A SOFTWARE PLATFORM TO ADMINISTER THE CANADIAN DIGIT TRIPLET TEST

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1 Introduction

A variety of tests using speech as sound material is available for use in hearing screening, assessment and rehabilitation. Of the materials used for speech tests in audiology, digits have received particular attention as they are highly familiar words and are acquired either at a young age or among the first words when learning a new language. The Digit Triplet Test was originally developed in the Dutch language as an automatic self-screening test [1]. It is a simple test in which the person being tested is presented with a list of digit triplets (*e.g.,* 6-1-8) in a background of noise and is asked to enter the digits heard using a telephone keypad. The test uses an adaptive 1-up-1-down triplet scoring procedure (a correct response is registered only if all three digits are entered correctly) to compute a speech reception threshold (SRT). This SRT corresponds to the signal-to-noise ratio at which the triplets are recognized 50% of the time. The test has been developed in different languages and can now be administered over the phone, the internet or smartphones [2]. Owing to its wide success, and to facilitate comparison between languages, recommendations for constructing such tests have been developed by a working group on multi-lingual speech testing of the International Collegium of Rehabilitative Audiology (ICRA) [3].

This paper describes the testing platform designed to administer the new Canadian Digit Triplet Test (CDTT). First, a summary of the test development is presented. This is followed by a description of the software interface, the supported features, and hardware recommendations. The paper concludes with a brief overview of test applications.

2 Development of the CDTT

Developing the Canadian-English and Canadian-French versions of the test according to the ICRA recommendations involved several steps [3]. First, digit-triplet sequences were recorded in both languages by two fluently bilingual adult talkers (a male and a female). For each language-talker combination, the recordings were segmented to obtain a set of 8 digits at each position in the triplet. Next, a speech-shaped noise signal was generated according to ISO 8253-3:2012 [4] and four test lists were created. The test development includes three testing phases: Phase I (fixed-level, digit scoring) to optimize the digits; Phase II (fixed-level, triplet scoring) to evaluate the test lists; Phase III (adaptive-level, triplet scoring) to establish test norms.

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3 Testing platform

3.1 Overview

The CDTT software is distributed as a cross-platform Java desktop application that can run on any major operating system (*e.g.,* Windows, Mac OS, Linux), with 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 test results (Figure 1). In addition to displaying results at the end of a test, the interface also includes a stimulus-response digits table to update the operator on progress throughout the test as responses are given. A Response Keypad is displayed as the test is running for the test subject to interact with the system (Figure 2). In a test configuration that includes only a single computer monitor, the software can hide the main interface while the test is running to prevent the person being tested from seeing the stimulus digits.

In addition to sound files for the speech test material, the software architecture includes a number of Excel files to store important application settings, list definitions, default test parameters, and calibration values. Test results are also exported into an Excel spreadsheet for each person tested to permit further analysis if needed.

3.2 Features and customizations

The system has been designed as a testing tool both to administer the CDTT in its final form and to carry out the
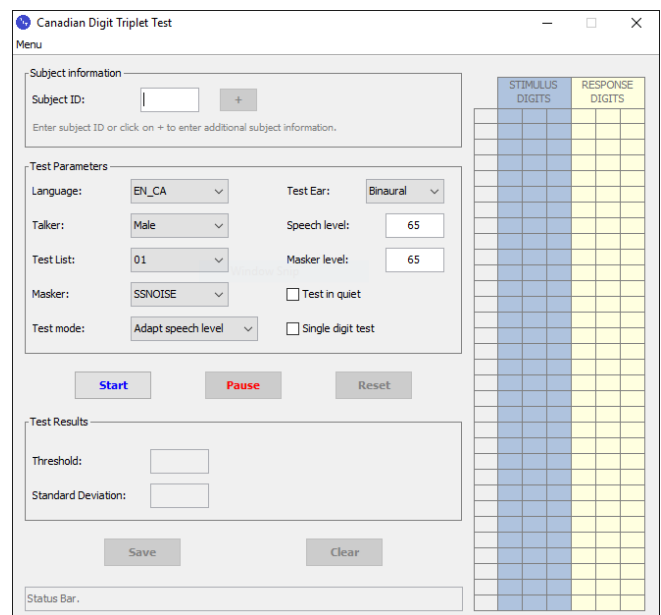

