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THE EFFECTS OF A VISUAL PROMPT ON THE SPEECH-PERCEPTION ABILITIES OF ADULTS WITH NORMAL HEARING

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Ashley Hall

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THESIS APPROVAL PAGE

This is to certify that the thesis prepared by Ashley Hall, entitled The Effects of a Visual Prompt on the Speech-Perception Abilities of Adults with Normal Hearing, has been approved by this committee as satisfactory completion of the requirement for the degree of Doctor of Audiology in the department of Audiology, Speech Language Pathology, and Deaf Studies.

Chair, Thesis Committee — Date

Brian M. Kreisman, Ph.D.
Print Name

Committee Member — Date

Stephen Pallett, Au.D.
Print Name

Committee Member — Date

Nicole V. Kreisman, Ph.D.
Print Name

Dean, College of Graduate Studies and Research — Date

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ABSTRACT

THE EFFECTS OF A VISUAL PROMPT ON THE SPEECH-PERCEPTION ABILITIES OF ADULTS WITH NORMAL HEARING

Ashley Hall

This investigation examined the effects of a visual prompt on speech perception in noise. Hearing in Noise Test (HINT) sentences served as speech stimuli in three different conditions of background noise: interrupted HINT, continuous HINT, and ICRA noise. Participants consisted of 30 adults with normal hearing sensitivity. Results indicated no significant differences in Reception Thresholds for Sentences (RTS) between conditions with or without a visual prompt, however; significant differences between noise routing and noise competitions were indicated. Theoretical, clinical, and research implications are discussed.

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CHAPTER 1

INTRODUCTION

Hearing loss affects approximately 31.5 million Americans and that number is expected to double by 2030 (Hearing Loss Association of America, 2006; Kochkin, 2005). There are varying types (conductive, sensorineural, and mixed) and degrees (mild to profound) of hearing loss, all of which impact multiple areas of life, including psychosocial, emotional, and financial aspects. Hearing loss affects not only the person with the hearing loss, but also their family, friends, coworkers, employers, and others. In any relationship, communication is essential. Individuals with hearing loss often find communicating with family and friends difficult. Frequently they tend to disengage in conversations, thus isolating themselves. In addition, hearing loss can lead to increased stress, frustration, anger, and anxiety. People with hearing loss often have a hard time at work and become easily fatigued because they continually struggle to hear their colleagues (Luterman, 2001).

Communication difficulties arise from a variety of environmental circumstances. Noisy listening environments are particularly challenging for communication. For example, gymnasiums, busy airports, crowded grocery stores, and restaurants are typical places where people have the most trouble hearing. People with a sensorineural hearing loss (SNHL) usually experience the greatest amount of hearing problems in such conditions, more so when background noise is present. Background noise can consist of speech babble (unintelligible sounds produced by talkers), reverberation, traffic sounds, industrial machinery, and electrical appliances in addition to a variety of other noise sources. "Reverberation refers to the prolongation or persistence of sound within an enclosure because of sound waves reflection off hard surfaces (bare walls, ceilings, windows, floor)" (Crandell and Smaldino, 2002, p.609). Because hearing aids amplify all sounds, not just speech, background noise and reverberation continue to be a problem. However, ongoing improvements are being made to digital hearing aids to help in these situations. Different microphone arrays, polar patterns, and noise cancellation algorithms have been created to help reduce the amount of background noise being amplified at any one given time. Various speech-intelligibility tests have shown that these new microphone arrays, polar patterns, and noise cancellation algorithms in hearing aids do improve speech intelligibility in noise (Lewis, Crandell, Valente, & Enrietto Horn, 2004; Preves, Sammeth, & Wynee, 1999; Trainor, Sonnadara, Wiklund, Bondy, Gupta, Becker, et al., 2004; Valente, Fabry, & Potts, 1995).

Speech-intelligibility tests have also shown improved speech-intelligibility scores in noise when an auditory stimulus is presented with visual cues as opposed to without visual cues (Bernstein, Auer, & Takayannagi, 2004; Sumby and Pollack, 1954). While a great deal of data has been collected regarding the positive effects of speechreading on speech intelligibility in noise, little is known about the effects of other visual prompts. Further research must be completed in order to determine whether speech intelligibility in noise is enhanced through visual reinforcements other than speechreading, such as a light prompt.

CHAPTER 2

LITERATURE REVIEW

A tremendous amount of literature has been published on the underlying etiology of SNHL, the difficulties that people with SNHL face, how those difficulties affect an individual's ability to function daily, and the rehabilitative strategies available for people with SNHL. In the subsequent review of literature, each of these areas will briefly be discussed.

Sound source separation

The sounds that arrive at a listener's ears are a combination of direct sound, early reflections, late reflections, and background noise. These various signals arrive at the outer ear, travel through the middle and inner ear, and then ascend towards the auditory cortex. Once in the auditory cortex, the sounds are identified and separated by the brain. This sequence of understanding and processing different sounds is what allows people to hear (Trainor et al., 2004).

