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A Speech in Noise Test for Cochlear - Retrocochlear Differential Diagnosis

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Abstract

The results of a simple and effective speech in noise test which utilises monosyllables in English in differentiating cochlear from retrocochlear lesions are reported. The test measures the percentage decrease in half peak speech discrimination with the introduction of speech pattern noise. The percentage decrease in discrimination with 5 dB SL of noise was found to be very effective in differentiating cochlear from the acoustic neuroma group. The test is useful not only in differentiating the patients with acoustic neuroma from the cochlear group, but also in obtaining useful diagnostic information from patients who complain of hearing loss, but who demonstrate normal audiometric thresholds and normal speech discrimination in quiet.

Many researchers have investigated the potential of speech discrimination scores in white noise as a diagnostic indicator of abnormality at different levels of the auditory pathway. Most of these investigations have employed monosyllabic words presented at a high sensation level (SL) of 40 dB with reference to the speech reception threshold (SRT) with white noise as competing stimulus at an overall sound pressure level (SPL) equal to, or 10 dB less than that of the primary signal. Abnormal findings have been reported for the speech in noise task in ears with Meniere's Disease (0 dB signal to noise -S/N-ratio) [1], in ears ipsilateral to VIIIth nerve lesions [1], [2], in one or both ears of patients with intra-axial lesions (0 and 5 dB S/N [3], 0 dB S/N [4]), in patients with multiple sclerosis (+10 dB S/N) [4], [5], in both ears of split brain patients, with poorer scores on the left compared with the right ear [6], and in ears contralateral to temporal lobe pathologies [1], [3], [7], [8].

In a clinical decision analysis of the results of 12 studies on the effectiveness of speech discrimination tests in identifying retrocochlear lesions, Turner et al [9] reported that the average hit rate was 45% (range: 15 to 58%) with an average false alarm rate of 18%. Hall [10] reported similar findings. These two studies revealed that the speech discrimination tests had the poorest performance of all the audiological tests in identifying retrocochlear disorders.

Olsen et al [1] reported, in what has been regarded as a definitive test of site of lesion and speech in noise findings [11], results of a speech in noise test (0 dB S/N ratio) for 6 groups of normal, noise trauma, Meniere's Disease, VIIIth nerve tumor, multiple sclerosis and temporal lobe lesion. The results were not suggestive of cochlear-retrocochlear differentiation and the authors concluded that the clinical significance of speech in noise tests is not helpful in suggesting a particular site of involvement.

In almost all the above tests, the investigators have chosen to present the primary message at a high SL (40 dB SL) and the white noise at the same level or 10 dB less than speech. This does not guarantee 0 dB or +10 dB S/N ratio because the SL for speech and noise differ. As an illustration, consider a patient with a SRT of 45 dB A and noise detection threshold of 15 dB A. This patient would perceive speech and noise at 40 and 65 dB respectively when the two stimuli are presented at 0 dB S/N ratio (presentation level of 80 dB SPL, for example). Another patient with a SRT of 45 dB and noise detection threshold of 10 dB would receive the two signals at different sensation levels in this instance. In other words, identical dial settings for all patients for speech and noise (measured in SPL), as in the above studies, do not guarantee a 0 dB s/N ratio (measured in SL).

It is the considered opinion of many that it is impossible to design a fixed S/N ratio test that would be applicable for a wide range of subjects [12] without ceiling or floor effects. This would be so as long as the emphasis is on presenting speech at supra-threshold levels (85 dB SPL of speech, for example, has the same SL as 85 dB SPL noise). This could be overcome by testing the patients with several intensities of noise at the 50% speech discrimination score in quiet and then comparing their performance at a predetermined level of competing noise.

