ASSESSMENT OF A NEW, COMPUTERIZED NONSENSE SYLLABLE TEST

Denise M. Keenan, M.A. and Petri Korhonen, M.S.

Widex Office of Research in Clinical Amplification, Widex USA

WIDEX high definition hearing

INTRODUCTION

With the growing popularity of open fit instruments and introduction of newer processing such as frequency transposition and receivers with broader bandwidths, speech tests that have adequate high frequency content are needed to assess these features. A new speech test was developed for this application. This thirty-two item nonsense syllable test uses a computerized presentation and scoring method. The nonsense syllables were formatted in a C-V-C-V-C order using the consonants /p, t, k, b, d, g, m, n, ŋ, f, v, θ, ð, s, z, ʒ,ʃ, ʧ, l, w, wh, ʤ, j, h, ɹ/. There were 5 vowels used /i, a, æ, ʌ, u/, covering the full range of vowel formant frequencies. An open format was used. Each item was preceded by the phrase "Please say the word…" by a female talker.

Objective

To assess the use of a new computerized nonsense syllable test on hearing impaired listeners.

Potential advantages of the new speech test:

1. Designed to optimize high frequency content e.g., female speaker.
2. The 32 item nonsense syllable test:
   a. Has all consonant phonemes
   b. Covers whole frequency range
   c. Each of the 32-items contains at least one fricative sound
   d. C-V-C-V-C order can evaluate position and/or co-articulation effect
3. Computerized presentation, scoring, and analysis:
   a. Results shown immediately
   b. Errors can be immediately examined by their phoneme class
   c. Confusion matrix available for error pattern analysis

METHOD

- The thirty-two item nonsense syllable test was presented unaided at a conversational speech presentation level (68 dB SPL).
- The speech was presented at a 0^0 azimuths one meter from the participant.
- The list of test items was randomized for each presentation of the test.
- Each phoneme was scored using a phonetic response form, Figure 1.
  - Green next button pressed if all phonemes correct
  - Responses for each incorrect phoneme indicated
  - Drop down menu for inserted phonemes
  - Red No Response button pressed for no response
- At the end of the test, complete results were displayed, Figure 2, including:
  - All phonemes, all consonants, and all vowels, etc.
  - Manner (fricative, stop, nasal, approximants, etc.)
  - Place (dental, velar, labial, bilabial, etc.)
  - Voicing (voiced phonemes or unvoiced phonemes)
- These results were then exported to Excel for further analysis.

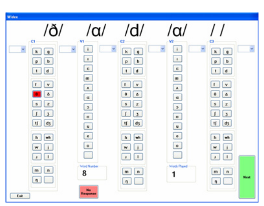

Figure 1: Response screen for nonsense syllable test

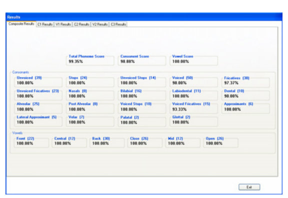

Figure 2: Results screen after completion

METHOD (cont.)

Participants

Thirty one participants of varying hearing loss degrees and configurations were evaluated with the new 32 item nonsense syllable test. The participants were divided into four groups based on degree of hearing loss and slope of the audiogram. Their average right/left audiograms were shown in Figure 3a-d.

- The first group (Figure 3a; n=7) presented with normal to mild hearing loss through 2000 Hz and a precipitous high frequency hearing loss.
- The second group (Figure 3b; n=7) presented with a mild-sloping hearing loss where the pure tone average was 40 dB or less.
- The third group (Figure 3c, n=7) presented with normal hearing at 500 Hz and a precipitous hearing loss. The pure tone average for this group was above 40 dB HL.
- The final group (Figure 3d; n=10) presented with a moderate sloping hearing loss with a pure tone average between 40 and 70 dB HL.
- Participants in all four groups were native English speakers.
- The age of the participants ranged from 46 years to 79 years with an average of 68 years.
- There were 21 male participants and 10 female participants.

