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SPEECH INTELLIGIBILITY IN PATIENTS WITH MULTIPLE SCLEROSIS

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Introduction

Multiple sclerosis (MS) is an immune-mediated disease of the central nervous system that affects more than 350,000 Americans. Although sudden hearing loss has been reported as one of the initial symptoms associated with MS, the prevalence of peripheral hearing loss has been estimated at less than 10%. Still, when patients with multiple sclerosis are asked specifically about difficulties with hearing, almost half report some difficulty comprehending speech, especially in a background the noise.

This poster is a report of work in progress on an ongoing investigation of auditory dysfunction in patients with multiple sclerosis. A primary focus of the study is to address objectively the most common auditory complaint from patients with MS: "I cannot understand speech in a setting where other people are talking." Measurements of speech intelligibility are being accomplished in the soundfield rather than under earphones. The resultant data then will be used in a subsequent investigation to measure improvements in speech intelligibility provided by prosthetic devices. These prosthetic approaches may include: 1) hearing aids with multiple-microphone arrays for the suppression of background noise; 2) assistive listening devices; 3) wearable auditory filters that restrict acoustic input to one ear; 4) processing circuits that enhance the formant frequencies of speech; and 5) algorithms that modify the temporal aspects of speech.

Methods and Materials

EXPERIMENTAL SUBJECTS:

- 11 ADULT HUMAN SUBJECTS WITH NORMAL HEARING. For each of these subjects, mean bilateral hearing sensitivity for 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz was ≤ 10 dB HL (4-frequency PTA). These subjects ranged in age from 21 to 40 years with a mean age of 29 years (SD = ± 4.7 years).

- 11 PATIENTS WITH MULTIPLE SCLEROSIS. Inclusion criteria for each patient in this group included: 1) a clinical or laboratory supported diagnosis of "definite MS" (Poser, et al., 1983); 2) a diagnosis of relapsing, remitting or secondary progressive MS; 3) a Kurtzke Expanded Disability Status Score (EDSS) of 0 to 7.0, inclusive; 4) no history of a clinical relapse or change in EDSS for three months preceding entry into the study; and 5) a brain MRI scan (within the preceding year) that showed at least three white-matter lesions consistent with MS on T2-weighted images. These subjects ranged in age from 41 to 60 years with a mean age of 52 years (SD = ± 6.3 years). Their mean, bilateral 4-frequency PTA was 23.9 dB HL (SD = ± 11.2 dB HL).

- 13 CONTROL SUBJECTS WITHOUT MS. These subjects were matched to the patient group with respect to age, to sex and to audiometric configuration (approximately). They ranged in age from 41 to 60 years with a mean age of 52 years (SD = ± 5.5 years). Their mean, bilateral 4-frequency PTA was 18.4 dB HL (SD = ± 10.89 dB HL).

EXPERIMENTAL STIMULI, APPARATUS AND PROCEDURES:

For this study, we used an updated version of the original Sentence-Intelligibility (SI) test (IEEE, 1969) that was developed at the Harvard Psycho-Acoustic Laboratory. Each of the 720 test sentences in this test contains 5 "key" words. Test sentences were presented to each subject in the sound field at 65 dBA L_{eq}. The speech loudspeaker in the sound-insulated test chamber was centered on the face of the listener (0° azimuth and 0° elevation) at a distance of 1.2 meters.

The competing babble of 16 talkers was presented from 4 loudspeakers. These loudspeakers were located at 45°, at 135°, at 270° and at 315° (in each corner of the test chamber). The level of the babble was varied systematically. The task of each subject in each group was to repeat entire test sentences while the level of the babble was increased from 55 dBA L_{eq} (+10 dB S/N) through 81 dBA L_{eq} (–16 dB S/N) in 1-dB steps.

Results

Figure 1 provides a summary of speech intelligibility in the soundfield for our group of adult subjects with normal hearing. In this figure, word-recognition score (mean percentage of the key words repeated correctly) is plotted against signal-to-noise ratio (S/N) in dB. The sigmoidal function on this graph was fit with a fifth-degree polynomial ($R^2 = 0.995$). This is displayed as a smooth, crosshatched curve in Fig. 1. Over the linear portion of the curve (from about –12 dB S/N to –8 dB S/N) the slope is approximately 12 % / dB S/N.

In Fig. 2 we have added the mean word-recognition function (in per cent correct) for our group of control subjects to the normal data of Fig. 1. As before, word-recognition score (WRS) is plotted against S/N in dB. Speech intelligibility for both groups is similar when the S/N is good (+6 to +10 dB S/N) and when the S/N is very poor (-16 to –14 dB S/N). Over the 10 dB range from –12 dB S/N through –2 dB S/N, however, speech intelligibility for the older control group is consistently worse than speech intelligibility for the younger group with normal hearing. As an example, at –8 dB S/N, the difference between the two curves is 2 dB S/N. This difference, however, translates into a difference of 52% in speech intelligibility. Over the linear portion of each curve the slope for both functions still is approximately 12 % / dB S/N. The separation between the two curves supports the clinical observation that the ability to understand speech in noise decreases with age.