Furthermore, most studies above have obtained speech discrimination scores at fixed S/N ratios (0 or 10 dB). Testing speech discrimination at a single presentation level does not ensure that it is the patient's best performance, unless the scores approximate 100% [13]. Therefore, in a situation where the maximum discrimination scores for the different clinical populations were not equal, as in Olsen et al [1], it would be difficult to equate a drop of 40 percentage points in speech discrimination from 90 to 50 with a drop of 40 percentage points from 80 to 40.

Jayaram et al [14] developed a speech in noise test primarily to obtain fast and reliable clinical measurements of the patients capability to recognise speech in a noisy environment. The purpose of this study, utilising part of the data of that investigation, was to.

a) investigate the effectiveness of the speech in noise [14] test in differentiating cochlear from retrocochlear disorders of hearing, and
b) to determine a speech in noise threshold level which would differentiate cochlear from retrocochlear disorders.

Method

The clinical population consisted of 34 subjects (58 ears, age range 14-68 years, mean age 47.7 years) with cochlear hearing loss and 10 patients with unilateral acoustic neuroma (6 males and 4 females, age range 33-62 years, mean age 50.7 years). Diagnosis in each case was confirmed by diagnostic audiology and Magnetic Resonance Imaging (MRI).

Each subject underwent a preliminary test battery consisting of pure tone testing, speech pattern noise (SPN) threshold detection, and speech discrimination in quiet. All testing was done in a sound treated room. Speech discrimination testing was done using tape recorded isophonemic word lists [15] in English. The speech signal was presented at 5 levels although more were used as required to specify the complete form of the curve and to identify roll over. The non-test ear was excluded by suitable levels of masking. From this data half peak thresholds, defined as the intensity at which a subject scores 50% of his maximum, were determined for each individual and for each ear.

Speech discrimination testing in noise was performed. The speech signal was presented at half peak threshold levels along with SPN at threshold level to the same ear and the discrimination score obtained. Thereafter, keeping the speech level constant, the S/N ratio was progressively decreased in 5dB steps till the subject gave a discrimination score of 0 per cent. All speech testing was done monoaurally through an audiometer (GSI 16) with a Marantz BX125E tape recorder. SPN was calibrated in effective masking level and consisted of equal energy per Hz from 250 Hz to 1 kHz with a 12 dB/octave roll-off from 1 KHz to 6 kHz.

Results

The mean audiometric thresholds, the mean half peak elevation scores and the mean of the maximum speech discrimination scores in quiet are given in Table I with the corresponding standard deviations. Subjects in the acoustic neuroma group failed to achieve 100% maximum speech discrimination score in quiet.

The mean percentage drop in half peak discrimination scores at different levels of noise are also given in Table I. As speech testing in noise was started at half peak level (50% of the subjects maximum), and since some of the subjects scored a maximum of less than 100%, it was necessary to convert these scores into percentages relative to the level at which the test was initiated for each subject. This was necessitated only in the case of subjects in the acoustic neuroma group. The scores were converted into z scores using the formula z=(x-y) / x (100) where 'x' denoted the half peak level and 'y' the obtained speech discrimination score at each noise level. These z scores indicate the percentage drop in half peak discrimination score at each of the noise levels.

Tabe I shows that, as could be expected, speech discrimination scores fall with the introduction of SPN. The steepest fall was observed with the introduction of noise at the threshold level for both the cochlear and the acoustic neuroma patients and was 4.9 and 11.4% dB, respectively. The intergroup difference in the mean percentage drop in half peak level scores was significant at 0.5 and 10 dB noise levels at 0.005 level, but was not significant at 15 dB noise level.

Table I - 3- and 4-frequency pure tone average (PTA), mean Speech Pattern Noise (SPN) detection thresholds, mean Half Peak Level discrimination (HPLE) scores and the mean percentage drop in half peak discrimination score with the introduction of noise for the cochlear and the Acoustic Neuroma (AN) groups. The standard deviations are shown in parenthesis

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Figures 1 and 2 are histograms of the distribution of percentage of half peak discrimination scores at 0 and 5 dB noise levels, respectively. Figure 2 shows that speech discrimination falls below 40% of half peak level in the case of all the acoustic neuroma patients and in about 36% of the cochlear group.

