ORCA NST SPEAKER GENDER AND AE EFFICACY

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INTRODUCTION

The Widex Office of Research in Clinical Amplification Nonsense Syllable Test (ORCA NST) was designed to demonstrate how high frequency speech information impacts phoneme identification abilities in listeners with sensorineural hearing loss. It has been used to evaluate listener performance when fitted with linear frequency transposition (LFT) technology (Kuk, Keenan, Korhonen, & Lau, 2009).

The ORCA NST was recorded using a male and female speaker. The male speaker was found to have a fundamental frequency of 106 Hz, and the female speaker a fundamental frequency of 196 Hz (Kuk, et al., 2010). The long-term output of the male and female speakers contain speech energy above 8000 Hz, , but the amount of high frequency energy present in individual phonemes is different between the male and female speech. Spectral peaks of the fricatives /s/, /z/, /θ/ and /ð/ was measured to be between 3600- 5700 Hz for the male speaker and between 6600- 8000 Hz for the female speaker (Kuk, et al., 2010).

The present study was designed to administer the male and female versions of the ORCA NST to subjects while they are wearing hearing aids fitted with Master (non-LFT) and AE (LFT) programs. Differences in performance were noted, in order to identify and quantify observed gender effect on the ORCA NST and to see how it affected the efficacy of AE observed during testing. It was theorized that the female version of the ORCA NST would be more sensitive in evaluating subject performance in the AE program than the male version of the test.

METHODS

Hearing instrument

Three models of the Clear 440 hearing aids (C4-9, C4-m-CB and C4-PA) were utilized in this study. Subjects with normal hearing in the low frequencies were fit with the C4-PA or C4-m-CB, while those with more low frequency hearing loss were fit with the C4-9. Subjects with normal hearing at 500 Hz (≥25 dB HL) and severe hearing loss at 4000 Hz were fit with open domes. Subjects with profound hearing loss at 4000 Hz were fit with custom CAMISHA shells. One subject with severe hearing loss at 500 Hz was fit with earmolds using standard #13 tubing.

Audibility Extender (AE)

Listeners with severe to profound SNHL typically cannot benefit from increased audibility in the high frequencies, as the damage to their auditory system in this region is too great to make use of this information. The AE program transposes this high frequency energy above a specified start frequency to lower frequency regions with less damage in the listener's auditory system. The transposed high-frequency information is linear, and therefore does not alter the harmonic structure of the transposed signal, which limits the amount of distortion presented to the listener (Kuk, Keenan, Korhonen, & Lau, 2009).

Subjects

Ten subjects

- Age range of 58- 82 years [mean = 71.7 years, sd = 7.5 years]
- Nine males, one female
- Five subjects wore hearing aids, five did not have any hearing aid experience

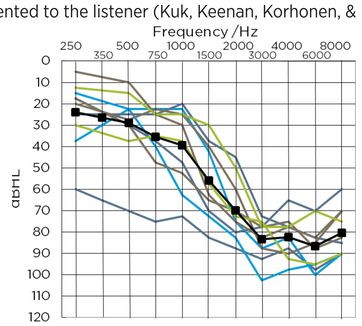

Figure 1: Average right/left audiogram

METHODS [cont.]

Equipment Set up

The test signal was routed through an EchoAudio24 sound card and presented to the subjects via a single loudspeaker (KRK ST6). To drive the loudspeaker, a four-channel power amplifier (Niles SI1230) was used. Testing was conducted in a double-wall sound-treated booth (Industrial Acoustics), with internal dimensions of 10' x 10' x 6'6".

Test Stimulus

Widex Office of Research in Clinical Amplification Nonsense Syllable Test (ORCA NST): The ORCA NST consists of 32 nonsense words created in the CVCVC format. 25 consonants found in American English (p, t, k, b, d, g, m, n, ŋ, f, v, θ, ð, s, z, ʃ, ʒ, l, w, ʍ, ɹ, j, h, tʃ, dʒ) and five vowels found in American English (i, ^, æ, ɑ, u) were used to create the nonsense words. The nonsense words were presented to the subject in a randomized order. The male and female versions of the test were utilized. A carrier phrase was presented to the subject, followed by the nonsense word. The subject was instructed to repeat the nonsense word exactly as they heard it, even if they were only able to hear part of the item. A custom computer program was used to present the speech stimuli and to allow the test giver to score the subject's responses. Percent correct scores are derived from the correct identification of items in each 32-item list.

Test Procedure

The male and female versions of the ORCA NST were presented to the subjects unaided and aided in the Master and AE programs. The test was utilized at 68 dB SPL and at 50 dB SPL. While aided, each subject performed the ORCA NST in the Master and AE program at both intensity levels. The order of test presentation and listening conditions were counterbalanced.

RESULTS

Before the study, subjects were fit with the study hearing aids and placed into one of two groups. Group 1 subjects [n=5] wore the study hearing aids for two weeks at home in the Master program, while subjects in Group 2 [n=5] wore the study hearing aids for two weeks at home in the AE program.

Results from the ORCA NST are analyzed based on percent correct score for consonants and percent correct score for the phoneme /s/. The overall Consonant score (which includes all 25 consonants on the ORCA NST) was chosen for analysis because it represents a wide spectrum of frequencies, while /s/ reflects a much narrower spectrum, along with the difference in spectral energy between the male and female speakers. Results obtained with male and female speech, at both intensity levels and both programs are analyzed separately for Groups 1 and 2.