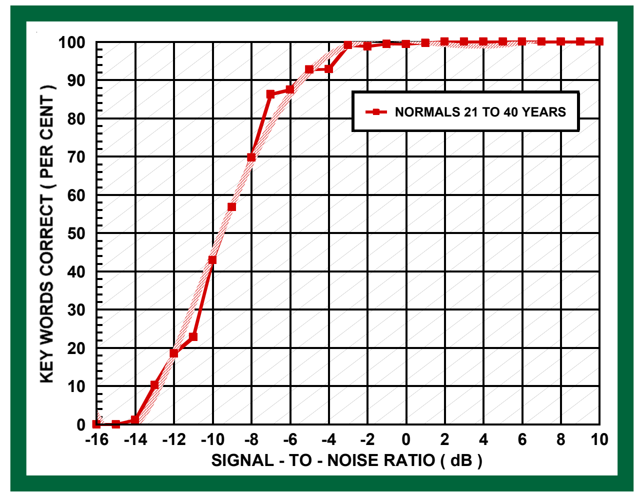

Figure 1.

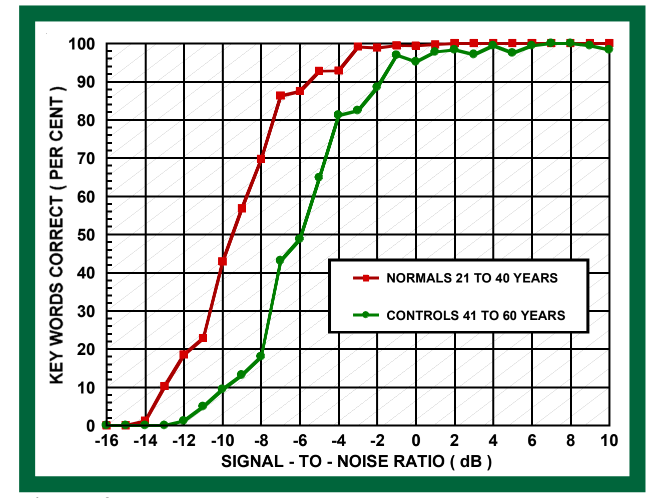

Figure 2.

Over the past decade, the IEEE test sentences have been used extensively for the clinical evaluation of speech intelligibility in noise (Fikret-Pasa, 1993; Killion & Villchur, 1993). With this "SIN" test, however, the test sentences and the multi-talker babble are presented in the soundfield through the same loudspeaker.

In Fig. 3 we have added the word-recognition functions (mean percentage of the key words repeated correctly) from Killion & Villchur (1993) to the data plotted in Fig. 2. Again, word-recognition scores are plotted against S/N in dB. The shape of all four curves is similar and their slopes all are approximately 12 % / dB S/N for their linear segments. Two major differences are apparent. Firstly, the curve from Killion & Villchur (1993) for young adults is displaced approximately 9.5 dB S/N to the right of our normal curve. Secondly, the curve from Killion & Villchur (1993) for older subjects lies within ≤ 2 dB S/N of the curve for their young adults. We believe that both of these differences are related to the spatial release from masking that is inherent to our test paradigm but is not present when the test sentences and the multi-talker babble are presented from the same loudspeaker.

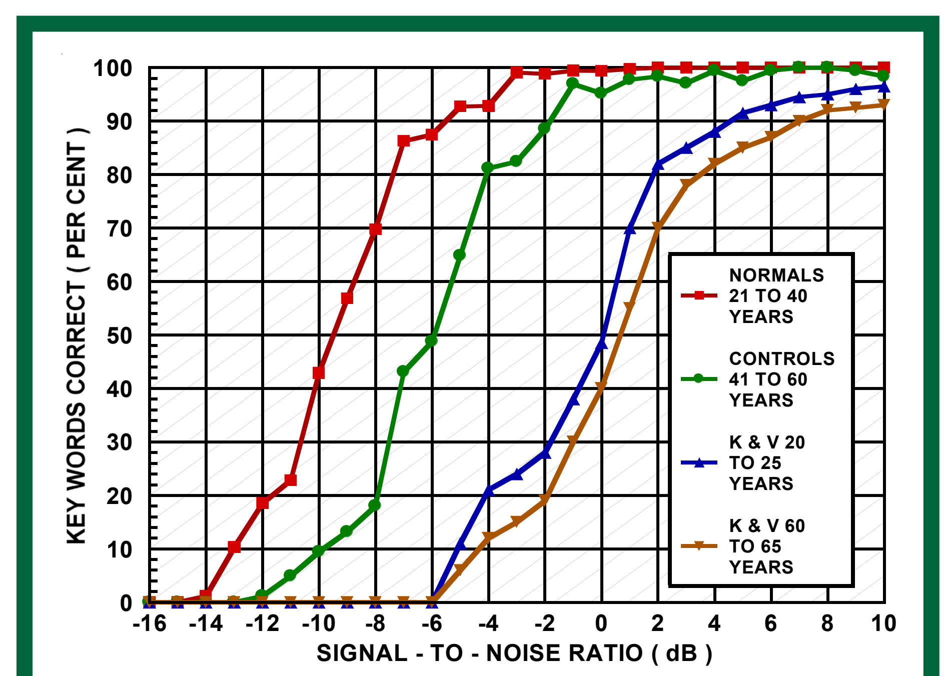

Figure 3.