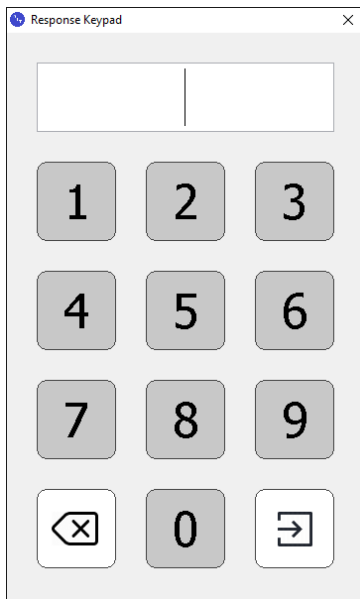**Figure 1:** Main interface of the Canadian Digit Triplet Test.

Figure 2: Response Keypad of the Canadian Digit Triplet Test.

different phases of test development. To date, the following features are supported:
- Selection from two test languages and two talkers.
- Selection from four different test lists.
- Testing in monaural or binaural listening conditions.
- Testing in quiet or in speech-shaped noise.
- Testing using a single digit or digit triplets.
- Two test modes: fixed level, or adaptive speech level.
- Triplet and digit scoring (fixed-level mode only).
- Ability to export stimulus-response digits table.
- Input response through software or hardware keypad.
- A calibration interface to calibrate the sound output.
- A detailed settings interface to customize the system.

A wide range of customization options have been built into the application with factory settings defaulting to values consistent with the ICRA recommendations [3]. Moreover, the software implementation has been made flexible in order to permit testing in different use-case scenarios. For example, after the first phase of testing, level adjustment factors are derived to homogenize the intelligibility of all digits at all positions. This requires fitting a psychometric function to achieve a target SRT [5]. Level adjustment factors were derived to align the target SRTs for 50% and 80% intelligibility. Thus, the original recordings used in the first phase are also used in subsequent tests with the level adjustment factors applied in the software at the time of presentation when the digits are resynthesized into triplets.

3.3 Hardware recommendations

The primary result of this speech-in-noise test, the SRT, is not sensitive to absolute sound presentation levels. Thus, it is possible to run the test by connecting a pair of earphones to any computer's audio output. For reliable results, it is recommended to use audiometric earphones, especially if testing in quiet. Moreover, for portability across test sites, it

is recommended to use a USB audio interface instead of relying on a computer's internal audio hardware. The calibration values included in the CDTT software have been obtained using pairs of DD45 audiometric earphones and a Creative Sound Blaster X-FI GO! Pro audio interface.

The Response Keypad (Figure 2), allows participants to provide a response using a mouse or touch screen. Its layout corresponds to a phone keypad such that it, like the DTT web interface in different languages, is consistent with versions that are administered over the phone. The number pad on a standard 101-key hardware keyboard or a USB numeric keypad has a different layout. If a hardware keypad is required, the physical keys for 1, 2 and 3 need to be swapped with the keys 7, 8 and 9 in order for the correct keys to be registered. Alternatively, an option is provided in the settings interface to use the physical keypad's layout ("calculator" type). Selecting this option modifies the layout of the software keypad to maintain consistency.

4   Summary and application

The CDTT is presently being developed and evaluated in two languages and using two different talkers, providing a unique set of speech test material. The versatile testing platform presented in this work is designed to administer the test and assist in its development. The test is being deployed in large-scale multi-site studies across Canada on aging: the Canadian Consortium on Neurodegeneration in Aging (http://ccna-ccnv.ca/en/) and the Canadian Longitudinal Study on Aging (https://www.clsa-elcv.ca/). In addition, the test may be a useful tool for lab-based research, audiologic assessment of francophone speakers in minority settings in Canada, studies of English or French as a second language.

Acknowledgments

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