In order to observe any difference in performance between each condition, the average AE score was subtracted from the average Master score. A positive difference revealed better performance on the ORCA NST in the AE program, while a negative difference revealed better performance in the Master program.

Figure 2 displays the average differences in Consonant scores between the Master program and AE program.

RESULTS [cont.]

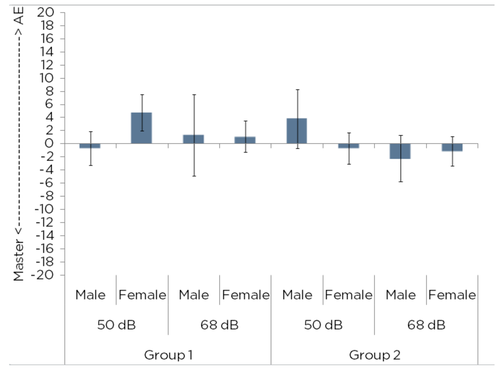

Figure 2: Average amount of difference in scores from condition to Male condition; Consonant score. Bars denote standard error about the mean.

Repeated- measures ANOVA revealed a significant difference between Intensity levels, with better performance noted at 68 dB SPL ($p < 0.05$). However, Tukey's Least Significant Difference test revealed there is no significant difference between scores for Master and AE program, Male and Female speaker or Group at both intensity levels ($p > 0.05$).

Figure 3 displays the average differences in /s/ scores between the AE program and Master program.

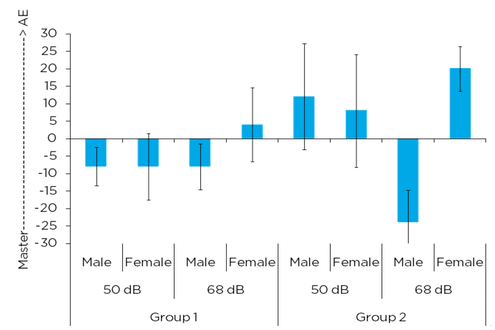

Figure 3: Average amount of difference in scores from condition to Male condition; /s/. Bars denote standard error about the mean.

As seen with the Consonant score, a significant difference between Intensity levels was observed for the /s/ score using repeated- measures ANOVA ($p < 0.05$). Post hoc analysis using Tukey's Least Significant Difference test revealed no difference between Male and Female speaker, Master and AE program or Group at 68 dB SPL ($p > 0.05$).

However, at 50 dB SPL, significant differences between factors were observed. For all subjects, the /s/ score obtained in the Master (Female) condition was significantly better than that obtained in the Master (Male) condition. Furthermore, performance in the AE (Female) condition was significantly better than the performance noted in the AE (Male) and Master (Male). When the subjects were split based on Group, AE (Female) performance remained significantly better than Master (Male) performance for Group 2 only. Figure 4 displays the difference in scores from AE (Female) and Master (Male) for the two groups.

RESULTS [cont.]

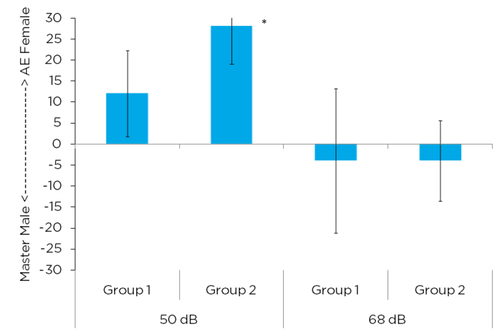

Figure 2: Average amount of difference in scores from AE Female to Master Male condition; /s/. Bars denote standard error about the mean.

Overall, the results show that when considering the whole Consonant score, there is no advantage to using either the Master or AE program and that the Male and Female speakers are equally intelligible. The higher frequency content present in /s/, especially for the female speaker, helps to explain the performance differences observed with /s/. When intensity level is low, the AE program proves more advantageous for identifying /s/ than the Master program when female speech is presented. Group 2, who were fit with the AE program for two weeks of at-home use, performed better with female speech while wearing AE, while Group 1 did not. Once the intensity level was increased, these advantages seen with using AE with female speech disappear.

CONCLUSIONS

- The female speaker on the ORCA NST is more sensitive in demonstrating differences in performance than the male speaker when evaluating the AE program at 50 dB SPL.
- When using the female version of the test, the AE program is shown to be more effective for identification of high frequency phonemes (such as /s/) than the Master program at 50 dB SPL. This result is consistent with those noted in previous studies on AE efficacy (Kuk, Keenan, Korhonen, & Lau, 2009).
- Previous experience with AE (in this case, 2 weeks) may allow for more accurate identification of high frequency phonemes when using the AE program with female speech. It is unclear how this may impact real-world performance in AE users.

REFERENCES

Kuk, F., Lau, C., Korhonen, P., Crose, B., Peeters, H., & Keenan, D. (2010). Development of the ORCA nonsense syllable test. Ear and Hearing, 31(6), 779-95.

Kuk, F., Keenan, D., Korhonen, P., , & Lau, C. (2009). Efficacy of linear frequency transposition on consonant identification in quiet and in noise. Journal of the American Academy of Audiology, 20(8), 465-79.