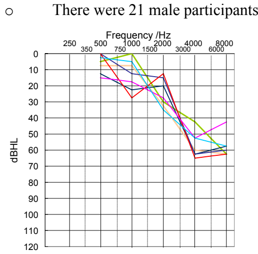

Figure 3a: Mild precipitous hearing loss (n=7)

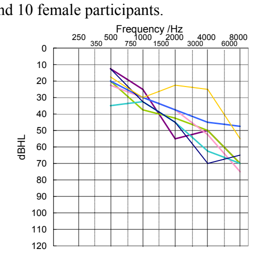

Figure 3b: Mild-sloping hearing loss (n=7)

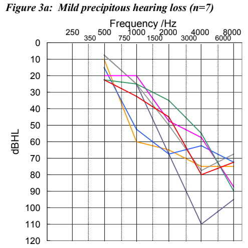

Figure 3c: moderate precipitous loss (n=7)

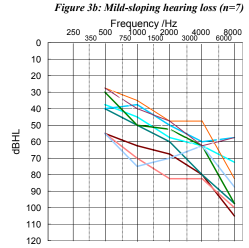

Figure 3d: Moderate sloping hearing loss (n=10)

RESULTS

The overall score for all consonants, for each test subject, was correlated with their predicted SII score as seen in Figure 4. The Pearson product correlation coefficient was r=0.87. This confirms that the more hearing loss a participant has, the less likely they can identify items on the test.

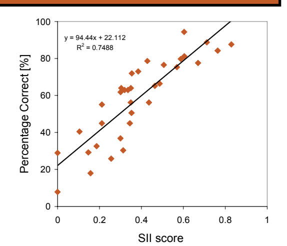

Figure 4: Correlation of SII and percent correct for all consonants

RESULTS (cont.)

The average results for all vowels were shown in Figure 5. The results for the precipitous groups were solid in color and sloping loss in stripes. The mild losses were dark orange and the moderate losses were the light orange color. Average normal hearing results were depicted by the asterisk in the upper left corner (98.6%). As expected, the group with the mild-precipitous hearing loss obtained the best score for vowels and the group with the moderate sloping loss obtained the worst score. This is understandable as it is an unaided test condition.

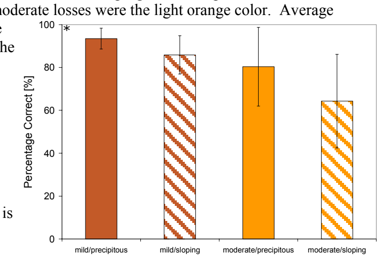

Figure 5: Percentage correct for all vowels by hearing loss group; normal hearing response designated by asterisk

For whole word tests, some listeners may be able to guess the word correctly even if they do not hear all the sounds in the word. With nonsense syllable tests, the listener needs to be able to hear all the sounds in order to repeat them correctly. The test results for this new test can be seen and analyzed by many different factors. You can compare results by place of articulation; manner of articulation; voicing, consonants only, vowels only, high frequency sounds such as fricatives etc, etc. To illustrate this, the results for correctly identifying fricative phonemes were shown in Figure 6. As with the vowel results in Figure 5, these results were also expected. The first group with the mild precipitous hearing loss obtained the best results for fricative identification; whereas, the last group with the moderate sloping hearing loss obtained the worst results for fricative identification.

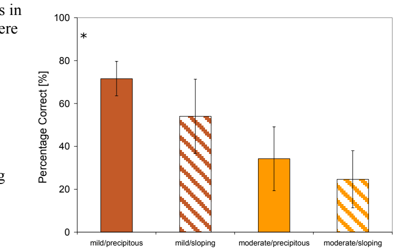

Figure 6: Percentage correct for all fricative sounds by hearing loss group; normal hearing response designated by asterisk

Case Study

The previous section had shown the results for different hearing loss test groups. By comparing the results of two test participants, it can be shown that this test may be more sensitive to the hearing impairment of the listener. The hearing loss of two participants was shown in Figure 7. They present with a normal to mild hearing loss in the lower frequencies and a 10-20 dB difference at 1000 Hz and above.

