Illinois State University

ISU ReD: Research and eData

AuD Capstone Projects - Communication Sciences and Disorders

Communication Sciences and Disorders

2017

Developing a Revised Performance-Perceptual Test Using Quick Speech-in-Noise Test Material

Matthew Wetmore
Illinois State University, mwetmor@ilstu.edu

Hua Ou
Wayne State University, huou@wayne.edu

Follow this and additional works at: https://ir.library.illinoisstate.edu/aucpcsd

Part of the Speech Pathology and Audiology Commons

Recommended Citation

Wetmore, Matthew and Ou, Hua, "Developing a Revised Performance-Perceptual Test Using Quick Speech-in-Noise Test Material" (2017). *AuD Capstone Projects - Communication Sciences and Disorders*. 9.
https://ir.library.illinoisstate.edu/aucpcsd/9

This Capstone Project is brought to you for free and open access by the Communication Sciences and Disorders at ISU ReD: Research and eData. It has been accepted for inclusion in AuD Capstone Projects - Communication Sciences and Disorders by an authorized administrator of ISU ReD: Research and eData. For more information, please contact ISUReD@ilstu.edu.

Developing a Revised Performance-Perceptual Test Using Quick Speech-in-Noise Test Material

Matthew Wetmore and Hua Ou

Illinois State University

April 24, 2017

First Reader: ____ Date: ___________________

Second Reader: ____ Date: ___________________

Developing a Revised Performance-Perceptual Test Using Quick Speech-in-Noise Test Material

Capstone Project Submitted by:

Matthew Wetmore

Under the Supervision of:

Dr. Hua Ou

In Fulfillment for the Degree of:

Doctoral of Audiology (Au.D.)

May 2017

ILLINOIS STATE UNIVERSITY

Department of Communication Sciences and Disorders

Department of Communication Sciences and Disorders

Signatures:

Capstone Advisor: ____________________ Date: 5 | 1 | 2017
Dr. Hua Ou

Second Reader: Benjamin Kirby Date: 5/1/2017
Dr. Benjamin Kirby

INTRODUCTION:

Hearing impairment is one of the most common conditions in adults. It has been shown that hearing loss can impair a person's participation in daily social activities and may lower his or her quality of life. Hearing aids remain an effective option for people with hearing loss and are associated with improvement of social and/or psychological functioning (Chisolm et al., 2007). However, approximately one-fourth or less of hearing-impaired people are using hearing aids (Chien & Lin, 2012; Fischer et al., 2011). McCormack & Fortnum (2013) conducted a literature review of potential reasons for the non-use of hearing aids for those fitted with them and found that 7 of the 10 studies reviewed reported the lack of perceived benefit as one of the main reasons for hearing aid non-use (Gopinath et al, 2011; Hartley et al, 2010; Bertoli et al, 2009; Vuorialho et al, 2006; Gianopoulos et al, 2002; Tomita et al, 2001; Kochkin, 2000). Additionally, McCormack & Fortnum (2013) found that difficulty in noisy situations and background noise were other common reasons for the non-use of hearing aids (Hartley et al, 2010; Bertoli et al, 2009; Vuorialho et al, 2006; Tomita et al, 2001; Kochkin, 2000). There is not yet an agreed upon definition of hearing aid success; however, Hickson, Meyer, Lovelock, Lampert, & Khan (2014) argued that "A successful outcome is one in which a person with hearing impairment wears the hearing aids on a regular basis and reports benefit from them" (p. S18). Hickson et al. (2014) defined the criterion for hearing aid success as a combination of self-reported regular use of more than 1 hour per day and at least moderate benefit. Hickson et al. (2014) found several key factors associated with successful hearing aid outcomes. Among these were positive support of significant others; claimed hearing difficulties in their daily lives prior to using hearing aids; having more positive attitudes to hearing aids, which supports the findings of Knudsen et al. (2010); and higher levels of self-efficacy. Utilizing a pre-test battery that would be able to predict patient success with hearing aids could help clinicians to make decisions about appropriate hearing aid technology and guide counseling for patients to address the issues that contribute to the lack of perceived benefit.

There are several components to the overall hearing aid fitting process. The primary areas include the selection of hearing aids and additional features, verification of the fitting, and validation of real-world performance. Mueller, Johnson, & Weber (2010) recommend the use of pre-testing in addition to the components of the fitting mentioned above. Pre-testing in the clinical setting typically includes pure-tone audiometry, immittance measures, and word recognition testing; however, Mueller, Johnson, & Weber (2010) suggests additional pre-hearing aid fitting measures should include loudness discomfort, speech understanding in quiet and/or in noise, noise annoyance, central auditory processing, cognitive function, patient expectations, and personality assessment. Walden & Walden (2004) found unaided Quick Speech-in-Noise (QuickSIN; Killion et al., 2004) test scores to be a useful tool in predicting hearing aid use success. Another test, the Performance-Perceptual Test (PPT; Saunders, Forsline, & Fausti, 2004), has been shown to provide information about a listener's ability to accurately estimate their ability to understand speech-in-noise, which is found to be associated with the listener's satisfaction with hearing aids (Saunders, 2009b, Saunders, Forsline, & Fausti, 2004). Mueller, Johnson, & Weber (2010) suggested that the PPT and QuickSIN might both be useful in the pre-hearing aid fitting stage to help predict hearing aid use success.

The Performance-Perceptual Test (PPT) is a measure in which objective and subjective evaluations are made by using the same test materials, the same test format, and the same unit of measure (signal-to-noise ratio, SNR). The speech material and competing signal from the Hearing In Noise Test (HINT; Nilsson, Soli, & Sullivan, 1994) are used to measure a

Performance Speech Reception Threshold in Noise (SRTN) and a Perceptual SRTN. The Performance and Perceptual SRTN use the HINT adaptive procedure (Nilsson, Soli, & Sullivan, 1994) to determine SNR-50, which is defined as the SNR at which the listener gets the material correct 50% of the time. A third result, the Performance-Perceptual Discrepancy (PPDIS), is used as a measure of the listener's ability to accurately assess his or her hearing ability. If the listener's perceptual SNR-50 is lower (better) than the performance, then he/she overestimates his/her hearing ability. If the perceptual SNR-50 is higher (poorer) than the performance, then he/she underestimates his/her hearing ability. The PPT results help detect subjects who significantly under/overestimate their ability to understand speech-in-noise, based on normative values (Saunders & Forsline, 2006; Saunders, Forsline, & Fausti, 2004). The information from of under/overestimating listening ability in noise is needed to implement PPT-based counseling during or after the hearing aid fitting process. Patients who underestimated their ability to listen in noise were more likely to report hearing aid dissatisfaction (Saunders, 2009b; Saunders, Forsline, & Fausti, 2004). Saunders (2009b) found that by using PPT-based counseling to address those who under/overestimated, patients reported improved perceived hearing ability without any changes to hearing aid programming. In summary, the PPT can provide information about a listener's ability to accurately estimate his or her ability to understand speech-in-noise, which has association with a listener's hearing aid satisfaction (Saunders, 2009b; Saunders, Forsline, & Fausti, 2004). However, the utility of the PPT in predicting perceived hearing aid benefit may be limited by the types of speech materials and background noise used and how they are presented to the listener.

