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The University of South Florida  
College of Arts and Sciences

Monaural Speech-in-Noise Thresholds Using the Hearing in Noise Test (HINT)

By

Denise Parrish

An Audiology Doctoral Project

Submitted to the Graduate Faculty of the  
Department of Communication Sciences and Disorders  
in partial fulfillment of the requirements  
for the degree of

Doctor of Audiology

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## ABSTRACT

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Understanding speech in background noise is occasionally difficult for normal hearing listeners and is often impossible for the listener with sensorineural hearing loss. The ability to understand speech in noise depends upon multiple factors such as the characteristics of the speech signal, the signal-to-noise ratio, and the listener's degree of hearing impairment. A routine hearing evaluation usually does not provide ample information about a listener's functional communication abilities. The Hearing-in-Noise Test (HINT) developed by The House Ear Institute provides an efficient and reliable method for evaluating an individual's suprathreshold speech understanding ability in quiet and in noise. The purpose of this pilot study was to investigate monaural speech reception thresholds for sentences (RTS) in quiet and in noise using the standardized Hearing-in-Noise Test (HINT). Data was collected from one clinical setting using twenty-five subjects with bilateral normal hearing (WNL) and twenty subjects with bilaterally symmetrical sensorineural hearing loss (SNHL). Subject age ranged from 40 to 65 years.

The study results were generally in agreement with the HINT norms. It was concluded that administering the HINT monaurally under headphones could differentiate between normal hearing individuals and individuals with cochlear hearing loss. The SNHL group exhibited higher RTSs than the WNL group in both quiet and in noise. The mean RTS difference between the two groups in quiet was 14.56 dB while the mean RTS difference in noise was only 2.85 dB signal-to-noise ratio. Surprisingly, the difference between the two subject groups in quiet was greater than was expected.

## Introduction

Daily communication requires the ability to understand speech in varying degrees of noise. Normal hearing individuals do not complain about understanding speech in quiet environments, but may have some difficulty with understanding speech in noisy environments (Wilson & Strouse, 1999). It has been established that individuals with sensorineural hearing loss (SNHL) demonstrate greater difficulty understanding speech in background noise than do normal hearing individuals under the same conditions (Dubno, Dirks & Morgan, 1984). The ability of a listener to understand speech may be affected by such factors as degree of hearing loss, age, presentation level, speaker, material, competing background noise, and signal-to-noise ratio. Each one of these variables interact and play a role in determining how well one understands speech in any given environment (Nilsson, Soli, Sullivan, 1994). Listeners with identical word recognition abilities in quiet can have significantly different word recognition abilities in background noise (Beattie, Barr & Roup 1997; Norwood-Chapman, Wilson & Thelin, 1997).

Speech is a redundant auditory signal comprised of many bits of information. Similarly, our language structure has both extrinsic and intrinsic language redundancies. The extrinsic redundancies involve information obtained from phonemes and syntax. The listener possesses the intrinsic language redundancies based on their experiences with the language (Miller, 1951). The more extrinsic and intrinsic redundancies available, the easier it becomes to understand the speech signal (Miller, Heise & Lichten, 1951). Due to speech redundancy, normal-hearing individuals can understand the signal even though it may be highly degraded, as in a crowded restaurant (Wilson & Strouse, 1999).

The redundancy of the speech signal varies depending on whether one is listening to words in isolation, listening to sentences or participating in a conversation (Feston & Plomp, 1990). Generally, it is much easier to understand longer speech signals than short ones, even when the speech is embedded in background noise. Sentences are the easiest signal to understand as they provide the listener with acoustic information, semantic and contextual cues and linguistic content, i.e. greater redundancy. It is much easier to understand a conversation about a known subject, than single syllable words. Monosyllabic words embedded in background noise are the most difficult speech signal to comprehend. However, due to the increased redundancy and contextual cues in sentence materials, it becomes more difficult to determine whether the listener has perceived the entire sentence or has responded to a few key words that convey the meaning of the sentence (Wilson & Strouse, 1999).