As mentioned above, the brain identifies and separates speech from noise. This separation and processing of sound is known as sound source separation. Sound source separation is more difficult for individuals with SNHL than individuals with normal hearing (Trainor et al., 2004). The difficulties lie in the fact that people with SNHL have damaged outer hair cells (OHCs). Since OHCs act as sound amplifiers, when they are damaged a reduction in auditory sensitivity as well as broader frequency tuning occurs. Broader frequency tuning makes understanding the temporal properties of sound, especially speech, difficult (Trainor et al.).

Audiovisual integration

One way to aid individuals with hearing loss is to provide them with visual reinforcements along with auditory stimulation. An enriched response may transpire when the brain combines the input from two spatially and temporally separated stimuli: auditory and visual. When the brain simultaneously integrates the input from both auditory and visual sensory modalities, audiovisual integration has occurred (Meredith, Nemwitz, & Stein, 1987). Audiovisual integration is believed to happen within the superior colliculus (Meredith et al.). To demonstrate the effects of audiovisual integration, Meredith and colleagues looked at the amount of neural discharge within the superior colliculus while various stimuli (visual, auditory, and somatosensory) were presented to medically paralyzed cats. Each stimulus was presented individually and in pairs (visual-auditory, visual-somatosensory, and auditory-somatosensory). Results indicated that more neural discharge occurred when the stimuli were presented in pairs than when presented alone. The increase in neural discharge when stimuli were presented in pairs suggests that auditory information is perceived better when visual cues are presented simultaneously.

Speechreading

The most common form of audiovisual integration is speechreading, which occurs when an individual understands what is being said by listening to the message as well as observing the speaker’s lip movements, facial expressions, and gestures. Speechreading enhances speech intelligibility in noisy environments because the mouth movements that a listener sees complement and reiterate what is being expressed verbally, which typically results in an easier extrapolation of speech from noise (Grant and Seitz, 2000).

Sumby and Pollack (1954) assessed speech intelligibility of one hundred and twenty-nine subjects with normal hearing and vision. Testing was conducted in noise with and without speechreading and in quiet with and without speechreading. Half of the subjects were presented with auditory information only and the other half were presented with auditory and visual information. Two hundred and fifty-six spondees (bi-syllabic words with equal stress on each syllable) broken down into vocabulary lists of 8, 16, 32, 64, and 128 words, were used as the speech stimuli, and electrically-mixed sounds were used as the noise source. An adaptive test procedure was used; noise was presented at a constant level and the speech level was varied. No carrier phrase was used; instead a light prompt was switched on one second prior to speech presentation. Results from this study demonstrated that the auditory and visual combined condition yielded better speech-intelligibility in noise scores than the auditory-only condition. No difference was noted between auditory-only and auditory-plus-visual stimuli for speech intelligibility in quiet, which is not surprising given that the subjects had normal hearing. From the results of their experiment, Sumby and Pollack hypothesized that watching the speaker's lips, facial movements, and gestures provided an increase in speech intelligibility, much like an increase in speech-to-noise ratio lends itself to improved speech intelligibility.

Grant and Seitz (2000) sought to prove that speechreading did in fact yield enhanced speech intelligibility in the presence of background noise. Two experiments were conducted using phonetically balanced Institute of Electrical and Electronics Engineers (IEEE) sentences (1969) that were spoken by a female talker. In their first experiment, Grant and Seitz used three different conditions: auditory-only speech, auditory speech with corresponding visual stimuli, and auditory speech with deprecating visual stimuli. Results yielded no significant difference between corresponding and deprecating visual stimuli. Grant and Seitz hypothesized that this may be indicative of our abilities as humans to disregard visual stimuli that are not completely related to, but happen to coincide with, auditory input. In addition, a second experiment was conducted using auditory speech with corresponding visual stimuli, but with a variation. Experiment two compared giving the subject a written copy of the sentence prior to presentation and not giving them a written copy prior to sentence presentation. Results of the second experiment revealed a small, but statistically significant, improvement in reception thresholds for sentences (RTS) when the subject was presented with a copy of the sentence prior to speech presentation.

In another study, Bernstein, Auer, and Takayannagi (2004) examined whether a visual prompt other than speechreading could produce an increase in speech intelligibility. Ten normal-hearing subjects participated in the study. Five different conditions were used to test speech detection thresholds in noise: auditory-only speech, audiovisual speech, audio /ba/ with a lissajous figure (two sine waves displayed at right angles to one another; [Margolin, 2001]), audio /ba/ with a dynamic rectangle whose horizontal extent was correlated with the speech envelope, and audio /ba/ with a static rectangle whose onset and offset were synchronous with the speech onset and offset. Each stimulus was presented at 60 dB SPL in the presence of background noise. An adaptive procedure was used. Results indicated that any of the visual stimuli presented along with auditory stimuli enhanced speech detection thresholds equally, except speechreading which enhanced speech detection thresholds significantly more.

