Subjective vs. Objective Intelligibility of Sentences in Listeners with Hearing Loss

Kathleen M. Cienkowski, Charles E. Speaks, and Amy S. McKee

Department of Communication Disorders, University of Minnesota, Minneapolis, MN 55455

Abstract: The relation between rated intelligibility and correct key word repetitions of sentences was examined in listeners with normal hearing and hearing loss. The ten lists of CID sentences were arranged in two randomly ordered groups. Listeners were asked to complete two tasks, 1) rate the intelligibility of fifty sentences on a scale of 0 to 100%, 2) repeat each of the fifty sentences, which were scored as the number of key words repeated correctly. Sentences were presented at five signal-to-noise ratios. The method of adjustment using the Revised Speech Intelligibility Rating passages was used to establish the start level for sentence presentation. Correlations of rated intelligibility and correct repetition were 0.85 for listeners with normal hearing and 0.86 for listeners with hearing loss. The findings demonstrate that listeners with normal hearing and with hearing loss preserve the ability to rate the intelligibility of speech.

INTRODUCTION

Subjective ratings of connected discourse and sentences has been suggested as a fast, reliable way to assess speech intelligibility (1,2). Previous research has shown that listeners with normal hearing are able to accurately estimate their performance on objective measures of sentence materials (1). It is not known if listeners with post linguistic onset of hearing loss retain this ability. Listening over a period of years through an auditory system that has filtered the incoming signal may result in a loss of the internal metric for what represents hundred percent intelligibility. It may no longer be possible for a listener to obtain complete subjective understanding. In addition, sensorineural hearing loss is often accompanied by a reduction in the dynamic range of hearing. This range may be reduced from 100 dB down to 30 dB in listeners with cochlear implants. It is not known if the entire function for intelligibility can be represented in this reduced dynamic range. The aim of this experiment was to determine if listeners with sensorineural hearing loss preserve the ability to rate the intelligibility of sentence materials.

METHOD

Thirty listeners participated in this experiment. Twenty were listeners with normal hearing. Audiometric thresholds were less than 20 dB HL at 500, 1000, 2000 and 4000 Hz. Listeners ranged in age from 17 to 42 years with a mean age of 26 years. Ten listeners had mild to moderately severe sensorineural hearing loss. Mean thresholds and standard deviations in dB HL were 21(14), 28(15), 38(11) and 51(13) at 500, 1000, 2000 and 4000 Hz respectively. The listeners ranged in age from 31 to 78 with a mean age of 63.1 years. Stimuli included the connected discourse passages as prepared by Cox and Mc Daniel for the Speech Intelligibility Rating (SIR) test and revised by Speaks, Trine, Crain and Niccum (2,3). Sentence materials were the ten lists of the CID Everyday sentences (4). Speech materials were digitized at a rate of 12.8 kHz. The overall RMS of the sentences was adjusted to match that of the connected passages. Stimuli were output from computer file using a 16 bit D/A converter and low pass filtered at 5 kHz. The speech and broad band noise were attenuated by a programmable attenuator, and then mixed and routed through an insert earphone (ER-3A). The speech and noise were calibrated independently to a level of 63 dB SPL.

Each listener used a method of adjustment (MOA) procedure to reach a criterion of 50% intelligibility for a given passage. Listeners completed five such trials. A standard deviation across trials was computed. A standard deviation of less than or equal to 3 dB was considered acceptable. If the standard deviation was greater than 3 dB subjects continued the trials until the standard deviation across the last 5 MOAs met criterion. The SIR passages were selected randomly without replacement from the set of 72 passages.

Listeners were presented the CID sentences at signal-to-noise ratios of +6 dB, +4 dB, +2 dB, 0 dB and -2 dB re: the dB S/N corresponding to 50% for the SIR passages. Stated another way, the S/N ratio corresponding to 50% intelligibility for the SIR passages became the 0 dB S/N reference point for the presentation of the CID sentences. Listeners responded in two ways. Rate intelligibility: listeners were asked to rate the amount of a sentence that they understood. They typed into a computer via keyboard a number between 0 and 100% that best represented the percentage of the sentence that was understood. Sentence repetition: subjects were asked to repeat back the sentence that was heard. Sentences were scored as the number of key words repeated correctly. The presentation order was counter balanced across lists. Practice sentences were devised and provided for each of the sentence presentation conditions (rating and repetition). All testing was completed in a double walled sound booth.
RESULTS AND CONCLUSIONS

Figures 1 and 2 show the results for listeners with normal hearing and hearing loss respectively. Percent correct key word repetition is plotted as a function of the rated intelligibility of sentences. All listeners and signal-to-noise ratios are shown. The correlations were 0.85 for listeners with normal hearing and 0.86 for listeners with hearing loss.

The group data display a linear trend, although not perfectly. With increasing subjective ratings, objective performance on key word repetition improves. There is overlap between the performance of listeners with hearing loss and those with normal peripheral hearing sensitivity. Not all listeners display clear monotonic functions. Examination of individual listener data shows that some listeners overestimate their objective performance as represented by the data points in the lower right quadrant. Likewise some individuals understate performance, shown by the spread in the upper left quadrant. For these individuals the group data may be misleading. These findings confirm the earlier work of Speaks, Parker, Harris and Kuhl on listeners with normal hearing and demonstrate that listeners with hearing loss, as a group, preserve the ability to rate the intelligibility of speech.

ACKNOWLEDGMENTS

This work was supported by NINCD grant DC 00110.

REFERENCES