As mentioned previously, the PPT utilizes the HINT speech material. The HINT is a speech-in-noise test, from which the speech material consists of 250 Bench-Kowal-Bamford

(BKB) sentences (Bench & Bamford, 1979) presented in the presence of competing speech-shaped noise. The sentences are rated at a first grade reading level and are phonemically matched and balanced (Nilsson, Soli, & Sullivan, 1994). The competing signal consists of non-modulated broadband speech noise, shaped to be similar to the long-term average speech spectrum (LTASS) of the sentences, and is presented at a constant 65 dB(A) SPL throughout the test (House Ear Institute [HEI], 1995; Nilsson, Soli, & Sullivan, 1994). The lack of modulation in the competing signal has been noted to be less representative of everyday speech-in-noise situations than babble noise (Wilson, McArdle, & Smith, 2007). The HINT utilizes an adaptive SNR, where the presentation level of the competing noise is fixed and the speech material is varied. The speech material presentation level is varied as a function of the individual's performance on the previous sentence and is used to determine the lowest SNR where the individual can understand the entire sentence in noise 50% of the time, also known as SNR-50.

The other pre-fitting test of interest in the present study is the QuickSIN. Unlike the HINT, the QuickSIN was designed to quickly estimate a person's ability to understand speech-in-noise. The QuickSIN can be used to demonstrate improvement through the use of directional microphones, provide a quantifiable SNR loss that cannot be gathered from the audiogram, and aid in the decision making of using additional amplification options (Killion et al., 2004; Etymotic Research, 2001). The QuickSIN has been shown to be a good predictor of everyday success with hearing aids (Walden & Walden, 2004). Patients who have a poorer SNR are less likely to be successful with hearing aids than patients with closer to normal SNR abilities (Walden & Walden, 2004). The QuickSIN speech material consists of 12 lists of six sentences with five key words per sentence, presented with a four-talker babble (one male, three females) competing noise (Killion et al., 2004). The sentences are rated at a high school reading level

(Mueller, 2010). The speech of the babble noise is amplitude-modulated, which allows the listener to pick up parts of the speech within the competing signal. This is a closer representation of real-world listening environments (Sperry, Wiley, & Chial, 1997; Killion & Villchur, 1993). The QuickSIN utilizes an adaptive SNR where the sentences remain at a fixed presentation level and the competing noise is increased at predetermined levels. The QuickSIN score represents SNR loss, which is the SNR a hearing impaired listener needs to achieve 50% correct sentence identification compared to what a normal hearing listener needs.

When comparing the HINT and the QuickSIN, the presentation level must also be considered. According to Mueller, Ricketts, & Bentler (2014), the presentation level of the speech material can influence results when comparing the HINT and QuickSIN. Depending on the patient's hearing loss, the level at which each test is presented may drastically change, resulting in one test being presented at a louder level than the other. The HINT stimulus presentation level is initially presented 4 dB below the noise level (65 dB[A] SPL) and is then presented adaptively based on the patient's response to the prior sentence (Nilsson, Soli, & Sullivan, 1994). The QuickSIN instructions specify that the stimulus is to be presented at 70 dB HL as long as the patient's pure-tone average (PTA) is less than 45 dB HL; however, if the patient's PTA is worse than 50 dB HL, the stimulus is presented at a "Loud, but ok" level. Mueller, Rickets, & Bentler (2014) suggested that a PTA of greater than 50 dB HL could result in the QuickSIN being presented at a higher presentation level than the HINT. The fact that the presentation level may be louder due to a hearing loss may be advantageous or disadvantageous for the listener, depending on distortion effects and the configuration of the patient's hearing loss. Refer to Table 1 for an outline of the differences between the HINT and QuickSIN.

Table 1. Features of the CD version of the Hearing in Noise Test (HINT) (House Ear Institute, 1995; Nilsson, Soli, & Sullivan, 1994) and the Quick Speech-In-Noise (QuickSIN) test (Etymotic Research, 2001). Table 1 is adapted from Duncan & Aarts (2006).

Features	HINT	QuickSIN
Speech Material	25 10-sentence lists or 12 20-sentence lists	12 6-sentence standard lists for clinical use and 3 practice lists
Competing Noise	Speech-shaped noise	4-talker babble
Talker	Male	Female
Stimulus Presentation Level	Begin at 4 dB below the noise level and then adaptively adjusted as a function of listener's performance on previous sentence	Stimulus is presented at a constant 70 dB HL if PTA is <45 dB HL; or a constant "Loud, but ok" level if PTA is >50 dB HL
Noise Presentation Level	Presented at a constant 65 dB(A) during test	Noise levels are presented starting at +25 dB SNR and decreased in 5 dB steps to 0 dB SNR at predetermined SNR levels pre-recorded
Listener Task	Repeat the entire sentence back correctly	Repeat as much of each sentence back as they can with only five key words being counted
Duration of Test	Approximately 1 minute per list	Approximately 1 minute per list
Scoring formula	Average Reception Threshold for Speech (RTS) – Noise Level dB = dB SNR	25.5 – Average Score = dB SNR Loss
Score represents	RTS where 50% of sentences are repeated correctly	SNR Loss = The SNR a hearing impaired listener needs above the SNR a normal hearing listener needs to identify sentences 50% correctly

Clinical efficiency is important to clinicians when considering a test battery, and the time it takes to administer the PPT and QuickSIN tests could be a factor in whether or not they are used in clinical practice. In a typical appointment, the PPT takes approximately 15 minutes to administer (Saunders, 2009a) where the QuickSIN takes approximately 5 to 10 minutes (1 minute per list; 5 sentences per list) (Killion et al., 2004). Many clinicians question the value of using clinical time to utilize pre-fitting tests, such as the PPT and QuickSIN, and therefore tend to use at most one test, with the choice of test being driven primarily by availability of test materials in that clinic. Mueller (2010) conducted a questionnaire with 107 hearing aid dispensers and audiologists, 80% being audiologists, and found that the QuickSIN was used the most (33% of the respondents), with 43% stating that they would probably start using it. Only 5% stated using the PPT and 18-23% stated they might start using it. Unfortunately, 75% of the group indicated that they would probably never use the PPT. It is evident then, that QuickSIN is both more widely used and more widely considered for use than the PPT. Mueller (2010) suggested that the popularity of the QuickSIN might be due to the information it provides about speech-in-noise understanding. Many dispensers believe the QuickSIN provides more information about the overall fitting than the patients' perception of their own understanding (PPT), which is likely a reason for the popularity of the QuickSIN (Mueller, 2010).

Although the PPT is not a popular test utilized in the clinical setting, it does provide valuable information about the listener's perceived ability to hear that can help predict benefit. It allows for a direct comparison of objective and subjective measures, using the same test material, procedure, and setting. The PPT allows for the detection of individuals who significantly under/overestimate their ability to understand speech-in-noise and provides opportunities for clinicians to implement counseling on realistic expectations for those patients (Saunders, 2009b). The QuickSIN has been found to be a good predictor of hearing aid use success (Killion et al., 2004). The competing signal (four-talker babble) used in the QuickSIN is reportedly more representative of real-world listening environments, compared to the speech-shaped noise used in the HINT (Sperry, Wiley, & Chial, 1997; Killion & Villchur, 1993). Utilizing the QuickSIN speech material to conduct the PPT, as a modified test, might allow for the collection of two pieces of information from one test that is already commonly used in the clinic. This combination of information may provide clinicians with more information from administering one test rather than two. The aim of this study was to:

1. Evaluate the validity and reliability of using the QuickSIN speech material to administer the PPT and establish normative data across listeners with normal hearing (NH) and hearing loss (HL).
2. Examine the relationship between the Revised-PPT and hearing aid use outcomes.

