COMPARISON BETWEEN PERCEIVED AND MEASURED SPEECH INTELLIGIBILITY

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INTRODUCTION

Measures that explain hearing aid wearers' satisfaction for their hearing aids would be useful in adjusting counseling or selecting appropriate technology to further enhance satisfaction. One such measure is a comparison between a person's subjective and objective speech-in-noise (SiN) intelligibility scores. In objective SiN tests listeners repeat the speech materials they heard at different signal-to-noise ratios, and the percentage of correct responses is calculated, whereas in subjective SiN test, listeners themselves estimate the percentage of words/passage they understood.

While it has been demonstrated that on a group basis there the subjective ratings of intelligibility and objective speech intelligibility are highly correlated (>0.8), some individual listeners under- or overestimate their speech understanding problems. Listeners whose subjective scores are better than their objective scores overestimate their hearing ability while those whose subjective scores are poorer than their objective scores underestimate their hearing ability. The extent to which the listener misjudges his/her hearing ability would likely provide insights into the listener and facilitate rehabilitation counseling (Saunders et al, 2012).

For a direct comparison between the subjective and objective performance, the two measures should be carried using the same materials. Also, the speech materials and test conditions that are used to evaluate subjective and objective performance should ideally reflect real-life communication difficulties. In this study, we developed materials that can be used to measure both the subjective and objective intelligibility performance. Normative data was collected in elderly normal hearing listeners. In addition, using these norms, we examined how data collected in HI listeners in the aided and unaided modes compared to those of NH listeners.

METHODS

Participants

- NH GROUP: N = 22 (mean age = 63.9 yrs, SD = 8.2 yrs, 16 female).
- HI GROUP: N = 17 (mean age = 76.9 yrs, SD = 8.4 yrs, 6 female).
- Bilaterally symmetrical (+/- 10 dB) mild-to-moderately severe sensorineural hearing loss.
- All native speakers of American English.
- >24 on the Montreal Cognitive Assessment (MoCA) test (Nasreddine et al., 2005).

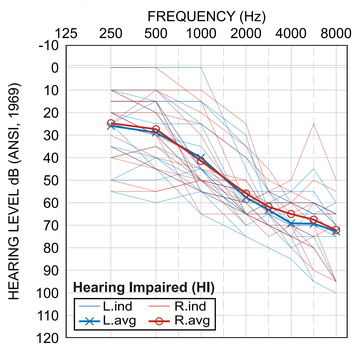

Figure 1: Audiograms of the HI participants.

Subjective-Objective Speech (SOS) test

- Speech materials originally from Tracking of Noise Tolerance test (TNT).
- 7 different passages each consisting of 5 lists of 3 sentences each.
- Each sentence includes 3 or 4 target words with ten target words per list.
- The equivalency of the lists was determined by measuring the objective SiN intelligibility of the sentences in a group of 10 NH participants. Sentences were rearranged into so that each sentence set is similar in difficulty.

Tasks

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

SUBJECTIVE (PERCEPTION):
Participants indicated their reponse 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 testing conducted before subjective rating using a different passage.

Conditions

- Each list was presented at one signal-to-noise ratio (randomized order).

	SNR (dB)
NH group	-9, -6, -3, 0 +3
HI group	Individualized SNR range to capture the whole P-I function.

- Test administered in free field at 75 and 82 dB SPL speech levels with a co-located (0°) speech shaped continuous ICRA noise.

Estimating intelligibility of TNT materials

P-I functions were derived for each participant individually by fitting a logistic regression function to the objective and subjective data

$$\varphi(x) = (1-\lambda)\left(1 + e^{(-\beta*(x-\alpha))}\right)^{-1}$$

Where x is the SNR, α is the threshold parameter (i.e., SRT-50), β is the rate of change parameter (i.e., slope), and λ is the lapse rate parameter (i.e., upper asymptote). Up to 10% lapse rate was allowed for the HI listeners who never reached 100% performance.

