DO DIFFERENT SPEECH-IN-NOISE TESTS LEAD TO SIMILAR OUTCOMES?

Chantal Laroche, David Morasse, Leila Boutarfa, Christian Giguère, Josée Lagacé and Véronique Vaillancourt

University of Ottawa, Ottawa, Ontario, Canada
email: claroche@uottawa.ca

The current project aims to compare the performance of individuals presenting various degrees of hearing loss on three Canadian French speech-in-noise tests: a digit test (Canadian Digit Triplet Test or CDTT), a word test (Test de Mots dans le Bruit or TMB) and a sentence test (Hearing-in-Noise-Test or HINT). The goal was to determine the spread of results for each test (e.g., range of performance, test-retest), the relationship of each test to hearing thresholds, and whether good performance on a particular test is indicative of good performance on the other tests. The TMB, a words-in-noise test using babble noise, yielded a wider range of results across individuals but a higher test-retest variance than the CDTT and HINT tests, which use a continuous speech-spectrum noise. Scores for the CDTT were more closely related to hearing thresholds than those of the TMB and HINT tests. Important differences in results were found across the three tests for certain individuals, indicating that selection of the speech material and/or noise type can have a significant impact on outcomes.

Keywords: speech testing, speech recognition threshold, hearing loss, noise

1. Introduction

Audiologists have access to an ever-increasing number of different speech-in-noise tests for diagnostic, functional evaluation and/or screening purposes. Even if the importance of evaluating speech perception in noise as part of the regular audiological assessment has been advocated for some years [1-3], surveys show that it is not common clinical practice [4]. One of the reasons put forward to explain this situation is that clinicians may be unaware of how to use the information gained from speech-in-noise tests, which is exacerbated by the growing number of such tests. The speech material varies widely across tests, from simply digits to highly-contextual sentences, as does the type of masking noise (from continuous and fluctuating energetic maskers to informational maskers). When it comes to choosing the right test, clinicians need to ensure that results are predictive of the hearing ability relevant to the intended application.

The current study compares the performance of individuals with hearing loss on three Canadian French speech-in-noise tests. The Canadian Digit Triplet Test (CDTT) [5] is an adaptive speech screening test based the recognition of three-digit sequences (in Canadian English or Canadian French) in speech spectrum noise. The “Test de Mots dans le Bruit” (TMB) [6] is a Canadian French monosyllabic word test (open set) presented in babble noise and is typically carried out at fixed signal-to-noise ratios (SNRs). The Hearing-In-Noise Test (HINT) is an adaptive sentence test conducted in speech spectrum noise.
noise and available in several languages, including Canadian French [7-8]. The goal of the study is to determine (1) the spread of results for each test (e.g., range of performance, test-retest), (2) the relationship of each test to hearing thresholds, and (3) whether good performance on a particular test is indicative of good performance on the other tests.

2. Methods

Data was collected for a first cohort of listeners with hearing loss between May and December 2018. Twenty (20) adults between the ages of 21 and 86 years old presenting with different degrees of sensorineural hearing loss participated. They were fluent speakers of Canadian French since at least the age of 5 years.

Participants were tested with all three speech tests (Table 1). A measure of the speech recognition threshold (SRT) in noise was obtained in each case. The test-specific automatic adaptive procedure was used with the CDTT and HINT. In the case of the TMB, a manual adaptive procedure similar to that for the other two tests was used. All participants were tested binaurally with supra-aural earphones. In the case of the HINT, only the Noise Front condition was used [6]. The noise was held constant across the three tests at 75 dBA (except for 6 individuals tested at 65 dBA). Each participant was tested twice in each test to determine test-retest variability.