Speech audiometry incorporates both sensitivity and acuity measures (Ward, 1964). Sensitivity measures are threshold measures that are typically referred to as the Speech Detection Threshold (SDT), Speech Recognition Threshold (SRT) and Reception Threshold for Sentences (RTS). The SDT represents the softest level at which speech is first audible and is not routinely used for testing adults. The SRT and the RTS measurements are defined as the sound pressure level at which 50% of the words or sentences are understood. When the ability to understand speech is measured at different noise levels, the SRT and RTS is expressed as a signal-to-noise ratio (S/N ratio) (Nilsson et al, 1994).

Central Institute for the Deaf (CID) developed an acuity measurement in the 1950s. The CID W-22 word lists are often used in measuring word recognition ability at the listener's most comfortable listening level (Wilson & Strouse, 1999). Word recognition tests, like the W-22 lists have been used routinely in audiological evaluations for the past fifty years with few

changes. Although these word lists are efficient, single word recognition tests are not representative of spoken language and the validity of these lists of words for predicting social adequacy of one's hearing has been extensively questioned (Orchik, Krygier & Cutts, 1979; Beattie, 1989). A study conducted by Speaks and Jerger (1965) concluded that the CID W-22 word lists are too easy and provide little sensitivity in separating normal hearing individuals from mild hearing loss individuals. Additionally, for the majority of the patients, the level required for maximum word recognition performance is higher than the listener's most comfortable listening level (Ullrich & Grim, 1976). Although, utilized less frequently during comprehensive testing, sentence-length materials have been shown to be efficient and reliable for determining thresholds for speech (Dubno, Dirks, Morgan 1984; Plomp & Mimpen, 1979).

One test using sentence-length materials is The Hearing In Noise Test (HINT), which was developed at The House Ear Institute and provides a reliable measure of reception threshold for sentences (RTS) in quiet and in background noise (Nilsson, Sullivan, & Soli, 1991; Nilsson et al., 1992; Nilsson et al., 1993). The HINT was designed for testing binaural listening in the sound field allowing for the assessment of amplification.

The HINT consists of 25 equivalent ten-sentence lists and speech spectrum noise. The sentences were derived from the Bamford-Bench sentences developed in the United Kingdom. The sentences were revised to remove British idioms, equate sentence length and alter verb tenses. The lists of sentences were normed for naturalness, difficulty and reliability (Nilsson et al., 1994). The sentences are 6 to 8 syllables in length and include monosyllabic and polysyllabic words that approximate a first grade reading level, thereby comprehensible by all adults (Nilsson et al., 1994) (See Appendix A). The speech stimuli are simple sentences with little contextual information, closely approximating performance intensity slopes for speech intelligibility word

lists (Nilsson, Soli, Sumida, 1995). The HINT masking noise is a speech spectrum noise that is spectrally matched to the long-term average spectrum of the stimulus sentences so that the signal-to-noise ratio is approximately equal at all frequencies (Nilsson, Soli & Sullivan, 1994). An adaptive method procedure is used for measuring the reception thresholds for sentences in quiet or in noise. The adaptive procedure avoids the ceiling and floor effects associated with most word recognition tests, which are presented at a fixed level (Nilsson, Soli & Sullivan, 1994). The listener repeats the entire sentence presented to him by a recorded CD. Each sentence is scored correct or incorrect with minor exceptions made for article and verb tense substitutions. The sentence level is adjusted depending upon the accuracy of the individual's response and is then averaged (RTS). This RTS score estimates the level at which sentences can be correctly repeated 50% of the time (Nilsson et al, 1994). The established HINT norms for soundfield testing were based on 100 Native English speaking applicants to the Los Angeles police academy. These participants exhibited clinically normal hearing (25 dB HL or better at all frequencies) with a mean age of approximately 25 years (Nilsson, Soli & Sumida, 1995).