Speech perception in noise

Communicating in the presence of competing sounds is unavoidable. Nearly all daily interactions require the ability to understand speech in the presence of noise. Dubno, Dirks, and Morgan (1984) found that both people with normal hearing and people with SNHL have more trouble understanding speech in noise than in quiet. However, a greater amount of difficulty was noted for individuals with SNHL. Not surprising, Beattie, Barr, and Roup (1997) found that individuals with the same speech perception ability in quiet produced very different results from one another in the presence of noise.

Because everyone has a varying degree of speech understanding in the presence of competing signals, researchers and clinicians have expressed the need to incorporate speech-in-noise testing into routine audiologic test batteries (Rupp, et al., 1997). Since adding noise to speech stimuli represents more realistic listening environments, many tests have been designed to assess speech intelligibility in the presence of background noise (Beattie, 1989).

Tests of speech in noise

For years researchers have been interested in speech intelligibility in quiet and in the presence of background noise, especially for people with SNHL.

The desire to determine speech recognition thresholds (SRT) stems from the idea that communicating with others is the most important part of daily activities (Northern and Downs, 2002). Monosyllables and spondaic words are used to measure word recognition and SRT, respectively. The Speech Intelligibility in Noise (SIN) test (Killion, 1997); the Speech Perception in Noise (SPIN) test (Kalikow, Stevens, & Elliott, 1977); and, the Hearing in Noise Test (HINT) (Nilsson, Soli, & Sullivan, 1994); are all designed to measure RTS. While all of these tests are used clinically, some take much longer to administer than word recognition and speech-recognition tests (Soli and Nilsson, 1994).

Many different stimuli are available to assess speech intelligibility; however, researchers disagree on the precision of various stimuli in accurately predicting an individual’s speech-recognition abilities. For example, early in the literature, Carhart (1946) stated that word lists were just as effective as sentence lists in their ability to quantify SRT. Since then, researchers have found that sentence lists are in fact better than word lists because they more closely resemble conversational speech (Nilsson et al., 1994; Soli and Nilsson, 1994). The reason that sentences more closely resemble conversational speech is that they consist of intensity and intonation changes that are part of daily communication (Nilsson et al.).

While there are advantages to using sentences to calculate speech-recognition abilities, disadvantages exist as well. One common disadvantage of certain RTS tests is that they are limited by floor and ceiling effects (Nilsson et al., 1994). In particular, floor and ceiling effects occur with the SIN and SPIN tests because the speech stimuli are presented at a fixed level (Nilsson et al.).

Monosyllables

Monosyllables are typically presented at a sensation level of 30-40 dB HL above a subject's SRT. This sensation level has been found to yield the greatest word recognition score (Beattie, Edgerton, & Svihovee, 1977; Wilson, Caley, Haenel, & Browning, 1975). The NU-6 (Northwestern University-6) test and the CID W-22 (Central Institute for the Deaf W-22) test are sets of monosyllabic word lists used to assess word recognition abilities. These lists are typically presented to a patient in a quiet environment as part of a full audiological test battery (Rupp et al., 1977). As mentioned above, the need to assess speech intelligibility in noise has been a growing area of interest for researchers and clinicians alike (Rupp et al.). A research synthesis was completed at The University of Michigan Medical School on the effects of different noise sources on speech intelligibility for normal hearing individuals who were tested using different CID W-22 word lists (Rupp et al.). The research synthesis examined six different studies and found that of speech-like noise, white noise, and traffic-like noise; white noise was the least distracting while speech-like noise was most distracting. Noise had no effect on speech intelligibility when speech and noise were kept at the same intensity level, and noise did not present much of a challenge when it was spatially separated from the phonemically balanced words (Rupp et al.).

Spondaic words

Spondaic word lists have been devised as a means of testing SRT, i.e., the ability to accurately detect at least 50% of speech (Brandy, 2002; Soli and Nilsson, 1994). The words on each list are bi-syllabic and are presented with equal stress on each syllable, with no variations in intonation (Carhart, 1946; Brandy). Early research conducted at Deshon General Hospital in the aural rehabilitation program suggested that spondees were equivalent to sentences when testing SRT/RTS. Using sentences, RTS were obtained in quiet from 129 young men with varying types and degrees of hearing loss. The average RTS for that group was 49.1 dB. For comparison, SRT were obtained from four different groups of young men with varying types and degree of hearing loss (Group I=283 subjects, Group II=199 subjects, Group III=100 subjects, and Group IV=100 subjects), using spondaic words. The average SRT for groups I-IV was 49.9 dB, 51.0 dB, 47.3 dB, and 44.5 dB; respectively. Statistical analysis showed no significant difference and thus confirmed the author’s belief that words and sentences could be considered of equal value when determining which method to use in measuring SRT/RTS (Carhart).

