A Comparison of the HINT and Quick SIN Tests

Comparaison entre les tests HINT et Quick SIN

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Abstract
Speech-in-noise measures are gaining relevance as audiologists understand the advantages of using outcome measures that demonstrate the need for and benefit from amplification. Two such speech-in-noise measures are the Hearing in Noise Test (HINT) and the Quick Speech-In-Noise (Quick SIN) test. This study was conducted to determine how HINT and Quick SIN performance among young adults with normal hearing (N=15) compared to normative values, as well as to reach conclusions about the clinical utility of both tests. Results showed that Quick SIN measures and normative values were not statistically significantly different while the HINT measures and normative values were. The Quick SIN was found to have some advantages over the CD version of the HINT in terms of clinical use.

Abrégé
La pertinence des mesures de la parole dans le bruit se fait de plus en plus sentir à mesure que les audiologistes comprennent les avantages d'utiliser les indicateurs de résultats montrant le besoin ou l'avantage de recourir à l'amplification. Les tests HINT (Hearing in Noise Test) et Quick SIN (Quick Speech-In-Noise) sont deux mesures de la parole dans le bruit. Cette étude visait à déterminer en quoi les résultats de ces deux mesures utilisées chez de jeunes adultes (N=15) ayant une ouïe normale se comparent aux valeurs normatives. Elle cherchait aussi à vérifier l'utilité en clinique de ces tests. Les résultats montrent que les mesures Quick SIN et les valeurs normatives ne comportaient pas de différences statistiquement significatives, tandis que les mesures HINT et les valeurs normatives en avaient. Le test Quick SIN présente certains avantages par rapport à la version CD du test HINT sur le plan clinique.

Key Words: Speech-in-noise, speech understanding, speech intelligibility, Hearing In Noise Test, Quick Speech In Noise test, adult, outcome measure

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Introduction

Speech-In-Noise Testing

Better speech understanding in noise is the highest ranked improvement desired by hearing aid users (nearly 95% of respondents) in the U.S. (Kochkin, 2002). These same hearing aid users also reported only a 29% satisfaction rate when using their hearing aids in noise (Kochkin, 2002). The importance adults place on improving speech understanding in noise demonstrates the need for outcome measures that assess speech-in-noise capabilities. Specifically, outcome measures are tools used to assess performance changes resulting from intervention. They can be used to identify individuals who have difficulty understanding speech in noise, and describe the amount of difficulty and the subsequent benefit provided by amplification (Bray & Nilsson, 2002). Audiology practitioners and researchers have called for clinical audiologists to use outcome measures and an evidence-based approach to determining the efficacy of intervention (Higdon, 2003; Johnson & Danhauer, 2002; Van Vliet, Cox, Abrams, & Beyer, 2004) yet few audiologists appear to be measuring speech in noise ability in adults during any point in the hearing aid assessment or verification process.

Clinical practice surveys of audiologists and hearing aid specialists show that up to 53% of hearing aid providers reported routine use of speech-in-noise tests (Medwetsky, Sanderson, & Young, 1999; Mueller, 2003; Strom, 2003). However, very low proportions of hearing aid providers use any particular speech-in-noise measure (see Table 1). Recent surveys found that between 2 and 10% of respondents reported using tests that generate a percent-correct score, such as word recognition lists or the Speech in Noise (SPIN) test (Bilger, Nuetzel, Rabinowitz, & Rzeczkowski, 1984). Even fewer respondents, only 1% to 6%, reported using tests that generate a signal-to-noise ratio (SNR), such as the Speech in Noise (SIN) test, the newer Quick SIN, or the Hearing in Noise Test (HINT) (Mueller, 2003; Strom, 2003).

It has been suggested that sentence-length speech-in-noise tests that result in a SNR score (such as the HINT and the Quick SIN tests) overcome limitations associated with word-length tests that use the traditional percent correct score. Percent correct tests may be prone to floor and ceiling effects (Nilsson, Soli, & Sullivan, 1994), and do not indicate SNR needs, a phenomenon that cannot be reliably predicted from the audiogram (Killion, 1997b). Sentence-length materials may redress limitations associated with single word-length tests. Specifically, single word materials do not include the coarticulation effects or dynamic range of conversational speech, and single words lack the real-world relevance provided by sentence-length stimuli (Killion & Niquette, 2000; Nilsson, Sullivan, & Soli, 1990). Also, in the case of the HINT and the Quick SIN tests, both require listeners to repeat five or more words per sentence, rather than only the last word, as is required in the SPIN test (Bilger et al., 1984). Including five or more opportunities to respond per sentence allows a decreased test length compared to tests using only one word per sentence (Etymotic Research, 2001).

