Perception of Backward Speech

Robert H. Margolis[1,2], Erica Williams[2], Angela Huang[2], Sara Jensen[2], Ingrid McBride[2], Aparna Rao[2], George L. Saly[1], Richard H. Wilson[2]
[1] Audiology Incorporated, Arden Hills, Minnesota
[2] Department of Speech and Hearing Science, Arizona State University, Tempe, Arizona

Introduction

The first stage of speech processing by the auditory system is the spectro-temporal analysis that is performed by the cochlea. Deficits in this process cause speech communication to be impaired in sensorineural hearing loss (SNHL). Clinical speech recognition tests aim to evaluate the speech processing deficit that results from SNHL but he development and validation of tests in all of the world languages is an insurmountable constraint on access to diagnostic audiology. This project is an exploratory study of a method that may be capable of testing speech processing with non-linguistic speech-like stimuli.

Speech played backwards has identical spectro-temporal characteristics to forward speech but the linguistic content is removed. Studies have been reported on the masking effects of backward speech, discriminability of backward speech by newborns, speaker recognition from backward speech, and age recognition from backward speech[3].

We hypothesize that the ability to process backward speech stimuli is affected by SNHL in the same manner that word recognition of forward speech is impaired.

The ability to match backward speech samples was measured in normal-hearing listeners and listeners with SNHL and compared to recognition of the same monosyllabic speech stimuli played in the forward direction. The stimuli were monosyllabic CNC words spoken by a male and a female speaker played forward and backward,

Methods

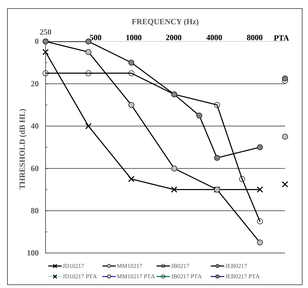
Speech Materials

Monosyllabic words recorded by a female talker (VA recordings[1]) and a male talker (Auditec recordings[2]) were digitally adjusted so the rms level in a 50-ms interval in the central portion of the vowel was identical for each word. Backward speech stimuli were the same words, digitally reversed with sound processing software (Adobe Audition).

Subjects:

One ear of nine normal-hearing subjects was tested. Thresholds at octave frequencies (250 – 8000 Hz) did not exceed 25 dB HL. The average 3-frequency pure tone average (500, 1000, 2000 Hz) was 4.8 dB HL. Subjects were screened with otoscopy and tympanometry and reported no recent signs of otologic disease.

One ear of four subjects with SNHL was tested. Subjects had normal otoscopy and tympanograms and had no recent history of middle ear disease. The audiograms of the test ear of the subjects with SNHL are shown in figure.



Procedures

Forward Speech Recognition

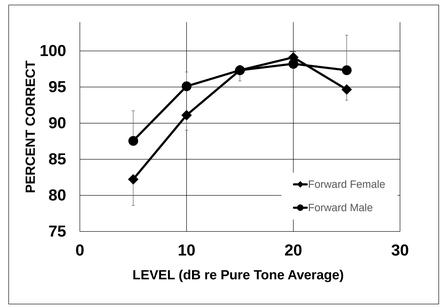
Speech recognition was tested using the recorded monosyllabic words in a four interval forced-choice paradigm. The test word and three rhyming foils were presented on a touch screen. The subjects touched the word they thought they heard. 25 words were presented at five levels (5 - 25 dB re pure tone average in 5 dB steps). SNHL subjects were tested at two additional levels.

Backward Speech Recognition

The same monosyllabic word recordings were digitally reversed and presented in a three-interval forced choice paradigm. A target "word" was presented followed by three foils, one of which was identical to the target. The listener touched a button on the touchscreen (labelled 1, 2, or 3 to Indicate which of the foils matched the target. Presentation levels were the same as those used for the forward speech experiment.