In most listening situations, normal hearing people can understand speech if it is loud enough (Plomp, 1986). Additionally, should the S/N ratio be increased, a person's ability to understand speech increases significantly (Studebaker, Pavlovi & Sherbecoe, 1987); a 1 dB increase in S/N will improve the intelligibility of running speech by as much as 20%.

Hearing-impaired individuals show a greater amount of variability in word recognition ability than normal hearing individuals. Some hearing-impaired individuals have understanding ability equal to a normal hearing person while others understand very little regardless of presentation level (Wilson & Strouse, 1999). A person with a conductive hearing loss can have the same word recognition function as a person with normal hearing, except that the presentation



level was higher. Persons with a cochlear hearing loss showed poorer word recognition performance than persons with normal hearing even when compensation was made for threshold differences (Wilson & Strouse, 1999).

Bronkhorst and Plomp (1989) found that listeners with symmetrical sensorineural hearing loss (SNHL) have a higher than normal RTS in noise. In other words, persons with symmetrical SNHL, required a better signal-to-noise ratio in order to understand speech 50% of the time. The results of a study by Smoorenberg (1992) showed that the RTS in noise is directly related to the hearing loss at frequencies above 2000 Hz and that the effect on speech clarity in noise can occur with mild hearing losses of 15 dB HL. One study by Humes (1996) showed that the degree of sensorineural hearing loss is either the sole or primary variable for speech understanding in noise. Humes (1996) reported that it remains possible that other factors may account for individual variations in word recognition ability in noise. Moore (1996) concluded that the most obvious symptom of cochlear hearing loss is a reduced ability to detect weak sounds. However, cochlear hearing loss causes a variety of changes within the inner ear system, which will directly affect understanding of speech. Moore (1996) stated that, “even if sounds are amplified so that they are well above the threshold of detection, the perception of those sounds are usually abnormal”.

Since hearing-impaired individuals have difficulty understanding speech, especially in noisy environments, testing speech recognition in noise should be evaluated during a routine audiologic evaluation. Adding background noise to the speech stimuli is more representative of real-life listening (Beattie, 1989). Without testing in noise, how do we know how difficult communication would be for a hearing-impaired individual or if a specific hearing aid will provide sufficient gain for speech recognition? Speech recognition testing in noise provides

useful information for hearing aid selection, auditory rehabilitation and in counseling the client towards realistic expectations. The primary purpose of this study was to investigate monaural RTS in quiet and in noise using the HINT. The reliability and sensitivity of the HINT is well established with normative data available for both quiet and noise conditions (Nilsson, Gelnett, Sullivan, Soli & Goldberg, 1992). However, since the HINT was designed for binaural listening in the sound field, information about monaural performance is obscure. Thus, the purpose of this pilot study was to evaluate the efficacy of administering the HINT monaurally under earphones to normal and hearing-impaired individuals. This study evaluated the listener's ability to hear soft speech in quiet and in noise using the standardized HINT sentences, which closely represent the spectral weighting, level fluctuations and supra-segmental information found in conversational speech.

## Methods

### Subjects

Twenty-five normal hearing and twenty hearing-impaired English-speaking persons, between the ages of 40 and 65 years of age served as subjects in this investigation. The forty-five subjects were contacted by phone after an extensive file review was conducted at Manatee Ear Center, Inc. Normal hearing sensitivity was defined as having pure-tone air-conduction thresholds less than 20 dB HL at audiometric test frequencies 250 Hz through 8000 Hz (American National Standards Institute, 1996). All hearing-impaired individuals had symmetrical SNHL equal or greater than 25 dB HL, not exceeding the pure-tone average of 60 dB HL for audiometric test frequencies of 1000, 2000, and 4000 Hz. (PTA2) All participating subjects had normal middle ear function as determined by normal type A tympanograms, present

ipsilateral acoustic reflex thresholds at 500, 1000, and 2000 Hz, and contralateral acoustic reflexes at 1000 and 2000 Hz in both ears. All subjects were history free of ear and neurological diseases, and exhibited normal central auditory processing as determined by a normal score on the two pair Dichotic Digit Test (DDT). The criterion for normal results for the normal hearing group was a score above 90% for either ear. For the SNHL group, the criterion for normal results was a score above 80% for either ear (Musiek, Gollegly, Kibbe & Verkest-Lenz, 1991).