Speech in Noise (SIN) Test

Killion (1997) developed the SIN test to assess speech intelligibility in noise for both loud (70 dB HL) and soft (40 dB HL) female speech. The SIN test consists of 40 different sentences; 20 are presented at each intensity level. For each intensity level, five different sentences are presented at four different signal-to-babble ratios: 0 dB, +5 dB, +10 dB, and +15 dB. Each sentence is five words long and is scored based on the number of words that the subject repeats back correctly. A percent correct is derived for each signal-to-babble ratio at each intensity level.

Revised Speech in Noise (SIN) Test

Cox, Gray, and Alexander (2001) created a revised version of the SIN test (RSIN test). The goal of the test revision was to increase test block equivalency. Forty-two elderly subjects with normal hearing were used to assess test block equivalency. The RSIN test consists of 80 different sentences in each test block. Forty of the sentences are presented at 70 dB HL and the other 40 are presented at 40 dB HL. For each intensity level, ten different sentences are presented at four different signal-to-babble ratios: 0 dB, +5 dB, +10 dB, and +15 dB. Five practice sentences are given prior to each test block presentation. When examining the results from the 42 subjects, Cox et al. found that the RSIN test was indeed more equivalent than the SIN test regarding test blocks, however a major disadvantage exists in that the RSIN test requires more time to administer then does the SIN test.

Quick Speech in Noise (SIN) Test

In contrast to the SIN and RSIN test, the QuickSIN test requires much less time to administer than the SIN test. Killion, Niquette, Gudmundsen, Revit, and Banerjee (2004) designed the QuickSIN test to assess word recognition abilities in the presence of four-talker babble. The QuickSIN test is made up of 18 test lists, each comprised of six IEEE sentences. Each list takes less than a minute to administer and is presented at six different Signal-to-Noise Ratios (SNR): 0

dB, +5 dB, +10 dB, +15 dB, +20 dB, and +25 dB. Like the SIN test, each sentence is five words long and scoring is based on the number of words that the subject repeats back correctly. A percent correct is derived for the 30 words. Scores of less than 50% indicate poor word recognition ability in the presence of background noise.

Speech Perception in Noise (SPIN) Test

The SPIN test is another clinical application designed to assess speech intelligibility in noise. Specifically, the SPIN test was designed to investigate sentence predictability and its effect on speech intelligibility in noise. The SPIN test consists of eight different lists containing 50 sentences each. A male speaker recorded the sentences and the background noise was comprised of speech babble from 12 different talkers. Each list consists of 25 high-predictability and 25 low-predictability sentences, which have been randomly ordered. Each sentence consists of five to eight words and is six to eight syllables long. The SNR can be adjusted since the sentences and background noise are recorded on two separate channels. Each sentence of the SPIN test yields two scores, a high predictability score and a low predictability score. These two scores are very useful when trying to determine what an individuals hearing aid benefit will be (Kalikow et al., 1977). The SPIN test has been criticized because some believe that an inconsistency exists across lists regarding reliability and validity (Morgan, Kamm, & Velde, 1981). Bilger, Neutzel, Rabinowitz, and Rzeckowski (1984) conducted an experiment to determine the reliability and equivalency of each list. After obtaining SPIN test results for 128 adults with SNHL under several conditions, they discovered that all lists were reliable but not equivalent. Bilger et al. felt that eliminating a few of the lists and developing different scoring mechanisms would enhance the equivalency of the various SPIN test forms. As a result, the Revised Speech Perception in Noise (R-SPIN) test was developed.

Revised Speech Perception in Noise (R-SPIN) Test

As mentioned above, Bilger et al. (1984) created the R-SPIN test. This test has been used to assess the effects that temporally distorted sentences have on listening for elderly people with hearing loss. Criticisms of the R-SPIN test include a lack of actual sentence material and floor and ceiling effects (Hanks & Johnson, 1998). Gordon-Salant and Fitzgibbons (1993) examined the effects of temporal factors on speech intelligibility in noise for older and younger individuals using eight lists from the R-SPIN test as speech stimuli. Subjects consisted of four groups of ten subjects each: 1) elderly people with normal hearing; 2) young people with normal hearing; 3) elderly people with mild SNHL; and, 4) young people with mild SNHL. After each sentence was presented, the subjects were instructed to write down the last word of that sentence. The sentences were presented to each group as either undistorted or distorted. Three different temporal distortions of speech were used: time-compression, reverberation, and interruption of the signal. The researchers of this study found that for subjects with hearing loss, speech intelligibility was poorer than for subjects with normal hearing, regardless of age, in the undistorted condition. However, in all three temporal distortion conditions, age and hearing loss effects were independent of each other. In this study, age, hearing loss, and temporal distortion of speech are listed as factors that contribute to difficulties hearing speech in the presence of background noise. When assessing speech intelligibility with competing background noise for hearing aid users, it is imperative that all of these factors be accounted for when reporting results.

