Comparison of Adaptive Versions of the CCT and NST

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Introduction

Improving the audibility of high-frequency information is the primary goal of most hearing-aid fittings. Therefore, whenever a new technology emerges that claims to improve access to high-frequency sounds, it is important to be able to quantify the impact that the new technology has on speech intelligibility. Two tests that have been used for this purpose are the California Consonant Test (CCT) and the Nonsense Syllable Test (NST).

Both the CCT and the NST were designed to be conducted at a fixed presentation level. Selecting a single presentation level that is appropriate for all participants and test conditions is challenging because there is likely a range in participants' performance; choosing a single test level means that some participants may perform at a floor or ceiling level for some of the test conditions. This is undesirable because it limits our ability to demonstrate improvements in speech recognition that are associated with different technologies.

In order to address the challenge of choosing a single fixed presentation level that is appropriate for all participants and test conditions, we modified the CCT and the NST so that they could be performed in an adaptive manner. The goal of this study was to compare these two adaptive tests in terms of repeatability, variability, test time and effect size.

Methods

Participants

—12 normal-hearing (24-56 years, 37 mean)

CCT (lists 1a and 1b)

—Four-alternative-forced-choice (4AFC) test

—CVCs that differed in the initial or final position

—Testing was performed in a sound booth

—Speech 0°

—55 dBA (fixed)

—Noise ±45°, ±90°, ±135°, 180°

—45 dBA (adaptive)

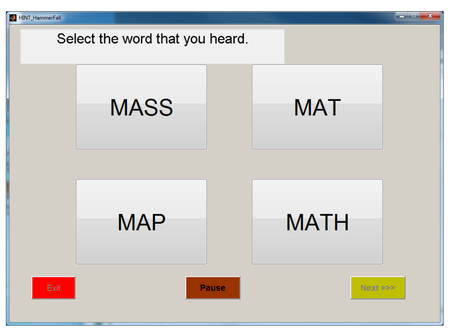
—increased 10 dB after each correct response

—decreased 2 dB after the first incorrect response

—changed by 2 dB (up or down) for subsequent responses

—The test terminated after 12 reversals

—The last 10 reversals were averaged to determine the test score



Methods

NST

—Consonant sounds were paired with 3 vowels "ah," "ee," and "oo"

—Female talker

—Participants selected which of 21 sounds they heard

—Testing was performed in a sound booth

—Speech 0°

—65 dBA (adaptive)

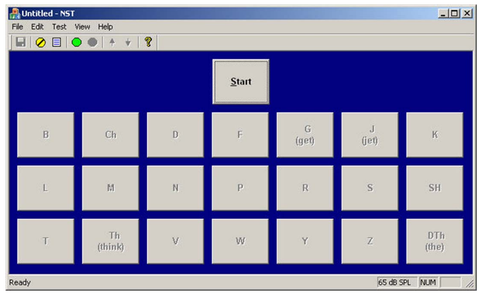
—changed by 4 dB (up or down) for the first 4 reversals

—changed by 2 dB (up or down) for subsequent responses

—Noise ±45°, ±90°, ±135°, 180°

—65 dBA (fixed)

—Threshold = average of signal-to-noise ratios (SNRs) for stimuli 5-63



Procedures

—**Session 1**

—Participants completed both tests 10 times (unaided)

—Results were examined for repeatability/variability/test time

—**Sessions 2**

—Participants were fitted bilaterally with directional hearing aids that had a particularly good Directivity Index (DI) in the high frequencies

—Hearing aids were programmed linearly for a mild, flat, SNHL

—Participants completed both tests 5 times in both the omnidirectional and directional microphone modes

—Results were examined for effect size

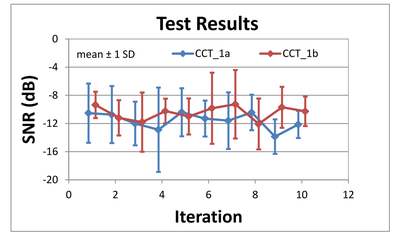
Results/Discussion

CCT

—For 7.5% of measurements, participants reported that they could not tell that a stimulus was being presented for most of the test—the stimulus was obscured by the background noise, which increased the variability in the participants' test scores (up to 20 dB for some participants). The large initial step size coupled with the 4AFC procedure, which increased the probability of a correct response by chance, likely contributed to this occurrence. When this occurred, the test scores were considered invalid, and the measurements were repeated.

Results/Discussion

CCT List



A Two-Way ANOVA showed **no significant differences** for:

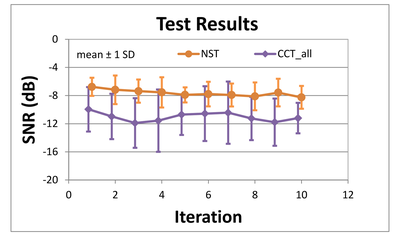
—list F (1, 1) = 3.083, p = .082

—iteration F (1, 9) = .389, p = .938

—interaction between list and iteration F (1, 9) = .762, p = .651

This implies that the scores for the two lists are equivalent. Therefore, data for both CCT lists were collapsed for further analysis.

CCT vs. NST



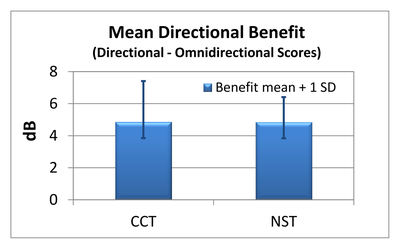
Repeatability: t-tests were performed comparing the results of the first two iterations of the test to the results of the last two iterations of the test. **No significant differences** were found for either test (CCT p = .236; NST p = .064). This implies that there were no learning effects associated with either test.

Variability: Across the different iterations of the tests, the standard deviation was approximately twice as great for the CCT as for the NST (3.4 dB vs. 1.7 dB). Standard deviations for the CCT were within the range reported by Tecca & Binnie (1982). This result indicates that the NST may provide a more accurate estimate of the mean, with the need for fewer iterations of the test.

Test Time: To complete one iteration of the test, it took an average of:

—4 minutes, 3 seconds for the CCT

—3 minutes, 36 seconds for the NST



Benefit: The amount of benefit was calculated for both tests as Directional Score — Omnidirectional Score. A t-test showed **no significant differences** (p = .993).

Summary

The goal of this study was to compare two adaptive high-frequency tests—the CCT or the NST—in terms of repeatability, variability, test time and effect size. Below is a summary of the findings and recommendations:

—The two tests performed similarly in terms of repeatability and directional benefit.

—The NST performed better than the CCT in terms of variability and test time.

—For the reasons stated above, the adaptive version of the NST was a better test than the adaptive version of the CCT. Additionally, because listeners can choose from all of the consonant sounds with the NST, this test allows for more extensive post hoc analysis of participants' confusions. Future studies should consider using this test as an alternative to fixed-level testing.

—If the adaptive version of the CCT is used for future studies, we recommend changes to the way in which it is administered in order to minimize the likelihood that the speech will be obscured by the background noise for much of the test. Specifically, we recommend using a smaller initial step size and adding a "Can't Hear" button to the application. When selected, the "Can't Hear" option could be scored similarly to other incorrect answers.

References

Tecca, J.E., & Binnie, C. A. (1982). The application of an adaptive procedure to the California Consonant Test for hearing aid evaluation. Ear & Hearing, 3 (2), 72-76.