The HINT Test

The HINT (see Table 2) became commercially available on compact disk (CD) in the early 1990s (Nilsson et al., 1994) and in a hardware and software system (HINT For Windows) a few years later (Bio-Logic Systems Corp, n.d.; Maico Diagnostics, 2003). Both versions of the HINT were developed at the Hearing Aid Research Laboratory in the Department of Human Communication Sciences at the House Ear Institute (Maico Diagnostics, 2003; Nilsson et al., 1994). Reportedly the HINT was developed to improve on shortcomings associated with speech tests used to measure hearing handicap (Nilsson et al., 1990) such as the poor representation of natural speech provided by spondees and the floor and ceiling effects associated with percent correct scoring (Hanks & Johnson, 1998).

The HINT is comprised of 250 Bench-Kowal-Bamford (BKB) British sentences (Bench & Bamford, 1979) which were equalized in length, difficulty, intelligibility, and phonemic distribution to ensure equivalency (Hanks & Johnson, 1998), and were subsequently rewritten in American English. The sentences, spoken by a male talker, are phonemically matched and balanced, are 5-7 syllables in length, and are rated at the first grade reading level (House Ear Institute [HEI], 1995; Nilsson et al., 1994).

The sentence lists are used to adaptively determine the thresholds at which sentences are correctly identified in quiet or in a background of spectrally matched (speech-weighted) noise. The noise may be presented from any of three speaker locations (0^{o} azimuth or Front, 90^{o} azimuth or Right, and 270^{o} azimuth or Left) when using the CD

Table 1

Results of surveys of routine use of speech-in-noise tests by audiologists (Aud) and hearing instrument specialists (HIS). Data represent proportion of all respondents who use speech-in-noise tests prior to or after hearing aid fitting, and the proportion of all respondents who use specific speech-in-noise measures.

Study	Survey Details	Proportion of All Respondents Reporting Routine Use of:					
		Speech-in-Noise Tests	NU-6	W-22	SPIN	HINT	Quick SIN
Mueller, 2003	On-line survey completed by 608 respondents (92% Aud, 8% HIS)	19% (pre-fitting) 30% (post-fitting)	<5% <8%	3% ~6%	<2% <6%	<3% ~1%	5% 4%
Strom, 2003	Written survey mailed to 750 offices, 167 (22.3%) responded (45% Aud, 55% HIS)	42%[a]	-	-	~8%	<6%	<2%
Medwetsky et al., 1999	Written survey mailed to 113 offices, 60 (53%) responded	53%[a]	~42%	~38%	<2%[b]	8%	-

Note. SPIN = Speech Perception in Noise; HINT = Hearing in Noise Test; SIN = use of Speech in Noise (SIN) and Quick SIN tests; dashes represent data not obtained or not reported. [a] Pre- or post-fitting use not specified; [b] Represents use of Synthetic Sentence Identification test, SPIN test, and CID Everyday Sentences.

Table 2

Characteristics of the CD and HINT For Windows versions of the Hearing In Noise Test (HINT) (House Ear Institute, 1995; Nilsson, Soli, & Sullivan, 1994) and the Quick Speech In Noise (Quick SIN) test (Etymotic Research, 2001).