Hearing in Noise Test (HINT)

The HINT was designed to measure the speech intelligibility of English-speaking Americans in quiet environments and in environments where non-continuous noise is spatially separated (Nilsson et al., 1994; Soli and Nilsson, 1994). Nilsson et al. designed the HINT materials using modified Bamford-Kowal-Bench (BKB) sentences, which were created to assess speech intelligibility in British children (Bench and Bamford, 1979).

After several test and re-test reliability measures, Nilsson et al. (1994) chose 250 sentences (25 lists of 10 sentences each) to include in the final version of the HINT. The final 250 sentences were recorded with a male speaker and were all phonemically balanced. The authors also ensured that each sentence was alike in naturalness, length, and intelligibility (Nilsson et al.).

Establishing protocols and procedures was the next step towards completion of the HINT battery. Nilsson et al. (1994) concluded through statistical analyses that after four sentences, people began scoring close to their RTS. Therefore, the final RTS was calculated based on the average presentation level of sentences five through twenty-one. Nilsson et al. determined this by repeatedly presenting the first sentence at an initial intensity level below the participant’s hearing threshold and increasing the presentation level by 4 dB each time the participant could not complete the task until the whole sentence was repeated back verbatim. Sentences two through four were then presented in an adaptive fashion: For each sentence repeated correctly, the presentation level was reduced by 4 dB; for each sentence repeated incorrectly the presentation level was elevated by 4 dB. Sentences five through twenty-one were also presented in an adaptive fashion however, the presentation level only varied by 2 dB. After sentence twenty was presented, the hypothetical presentation level of sentence twenty-one was determined based upon the adaptive method used for the previous sentences. Therefore, the final RTS was calculated based upon the average presentation level of sentences five through twenty-one (Nilsson et al.). The HINT provides several advantages over other sentence tests, including: no floor and ceiling effects, an abundance of sentence material, an assessment of speech intelligibility in noise for cochlear implant users, as well as a comparison of the directionality effects of various hearing aids (Valente, Mispagel, Tchorz, & Fabry, 2006; Compton-Conley, Neuman, Killion, & Levitt, 2004; Dorman, Loizou, & Fitzke, 1998).

Factors affecting RTS

One challenge in reviewing research on speech intelligibility in noise is that many different factors influence each study. The different RTS that each study yields can be influenced by, but not necessarily attributed to, differing test administration, subject pools, speaker configuration, and noise/speech presentation (Wagener and Brand, 2005). Wagener and Brand examined some of these factors (noise level, type, and presentation mode) and their effects on sentence intelligibility for individuals with normal hearing and with hearing loss. The Oldenburg sentence test (sentences that are five words long each and follow the same syntactic structure) was used as speech stimuli and three different noise manipulations were looked at: 1) noise presentation levels of 45, 55, 65, 75, or 80 dB SPL; 2) noise type; either stationary olnoise, which defined by Wagener and Brand is “stationary speech-shaped noise generated by randomly superimposing the speech material of the Oldenburg sentence test,” (147), stationary ICRA noise, fluctuating ICRA5 noise, or fluctuating ICRA7 noise; and, 3) noise presentation mode; interrupted, continuous, or adaptive.

The results of experiment one showed no substantial difference in RTS for either group regardless of noise presentation level. In experiment two, RTS was highest for both the normal hearing and hearing impaired individuals when either olnoise or ICRA noise was used. RTS was lowest when ICRA5 or ICRA7 noise was used; 14 dB HL lower for subjects with normal hearing and 10 dB HL lower for subjects with hearing loss. In experiment three, the conditions using interrupted noise generated much higher RTS than the conditions using continuous noise for both the normal hearing and hearing impaired groups (Wagener and Brand, 2005). The authors found that certain test parameters do in fact influence RTS in noise over various populations, particularly presentation mode. However, Wagener and Brand caution that careful considerations need to be made when comparing results in interrupted versus continuous noise. In addition, it should be noted that when testing hearing-aid benefit in noise, continuous noise is recommended (Wagener and Brand).

Age and Hearing Loss

Age and hearing loss both have an effect on speech intelligibility in noise. Dubno, Dirks, and Morgan (1984) used SPIN test sentences to study the effects of mild hearing loss and age on speech intelligibility in the presence of background noise. Subjects consisted of four groups: 1) young people with normal hearing; 2) young people with mild hearing loss; 3) older people with normal hearing; and, 4) older people with mild hearing loss. Using an adaptive procedure, low-predictability, and high-predictability SPIN test sentences with speech babble as the background noise were presented to each individual. Each time a subject responded correctly the noise level was increased by 2 dB SPL and when a subject responded incorrectly the noise level was decreased by 2 dB SPL. The results of this study revealed that elderly people with and without hearing loss exhibited poorer RTS in the presence of background noise than younger people with and without hearing loss. These data suggest that age has a greater impact on speech intelligibility in noise than a mild degree of hearing loss.