In Fig. 4 we have added the WRS function for our group of patients with multiple sclerosis to the curve for the control subjects of Fig. 2. Again, word-recognition score in % correct is plotted against S/N in dB and speech intelligibility for both groups are similar when the S/N is good (+3 to +10 dB S/N) and when the S/N is very poor (-16 to –12 dB S/N). Over the 10-dB range from –10 dB S/N through 0 dB S/N, however, speech-intelligibility for the MS group differs from that of the control group. Over the linear portion of the curve for the MS group the slope of the function has decreased to approximately 8 % / dB S/N. As an example at –8 dB S/N, the difference between the two curves is about 1.2 dB S/N. This difference in S/N results in a difference of 21 % in speech intelligibility.

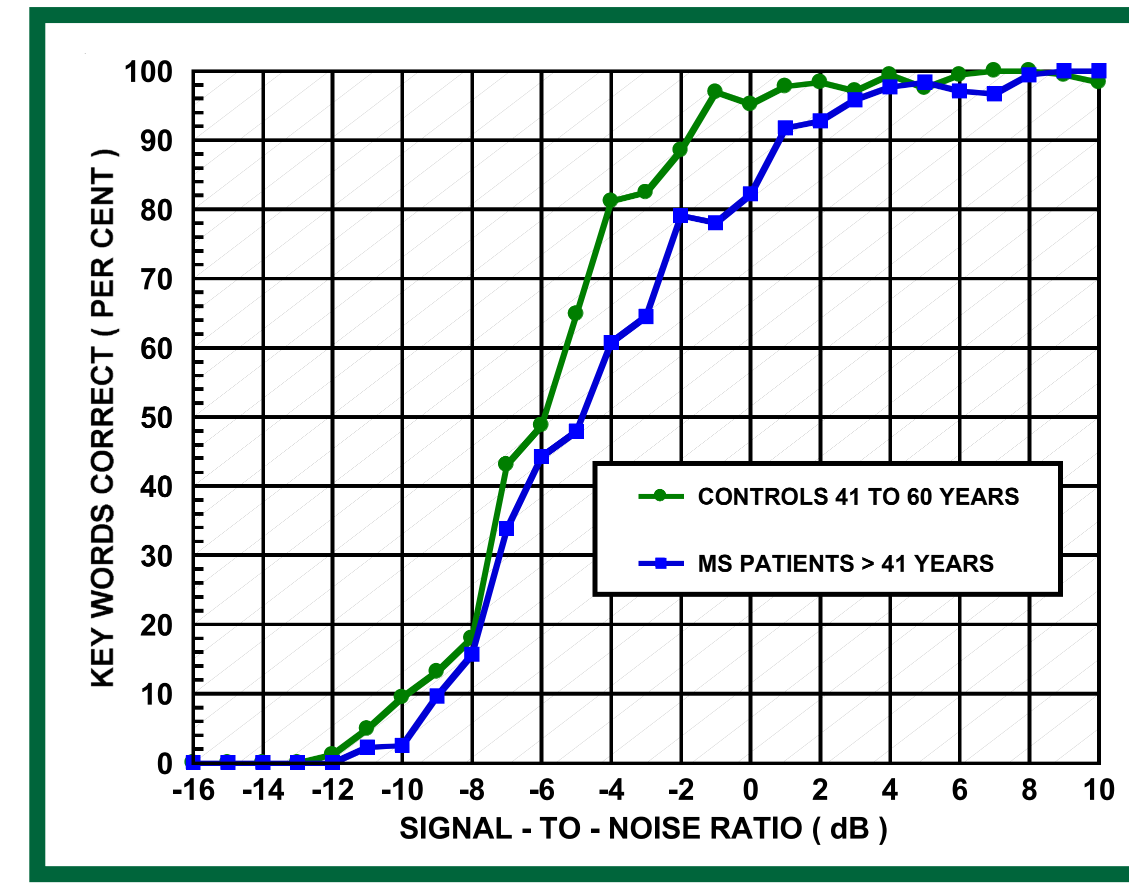

Figure 4.

Summary

Our observations to date provide objective support for clinical reports regarding poor speech intelligibility in noise for patients with MS. Moreover, the experimental stimuli we have recorded, our soundfield system and our test procedures allow us to generate rapidly complete WRS functions for patients. These tools should prove useful as we evaluate the efficacy of prosthetic devices for improving speech intelligibility in noise.

References

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Acknowledgments

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