Characteristic	HINT	Quick SIN
Stimuli	25 10-sentence lists or 12 20-sentence lists	12 6-sentence standard equivalent lists for clinical testing and 3 practice lists
Sample sentence	(An/the) apple pie (is/was) baking.	The desk was firm on the shaky floor.
Talker	Male	Female
Stimulus presentation level	Initially presented 4 dB below noise level, then adaptively presented depending on response to prior sentence	70 dB HL if PTA <45 dB HL or "Loud, but ok" level if PTA >50 dB HL, stimulus level remains constant during test
Noise	Spectrally matched noise	4-talker babble
Noise presentation level	Held constant at 65 dB(A) throughout test	Noise levels in standard lists pre-recorded at SNR that decrease in 5 dB steps from +25 to 0 dB SNR
Transducers	Loud speakers 0° (signal), 0°, 90°, or 270° azimuth (noise) 1 meter from listener, or under headphones that simulate sound field performance	Loud speaker for signal and noise at 0° azimuth binaural inserts, or binaural TDH earphones
Listener task	Repeat verbatim all words in sentence (some substitutions are acceptable)	Repeat as many of five key words in each sentence as possible
Duration of test	About 1 minute per list	About 1 minute per list
Scoring formula	Average Reception Threshold for Speech (RTS) - Noise Level dB = dB SNR, average RTS is average dB(A) of 21 sentences RTS, score in quiet is RTS in dB(A)	25.5 - Average Score = dB SNR Loss, average score is total number of words correct for two lists relative to normal performance
Score represents	RTS at which 50% of sentences were repeated correctly	SNR Loss = SNR a listener with hearing impairment needs above SNR normal hearing listener needs to reach 50% correct sentence identification
Normative population (normal hearing)	44 adults with normal hearing who were native English speakers	26 adults with normal hearing

version of the HINT, and from speakers or headphones when the Windows version is used. Speech-shaped noise was used rather than more "real-world" noise because the stability of this signal's level can increase the reliability of individual SNR scores compared to when a more variable noise signal is used (Maico Diagnostics, 2003; Nilsson et al., 1994; Nilsson, Soli, & Sumida, 1995; Ricketts, 2000).

In general, the HINT measures the effect of hearing loss on speech understanding in noise. The goal of the HINT is to determine the advantage of binaural directional hearing by obtaining the listener's thresholds for sentences in quiet and in noise coming from any of three directions. Additionally, the HINT is said to provide a measure of supra-threshold hearing not available from the audiogram (HEI, 1995; Nilsson et al., 1994; Nilsson et al., 1995).

Prior to test administration, the transducers used in the CD and the HINT For Windows versions of the test must be calibrated to determine the dB HL dial reading associated with a competing noise presentation level of 65 dB(A). For the CD version, loud speakers are used and their height and distance from the listener for all speaker locations are specified. In the software driven version, headphones (but not insert phones) are used to simulate the sound field environment through use of head-related transfer functions. Speakers can also be used (Bio-Logic Systems Corp., n.d.; HEI, 1995).

When the HINT is administered, listeners are required to repeat each sentence "100% correctly" with some variations allowed (such as "a" for "the"). Initially an ascending approach is used to determine the presentation level at which the first sentence is correctly repeated. The presentation levels of sentences #2 through #4 are adaptively increased or decreased in 4 dB steps. The presentation level of sentences beginning with #5 are adaptively increased or decreased in 2-dB steps. This adaptive procedure is used in quiet and in noise to obtain a reception threshold for sentences (RTS). This adaptive approach was used in an effort to eliminate ceiling and floor effects associated with tests administered at a fixed presentation level (HEI, 1995; Maico Diagnostics, 2003; Nilsson et al., 1994).

In the quiet condition, the sound pressure level (SPL) for all sentences are averaged, resulting in a RTS in dB (either dB(A) or its dB HL equivalent) associated with 50% sentence recognition. In the noise conditions, the SPL levels are also averaged, and the dial HL value associated with a 65 dB(A) noise signal is deducted from this value (RTS – Noise Level = dB SNR). The resulting score is the SNR needed to reach 50% correct performance (Nilsson & Soli, 1994; Nilsson et al., 1994).

Information about the development of the original CD version of the HINT and norms for presentation in quiet and in noise were provided with the CD and can be found in self-published documents (HEI, 1995; Nilsson et al., 1995). Additional normative information was made available by past and current distributors of the automated version of the HINT, specifically, the HINT For Windows versions of the HINT test previously available from Maico Diagnostics (2003) and the HINT Pro Hearing in Noise Test available from Bio-Logic Systems Corp (n.d.) at the time of this writing.