All participants in this study signed an informed consent form. This consent form was in compliance with the guidelines established by the University of South Florida Internal Review Board (IRB). All data collected was kept in a locked file cabinet at Manatee Ear Center, Inc. located in Bradenton, Florida. The participant's identities were not revealed in any published report or oral presentation. There was no monetary remuneration to the participants.

### Instrumentation

All testing took place in a sound-treated room meeting ANSI (1991) specifications for permissible ambient noise levels. Immittance measurements were obtained on all subjects using a Madsen Zodiac 901 immittance audiometer calibrated in accordance with ANSI (1996) standards. All pure-tone thresholds and speech audiometry was completed with a Qualitone Acoustic Analyzer AA30 audiometer calibrated in accordance with ANSI (1989) specifications for a Type 2 audiometer with a built-in Panasonic CD player and equipped with TDH-39 headphones. All speech testing employed the use of pre-recorded calibrated test material on a compact disk (CD).

### Test Protocol

Otосcopy was performed on all individuals. All subjects received a complete hearing assessment, which followed a standard clinical protocol. Testing included bilateral pure-tone

thresholds, speech reception thresholds, word recognition scores (CID-W22), tympanograms and acoustic reflex testing. All participants received a DDT to insure the integrity of the central nervous system. RTS measurements using the HINT sentence lists were obtained for the right ear only in quiet and in noise. All RTS measurements were obtained using an adaptive test procedure. Participants were instructed to repeat everything they heard, even if they only heard part of a sentence. Two sequential 10-sentence lists were presented. The listener's were given 4 practice sentences to become familiar with the task. Four dB steps were used between Sentences 1-4 and 2 dB steps were used for sentence 5-20. Starting with sentence 5, if the participant's response was correct, the presentation level was decreased by 2 dB. If the listener's response was incorrect, the presentation level of the sentence was increased by 2 dB. After testing in quiet, the participants were tested in noise using the same protocol. They received instructions and were given 4 more practice sentences with the noise signal. The noise was presented at a fixed level of 65 dB HL in their right ear. Once more, the presentation of the test sentence was either increased or decreased depending on the accuracy of the listener's response to the previous sentence. The RTS was calculated by averaging the presentation levels for the last 17 sentences in two 10-sentence HINT lists. The calculated RTS followed the recommended HINT scoring procedure. The individual test scores were compared to the HINT's normative rankings for quiet and in noise at a zero degree azimuth (See Appendix B). All participants were assessed in a 50-minute session.

## Results

Pure tone air conduction thresholds were obtained for the octave intervals of 250-8000 Hz for all 45 participants. Twenty-five of the participants exhibited bilateral normal hearing (WNL) and twenty participants or 44% of the participants had bilaterally symmetrical SNHL

with a PTA2 greater than 20 dB HL. Additionally, word recognition scores in quiet, Reception Thresholds for Sentences in Quiet (RTS Quiet) and Reception Thresholds for Sentences in Noise (RTS Noise) were obtained for all participants. Tables 1 and 2 shows the means and standard deviations for these measurements for the test ear.

Table 1. Means and standard deviations (SD) for pure tone thresholds, PTA2, word recognition score (WRS), Reception Thresholds for Sentences in Quiet (RTS Quiet in dB) and Reception Thresholds for Sentences in Noise (RTS Noise in dB signal-to-noise ratio) for normal hearing subjects.

