A CANADIAN VERSION OF THE DIGIT TRIPLETS TEST

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Of all the stimuli used for speech-in-noise tests, digits have received a particular attention as stimuli because they are highly familiar words to all age groups, including populations learning a new language. The Digit Triplets Test (DTT; Smits et al., 2004) was originally developed in the Dutch language as an automatic self-screening test. The test uses an adaptive procedure to find the speech recognition threshold (SRT) in noise, which corresponds to the signal-to-noise ratio at which the digit triplets are correctly identified 50% of the time. The DTT has been adapted in different languages and can be administered over the phone, the internet, or smartphones. Digits triplets (e.g., 4-1-8) are presented in a background noise and the listener enters the digits heard on a keypad. A Canadian French and English version of the DTT has been developed in a collaborative effort between the University of Ottawa and the University of Toronto (CDTT). The digits were recorded in both languages from two fluently bilingual adult talkers (one male, one female). The recordings were then processed and optimized, according to the ICRA recommendations (2015) and ISO standard on speech audiometry (ISO 8253-3:2012). A speech-shaped noise was developed for each language-talker combination. This presentation will describe the development stages of the CDTT. Data obtained with normal hearing adults and school-aged children using the CDTT software will be presented, as well as some metrics and characteristics of the test (e.g., test-retest reliability, etc.). Some details about the required hardware will also be presented for laptop implementation. The CDTT requires little practice and can be quickly administered, making it ideal for measuring speech-in-noise performance with many populations, including in children or non-native speakers of French or English.

Keywords: Digit triplet test, speech-in-noise, hearing screening

1. Introduction

The Digit Triplet Test (DTT) (Smits, Kapteyn, & Houtgast, 2004) was originally developed in Dutch to identify individuals with hearing loss and promote help-seeking. The DTT is a speech-in-noise screening test that uses combinations of three digits as speech material, also called digit triplets. The test uses
an adaptive procedure to determine the speech reception threshold (SRT). The SRT corresponds to the speech-to-noise ratio at which 50% of the triplets are correctly recognized.

The DTT was initially developed for self-assessment via telephone, but it is now used over a wide range of platforms including smartphones, personal computers, etc. It has been adapted in about 15 different languages or dialects (Denys et al., 2018).

Compared to pure-tone screening protocols, the advantage of using speech-in-noise screening lies in the suprathreshold nature of this type of tests, overcoming ambient noise level issues. Using digits instead of words or sentences also presents some advantages. Digits are highly familiar words, they are among the first words acquired by both first and second language learners and they are known even by individuals with limited linguistic abilities. Digit triplets also present low contextual redundancy which is tapping less on the listener’s cognitive and linguistic competencies. Compared to words or sentences, recognition scores obtained with digits appears to be more specifically related to the auditory abilities.

The Canadian Digit Triplets Test (CDTT) has been developed based on Smits et al. (2004) experience. Digit triplet recordings were created in both Canadian French and English, from both a female and a male speaker. Each version of the CDTT includes four lists of 24 triplets that are counterbalanced so that each digit occurs three times in each triplet position, without repetition of the same digit within a triplet.

The presentation order of the 24 triplets is randomized on each run of a list. This paper describes the development stages of the CDTT.

2. Methods

2.1 CDTT software and required software

The CDTT software was developed as a cross-platform Java desktop application that can be run on any major operating system (e.g., Windows, Max OS) that has a Java Runtime Environment installed. The main interface provides controls for the test operator to enter participant information, select test parameters, run a test, and save the results (Figure 1). The interface also includes a stimulus-response digits table to update the operator on the progress as responses are given throughout the test. Although participant can enter their responses on an external USB numeric keypad, it is also possible to use the response keypad that is displayed on the screen as the test is running. In a test configuration that includes only a single computer monitor, it is possible to hide the main interface while the test is running to prevent the participant from seeing the stimulus digits.

Other than any desktop or laptop computer that has a Java Runtime Environment installed, the only additional hardware that is required for conducting the CDTT is a USB sound card and a pair of audiometric earphones. The USB sound card is used for portability and reproducibility across computers and sound playback hardware. The use of Radioear DD45 earphones (Eden Prairie MN) are recommended as normative data were developed with this grade of earphones.