Sound field (noise front) norms, reliability information, and subject characteristics associated with the CD HINT version are shown in Table 3. The instructions accompanying the CD version of the HINT suggest that users test 10-20 normal hearing listeners and compare the mean score to the normative 50th percentile score provided. If there is a difference between the clinic's mean and the 50th percentile score, all percentile scores provided should be shifted up or down by the difference for that condition. Reportedly this adjustment will allow users to compare individual HINT scores to normative values that have been changed to accommodate variations caused by the test setting (HEI, 1995). While the instructions for the CD version of the HINT provide detailed testing, scoring, and normative information, written materials accompanying the newest automated HINT state that, for the CD version, these procedures are not standardized. Additionally, the previous automated version of the HINT states that users testing in sound field must determine site-specific sound field norms (means or means and standard deviations) using 16-20 adults with normal hearing and enter these values in the HINT software. The software will then compute percentile rankings (Maico Diagnostics, 2003). This method eliminates the need to determine and apply a correction factor to the norms provided. The newest automated HINT also offers this feature (Bio-Logic Systems Corp., n.d.). Finally, the norms provided with the CD version and automated version were all collected using the automated system. No norms have been provided that were obtained using the manually administered CD version of the HINT.

Table 3

Participant characteristics and descriptive statistics for normative and measured values obtained from 15 subjects with normal hearing in sound field at 0° azimuth using the Hearing In Noise Test (HINT) (House Ear Institute, 1995; Nilsson, Soli, & Sumida, 1995) and the Quick Speech In Noise (Quick SIN) test (Etymotic Research, 2001).

	HINT		Quick SIN	
	Norm	Measured	Norm[a]	Measured
Participant characteristics				
N	100	15	29	15
Age				
Mean (years)	-	25	-	25
Range	-	22-29	-	22-29
SD	-	2.24	-	2.24
Descriptive statistics				
M	-2.82	-.85	1.90	1.70
Range				
Lower	-	-3.50	-	0.00
Upper	-	2.50	-	3.50
SD	1.07	1.65	1.25	1.25
SEM	-	.43	-	.32
95% CI for mean	.21[b]	±.80	±1.9[c]	±.60
Lower	-3.03	-1.74	0.00	1.10
Upper	-2.60	.06	3.80	2.33

Note. Loud speaker (signal and noise) at 0° azimuth for both tests. Participants had normal hearing and used English as their first language with exception of participants used to define Quick SIN normative values. Descriptive statistics are for two lists with exception of Quick SIN SD. CI = confidence interval. Dashes represent data not provided.

[a]Quick SIN norms obtained using insert earphones. [b]This CI is not based on SD and requires a SEM of .11. [c]This CI based on SD (not SEM) associated with one list administered to subjects with hearing loss

At the time of this writing, use of the automated HINT has not yet appeared in published peer-reviewed studies, possibly due to the fact that this version is newer as well as more costly than the CD version. The original CD version of the HINT, however, has been used extensively in peer-reviewed and trade publication studies investigating directional microphone performance (Agnew & Block, 1997; Agnew, Potts, Valente, & Block, 1997; Bray & Nilsson, 2001; Bray & Valente, 2001; Kuk, Keenan, & Nelson, 2002; Novick, Bentler, Dittberner, & Flamme, 2001; Preves, Sammeth, & Wynne, 1999; Pumford, Seewald, Scollie, & Jenstad, 2000; Ricketts, 2000; Ricketts & Dhar, 1999; Ricketts, Lindley, & Henry, 2001; Ricketts & Mueller, 2000; Valente, Fabry, & Potts, 1995; Valente, Schuchman, Potts, & Beck, 2000), in studies comparing different hearing aids to each other or determining the benefit provided by a particular hearing aid or cochlear implant (Cord, Leek, & Walden, 2000; Kam & Wong, 1999; Knebel & Bentler, 1998; Matthes, Saunders, Cienkowski, & Levitt, 1995; Nilsson, Fang, Ghent, Murphy, & Bray, 2000; Parkinson, Arcaroli, Staller, Arndt, Cosgriff, & Ebinger, 2002; Skinner, Arndt, & Staller, 2002; Tyler, Gantz, Rubenstein, Wilson, Parkinson, Wolaver et al., 2002; Valente, Fabry, Potts, & Sandlin, 1998) and in other clinical investigations (Cook, Bacon, & Sammeth, 1997; Humes, Halling, & Coughlin, 1996, Sargent, Hermann, Hollenbeak, & Baukaitis, 2001; Saunders & Cienkowski, 2002; Soli & Nilsson, 1994; Soli, Vermiglio, & Cruz, 2000; Vermiglio, Freed, & Soli, 2000; Walden, Walden, & Cord, 2002; Waltzman, Cohen, & Roland, 1999).