METHODS

This was a cross sectional study with repeated measures. Of the total 65 participants between 18 and 88 years of age, 20 (31%) had normal hearing (mean age, 23.3 yr, SD, 6.7 yr), and 45 (69%) had sensorineural hearing loss, ranging from mild to profound in both ears. Thirty-two of the 45 participants with hearing loss were hearing aid users (mean age, 54.0 yr, SD, 19.8 yr). Figure 1 shows the mean thresholds, for all participants, from .25 to 8 kHz.

Per Institutional Review Board (IRB) approval, all participants completed the original PPT using HINT and the Revised-PPT using QuickSIN, via soundfield at 0^{o} azimuth. The Revised-PPT was repeated in the same appointment to establish test-retest reliability for participants with hearing loss. Testing was completed in a sound attenuation booth meeting ANSI standards. The original PPT was run using the HINT adaptive protocol and materials where the starting presentation level was at 65 dB(A). Two full HINT lists were used in the perceptual and performance conditions, using the same two lists for both conditions. The Revised-PPT was run using the attenuator dial set to 70 dB HL, as instructed in the QuickSIN manual. Four full QuickSIN lists were used for both conditions. All hearing impaired participants repeated the Revised-PPT at the same appointment to determine test-retest reliability. Subjects with PTA hearing losses greater than 45 dB HL set the attenuation dial to a level that was "loud but OK." Hearing aid users completed the tests unaided, along with completing the International Outcome Inventory for Hearing Aids (IOI-HA; Cox & Alexander, 2002) using paper and pencil. The IOI-HA is a seven-item questionnaire designed to be applied generally in evaluating hearing aid treatment effectiveness.

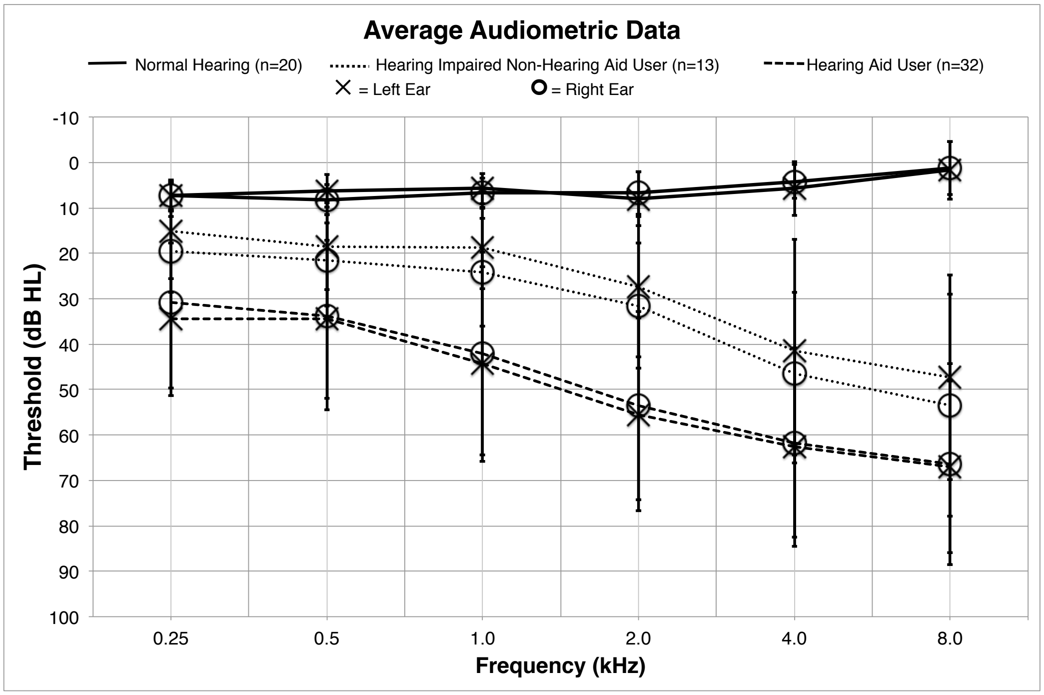

Figure 1. Mean thresholds for the left (X) and right (O) ears in dB HL for all participant groups. The error bars shows one standard deviation.

RESULTS

There were no significant PPDIS differences between the NH and HL groups ($t(63) = 1.08$, $p = .28$). The performance and perceptual results from the Revised-PPT and original PPT are shown in Figures 2 and 3, along with the PPDIS results in Figure 4. Normative values for the Revised-PPT were established using the rule of three, placing underestimators with a PPDIS at ≤ -1.0 dB, overestimators at ≥ 0.63 dB, and accurate estimators in between these two values. Refer to Table 2 for the normative values for the Revised-PPT and original PPT. As shown in Table 3, the results revealed 14% of disagreement across all participants when participants were identified as underestimators on the Revised-PPT but overestimators on the original PPT, or vice versa. The Revised-PPT provided high test-retest reliability (Performance $r = 0.92$; Perceptual $r = 0.84$; PPDIS $r = 0.62$; all p values < .0001). The results from a step-wise multiple regression indicated that the PPDIS from the Revised-PPT and age explained 18.5% of the variance in reported hearing aid outcome on the IOI-HA ($F(2,29) = 3.3$; $p = .05$). The larger the discrepancy between the Revised-PPT perceptual and performance measures ($R^2 = 10.8\%$), the better the self-reported hearing aid outcome. However, this result was the opposite of the relationship between the IOI-HA and the PPDIS obtained from HINT. It appeared that the smaller the discrepancy between the performance and the perceptual component of the PPT using HINT, the more likely to become a successful hearing aid user. From the participants in the present study, older age resulted in better self-reported hearing aid outcome ($R^2 = 7.7\%$). It appeared that better self-reported hearing aid outcome on the IOI-HA is associated with older age and overestimation of listening ability.

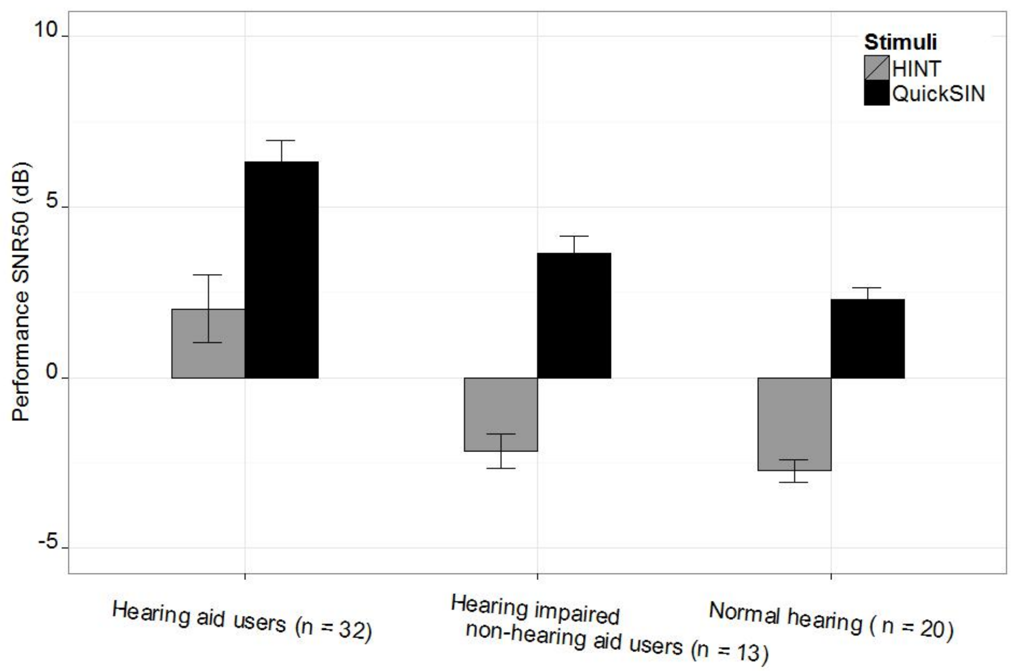

Figure 2. Group mean performance SNR50 results from the original PPT using HINT and Revised-PPT using QuickSIN, for each participant group. Standard error bars are used.