2.2 Speech material and masking noises

English and French digit-triplet sequences were recorded in a sound proof room from two fluent bilingual adults, one male and one female. Eight monosyllable-digits were selected in each language: digits 1, 2, 3, 4, 5, 6, 8 & 9 for the English version and 1, 2, 3, 5, 6, 8, 7 & 9 for the French version. A short carrier phrase, “The numbers” in English and “Les numéros” in French, was also recorded for each version.

For each language-speaker version, a unique speech-shaped noise matching the long-term average of the digit material was also created, according to ISO 8253-3:2012. During playback, the noise is presented continuously starting 500 ms before the first item and ending 500 ms after the last item.
2.3 Digit optimization and development of normative data

The recordings were processed and optimized, according to the ICRA recommendations (Akeroyd et al., 2015) and included three testing phases: the digit optimization, the evaluation of the test lists equivalence and the creation of normative data. A total of 112 young adult participants took part in the different phases of the test development. Testing for the English version was carried out at the University of Toronto, and testing for the French language versions of the CDTT was conducted at the University of Ottawa. All participants were between the age of 18 and 30 years and were screened for normal hearing. Participants were native speakers in the language they were tested. Testing procedures were approved by the research ethics boards of the two universities.

Results obtained show that the test lists of the four language and talker versions of the CDTT are equivalent. The normative SRT for the adults is similar for each version, ranging from -12.1 to -12.7 dB, with a standard deviation of 0.7.

The effect of development on the performance measured with the CDTT was evaluated with the French version of the CDDTT. A total of 119 children between the age of 5 and 12 years were tested with each talker version. Testing was carried out in a public French school (St-Basile, NB, Canada). All participants were native speakers of Canadian French and were screened for normal hearing prior to testing. They were divided into three age groups: 5-6 years, 8-9 years and 11-12 years.

The results revealed that the actual test paradigm is too difficult for the youngest group (5-6 years). The mean SRT value is similar for the two older age groups, ranging from -10.45 to -11.17 dB. There is a significant difference between SRT value obtained with each speaker recording for the 8-9 years old ($t = -2.64, p = .02$), but not for the 11-12 years old ($t = -1.36, p = 1.86$). More testing is required to confirm this difference noted in the ability to recognize speech in background noise, according to the gender of the speaker. The test-retest standard deviation of the CDTT is in the order of 1.2 dB for the children groups, which is about twice the value of the adult participants.
3. Discussion and Conclusion

The CDTT includes a female and a male talker for both the French and the English version of the test, which provides a unique set of speech test stimuli. The versatile testing platform offers the possibility to conduct the test in different environments (e.g., waiting rooms, pharmacies) and conditions (e.g., monaural or binaural, adaptive or fixed levels procedures).

As for the original version of DTT, the Canadian version could be used as hearing screening test. Studies conducted with the DTT (in other languages) have shown very high accuracy to distinguish between normal-hearing and hearing impaired listeners (Denys et al., 2018; Jansen, Luts, Dejonckere, van Wieringen, & Wouters, 2013; Jansen, Luts, Wagener, Frachet, & Wouters, 2010). Compared to pure tone screening, which has traditionally been used for detection of hearing loss, the CDTT can be used in less favourable acoustic conditions and it is automatic.

Although more testing is needed in that regard, the CDTT could also be used as a clinical hearing test. Measures of pure tone thresholds are often deemed unsuitable for early detection of noise-induced hearing loss or early onset of presbycusis for example. Pure tone thresholds are often within normal range, or near normal range, in these specific cases. While affected individuals are complaining about speech processing in noise, the CDTT could be considered as a tool for the early detection of mild hearing losses as speech-in-noise problems are the first indication of impairment.

The CDTT has great potential as research tool. It allows multi-sites comparisons and also allows international collaboration as similar digit triple in noise tests are available in many other languages. It is presently being used in two large-scale multi-site studies on aging across Canada: the Canadian Consortium on Neurodegeneration in Aging (http://ccna-ccnva.ca/en/) and the Canadian Longitudinal Study on Aging (https://www.clsa-elcv.ca/).

The CDTT requires little practice and can be quickly administered, making it ideal for measuring speech-in-noise performance with many populations, including children and non-native speakers of French or English. The CDTT has the potential for many applications: not only as a hearing screening tool as it the original version was developed for, but also for clinical and research uses.

REFERENCES