In a small proportion of these studies the HINT has been administered and scored according to the HINT user's manual (Agnew & Block, 1997; Agnew et al., 1997; Bray & Valente, 2001; Kam & Wong, 1999; Knebel & Bentler, 1998; Soli et al., 2000; Valente et al., 1998; Vermiglio et al., 2000; Walden et al., 2002). Typically, however, the HINT is administered using additional speakers and/or uncorrelated noise sources (Bray & Nilsson, 2001; Preves et al., 1999; Pumford et al., 2000; Ricketts, 2000; Ricketts & Mueller, 2000; Valente et al., 1995; Valente et al., 2000), or by altering the sentences or changing the administration or scoring method (Cook et al., 1997; Dorman, Loizou, & Fitzke, 1998; Dubno, Ahistrom, & Horwitz, 2002; Humes et al., 1996; Kuk et al., 2002; Novick et al., 2001; Parkinson et al., 2002; Ricketts & Dhar, 1999; Ricketts et al., 2001; Saunders & Cienkowski, 2002; Skinner et al., 2002; Tyler et al., 2002).

The Quick SIN Test

The Quick SIN test (see Table 2) was developed by Etymotic Research and became commercially available in 2001. This test began as the Speech In Noise (SIN) test (Killion & Villchur, 1993) and the subsequent Revised Speech In Noise (RSIN) test (Cox, Gray, & Alexander, 2001). It was developed to overcome the limitations associated with the first SIN test, namely, its length, insufficient number of lists, lack of list equivalence, and inability of some listeners to achieve 50% correct sentence identification (Bentler, 2000; Etymotic Research, 2001; Killion, 1997a). Additionally, the Quick SIN test was designed to give audiologists a quick way to express a listener's ability to understand speech in noise as a SNR rather than as a percent correct score (Killion, 1997b). Its goals are to provide a fast means of quantifying the real-world SNR loss that is not well inferred from the audiogram, demonstrate improvement provided by directional microphones, and help audiologists and hearing aid dispensers identify amplification options for individual patients (Etymotic Research, 2001; Killion, Niquette, Gudmundsen, Revit, & Banerjee, 2004).

The Quick SIN includes a total of 18 unique 6-sentence lists composed of Institute of Electrical and Electronics Engineers (IEEE) sentences, which were designed to provide limited contextual cues to aid in understanding (Etymotic Research, 2001). These sentences subsequently underwent an equalization process to correct for high frequency attenuation present in source recordings obtained from the Massachusetts Institute of Technology (Fikret-Pasa, 1993).

The sentences are spoken by a female talker and are presented at a constant level in a background of 4-talker babble (one male and three females), rather than the speech-weighted noise used with the HINT sentences. Four-talker babble is employed because the Quick SIN developers reported it is more representative of the noise typically encountered in social situations than is speech-weighted noise (Killion & Villchur, 1993). Reportedly this background noise is most representative of real-world performance, such as a social gathering, than are other types of background noise (Sperry, Wiley, & Chial, 1997). The babble level in each list decreases in intensity in 5 dB steps from +25 to 0 dB in order to vary SNR (Etymotic Research, 2001; Killion et al, 2004).

The test may be administered in sound field with the signal and noise presented from the same speaker at 0^0 azimuth. As an alternative, the test can be administered binaurally under insert earphones (Etymotic Research, 2001). The presentation level is 70 dB HL for listeners with a pure-tone average (PTA) of 45 dB HL or less. The presentation level is "loud but OK" (Valente & Van Vliet, 1997) for listeners with a PTA greater than 45 dB HL (Etymotic Research, 2001).

The listener's task is to repeat the sentences presented. Each sentence has five key words and each correctly repeated word is awarded one point for a total possible score of 30 points per list. The score is determined by use of the formula 25.5 – Total Words Correct = SNR Loss. The SNR Loss score represents the SNR a listener with hearing loss requires above the SNR a normal hearing listener requires to achieve 50% correct sentence identification (Killion, 1997b). This formula is based on the Tillman-Olsen method for obtaining spondee thresholds (Etymotic Research, 2001; Killion et al., 2004).