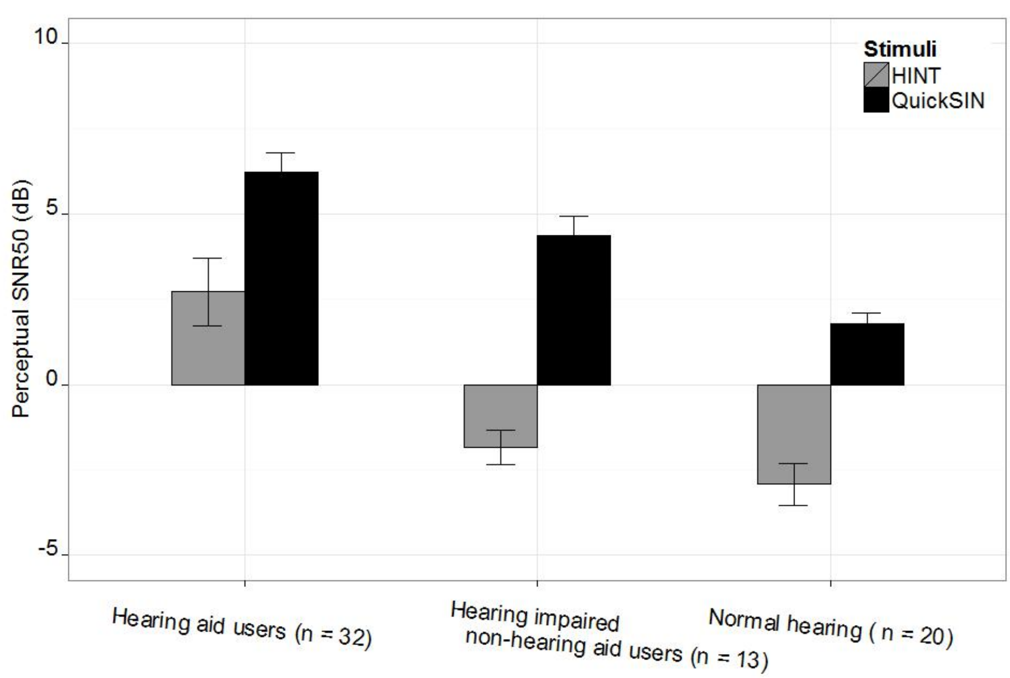

Figure 3. Group mean perceptual SNR50 results from the original PPT using HINT and Revised-PPT using QuickSIN, for each participant group. Standard error bars are used.

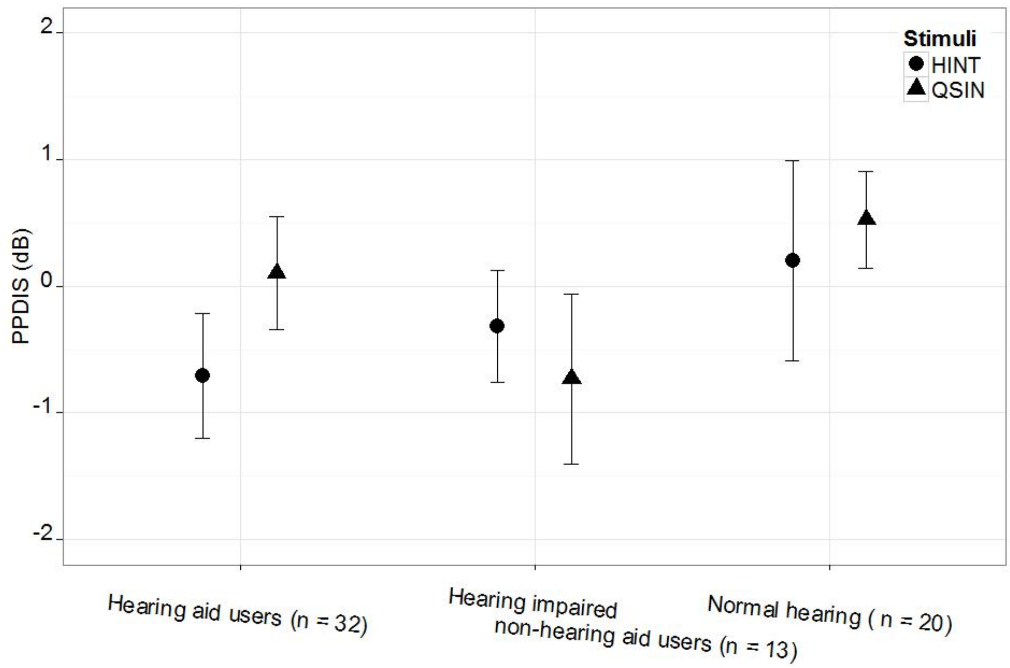

Figure 4. Mean Performance-Perceptual Discrepancy (PPDIS) results from the original PPT using HINT and Revised-PPT using QuickSIN, for each participant group. Standard error bars are used. There were no significant PPDIS differences between the NH and HL groups (t(63) = 1.08, *p* = .28) within each stimulus.

Table 2. Normative PPT value ranges for the original PPT and Revised-PPT to rate listening in noise ability derived from subjects in this study (n=65). Normative values for the Revised-PPT were established, placing underestimators with a PPDIS at ≤ -1.0 dB, overestimators at ≥ 0.63 dB, and accurate estimators in-between these two values.

Revised-PPT Normative Values		
Underestimator	Accurate	Overestimator
≤ -1	> -1 & < 0.63	≥ 0.63
Original PPT Normative Values from the Present Study		
≤ -1.65	> -1.65 & < 0	≥ 0

Table 3. The results revealed 14% of disagreement (cells highlighted in yellow) across all participants when participants were identified as underestimators on the Revised-PPT but overestimators on the original PPT, or vice versa.

Original PPT Using HINT Speech Material	**Revised-PPT Using QuickSIN Speech Material**			
	U	**A**	**O**	**Total**
U	11	3	6	20
A	9	8	4	21
O	3	9	12	24
Total	23	20	22	65

DISCUSSION

The present study aimed to evaluate the validity and reliability of using the QuickSIN speech material to administer the PPT and establish normative data across listeners with normal hearing (NH) and hearing loss (HL). Additionally, the study examined the relationship between the Revised-PPT and hearing aid use outcome. It was hypothesized that utilizing the QuickSIN and PPT (Revised-PPT) could provide a clinician with two important pieces of information from one test to predict hearing aid use success and the need for counseling.