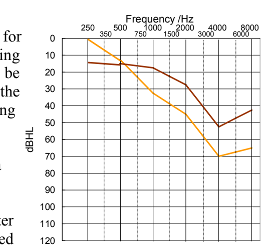

Figure 7: Audiograms of participant 1 (dark orange); subject 2 (light orange)

Because these two test subjects have better hearing in the low frequencies, it is expected that their performance on phonemes with more low frequency information would be good. For phonemes that contain higher frequency information, such as fricatives, their performance should be different due to the difference in their high frequency hearing loss.

As can be seen in Figure 8, these two participants had the same results for all voiced phonemes, vowels, and nasals. However, when higher frequency information was needed for identification, participant 1 (dark orange) had better performance than participant 2 (light orange). This was most notable for all unvoiced phonemes and fricatives. If the speech test did not have the high frequency content, the performance difference may not have been noted.

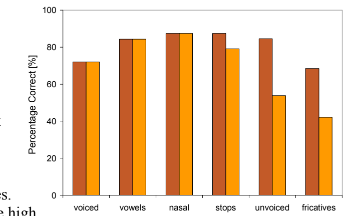

Figure 8: Percentage correct for participant 1 (dark orange) and participant 2 (light orange)

The results with this test can also be displayed as a confusion matrix. In this way, error analyses can be made. For the confusion matrix, the stimulus phoneme was on the x-axis and the response was on the y-axis. The numbers on the diagonal indicate a correct response. Numbers anywhere else represent an error. Not only can the errors be observed, but also the confusions the listener makes. This will give insight as to which phonemes the patient has difficulty with instead of scoring a whole word. The confusion matrix for participant 1 was shown in Figure 9. The responses for the phoneme /f/ were all correct (5/5). For the /s/ phoneme, there were 4 out of 5 responses correct. The one confusion was with /f/. The confusion matrix for participant 2 was shown in Figure 10. The responses for the phoneme /f/ were correct 2 of the 5 times and confused with /s/ 3 times. For the phoneme /s/, it was correct 2 times; was not heard one time; and interestingly was confused with /d/ twice.

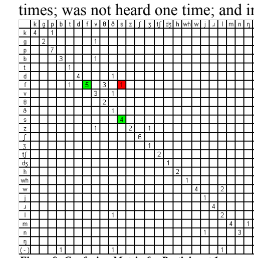

Figure 9: Confusion Matrix for Participant 1

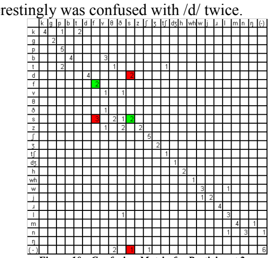

Figure 10: Confusion Matrix for Participant 2

CONCLUSIONS

The results of these preliminary measures for the new computerized nonsense syllable test were as expected.

1. The correlation of the results to SII scores indicated that the content of the nonsense test was representative of the speech intelligibility for spoken English.
2. The new test was able to demonstrate moderate performance difference between hearing loss configurations.

REFERENCES

ANSI (1997). "ANSI S3.5-1997, "American national standard methods for calculation of the speech intelligibility index" (American National Standards Institute, New York).

Boothroyd, A. (1999). Computer-Assisted Speech Perception Assessment (CASPA 2.2). *San Diego: Arthur Boothroyd*

Cornelisse, L.E., Gagné, J.P., Seewald, R.C. (1991). Ear level recordings of the long-term average spectrum of speech. *Ear Hear,* 12(1), 47-54.

Danhauer, J.L., Edgerton, BJ. (1988). Edgerton-Danhauer Nonsense Syllable Test (NST) (Information from the authors). *An Auditec Publication: St. Louis Missouri.*

Denes, P.B. (1963). On the statistics of spoken English. *J Acoust Soc Am,* 35(6):892-904.

Gardner, H.J. (1987). High frequency consonant word lists. *Hear Instr,* 38(7), 28-29.

Owens, E., Schubert, E.D. (1977). Development of the California Consonant Test. *J Speech Hear Res.,* 20: 463-474.

Pascoe, D.P. (1975). Frequency Responses of hearing aids and their effects on the speech perception of hearing-impaired subjects. *Ann Otol. Rhinol Laryngol,* 84 (5 pt 2 suppl 23): 1-40.