Table 1: Test parameters

<table>
<thead>
<tr>
<th></th>
<th>Canadian Digit Triplet Test (CDTT)</th>
<th>Test de mots dans le Bruit (TMB)</th>
<th>Hearing-In-Noise-Test (HINT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stimuli</td>
<td>Digit triplets</td>
<td>Monosyllabic words</td>
<td>Sentences</td>
</tr>
<tr>
<td>Noise type</td>
<td>Speech spectrum</td>
<td>Babble</td>
<td>Speech spectrum</td>
</tr>
<tr>
<td>Speaker voice</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
</tbody>
</table>

3. Results

3.1 Test result statistics

Table 2 presents descriptive statistics about the speech test results. The range (min, max) expresses the extent of results across individuals in each test (data averaged over the two trials). In the case of the CDTT and HINT, the values represent the minimum and maximum SNR loss (i.e., measured SRT - normative value) observed over the 20 participants. In the case of the TMB, for which no normative data in the adaptive mode were available, an arbitrary SRT normative reference of 0 dB was used. The test-retest SD is the within-subject standard deviation for each test and represents the measurement error upon repeated measurements with a given individual.

For the CDTT and HINT, which are carried out in speech-spectrum noise, the test results varied over a range of 6-7 dB and the test-retest SDs were similar at around 1 dB. For the TMB, which was carried out in babble noise, the range of results was much larger at 16 dB, and the test-retest SD was twice as much that of the two other tests.
Table 2: Test result statistics (n=20)

<table>
<thead>
<tr>
<th>Range (dB) (re: norm)</th>
<th>Canadian Digit Triplet Test (CDTT)</th>
<th>Test de mots dans le Bruit (TMB)</th>
<th>Hearing-In-Noise-Test (HINT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test-retest SD (dB)</td>
<td>0.7</td>
<td>2.2</td>
<td>1.1</td>
</tr>
</tbody>
</table>

3.2 Relationship to hearing thresholds

Table 3 lists the coefficients of determination ($R^2$) of regression analyses carried out between the speech test results and the hearing thresholds of the participants, the latter taken as the pure-tone average (PTA) over three frequencies from both ears. Regression analyses were also conducted using hearing thresholds at individual frequencies and for other PTA combinations. Invariably, hearing thresholds best correlated with the CDTT and the least with the HINT.

Table 3: Correlation between speech tests and hearing thresholds (mean PTA: 1000, 2000, 4000 Hz)

<table>
<thead>
<tr>
<th></th>
<th>Canadian Digit Triplet Test (CDTT)</th>
<th>Test de mots dans le Bruit (TMB)</th>
<th>Hearing-In-Noise-Test (HINT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>0.7</td>
<td>0.38</td>
<td>0.05</td>
</tr>
</tbody>
</table>

3.3 Correlation between tests

Table 4 lists the coefficients of determination ($R^2$) of regression analyses carried out between the three speech tests. The CDTT and the HINT are the least correlated.

Table 4: Correlation between speech tests

<table>
<thead>
<tr>
<th></th>
<th>CDTT vs TMB</th>
<th>HINT vs TMB</th>
<th>CDTT vs HINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>0.60</td>
<td>0.39</td>
<td>0.18</td>
</tr>
</tbody>
</table>

4. Discussion

This paper compares the results of three speech recognition tests on an initial cohort of 20 individuals with sensorineural hearing losses. The data to date indicate that the TMB, which is carried out in babble noise, leads to a wider spread of results (both the range across individuals and the within-subject test-retest) than the CDTT and HINT, which are carried out in continuous speech spectrum noise. Further, the CDTT is much more closely related to hearing thresholds than the TMB, and especially the HINT, likely because the latter requires higher-level extraction of linguistic and contextual information. As such, the CDTT and the HINT tests are the least correlated. The TMB is somewhat correlated to the two other
tests, but the proportion of variance that can be explained from the other two tests is only in the 40-60% range, perhaps in part because it is conducted in an informational masker (babble noise) instead of an energetic masker (speech spectrum noise). Important differences in results were found across the three tests for certain individuals, indicating that selection of the speech material and/or noise type can have a significant impact on outcomes.

In summary, the parameters of each speech test (speech material, type of noise) are likely tapping into different auditory, linguistic and cognitive skills. A battery composed of various speech-in-noise tests may help to fully capture an individual’s hearing abilities in noise.

REFERENCES