No significant differences were found in the PPDIS between the NH and HL groups. Normative values for the Revised-PPT were established, placing understimators with a PPDIS at ≤ -1.0 dB, overstimators at ≥ 0.63 dB, and accurate estimators in-between these two values. Comparison of the results between the Revised-PPT and original PPT indicated good overall agreement and high test-retest reliability, indicating that the Revised-PPT can be used to replace the original PPT.

The results from a step-wise multiple regression indicated that the PPDIS from the Revised-PPT and age explained 18.5% of the variance in reported hearing aid outcome on the

IOI-HA. The larger the discrepancy between the Revised-PPT perceptual and performance measures, the better the self-reported hearing aid outcome. However, this result was the opposite of the relationship between the IOI-HA and the PPDIS obtained from HINT on the original PPT. In this case, it appeared that the smaller the discrepancy between the performance and the perceptual component of the PPT using HINT, the more likely to become a successful hearing aid user. The type of background noise might be one of the reasons for the differences between the PPT using QuickSIN versus HINT. The four-talker babble competing noise used in the QuickSIN has been shown to be more representative of real world environments. From the participants in the present study, older age resulted in better self-reported hearing aid outcome. Additionally, it appeared that better self-reported hearing aid outcome on the IOI-HA is associated with older age and overestimation of listening ability on the Revised-PPT. Further analysis is needed to assess the direction and size of the discrepancy needed to determine what is significant for better self-reported hearing aid outcome. There is one limitation to the present study worth noting. It was not determined whether the participants with hearing aid use had optimally prescribed hearing aid fittings. This could influence how the participants rated their outcome measures on the IOI-HA.

CONCLUSIONS

It is concluded that the QuickSIN speech material could be used to replace HINT to measure PPT. The Revised-PPT might be a useful tool in predicting hearing aid use success. It is valid and reliable to measure PPDIS using the QuickSIN speech material compared to the original PPT. The agreement to in self-rated hearing ability in noise was high between the Revised-PPT and the original PPT. It appeared that larger discrepancies between the performance and perceptual measures of the QuickSIN resulted in better self-reported hearing aid outcome, which is the opposite of the relationship between the IOI-HA and the original PPT using HINT. Although speech testing in the booth does not always equal real-world performance, clinicians can utilize a test, such as the Revised-PPT to gather two important piece of information to aid in determining a patient's potential success with hearing aids. This will allow clinicians to make the most of clinical efficiency, while also obtaining useful information in making decisions regarding hearing aid selections and options.

References

Bench, J., & Bamford, J. (1979). Speech-hearing tests and the spoken language of hearing-impaired children. New York: Academic Press.

Bertoli, S., Staehelin, K., Zemp, E., Schindler, C., Bodmer, D. (2009). Survey on hearing-aid use and satisfaction in Switzerland and their determinants. *International Journal of Audiology, 48*, 183–195.

Chien, W., & Lin, F. (2012). Prevalence of hearing aid use among older adults in the united states. *Archives of Internal Medicine, 172*(3), 292-293.

Chisolm, T., Johnson, C, Danhauer, J., Portz, L., Abrams, H., Lesner, S., McCarthy, P., & Newman, C. (2007). A systematic review of health-related quality of life and hearing aids: Final report of the american academy of audiology task force on the health-related quality of life benefits of amplification in adults. *Journal of the American Academy of Audiology, 18*(2), 151-183.

Cox, R. M., & Alexander, G. C. (2002). The International Outcome Inventory for Hearing Aids (IOI-HA): psychometric properties of the English version. *Int J Audiol*, *41*(1), 30- 35.

Duncan, K., & Aarts, N. (2006). A comparison of the HINT and QuickSIN tests. *Journal of Speech-Language Pathology and Audiology, 30*(2), 86-94.

Etymotic Research (2001). QuickSIN Speech in Noise Test Version 1.3. Elk Grove Village, IL.

Fischer, M., Cruickshanks, K., Wiley, T., Klein, B., Klein, R., & Tweed, T. (2011). Determinants of hearing aid acquisition in older adults. *American Journal of Public Health, 101*(8), 1449-1455.

Gianopoulos L., Stephens, D., & Davis, A. (2002). Follow-up of people fitting with hearing aids after adults hearing screening: The need for support after fitting. *BMJ, 325*, 471.

Gopinath, B., Schneider, J., Hartley, D., Teber, E., McMohon, C.M. (2011). Incidence and predictors of hearing aid use and ownership among older adults with hearing loss. *Annals of Epidemiology, 21*, 497-506.

Hartley, D., Rochtchina, E., Newall, P., Golding, M. & Mitchell, P. (2010). Use of hearing aids and assistive listening devices in an older Australian population. *Journal of the American Academy of Audiology, 21*, 642–653.

Helfer, K., & Freyman, R. (2005). The role of visual speech cues in reducing energetic and informational masking. *The Journal of the Acoustical Society of America, 117*(2), 842-849.

Hickson, L., Meyer, C., Lovelock, K., Lampert, M., & Khan, A. (2014). Factors associated with success with hearing aids in older adults. *International Journal of Audiology, 53*, 18-27.

House Ear Institute (1995). Hearing in noise test operator's manual. Los Angeles, CA: Starkey Laboratories.

Jerger, J. F. (2006). Informational masking. *Journal of the American Academy of Audiology, 17*(6), 1.

Katz, J. (2009). Speech audiometry. In *Handbook of Clinical Audiology* (6th ed., pp. 64-79). Philadelphia, Pennsylvania: Lippincott Williams & Wilkins.

Killion, M., & Gudmundsen, G. (2005). Fitting hearing aids using clinical prefitting speech measures: An evidence-based review. *Journal of the American Academy of Audiology, 16*(7), 439-447.

Killion, M., Niquette, P., Gudmundsen, G., Revit, L., & Banerjee, S. (2004). Development of a quick speech-in-noise test for measuring signal-to-noise ratio loss in normal-hearing and hearing-impaired listeners. *The Journal of the Acoustical Society of America, 116*(4), 2395-2405.

Killion, M., & Villchur, E. (1993). Kessler was right – partly: But SIN test shows some aids improve hearing in noise. The Hearing Journal, 46(9), 31-35.

Knudsen, L. V., Oberg, M., Nielsen, C., Naylor, G., & Kramer, S. E. (2010). Factors influencing help seeking, hearing aid uptake, hearing aid use and satisfaction with hearing aids: A review of the literature. *Trends in Amplification, 14*(3), 127-154.

Kochkin, S. (2000). MarkeTrak V: 'Why my hearing aids are in the drawer': The consumers' perspective. *The Hearing Journal, 53*, 34–41.

Lidestam, B., Holgersson, J., & Moradi, S. (2014). Comparison of informational vs. energetic masking effects on speech reading performance. *Frontiers in Psychology, 5*(639), 1-7.

McCormack, A., & Fortnum, H. (2013). Why do people fitted with hearing aids not wear them? *International Journal of Audiology, 52(*5), 360-368.

Mueller, H.G. (2010). Three pre-tests: What they do and why experts say you should use them more. *The Hearing Journal,* 63(4), 17-24.