Knowing that age and hearing loss both, to some degree, play a role in speech intelligibility, Gelfand, Ross, and Miller (1988) examined babble detection thresholds, sentence reception thresholds, and spatial separation abilities in noise for young normal-hearing individuals and elderly individuals with SNHL. Sample size varied according to availability of subjects within each group.

Speech was presented at a fixed level of 70 dB SPL and background noise was varied until RTS was obtained. Two different speaker arrangements were used for presentation in order to see if a particular age group was more or less likely to utilize spatial separation of speech and noise. Results of this experiment verified that in both quiet and in noise, older individuals with hearing loss have a harder time understanding speech than younger individuals with normal hearing. Interestingly enough, when the effects of spatial separation were looked at, all subjects were able to use spatial separation to their advantage; however, since all of the younger subjects had normal hearing, this study could not determine whether older individuals with hearing loss could take advantage of spatial separation as well as younger individuals with hearing loss.

Spatial separation aside, hearing in the presence of background noise is difficult for the young and the elderly. However, Sapp and McCarthy (1993) acknowledge the fact that elderly listeners have more trouble hearing speech in noise than younger listeners, which is primarily due to a coinciding hearing loss. To study the difference in the speech understanding ability of young and old listeners, Sapp and McCarthy looked at omission rates of an elderly population and compared their responses to that of a younger population. An omission error, as defined by the authors, is a failure to correctly identify or at least guess at the word being presented when testing speech-recognition ability. Sapp and McCarthy only were interested in the effects of age on omission errors, and for that reason all of their subjects had normal hearing. A group of 12 subjects aged 67-73 with a PTA of 10.33 dB HL and a group of 12 subjects aged 19-26 with a

PTA of 3.89 dB HL participated in the study. All of the subjects had normal tympanograms. Speech stimuli consisted of NU-6 word lists presented at 80 dB SPL. Background noise from the SPIN test was presented at a SNR that allowed for 50% intelligibility for each subject; omission errors and word recognition scores were calculated. The results of this study found that no significant difference in omission errors existed across groups. In other words, younger listeners are not more likely than older listeners to make a guess when speech is difficult to discriminate.

Summary

Hearing loss, age, and noise are three factors that influence speech perception in noise. The greater the degree of hearing loss, the older the individual, and the greater the amount of background noise present, the poorer the speech-intelligibility scores. One rehabilitative strategy that has proven to be a useful means of improving speech intelligibility for people with normal hearing and people with a SNHL is to present auditory and visual cues simultaneously.

Purpose of Study

As mentioned earlier, the HINT was designed to measure RTS in the presence of non-continuous background noise; the onset of noise serves as a prompt to alert the listener that a sentence is about to be presented. It has also been noted that various researchers have convolved the interrupted HINT noise into continuous HINT noise in order to examine the effectiveness of digital hearing aids. The theory for using continuous noise is supported by the idea that the onset and offset of interrupted noise causes digital hearing aid circuits to go into compression, which does not accurately represent the real-world effectiveness of these instruments. However, there remains a paucity of data regarding the relative speech-perception scores that these varying noise sources produce. Considering the information above, this study will investigate the effects of a light prompt on the speech-perception abilities of listeners with normal hearing in the presence of various noise sources by assessing RTS.

Based on the fact that improved speech intelligibility in noise occurs when a visual stimuli accompanies an auditory stimuli (Bernstein et al., 2004; Grant and Seitz, 2000; Sumby and Pollack, 1954) and that uncorrelated spatially separated noise has been shown to have greater masking effects on speech materials than correlated noise for individuals with and without hearing loss (Sperry, Wiley, & Chial, 1997), three null and three alternative hypotheses were formed. One null hypothesis (H_o) and one alternative hypothesis (H_a) was formed for each of the three main factors in the study (visual prompt, noise competition, and noise azimuth). Specifically, the hypotheses for each of the three main factors were as follows:

1) H_o: Speech-perception abilities for conditions with visual prompt and without visual prompt will be equal. H_a: Speech-perception abilities for conditions with visual prompt and without visual prompt will not be equal. 2) H_o: Speech-perception abilities for conditions in continuous HINT, interrupted HINT, and ICRA7 noise will be equal. H_a: Speech-perception abilities for conditions in continuous HINT, interrupted HINT, and ICRA7 noise will not be equal. 3) H_o: Speech-perception abilities for conditions

presented from 0^o azimuth (single speaker configuration) or from 45^o, 135^o, 225^o, and 315^o azimuth (multiple speakers configuration) will be equal.