	250	500	1000	2000	4000	8000	PTA2	WRS	RTS QUIET	RTS NOISE
Mean	14.60	9.80	5.60	5.21	8.60	10.80	6.53	97.92	19.64	-1.07
SD	6.44	5.30	4.64	4.29	6.38	5.89	3.67	2.86	3.06	1.51

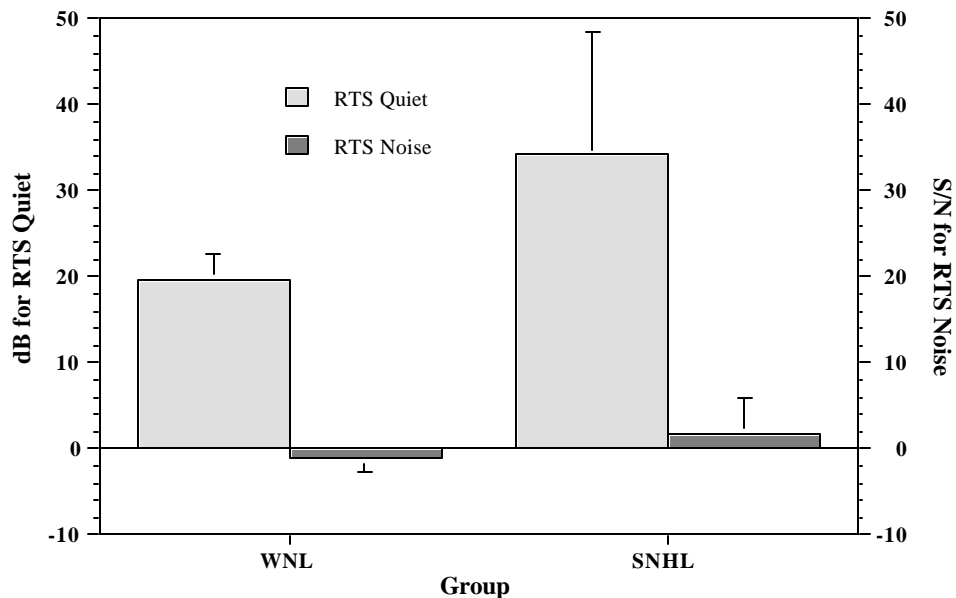
Table 2 Means and standard deviations (SD) for pure tone thresholds, PTA2, word recognition score (WRS), Reception Thresholds for Sentences in Quiet (RTS Quiet in dB) and Reception Thresholds for Sentences in Noise (RTS Noise in signal-to-noise ratio) for sensorineural hearing impaired subjects.

	250	500	1000	2000	4000	8000	PTA2	WRS	RTS QUIET	RTS NOISE
Mean	22.50	20.00	21.75	27.00	42.25	44.00	30.33	94.20	34.20	1.78
SD	9.25	9.79	14.71	16.81	18.81	23.15	10.08	8.73	14.25	4.13

The mean WRS for the normal hearing participants was 97.92% while the mean WRS for the sensorineural participants was 94.20%. The not clinically significant difference of 3.9% in word recognition for these two groups of participants suggests that the high frequency hearing loss did not greatly hinder word recognition for the twenty subjects with SNHL. This finding is in general agreement with previous studies done by Moore (1996). Hearing-impaired listeners

with mild cochlear hearing loss generally do not have difficulty understanding speech in a quiet and non-reverberant listening environment (Beattie, 1989, Moore, 1996).

The mean RTS Quiet for the normal hearing participants was 19.64 dB, which is within the HINTs normal performance range and represents 95% of normal listeners. The mean RTS Noise for normal hearing participants was -1.07 dB signal-to-noise ratio (SNR); thus, slightly poorer than the HINTs established norm of -1.25 dB SNR (Nilsson, Gelnett, Sullivan, Soli & Goldberg, 1992) (See Appendix B). A graphic representation of the mean percent correct scores for RTS Quiet and RTS Noise can be seen in Figure 1.



**Figure 1.** Mean Reception Thresholds for Sentences in Quiet (RTS Quiet) and Thresholds for Sentences in Noise (RTS Noise) for the two subject groups.