RESULTS

Performance intensity functions

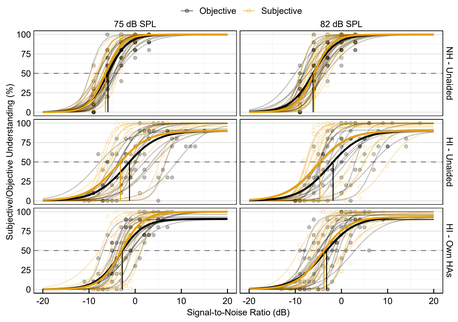

Figure 2: Individual data and fitted subjective and objective performance-intensity (P-I) functions for NH (top) and HI listeners in unaided (middle) and aided (bottom) conditions.

- The discrepancy between subjective and objective functions along the slopes of the P-I functions was greatest with the HI listeners in the unaided mode. The performance at SRT50 likely reflects the maximum subjective-objective performance difference.

Unaided performance

- Linear mixed effects (LME) model assessed the fixed effects of listener group (2 levels, NH and HI), intelligibility type (2 levels, subjective and objective), and speech level (2 levels, 75 and 82 dB SPL) on threshold (i.e., SRT-50). Listeners were coded as random effects with unique intercepts.
- Thresholds were significantly affected by listener group and intelligibility type as qualified by their two-way interaction.
- NH listeners did not show a significant difference between subjective and objective intelligibility.
- HI listeners had poorer objective and subjective intelligibility performance compared to the NH listeners.
- HI listeners overestimated their intelligibility as evidenced by lower/better thresholds modelled for subjective relative to objective intelligibility functions.

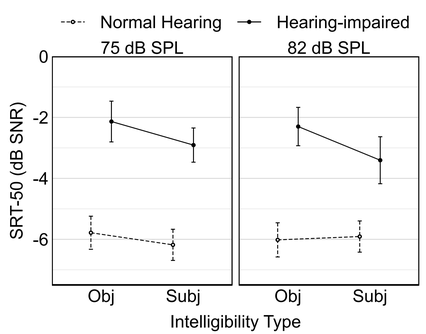

Figure 3: Speech Reception Thresholds at a 50% criterion (SRT50) measured subjectively and objectively in NH and HI listsners in the unaided mode at 75 and 82 dB SPL levels.

Aided performance

- HI listeners' thresholds (SRT50) were significantly affected by the fixed effects of hearing mode and intelligibility type.
- Overall intelligibility thresholds were lower/better when tested aided than unaided.
- Listeners overestimated their intelligibility as evidenced by lower/better thresholds modelled for subjective relative to objective intelligibility functions.
- HI listeners overestimated their ability in the unaided mode but become more accurate in their estimation in the aided mode.

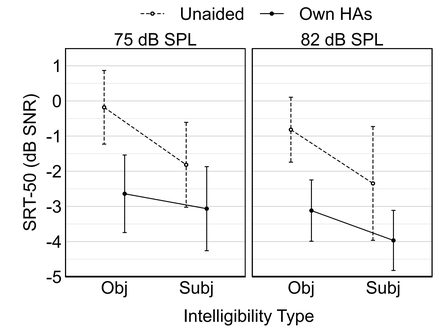

Figure 4: Speech Reception thresholds at a 50% criterion (SRT50) measured subjectively and objectively in HI listeners in the unaided and aided mode at 75 and 82 dB SPL levels.

SUMMARY

Normal hearing listeners were accurate in estimating their speech performance. Compared to the normal-hearing group, the hearing-impaired listeners had higher subjective than objective intelligibility across SNRs in unaided mode. Overestimation of their speech performance may result in underestimation of their need for amplification. Aiding narrowed the subjective/objective intelligibility discrepancy. Consequently, the perceived (i.e., subjective) performance improvement from amplification was on average smaller than the actual (i.e., objective) benefit. Identifying listeners who overestimate their unaided listening skills may help clinicians adjust counseling or selection of appropriate technology to enhance hearing aid satisfaction. The test materials developed in the current study may help identify such listeners.

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