H_a: Speech-perception abilities for conditions presented from single speaker configuration or from multiple speakers configuration will not be equal.

CHAPTER 3

METHODS AND MATERIALS

Participants

Thirty adult volunteers, 6 males and 24 females, with normal hearing as defined by ASHA (2005) were recruited from Towson University. All participants were between the ages of 18-30 years old with a mean age of 23 years 8 months. All participants spoke American English as their primary language and had normal visual acuity or wore corrective lenses. In addition, none of the participants had documented central auditory processing or psychiatric disorders, as self-reported. Individuals with depression were allowed to participate in the study, so long as they were taking anti-depressant medication. Each participant also had normal middle ear function and clear ear canals with visible tympanic membranes, bilaterally.

Speech Stimuli

Speech stimuli consisted of HINT sentences from the commercially available CD (Nilsson et al., 1994). The sentences were presented at 0^o azimuth from a Tannoy Precision 6 speaker via a Sony CDP-CE375 CD player routed through channel one of a Grason-Stadler-61 (GSI-61) audiometer. A daily calibration was completed in the sound field using an Ivie IE35 Audio Analysis System. A Type I calibration microphone was placed in the middle of the sound treated booth at the approximate ear-level height of a seated participant to measure the overall output. The calibration track for the HINT sentences was played and channel one of the GSI-61 audiometer was adjusted until the overall output was 65 dBA.

Noise Competition

Three different noise competitions were used: Interrupted HINT, Continuous HINT, and ICRA7. The first noise competition used was standard interrupted HINT noise. Using ADOBE Audition software, continuous HINT noise was created by splicing the interrupted noise from the first HINT sentence together, and served as the second competing stimuli. The third noise competition was uninterrupted ICRA noise from track 7 of the ICRA CD (ICRA7) (Dreschler, Verschuure, Ludvigsen, & Westermann, 2001), which simulates a six-speaker babble. All three-noise competitions were presented from either 0^o azimuth (single speaker configuration) or from 45^o, 135^o, 225^o, and 315^o azimuth (multiple speakers configuration). In the multiple speakers conditions, the interrupted HINT noise was correlated while the continuous HINT noise and ICRA7 noise were uncorrelated. The correlated noise came from two identical CDs with four identical tracks. The uncorrelated noise came from two different CDs with four different tracks.

The standard interrupted HINT noise from single speaker configuration was presented from a Tannoy Precision 6 speaker via a Sony CDP-CE375 CD player routed through channel two of a GSI-61 audiometer. The continuous HINT noise and ICRA7 noise used in the conditions requiring a single speaker configuration was presented via an RCA RP-8070D CD player routed through channel two of a GSI-61 audiometer. All three noise competitions used in the conditions requiring the multiple speakers configuration were presented via two Sony CDP-CE375 CD players, each routed through a separate channel of two Crown D75A amplifiers. Each channel of the Crown D75A amplifiers was connected to one of four Tannoy i5AW speakers. All noise competitions were presented at 65 dBA.

A daily calibration of the six different noise conditions was completed in the sound field using an Ivie IE35 Audio Analysis System. A Type I calibration microphone was placed in the middle of the sound treated booth at the approximate ear-level height of a seated participant to measure the overall output. Each calibration track for the three noise competitions presented in the single speaker condition was played. Channel two of the GSI-61 audiometer was adjusted until the overall output was 65 dBA. The calibration track for the three noise competitions presented via multiple speakers was played through two Sony CDP-CE375 CD players. As stated previously, each Sony CDP-CE375 CD player was routed through a separate channel of two Crown D75A amplifiers. Each amplifier had two channels, which routed sound to two of the four Tannoy i5AW speakers. Adjustments were made evenly to each channel of the two Crown D75A amplifiers until the overall output was 65 dBA.

Visual Prompt

A 40-watt light bulb located above the Tannoy Precision 6 speaker at 0^o azimuth served as the visual prompt. For the light prompt conditions, the light was switched on by the researcher 0.5-second before each sentence was presented and switched off after the sentence ended. This sequence was selected to match the onset and offset of the interrupted noise for the standard HINT presentation.

Procedures

The hearing screening consisted of an otoscopic examination, pure-tone audiometry screening, and tympanometry. Otoscopy was performed using a Welsh-Allyn otoscope. Hearing was screened at 20 dB HL from 250-8000 Hz using a GSI-61 audiometer and TDH-50P supra-aural headphones. Screening at this level ensured that each participants hearing was within normal limits, as ASHA (2005) defines normal hearing as hearing thresholds at 20 dB HL or below from 250-8000 Hz. Acoustic immittance audiometry was completed via a Grason-Stadler (GSI) Tympstar Middle Ear Analyzer.