Figure 1 shows that the SNHL participants have a higher RTS Quiet and RTS Noise mean than do the WNL subjects. The difference between the two groups for RTS Quiet was 14.56 dB. The difference between the WNL and SNHL participants for RTS Noise was 2.85 dB SNR. To determine the significance of RTS Quiet and RTS Noise for these two test groups,

unpaired t-tests were performed. The group differences for the RTS Quiet ( $t = -4.98$ ,  $p = <.0001$ ) and the RTS Noise ( $t = -3.204$ ,  $p = <.0026$ ) were significant (See Tables 3 and 4).

Table 3 Mean, t-values and p-values for Reception Thresholds for Sentences in Quiet (RTS Quiet) for the normal hearing (WNL) and sensorineural hearing loss (SNHL) subjects.

Participant	Mean	t - value	p - value
WNL	19.637	-4.98	<0.0001
SNHL	34.204		

Table 4 Mean, t-Values and p-values for the Reception Thresholds for Sentences in Noise (RTS Noise) condition for the normal hearing (WNL) and sensorineural hearing loss (SNHL) subjects.

Participant	Mean	t - value	p - value
WNL	-1.070	-3.204	<0.0026
SNHL	1.780		

## Discussion

Numerous studies have shown that listeners with sensorineural hearing losses often complain and have more difficulty with speech reception in the presence of noise, competing speech and reverberation than individuals with normal hearing (Dubno, Dirks, Morgan, 1984; Duquesnoy, 1983; Plomp, 1986; Plomp, Mimpen, 1979). Research by Plomp and Duquesnoy (1983) supported these studies and showed that listeners with hearing impairment have an elevated speech recognition threshold even at supra-threshold noise levels. Bronkhorst and Plomp (1989) stated that the true handicap of hearing-impaired listeners in noise may well be underestimated.

Speech recognition testing in quiet using monosyllabic words is part of the standard test protocol in most audiology clinics and practices. Yet, Gelfand (1998) and others have shown that these short word lists are not highly reliable. If audiologists are using word recognition scores for making clinical decisions, a sufficient number of test items should be used so that the testing is adequately sensitive to true differences among hearing losses (Beattie, 1989). Additionally, evaluating speech recognition in quiet may not provide a realistic index of communicative difficulty experienced by the hearing-impaired listener (Beattie, 1989). Every day reception of speech involves the understanding of sentences, not monosyllabic or multi-syllabic words (Plomp, 1986). It would be difficult to anticipate how well a listener with hearing impairment will understand speech in noise using a standard testing protocol. However, audiologists are often making recommendations for amplification based on this type of word recognition data alone. The data collected in this study showed that traditional word recognition testing in quiet did not differentiate between the subjects with normal hearing and those with hearing loss. The mean percentage difference between the two groups was 3.72%; not an unexpected finding.

Current research has shown that measuring RTS provides a more reliable method for assessing speech intelligibility and auditory functioning (Nilsson, Soli, Sullivan, 1994; Plomp & Mimpen, 1979). RTS measurements reliably help evaluate how individuals understand speech in easy and difficult listening situations. Obtaining RTS measurements can be used to supplement a routine hearing evaluation or can be used as a screening device to determine if a persons supra-threshold speech understanding ability is within normal limits. Furthermore, evaluating auditory function in quiet and in noise assists in the selection and fitting of amplification.