Mueller, H.G., Johnson, E.E., & Weber, J. (2010). Fitting hearing aids: A comparison of three pre-fitting speech tests. AudiologyOnline, Retrieved January 31, 2016, from http://www.audiologyonline.com/articles/fitting-hearing-aids-comparison-three-861

Mueller, H., Ricketts, T., & Bentler, R. (2014) Pre-fitting testing using speech material. In *Modern Hearing Aids: Pre-Fitting Testing and Selection Considerations* (1st ed., pp. 123-193). San Diego, CA: Plural Publishing.

Nilsson, M., Soli, S.D., & Sullivan, J.A. (1994). Development of the Hearing in Noise Test for the measurement of speech reception thresholds in quiet and in noise. *Journal of the*

Acoustical Society of America, 95(2), 1085-1099.

Saunders, G., Forsline, A., & Fausti, S. (2004). The performance-perceptual test and its relationship to unaided reported handicap. *Ear and Hearing, 25*(2), 117-126.

Saunders, G., Forsline, A. (2006). The performance-perceptual test and its relationship to aided reported handicap and hearing aid satisfaction. *Ear and Hearing, 27*(3), 229-242.

Saunders, G. H. (2009a). The performance perceptual test (PPT): Clinical applications. AudiologyOnline, Retrieved January 31, 2016, from http://www.audiologyonline.com/articles/performance-perceptual-test-ppt-clinical-889

Saunders, G. H. (2009b). Understanding in noise: Perception vs. performance. *Hearing Journal, 62*(5), 10-16.

Sperry, J., Wiley, T., & Chial, M. (1997). Word recognition performance in various background competitors. Journal of the American Academy of Audiology, 8, 71-80.

Tomita, M., Mann, W.C., & Welch, T.R. (2001). Use of assistive devices to address hearing impairment by older persons with disabilities. *International Journal of Rehabilitation Research, 24*, 279–289.

Vuorialho, A., Karinen, P. & Sorri, M. (2006). Counseling of hearing aid users is highly cost-effective. *European Archives of Otorhinolaryngology, 263*, 988–995.

Wilson, R., Mcardle, R., & Smith, S. (2007). An evaluation of the BKB-SIN, HINT, QuickSIN, and WIN materials on listeners with normal hearing and listeners with hearing loss. *Journal of Speech Language and Hearing Research, 50*, 844-856.

Developing a Revised Performance-Perceptual Test Using Quick Speech-in-Noise Test Material

Matthew Wetmore and Hua Ou

Department of Communication Sciences and Disorders, Illinois State University, Normal, IL, USA 61790

Introduction

- Two audiometric speech measures have been recognized to be useful to predict hearing aid use success: the Quick Speech-in-Noise (QuickSIN; Killion et al., 2004) test and the Performance-Perceptual Test (PPT; Saunders, Forsline, & Fausti, 2004).
- The PPT involves using the same speech test material (Hearing In Noise Test; HINT; Nilsson, Soli, & Sullivan, 1994) twice, to evaluate patients' objective and subjective speech recognition performance in noise and the discrepancy between the two measures (Performance-Perceptual Discrepancy; PPDIS).
- Utilizing the QuickSIN with the PPT (Revised-PPT) may provide a clinician with two important pieces of information from one test to help predict hearing aid use success and the need for counseling.

Purposes

1. To evaluate the validity and reliability of using the QuickSIN speech material to administer the PPT and establish normative data across listeners with normal hearing (NH) and hearing loss (HL).
2. To examine the relationship between the Revised-PPT and hearing aid use outcome.

Methods

- This was a cross-sectional study with repeated measures.
- All participants, 20 normal hearing subjects and 45 subjects with hearing loss (unaided), were administered the original PPT using HINT and the Revised-PPT using QuickSIN, via soundfield, between January 2015 and May 2016 at Illinois State University.
- The International Outcome Inventory for Hearing Aids (IOI-HA; Cox & Alexander, 2002) was administered using paper and pencil.

Table 1. Demographic information of the participants.

Key: Normal Hearing (NH), Hearing Impaired (HI), Hearing Aid User (HA), Non-Hearing Aid User (Non-HA)		Gender		Age (yrs)	
		Male	Female	Mean	SD
NH (n=20)		2	18	23.3	6.7
HI (n=45)	HA (n=32)	14	18	54.0	19.8
	Non-HA (n=13)	7	6	63.8	10.5

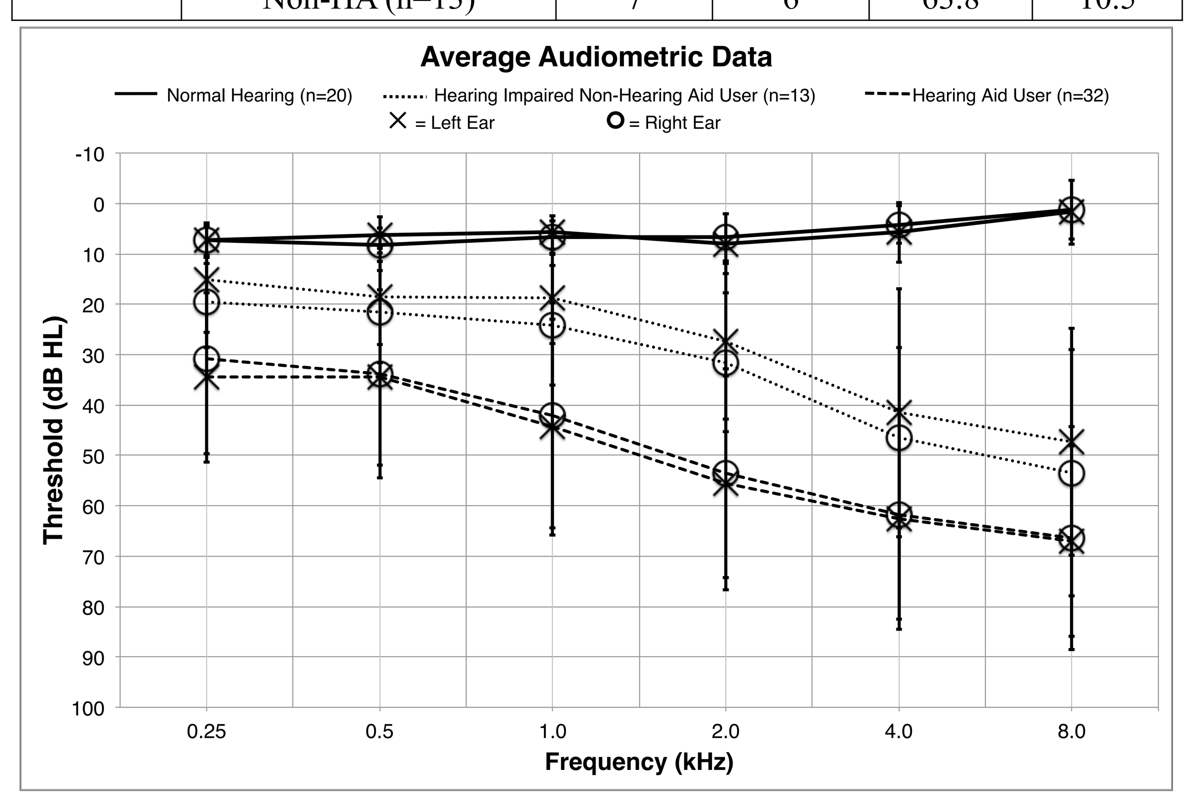

Figure 1. Mean thresholds for the left (X) and right (O) ears in dB HL for all participant groups. The error bars shows one standard deviation.