Subject characteristics, descriptive statistics, and reliability information associated with the Quick SIN test found in the user's manual are shown in Table 3 (Etymotic Research, 2001). The user's manual also provides 80%

and 95% critical difference values that can be used when comparing an individual's performance in two conditions. These critical differences allow audiologists to use the Quick SIN as an outcome measure when selecting and fitting amplification. Whereas this test may be administered in sound field or under insert earphones, the data from which normative values were determined were collected under insert earphones only (Etymotic Research, 2001).

The Quick SIN user's manual provides guidelines for interpreting performance on the Quick SIN test based on adjectives that describe the amount of SNR loss. Specifically, a score of 0-2 dB SNR loss is considered normal; a score of 2-7 dB is considered indicative of a mild SNR loss, while a score of 7-15 dB is associated with a moderate SNR loss and suggests that a directional mic should be considered. A score of >15 dB indicates a severe SNR loss which would lead an audiologist to consider an FM system. These categories of SNR loss (normal, mild, etc.) and their associated recommendation (directional mic or FM system) are suggestions; no recognized scale of SNR loss categories or their appropriate intervention exists (Killion & Niquette, 2000).

The Quick SIN, as well as other tests, was recently reported in an evaluation of a new speech recognition measure (Bochner, Garrison, Sussman, & Burkard, 2003). Otherwise, compared to the HINT, the Quick SIN test has little presence in peer-reviewed studies, perhaps because it is fairly new.

This study was undertaken in an attempt to determine if the average performance of adults with normal hearing on the HINT and Quick SIN tests differed from the tests' normative values. If measured performance is found to differ significantly from the normative data supplied by each test's distributors, then reported normative values should not be used clinically and users should obtain their own clinic norms. In the case of the HINT the original CD, rather than the automated version, was used because the CD appears to be in wider use than the automated test in that its use has been reported most often in the literature. A comparison between measured and normative HINT performance is needed because this test's instructions encourage users to obtain their own clinic-based norms. In the case of the Quick SIN test the comparison is needed because normative data were collected under insert earphones, not in sound field, yet the test needs to be administered in sound field when using it as an outcome measure when selecting and fitting amplification systems. Additionally, the Quick SIN test has little representation in the literature.

Methods

Participants

Participants were 15 adults (7 men and 8 women). Fifteen is the number of subjects suggested in the HINT user's manual for clinics that determine their own norms (HIE, 1995). Participants' age ranged from 22 to 29 years of age (M = 25 years). All participants were native English speakers, had normal hearing in both ears (that is, no thresholds were poorer than 20 dB HL from 500-6000 Hz), normal middle ear system function, and an uneventful health history.

Equipment

All audiometric testing was conducted using a Madsen Auricle software-driven two-channel audiometer (Madsen Electronics, 1998), E-A-R 3A insert earphones, a B-71 bone conduction oscillator, and two Tandy Lifeline sound field loud speakers. Immittance testing was conducted using a Madsen Zodiac 901 unit. Commercially available CD versions of the HINT and Quick SIN tests were used. All testing was conducted in a double-walled Industrial Acoustics Company single-room test booth located in the Audio Lab in the Department of Speech Pathology and Audiology. The speech-in-noise testing was part of a larger study. The entire test session lasted no more than 90 minutes.

Procedures

Both the Quick SIN and the HINT tests were administered according to their respective user's manuals. That is, both tests were administered in sound field with the signal and noise presented to both ears simultaneously from a speaker located at a 0^{o} azimuth one meter in front of the listener and 45" from the floor. The floor was marked to indicate the speaker and chair positions to ensure consistency throughout data collection.

Prior to HINT administration the dB HL level that resulted in a 65 dB(A) noise level was determined using the procedure provided in the user's manual (HEI, 1995). Specifically, the VU meter on both channels of the Auricle audiometer was calibrated to zero while the 1000 Hz calibration tone (track 29 on the CD) was presented. Next, the calibration microphone of a sound level meter was placed 39" from the floor, 1 meter in front of the speaker, which was a point consistent with the center of a typical listener's head. The calibration noise found on track 30 of the CD was presented via channel one of the audiometer and the intensity level of the signal was adjusted until the sound level meter measured a 65 dB(A) level. The dial setting that resulted in a measurement of 65 dB(A) was 67 dB HL.

