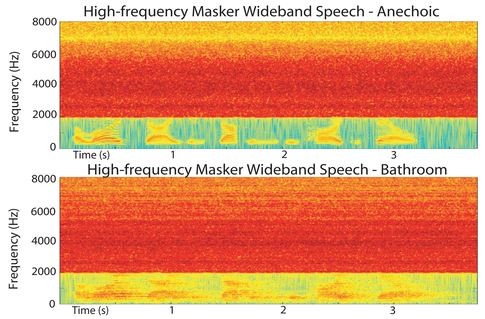


Figure 1: Block diagram of signal processing of stimuli

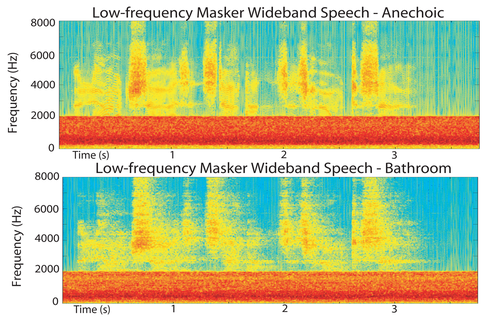
Spectrograms of Stimuli at Threshold:



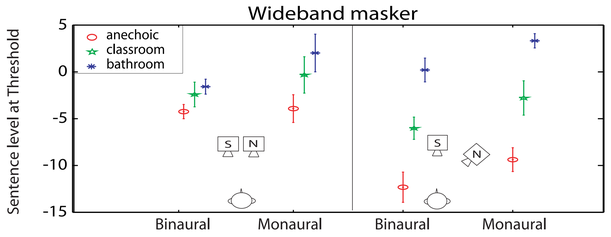
- Modulations of speech come through noise in wideband masking case



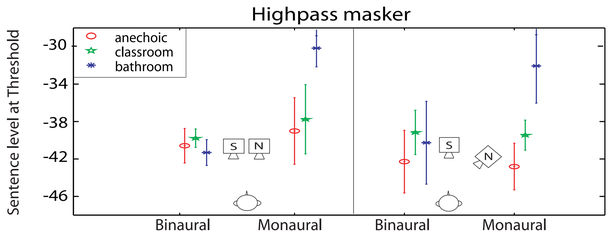
- Speech modulations are decreased by reverberation
- Signal-to-noise ratios in masked regions are very small compared to unmasked regions



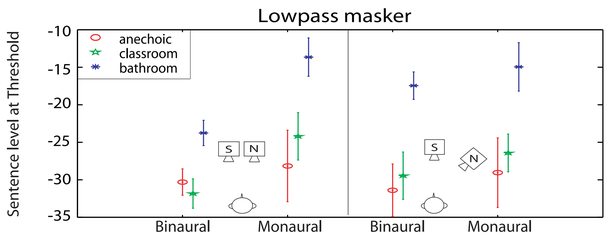
Results:



- Binaural benefit in all reverberant conditions
- Advantage of spatial separation decreases with increasing reverberation

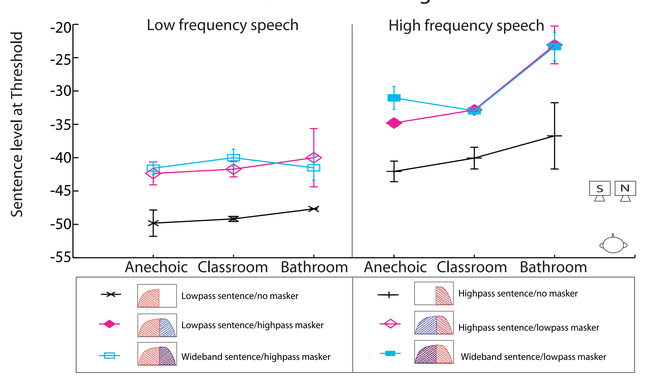


- Monaural intelligibility in high reverberation poor when information is in low frequencies of speech
- Highpass noise perceived as a compact image (not shown)



- Monaural and binaural intelligibility in high reverberation poor when information is in high frequencies of speech
- Binaural benefit in all conditions
- No benefit of spatial separation
- In bathroom, neither ear has consistently better signal-to-noise-ratio
- Lowpass noise in bathroom perceived as very diffuse

Results (continued):



- Listeners perform the same with and without masked portion of speech
- Presence of non-overlapping masker causes substantial masking (informational?)
- Speech Transmission Index (STI) does not predict that maskers non-overlapping in frequency reduce intelligiblity - need to modify STI as suggested by Houtgast and Steeneken, 1999

Conclusions:

- Reverberation degrades speech intelligibilty (modulations decrease)
- Binaural advantage for all reverberant conditions in wideband and lowpass noise
- Spatial separation benefit disappears with increasing reverberation
- There is more variability in performance under half-masking conditions
- Listeners not using masked part of wideband speech
- The coherence of the highpass masker and diffuseness of the lowpass masker provide a source separation cue
- Psychometric functions for non-overlapping masking conditions may provide additional information

References:

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