.Probability distribution curves for speech in noise discrimination test at the 0 dB noise level. The range of possible speech discrimination scores (actually the percentage drop in discrimination from the half peak level with the introduction of noise) is divided into 10 ranges: 0-10, 11-20 etc. Each number below the bar equals the upper limit of the discrimination score interval. Note that the shape of the distribution differs significantly from Gaussian with equal variance

.Probability distribution curves for speech in noise discrimination test at the 5 dB noise level. The range of possible speech discrimination scores (actually the percentage drop in discrimination from the half

peak level with the introduction of noise) is divided into 10 ranges: 0-10, 11-20 etc. Each number below the bar equals the upper limit of the discrimination score interval. Note that the shape of the distribution differs significantly from Gaussian with equal variance

Figures 1 and 2 enable specification of a criterion for the differential diagnosis of cochlear and retrocochlear disorders. Specifying a score of 50% at 0 dB noise level (Figure 1) would result in a hit rate of 70% for the acoustic neuroma group and a false alarm rate of 30% for the cochlear lesions. On the otherhand fixing a criterion of 40% at the 5 dB level of noise .(Figure 2) would give us a hit rate of 100% for the acoustic neuroma patients, but a high false alarm rate of 36% for the cochlear group.

Discussion

The results indicated that a cochlear -retrocochlear differentiation can be made on the basis of results of this speech in noise test- specifically on the basis of the distribution of the scores at the 5 dB noise level which yields the best proportion of hit and false alarm rates. It should, however, be pointed out that the sample size of acoustic neuroma was too small to provide conclusive evidence and also retrocochlear disorders in this study consisted only of acoustic neuroma. Furthermore, a criterion of 40% score at 5 dB noise level above the detection threshold results in a hit rate of 100% for the acoustic neuroma, it also results in an undesirably high false alarm rate of 36% for the cochlear disorders. However, Figures 1 and 2 enable the fixing of an optimum criterion for the differentiation of cochlear from retrocochlear disorders depending upon the clinician's perception of the cost of a false negative (misses) and false positive (false alarms). As this test was administered on confirmed cases of acoustic neuromas, the result of this study seem very encouraging despite the small sample size. Further studies on a large sample are warranted.

The results of previous research on the interaction of speech in noise scores and site of lesion testing have been equivocal [1], [2], [3], [4], [5]. A clinical decision analysis of the results of 12 studies on the effectiveness of speech discrimination tests to identify retrocochlear pathologies [9] showed that the speech tests result in a hit rate of 45% for the retrocochlear disorders (with a false alarm rate of 18%). The results of the present study, on the contrary, suggest that a cochlear-retrocochlear differentiation can be made on the basis of a speech in noise test with a high degree of sensitivity. However, the present study is different from the above mentioned studies in several aspects including the type of speech material and the level of presentation, the nature of scores, S/N ratio, and most importantly on the nature of scores considered as a diagnostic indicator. Difference in quiet-while noise scores have been considered in the previous studies [1], [3], [16] whereas in the present study only the percentage drop in half peak discrimination with noise has been considered.

There is a statistically significant difference between the discrimination scores in noise for the cochlear and retrocochlear diagnostic groups. The authors would not suggest that speech in noise be used as a sine qua non for cochlear-retrocochlear differential diagnosis due to the accuracy of other test procedures, notably auditory brainstem responses [9], [17], [18], [19], although it might be useful in the absence of such techniques. This test is especially relevant in the Indian context where the use of Computerised Tomographic Scanning and MRI are not widespread. However, monosyllabic speech material suitable in the Indian context (particularly considering the plethora of languages) will have to be developed. Speech in noise testing using this protocol does give a better hit rate for acoustic neuroma than other previously reported speech discrimination tests [9].

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