Immediately prior to Quick SIN and HINT administration, both channels of the audiometer were calibrated using the 1000 Hz calibration tone provided on the respective CD; participants listened to orally presented test instructions while reading a written copy of the instructions, and one practice list was administered. Two lists of both speech-in-noise tests were administered to improve reliability above that provided by one list as recommended by the test developers (Etymotic Research, 2001; Nilsson & Soli, 1994; Nilsson, Jayaraman, & Soli, 1993; Nilsson et al., 1995). Both tests were administered according to user's manuals instructions. Test and lists presented were randomized and counterbalanced.

In order to administer the Quick SIN test, the sentences (channel one of the CD) were routed to channel one of the audiometer while the four-talker babble (channel two of the CD) was routed to channel two of the audiometer. The presentation level for both the signal and noise were set according to Quick SIN directions (Etymotic Research, 2001). That is, because the pure-tone average of all participants was ≤45 dB HL, the presentation level was always 70 dB HL. The signal and noise levels were not adjusted during testing because the constant sentence level and the changing noise level are pre-recorded on the CD. Participants were required to correctly repeat the five key words in each test sentence. The total number of words repeated correctly in each list of six sentences was totaled, the totals were averaged, and the formula 25.5 – Average Total Correct = SNR Loss was applied to obtain Quick SIN scores.

In order to administer the HINT, the sentences (channel one of the CD) were routed to channel one of the audiometer while the spectrally matched noise (channel two of the CD) was routed to channel two of the audiometer. The noise presentation level was held constant at 67 dB HL (65 dB(A)) while the sentence presentation level was varied adaptively according to HINT instructions based on the participants' responses. The SNR at which 50% of the stimuli were repeated correctly was calculated by determining the average presentation level (the average RTS) for sentences 5-21 (the dB associated with sentence 21 was determined based on the response to sentence 20) and using the formula RTS – 67 dB HL = SNR (Nilsson et al., 1994).

Test reliability and intra-tester error were addressed during both Quick SIN test and HINT administration by the experimenter and a second tester simultaneously scoring 20% of all responses. Both the experimenter and the second tester were in agreement on all responses.

Statistical Analyses

Descriptive statistics and t-tests were conducted on the HINT and the Quick SIN scores in order to answer the research questions. Analyses were carried out using the SPSS (version 10.1) program (Green & Salkind, 2003). In each analysis, an alpha level of $p = .05$ was used for judging statistical significance. This two-tailed alpha level was used because of the non-directional nature of the hypothesis.

Results

Table 3 shows the participant characteristics and descriptive statistics associated with their performance on the HINT and Quick SIN tests. Normative values are also included. Figure 1 shows the mean scores and standard deviations for both tests and their respective normative values. As can be seen, the measured variance and standard deviations associated with the HINT are larger than those associated with the Quick SIN.

One-sample t-tests were conducted to determine if the average HINT and Quick SIN scores found here were different from the normative HINT and Quick SIN scores, respectively. The HINT sample mean of -.867 ($SD = 1.65$) was significantly different from the normative mean of – 2.82, $t(14) = 4.58$, $p = .000$. The 95% confidence interval for the measured HINT mean ranged from –1.74 to .06. The effect size d of 1.18 indicates a large effect size.

The Quick SIN sample mean of 1.7 ($SD = 1.25$) was not significantly different from the normative mean of 1.9, $t(14) = -.619$, $p = .546$. The 95% confidence interval for the measured Quick SIN mean ranged from 1.10 to 2.33.

Discussion

The research question was answered by examining the descriptive statistics and reliability information shown in Table 3 and Figure 1, and the one-sample t-test results. Specifically, the HINT sample values found here differed from the normative values while the Quick SIN sample and normative values were similar.

First, the HINT sample variability found here exceeds the normative standard deviation (SD) value provided by HINT developers (Nilsson et al., 1995) while Quick SIN variability found here was the same as the normative SD.

Second, the reported HINT 95% confidence interval (CI) for the mean (based on two lists administered to young adults with normal hearing) was narrower than the CI associated with the sample data. The importance of the difference between the measured and normative 95% CI cannot be determined because the HINT's standard error of the mean (SEM), which is used to calculate CI, was not reported (Nilsson et al., 1995) and the normative 95% CI was not generated using the HINT SD. Conversely the Quick SIN 95% CI provided in the user's manual (±1.9 dB) was wider than the sample's CI found here. The Quick SIN normative 95% CI for two lists was based on the SD, not the SEM, and was associated with subjects with impaired hearing, not the subjects with normal hearing.

