EVALUATION OF SPEECH INTELLIGIBILITY DURING THE TRACKING OF NOISE TOLERANCE (TNT) TEST

Petri Korhonen, Christopher Slugocki, Francis Kuk
ORCA-US WS Audiology

INTRODUCTION

The amount of background noise that an individual is willing to accept while listening to speech is predictive of his/her hearing aid satisfaction. The Tracking of Noise Tolerance (TNT) test was designed to measure how much noise an individual accepts over time while still understanding 90% of the speech. The TNT is a reliable and efficient clinical test that allows measurement of a listener’s acceptance for noise — with and without hearing aids — so that the results can be compared to normal hearing listeners, across various hearing aid features, and on the same individual over time. The test has a within-session test-retest reliability of 0.7 and a between-session reliability of 0.8. The tolerable noise level has been shown to correlate with hearing aid satisfaction in real-life noise situations.

What constitutes > 90% speech understanding varies among individuals. People who overestimate their speech understanding would likely accept a higher noise level than those who underestimate. Furthermore, it would also be reasonable to suspect that people who overestimate their speech intelligibility will be more accepting of their hearing aids in noise than those who underestimate. Listener’s subjective criterion for speech intelligibility in noise could be an important piece of profiling information to identify challenging patients, and to establish necessary subjective criterion for speech intelligibility in noise. Therefore, it would also be reasonable to suspect that people who overestimate their speech understanding would likely accept a higher noise level than those who underestimate. Furthermore, it would also be reasonable to suspect that people who overestimate their speech intelligibility will be more accepting of their hearing aids in noise than those who underestimate. Listener’s subjective criterion for speech intelligibility in noise could be an important piece of profiling information to identify challenging patients, and to establish necessary subjective criterion for speech intelligibility in noise.

Estimation of intelligibility of TNT materials

Participants

- Normal hearing listeners: N = 25 (16 females / 9 males)
- Mean age: 63.9 years ±8.2 SD, range = 51–82 years
- Binural PTA*: Range from 18 to 19 dBHL (mean = 10.1 dBHL, SD = 4.7 dBHL)

All participants were native speakers of English and exhibited normal cognitive function as assessed using the Montreal Cognitive Assessment (MoCA) (score ≥ 26).

Measuring TNT

During the TNT test the listener adjusted the noise level adaptively while listening to a speech passage (8 passages available). A fixed 75 or 82 dB SPL continuous speech shaped noise was presented at a fixed SNR of -9, 0, 3, and 5 dB. Speech and noise were presented in free field from 0º.

SUBJECTIVE (PERCEPTION): Participants indicated their response to “Please, estimate how much of the speech you can understand?” on a scale from 0% to 100% using a slider displayed on a touch screen monitor.

OBJECTIVE (PERFORMANCE): Participants verbally repeated the presented sentences. Scoring was based on correctly repeated keywords (3 sentences / 10 keywords per SNR).

SII BASED ESTIMATE: Audibility based estimates for speech intelligibility were calculated using SII.

The current study both speech and noise were presented co-located in free field. The TNT instructions: “You will hear some noise in the background while you listen to the male talker. The noise will automatically get louder. I want you to monitor the noise level and hold the noisiest level you can put up with while still understanding 90% of the words. If the noise becomes too loud, where you can no longer follow up with or understand, 90% of the words in the story, you can turn the noise down by pressing and holding the space bar. If it appears softer than before, you should allow the volume to increase by letting go of the space bar. If it is louder than before, you should turn the volume down to keep at the same level by pressing the space bar again. Your ability to understand should never change to < 90%. The test will run for 2 min and then stop.”

RESULTS

Equivalence of subjective and objective intelligibility

The I-P functions were measured using the same source materials as were used during the TNT task. Also, the testing conditions were identical. This allows us to use each listener’s individual I-P functions to derive a running estimate of the speech intelligibility during each noise tracking task (Figure 3). Intelligibility estimates provide ranges of speech intelligibility during the trial, and can reveal the discrepancies between objective and subjective intelligibility. Also, the intelligibility measure provides a tool to verify that the listener has understood the task and is performing it in a meaningful way (e.g., understanding at least some of the speech).

Figure 2. Average performance-intelligibility (I-P) functions for the objective (black) and subjective (yellow) intelligibility of the TNT speech materials.

A linear mixed effects model evaluated fixed effects of intelligibility type (objective and subjective), speech level (75 and 82 dB SPL), and SNR (0, 3, 5 dB) on the measured intelligibility. Intelligibility scores were significantly affected by SNR (LMx model suggested that subjective and objective PI were similar for the normal hearing participants.

Figure 3. An example of a single noise tracking trial with noise level (black) as well as estimated subjective (green), objective (blue), and SII based (red) speech intelligibility.

The average TNT scores (i.e., noise-to-signal ratio) of different TNT outcome measures were summarized in Table 1. We estimated the speech intelligibility during the tracking for each individual separately. The objective, subjective, and SII based speech intelligibility estimates during the noise tracking task were similar (Figure 4). Noise level associated with the average of valleys of the TNT trace more consistently coincided with the 90% intelligibility criterion across listeners. The speech intelligibility at the mean TNT and at the average TNT peaks was below the 90% intelligibility criterion that listeners were instructed to maintain during the task.

Figure 5. The distribution of estimated objective (left), subjective (center), and SII based (right) intelligibility measured at 5dB steps each of the average TNT scores, as well as the average of the peaks and valleys in the TNT trace. The intelligibility criterion of 90% (as per the TNT instructions), shown in the dashed line.

Table 1: Summary of different TNT outcome measures.

<table>
<thead>
<tr>
<th>TNT Score (dB)</th>
<th>Peak TNT</th>
<th>Valley TNT</th>
<th>SII Based TNT</th>
<th>Subjective TNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 dB SPL</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>82 dB SPL</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
</tbody>
</table>

SUMMARY

We developed test materials that allow evaluation of noise acceptance and speech intelligibility using the same stimuli. The objective and subjective intelligibility of these materials were similar, and the SII based speech intelligibility estimates accurately reflected the individually measured intelligibility estimates. Because the same materials were used to derive the P-I functions, this allowed us to evaluate speech intelligibility during the noise tracking task. The future studies are needed to evaluate the performance with hearing impaired listeners.

REFERENCES