Methods (cont.)

Table 2. Summarized differences between the original PPT speech material (HINT) and the QuickSIN speech material.

Features of the CD version of the Hearing in Noise Test (HINT) (House Ear Institute, 1995; Nilsson, Soli, & Sullivan, 1994) and the Quick Speech-In-Noise (QuickSIN) test (Etymotic Research, 2001)

Features	HINT	QuickSIN
Speech Material	25 ten-sentence lists or 12 twenty-sentence lists	12 six-sentence lists for clinical use and three practice lists
Competing Noise	Speech-shaped noise	4-talker babble
Target Talker	Male	Female
Stimulus Presentation Level	Begin at 4 dB below the noise level and then adaptively adjust as a function of listener's performance on previous sentence	Stimulus is presented at a constant 70 dB HL if PTA is <45 dB HL; or a constant "Loud, but ok" level if PTA is >50 dB HL
Listener Task	Repeat entire sentence back correctly	Repeat as much of each sentence back as they can with only five key words being counted
Duration of Test	Approximately 1 minute per list	Approximately 1 minute per list
Scoring Formula	Average Reception Threshold for Speech (RTS) – Noise Level dB = dB SNR	25.5 – Average Score = dB SNR Loss
Score Representation	RTS where 50% of sentences are repeated correctly	SNR Loss = the SNR a hearing impaired listener needs above the SNR a normal hearing listener needs to correctly identify sentences 50% correctly

Results

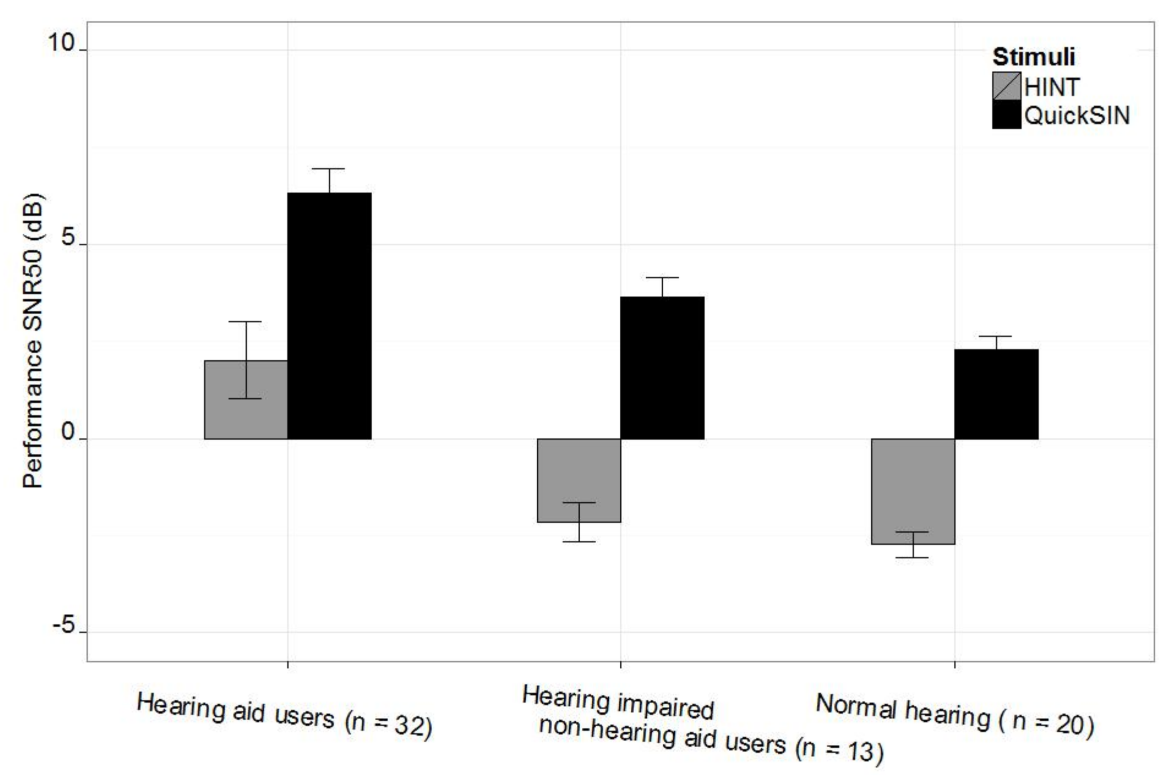

Figure 2. Group mean performance SNR50 results from the original PPT using HINT and Revised-PPT using QuickSIN, for each participant group. Standard error bars are used.

Results (cont.)

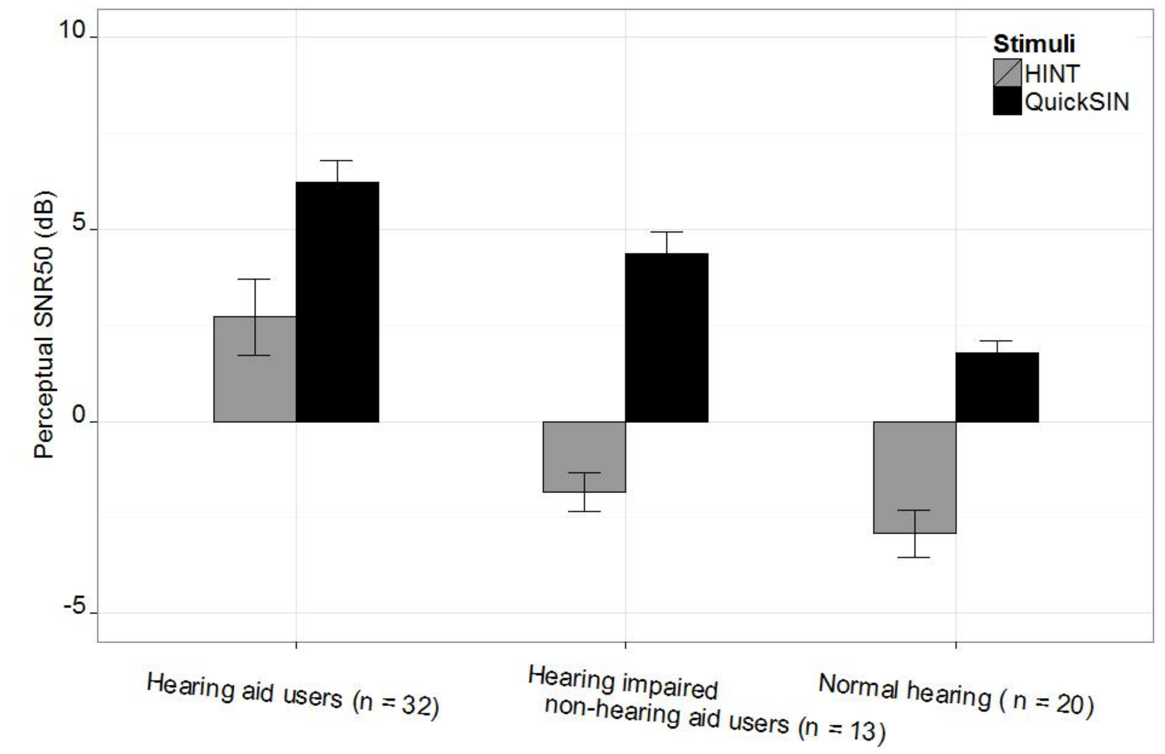

Figure 3. Group mean perceptual SNR50 results from the original PPT using HINT and Revised-PPT using QuickSIN, for each participant group. Standard error bars are used.