Third, the one-sample t-tests showed that there was a statistically significant difference between the HINT sample mean and the HINT normative mean. The Quick SIN sample and normative mean were not significantly different. These differences between sample and normative values occurred despite the fact that the sample size used here was recommended by HINT developers (HEI, 1995).

There are several possible reasons why HINT sample values differed from HINT normative values. First, as indicated in the HINT user's manual and elsewhere (HEI, 1995; Nilsson et al., 1995), HINT performance measured in sound field in clinics may differ from HINT norms collected in sound field due to differences in room acoustics and equipment used. Second, the HINT lists were administered manually to this study's participants, not in an automated fashion as they were when norms were developed. However, the lists were administered exactly as specified in the user's manual.

Unlike the HINT, the Quick SIN sample and normative values were similar (the means) or exactly the same (the

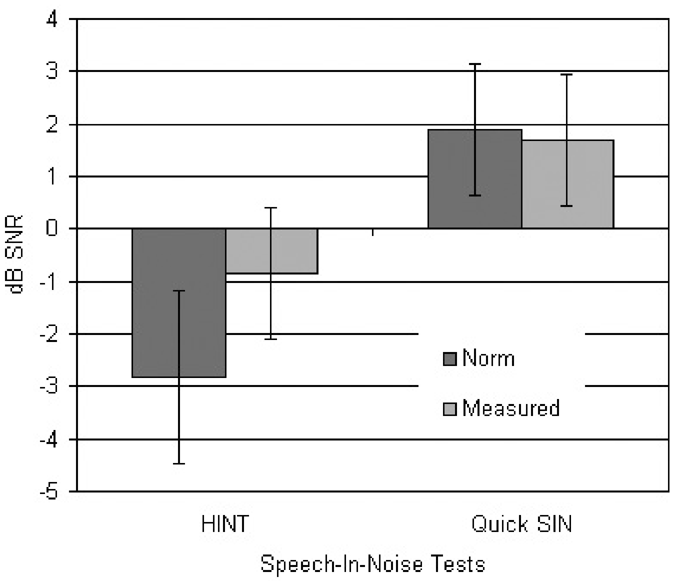

Figure 1. Measured and normative means and standard deviations for the Quick Speech In Noise (SIN) test and Hearing In Noise Test (HINT) (N=15). All data collected in sound field (noise and signal at 0^0 azimuth) with exception of Quick SIN normative values which were obtained under insert phones. Quick SIN norm and the average measured performance were not statistically significantly different (p=.546) while the HINT norm and average measured performance were (p=.000).

SD). The similarities between the Quick SIN sample values reported here and the normative values occurred despite the fact that the Quick SIN norms were developed based on data collected under insert earphones.

Both tests used here are similar in terms of administration time (about one minute per list). Both provide the SNR at which listeners understand 50% of the stimuli, rather than a percent correct score. These characteristics support the clinical use of both tests.

The Quick SIN test, however, has some attributes that make its clinical use preferable to that of the HINT. The Quick SIN surpasses the HINT in terms of set-up requirements, ease of administration and scoring, low cost, and the similarity between normative and sample values found here. Also, based on the results reported here, the Quick SIN test does not require that clinics obtain their own sound field norms before using the test as an outcome measure, while the HINT does, at least where the CD version of the HINT is concerned. Additionally, the Quick SIN SNR Loss score is relative to normal performance. That is, the Quick SIN score represents the SNR a listener with hearing loss requires above the SNR a normal hearing listener requires to achieve 50% correct sentence identification (Killion, 1997b). The HINT score does not include reference to normal performance.

Conclusion

The two tests examined here, the CD version of the HINT and the Quick SIN, provide information about supra-threshold hearing that cannot be inferred from the audiogram, information that can be used to determine the need for and benefit from interventions that address SNR needs. The results reported here demonstrate the need for clinic-specific norms for the HINT, as well as the clinical utility of the Quick SIN test and its norms. The reliability and validity of the currently available automatic HINT test need to be examined. The appropriateness of the Quick SIN performance descriptors (for example, severe SNR Loss) and the recommended interventions associated with SNR Loss also need to be examined. Further evaluation of both tests may assist clinicians in selecting and consistently using a speech-in-noise test as an outcome measure when providing intervention to adults with hearing loss.

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