Adaptation of psychoacoustic methods to examine the benefit of acoustic beamforming in persons with aphasia

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Aphasia and Background Noise

It is common for persons with aphasia (PWA) to report difficulty understanding conversational partners in noisy listening environments, such as restaurants, stores, or family/social gatherings. This issue may have implications for social engagement and community participation in PWA.

Acoustic Beamforming

Acoustic beamforming has been shown to improve identification of target speech in noisy environments for listeners with sensorineural hearing loss (SNHL) (Kidd et al, 2015). The beamformer has a sharply tuned directional response attenuating sounds from sources outside the focus of the beam (i.e., maskers) while amplifying the sound source where the beam is aimed (i.e., the target). It then presents the target and the maskers to the listener through a single channel.

Psychoacoustic Methodology

Typically, the benefit of beamforming would be measured using psychoacoustic methodology. However, standard psychoacoustic methods may not be appropriate for PWA, as they assume intact language comprehension, reading/scanning abilities, and verbal working memory.

Research Questions

1. Can acoustic beamforming facilitate improved speech intelligibility for PWA in multi-source listening situations?
2. Can psychoacoustic methods be effectively modified for use with PWA?

Participants

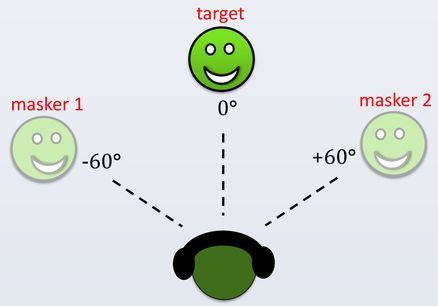
	Age	Sex	Hearing loss	Aphasia type[1]	Aphasia quotient[1]	TEA selective attention[2]
P1	54	M	Mild HF[3] SNHL	Broca's	63	90%
P2	53	M	Mild HF SNHL	Anomic	98	80%
P3	61	F	Mild HF SNHL	Anomic	96	100%
P4	56	F	Mild HF SNHL	Anomic	98	20%
P5	67	M	Mild HF SNHL	Anomic	90	60%

[1]Western Aphasia Battery (Kertesz, 2006)
[2]Elevator Counting w/Distraction, Test of Everyday Attention (Robertson et al, 1994)
[3]High-frequency, i.e., 4-8 kHz

Methods

- The listener was seated in front of a computer screen. All auditory stimuli were delivered through headphones and spatialized using head-related impulse responses.
- Three sentences were played simultaneously (1 target, always beginning with "Jane", and 2 maskers), drawn from a closed-set matrix →

Jane	took	new	toys
Gene	gave	old	hats
Pat	lost	big	shoes
Bob	found	small	cards
Sue	bought	red	pens
Mike	sold	blue	socks
Lynn	held	cold	bags
Jill	saw	hot	gloves



Two microphone conditions:
1. KEMAR (normal listening)
2. BEAM (with beamformer)

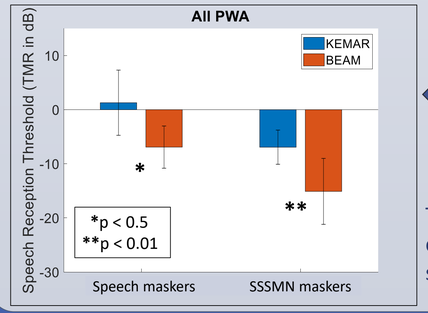
Two types of masking:
1. Speech maskers
2. Speech-shaped, speech-modulated noise (SSSMN) maskers

	Speech maskers	SSSMN maskers
KEMAR	KEMAR-speech	KEMAR-SSSMN
BEAM	BEAM-speech	BEAM-SSSMN

After listening, participants selected the target words from presented columns. They completed four one-up/one-down adaptive tracks in each condition to determine a speech reception threshold (SRT) estimate in each condition.

Frequency-specific amplification and individually-tailored modifications

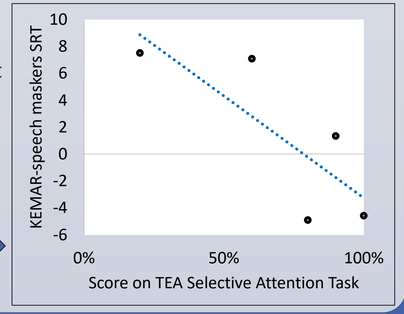
1. National Acoustic Laboratories (NAL) gain added individually for each participant based on pure tone hearing results:
   - **P1**: about 1.6 dB overall gain
   - **P2**: about 4.4 dB overall gain
   - **P3**: about 1.0 dB overall gain
   - **P4**: about 2.1 dB overall gain
   - **P5**: about 8.2 dB overall gain
2. Sentence length adjusted to reduce verbal working memory burden and help ensure 100% correct in quiet:
   - **P1**: 2 words (e.g. "Jane sold")
   - **P2**: 4 words (e.g. "Jane sold red socks")
   - **P3**: 4 words (e.g. "Jane sold red socks")
   - **P4**: 4 words (e.g. "Jane sold red socks")
   - **P5**: 4 words (e.g. "Jane sold red socks")
3. Number of response options adjusted to reduce reading/visual scanning burden and ensure 100% correct in quiet:
   - **P1**: 4 response options per word
   - **P2**: 4 response options per word
   - **P3**: 6 response options per word
   - **P4**: 8 response options per word
   - **P5**: 8 response options per word



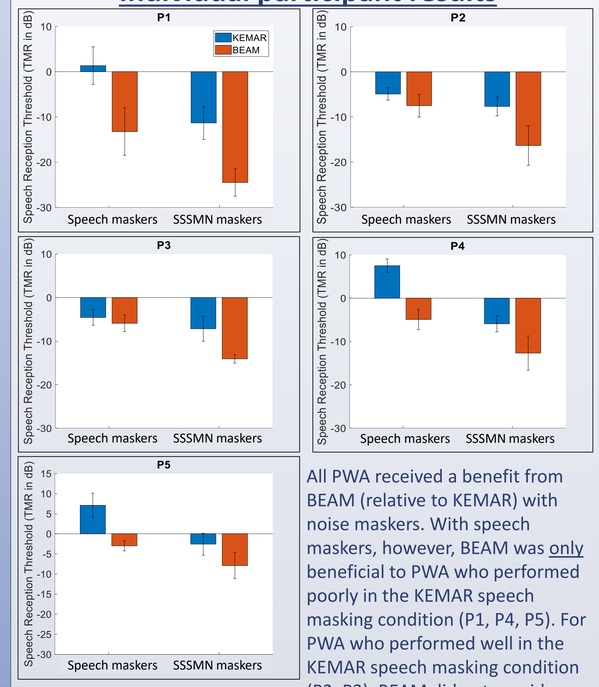
Group-level results

PWA showed a significant benefit of BEAM (relative to KEMAR) in both conditions.

Thresholds on the KEMAR-speech condition may be associated with selective attention abilities.



Individual participant results



All PWA received a benefit from BEAM (relative to KEMAR) with noise maskers. With speech maskers, however, BEAM was only beneficial to PWA who performed poorly in the KEMAR speech masking condition (P1, P4, P5). For PWA who performed well in the KEMAR speech masking condition (P2, P3), BEAM did not provide an additional benefit.

Conclusions

- Beamforming may improve speech intelligibility for PWA in complex, multi-source listening situations.
- Individually tailored experimental modifications may facilitate the use of psychoacoustic methods in PWA.

Disclosures

There are no relevant financial or non-financial relationships to disclose.

References

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