The purpose of this study was to examine the relationship between RTS Quiet and RTS Noise monaurally for two groups of participants using the HINT protocol and norms. This study initially hypothesized that the SNHL participants would have a higher RTS in quiet and in the presence of noise. The study data reliably supported this hypothesis. The difference between the WNL and SNHL groups for RTS Quiet was 14.56 dB. This mean difference was surprisingly high, considering that the SNHL group had a mean PTA2 of 30.33 dB HL. Was the difference between these two groups a function of the degree of hearing loss or the shape of the audiogram? Age certainly would not have been a large contributing factor since the mean age for the WNL group was 52 years compared to 54 years of age in the SNHL group. Or do the findings suggest that the speech recognition difficulties experienced by the SNHL group was related to factors other than auditory sensitivity? Lee and Humes (1993) concluded that the loss of high frequency audibility rather than hearing loss distortion contributes to speech recognition difficulties for the SNHL group. Moore (1996) concluded that SNHL is accompanied by a variety of changes within the cochlea and affects the way a person may perceive sound. As a result of outer hair cell damage, sensitivity of weak sounds may be reduced (Moore, 1996). Additionally, Moore (1996) reported that when sounds are presented at audible levels to cochlear-impaired individuals, the perception of these sounds is usually abnormal. The test data obtained from this study is in agreement with Moore (1996). Even in a quiet listening situation, the SNHL subjects have more difficulty with speech understanding than the normal hearing group.

When the performance of the SNHL subjects was compared to the performance of the WNL group in noise, a much smaller RTS difference (2.85 dB SNR) was seen. Intuitively, one would think that there would be a larger RTS difference between these two groups of participants. Lee

and Humes (1993) demonstrated in their study that once background noise is sufficiently intense to be the factor limiting the audibility of the speech signal (250 – 4000 Hz), for both normal and SNHL subjects, both groups performed equivalently. Humes (1996) explains that at lower noise levels, the high frequency hearing loss of the individual reduces the audible bandwidth of both speech and noise. In order to compensate for this reduced bandwidth of audibility, the signal-to-noise ratio needs to be increased. Had we changed the intensity of the competing noise, would there had been a larger RTS difference?

Importantly this study did present a clear differentiation between the WNL group and the SNHL group in quiet and in noise. Overall, the data obtained was consistent and in agreement with the HINT norms (Nilsson, Gelnett, Sullivan, Soli & Goldberg, 1992). However, it is possible that administering the HINT under headphones did not measure the same parameters that other signal-to-noise ratio tests examined (Plomp, 1986; Smoorenburg, 1992; Moore, 1996). The HINT was designed to demonstrate the substantial role that binaural, directional hearing plays in normal hearing individuals in quiet and in noise. Any degree of hearing impairment reduces the benefits of directional hearing in noise and decreases communication ability. Additionally, it is possible that the degree of hearing loss and the configuration of the audiograms of the SNHL group greatly influenced the test results (Lee & Humes, 1993).

There are several implications of these results for the audiological assessment of individuals with hearing impairment. For counseling and rehabilitation purposes, audiologists need to be able to differentiate between individuals that might have difficulty with speech recognition in quiet as well as in noise. Assessing speech intelligibility using monosyllabic words in quiet will not differentiate between normal and mild hearing-impaired listeners. Whereas, assessing speech intelligibility using the HINT protocol and norms provides reliable information. Additionally,

this pilot study has raised other questions and implications for further research. Would a larger testing sample produce different results? How would individuals with moderate to severe hearing losses perform under the same test conditions? Would different audiogram configurations change the test results? Finally, how would these subjects perform binaurally under headphones? Presently, there are no clear answers. In order to properly treat individuals with cochlear hearing loss, continued research investigating how noise affects speech discrimination is necessary.

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## Appendix A

## Hint Sentence Lists

Note: Acceptable variations in responses are in parentheses. These lists are number 1 and 2 out of 25 ten sentence lists.

## List 1

1. (A/the) boy fell from (a/the) window.
2. (A/the) wife helped her husband.
3. Big dogs can be dangerous.
4. Her shoes (are/were) very dirty.
5. (A/the) player lost (a/the) shoe.
6. Somebody stole the money.
7. (A/the) fire (is/was) very hot.
8. She's drinking from her own cup.
9. (A/the) picture came from (a/the) book.
10. (A/the) car (is/was) going too fast.