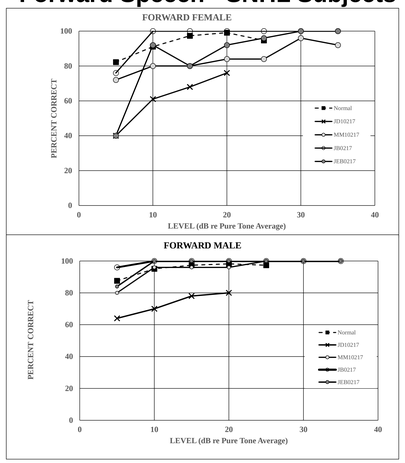
Results

Forward Speech - Normal-Hearing Subjects



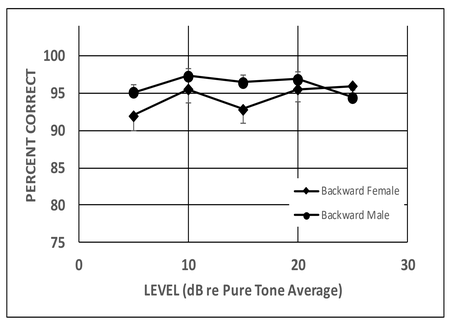
Closed set word-recognition scores were lower for the female speech than for male speech. The performance-intensity function for female speech is shifted toward higher levels by about 4 dB. Error bars are the standard error of the mean.

Forward Speech - SNHL Subjects



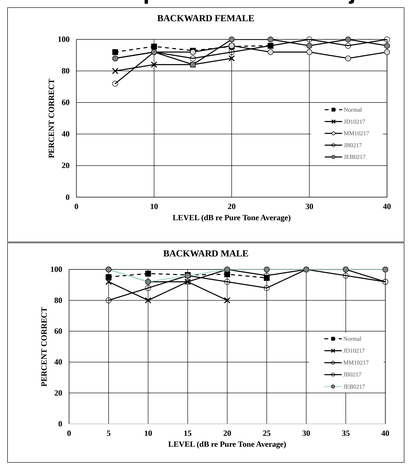
Subjects with SNHL had higher recognition scores for male speech than for female speech at pre-asymptotic levels.

Backward Speech - Normal-Hearing Subjects



The ability to match backward speech "words" was better for when the stimuli were derived from words spoken by a male talker than for a female talker. Error bars are the standard error of the mean.

Backward Speech - SNHL Subjects



Subjects with SNHL had no difficulty matching backward speech stimuli.

Listen to Backward Speech

Conclusions

Forward Speech Recognition

1. In a closed set paradigm, normal-hearing listeners and listeners with SNHL have higher recognition scores for male speech than for female speech when word levels are adjusted to equalize the level in the steady state portion of the vowel of monosyllabic CNC words. For normal subjects the difference is equivalent to a shift of 4-dB in the performance-Intensity function.

2. The scores of subjects with SNHL reached an asymptote at 100%. In a previous study with a larger sample of subjects with SNHL some listeners Achieved significantly reduced scores at high levels[4].

3. The levels of the words were matched based on the rms level in a 50-ms Interval in the central vowel. It is possible that another method for matching the levels of the words would produce equivalent performance.

Backward Speech Recognition

1. Normal-hearing and SNHL listeners had no difficulty matching backward monosyllabic words in a 3-alternative forced choice paradigm.

2. Normal-hearing listeners achieved higher matching scores for backward utterances derived from male speech than from female speech.

References

[1]Department of Veterans Affairs. Speech Recognition and Identification Materials, Disc 4.0. Produced by Auditory Research Laboratory, VA Medical Center, Mountain Home, Tennessee.
[2]Auditec, Inc. NU-6 (Northwestern University Auditory Test #6). Available from www.auditec.com.
[3]References to studies using backward speech are available at http://audiologyincorporated.com/articles.
[4]Margolis, RH, Gilbert, HM, Madsen, BM, Wilson, RH, Saly, GL. Automated Forced Choice Word-Recognition Test. Presented to the American Auditory Society, March 3, 2016. Available at http://audiologyincorporated.com/articles.

This poster is available at http://audiologyincorporated.com/articles
For further information, please contact Robert H. Margolis (rhmargo001@gmail.com).