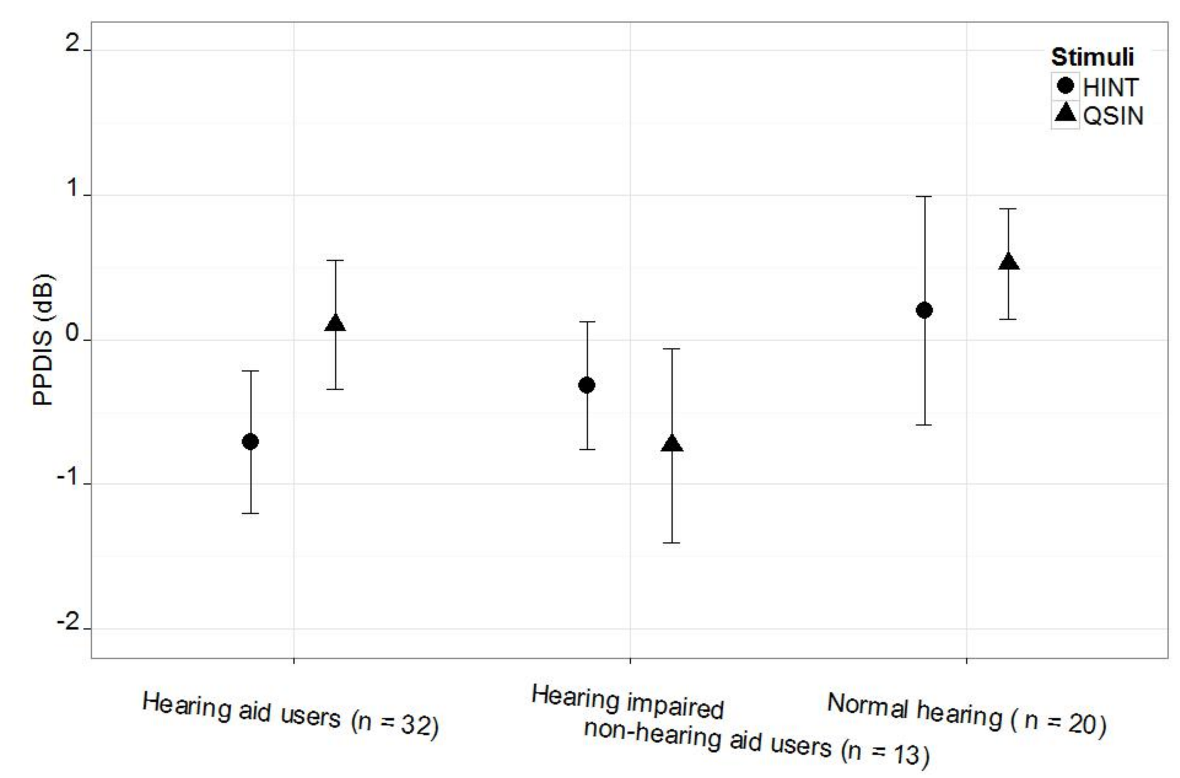

Figure 4. Mean Performance-Perceptual Discrepancy (PPDIS) results from the original PPT using HINT and Revised-PPT using QuickSIN, for each participant group. Standard error bars are used. There were no significant PPDIS differences between the NH and HL groups ($t(63) = 1.08$, $p = .28$) within each stimulus.

Reliability. The Revised-PPT provided high test-retest reliability (Performance $r = 0.92$; Perceptual $r = 0.84$; PPDIS $r = 0.62$; all p values $< .0001$).

IOI-HA. The results from a step-wise multiple regression indicated that the PPDIS from the Revised-PPT using QuickSIN and age explained 18.5% of the variance in reported hearing aid outcome on the IOI-HA ($F(2,29) = 3.3$; $p = .05$). The larger the discrepancy between the Revised-PPT perceptual and performance measures ($R^2 = 10.8\%$), the better the self-reported hearing aid outcome. However, this result was the opposite of the relationship between the IOI-HA and the PPDIS obtained from HINT. It appeared that the smaller the discrepancy between the performance and the perceptual component of the PPT using HINT, the more likely to become a successful hearing aid user. From the participants in the present study, older age resulted in better self-reported hearing aid outcome ($R^2 = 7.7\%$).

Results (cont.)

Table 3. Normative PPT value ranges for the original PPT and Revised-PPT to rate listening in noise ability derived from subjects in this study (n=65). Normative values for the Revised-PPT were established, placing understimators with a PPDIS at ≤ -1.0 dB, overstimators at ≥ 0.63 dB, and accurate estimators in-between these two values.

Revised-PPT Normative Values		
Underestimator	Accurate	Overestimator
≤ -1	> -1 & < 0.63	≥ 0.63
Original PPT Normative Values from the Present Study		
≤ -1.65	> -1.65 & < 0	≥ 0

Table 4. The results revealed 14% of disagreement (cells highlighted in yellow) across all participants when participants were identified as understimators on the Revised-PPT but overestimators on the original PPT, or vice versa.

Original PPT Using HINT Speech Material	Revised-PPT Using QuickSIN Speech Material			
	U	A	O	Total
U	11	3	6	20
A	9	8	4	21
O	3	9	12	24
Total	23	20	22	65

Conclusions

- It is valid and reliable to measure PPDIS using the QuickSIN speech material compared to the original PPT. The agreement to judge the self-rated hearing ability in noise was high between the Revised-PPT and the original PPT.
- It appeared that larger discrepancies between the performance and perceptual measures of the QuickSIN resulted in better self-reported hearing aid outcome. It was controversial compared to the relationship between the IOI-HA and the original PPT using HINT. The type of background noise might be one of the reasons for the difference.

References

Cox, R. M., & Alexander, G. C. (2002). The International Outcome Inventory for Hearing Aids (IOI-HA): psychometric properties of the English version. *Int J Audiol*, *41*(1), 30- 35.

Etymotic Research (2001). QuickSIN Speech in Noise Test Version 1.3. Elk Grove Village, IL.

House Ear Institute (1995). Hearing in noise test operator's manual. Los Angeles, CA: Starkey Laboratories.

Killion, M., Niquette, P., Gudmundsen, G., Revit, L., & Banerjee, S. (2004). Development of a quick speech-in-noise test for measuring signal-to-noise ratio loss in normal-hearing and hearing-impaired listeners. *The Journal of the Acoustical Society of America, 116*(4), 2395-2405.

Nilsson, M., Soli, S.D., & Sullivan, J.A. (1994). Development of the Hearing in Noise Test for the measurement of speech reception thresholds in quiet and in noise. *Journal of the Acoustical Society of America, 95*(2), 1085-1099.

Saunders, G., Forsline, A., & Fausti, S. (2004). The performance-perceptual test and its relationship to unaided reported handicap. *Ear and Hearing, 25*(2), 117-126.

Acknowledgement

- This study was supported by Illinois State University New Faculty Initiative Grant and Academic-Research Careers (AARC) Award from American Speech-Language Hearing Association (ASHA).
- Special thanks to all members in Hearing Aid and Spatial Hearing Research (HASHR) Lab.

For further information

Please contact *hou@ilstu.edu*

STATE and be heard.