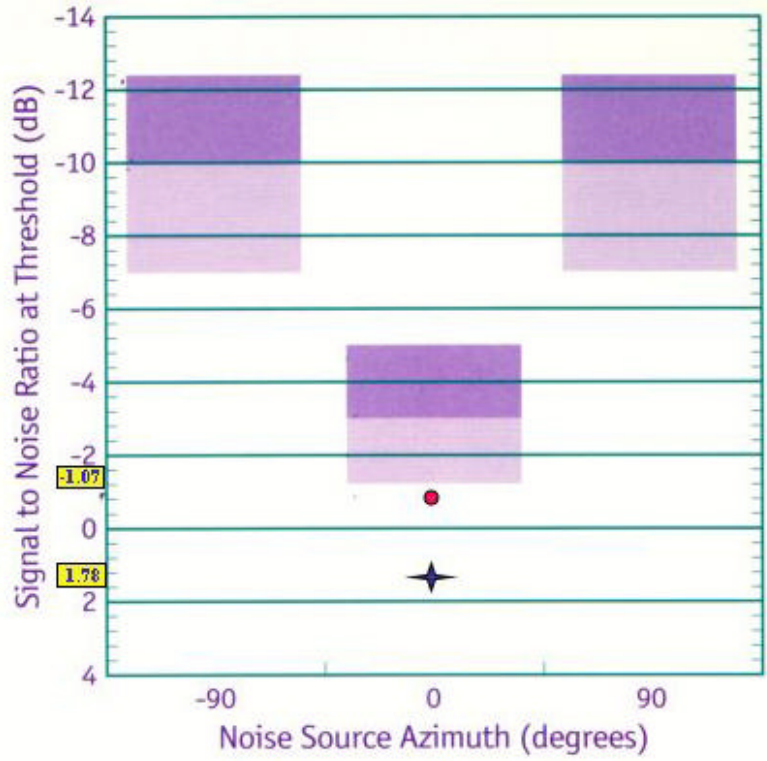
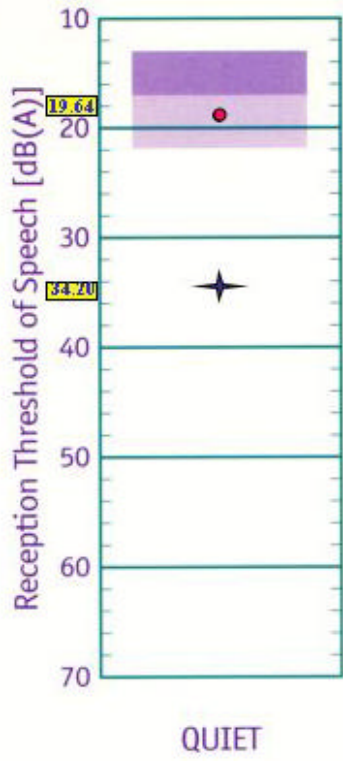
## List 2

1. (A/the) boy ran down (a/the) path.
2. Flowers grow in (a/the) garden.
3. Strawberry jam (is/was) sweet.
4. (A/the) shop closes for lunch.
5. The police helped (a/the) driver.
6. She looked in her mirror.
7. (A/the) match fell on (a/the) floor.
8. (A/the) fruit came in (a/the) box.
9. He really scared his sister.
10. (A/the) tub faucet (is/was) leaking.



Appendix B

HINT Norms Summary Sheet



## Appendix C

Percentile Boundaries for Reception Thresholds for Sentences in Quiet (RTS Quiet) and Reception Thresholds for Sentences in Noise (RTS Noise) at 0 Degree Azimuth (Nilsson et al., 1995)

<b>Percentage</b>	<b>RTS Quiet</b>	<b>RTS Noise</b>
90	13.27	-4.19
80	14.49	-3.72
70	15.37	-3.38
60	16.12	-3.00
50	16.62	-2.82
40	17.52	-2.55
30	18.27	-2.26
20	19.15	-1.92
10	20.37	-1.45