Speech-perception testing was performed in a standard sound treated booth using a GSI-61 clinical audiometer. The HINT sentences were always presented at 0^{o} azimuth and the competing noise was always presented from either 0^{o} azimuth only (single speaker configuration) or from four speakers at 45^{o}, 135^{o}, 225^{o}, and 315^{o} azimuth (multiple speakers configuration). All loudspeakers were one meter away from the subject. The center of each loudspeaker was 33 inches high, approximating the ear-level height of a seated participant. Twelve test conditions were used to assess RTS in noise: two HINT speaker configurations, three noise competitions, and two light prompt conditions, as summarized in Table 1.

An adaptive test procedure was used. For each of the 12 conditions, two HINT lists (20 sentences) were presented. All randomization was done using a non-biased randomization software program (Haahr, 2007). It should be noted that there are 25 HINT lists, however only 24 were used. Lists one & two were used as one test condition; lists three & four were used as another test condition; with lists 23 & 24 being used as a twelfth test condition. Due to the complexity of the presentation setup, the conditions were pseudorandomized in the following order: 1) the 12 combined HINT lists were randomized; 2) the noise presentation azimuths were randomized to determine if all six of the single speaker or all six of the multiple speakers conditions would be presented first; 3) a randomization was done to determine the presentation order of the three noise competitions; and, 4) a randomization to determine which of the light prompt conditions would occur first within each of the three noise competitions.

The first sentence was played and each participant was asked to repeat the whole sentence back verbatim. An initial intensity level of 50 dB HL was used to present the first HINT sentence. If the participant did not repeat the whole sentence back correctly then the presentation level was raised 8 dB and then in 2 dB steps until the first sentence could be repeated back verbatim. After that, the intensity level was varied in 4 dB steps for sentences two through four. The intensity level of the remaining 16 sentences was varied in 2 dB steps. The intensity level was lowered by 2 dB if the participant repeated the previous sentence verbatim and raised by 2 dB if the participant did not repeat the sentence verbatim. Sentences one through four were considered practice. The RTS was calculated by averaging the intensity levels of sentences five through 21, in other words, the presentation levels of sentences five through 21 were

Table 1

The Twelve Test Conditions Presented to Each Participant

Condition	Noise Azimuth(s) (Degrees)	Noise Competition	Visual Prompt (Light)
1	0	Interrupted HINT	Yes
2	0	Interrupted HINT	No
3	0	Continuous HINT	Yes
4	0	Continuous HINT	No
5	0	ICRA7	Yes
6	0	ICRA7	No
7	45, 135, 225, 315	Interrupted HINT	Yes
8	45, 135, 225, 315	Interrupted HINT	No
9	45, 135, 225, 315	Continuous HINT	Yes
10	45, 135, 225, 315	Continuous HINT	No
11	45, 135, 225, 315	ICRA7	Yes
12	45, 135, 225, 315	ICRA7	No

summed and then divided by 17. Since there are only 20 sentences in each HINT condition, it is important to note that the presentation level of sentence 21 was hypothetical. Since a 21st sentence was not presented, the response to sentence 20 was what determined the presentation level for sentence 21. If the participant repeated sentence 20 correctly, then the presentation level for sentence 21 was recorded as being 2 dB below the previous presentation level. If the sentence was not repeated correctly the presentation level for sentence 21 was recorded as 2 dB above the previous presentation level.

For the test procedures with a visual prompt, the examiner switched on the light 0.5-second before each sentence was presented and off after the sentence ended. As an indicator for when the examiner should turn on and off the light, interrupted HINT noise was externally monitored through Apple iPod ear buds plugged into the phone jack of a Sony CDP-CE375 CD player. For each light prompt condition a remote control was used to turn on all necessary Sony CD players simultaneously to ensure that the light was turned on and off at the proper time.

CHAPTER 4

RESULTS

The 12 test conditions given to each participant are listed in Table 1 (as mentioned previously). Mean RTS, standard deviation, standard error, and the lower and upper bounds of the 95% confidence interval (CI) of the 12 conditions presented to each participant are summarized in Table 2. An error bar graph displays the 95% confidence interval (CI) for mean RTS of each condition (see Figure 1). Repeated measures analysis of variance (ANOVA) comparing the two light prompt conditions within the same speaker configuration and noise competition was completed. No differences were found for this comparison. Specifically, mean RTS was 68.73 dBA for conditions with prompt and 68.75 dBA for conditions without prompt across all other factors.

Repeated measures analysis of variance (ANOVA) comparing the two noise azimuth(s) configurations within the same noise competition and light prompt condition was completed. Statistically significant differences were found for four of the six different combinations analyzed: 1) continuous HINT noise from a single speaker with prompt and continuous HINT noise from multiple speakers with prompt (p= .019); 2) continuous HINT noise from a single speaker without prompt and continuous HINT noise from multiple speakers without prompt (p=.015); 3) ICRA7 noise from a single speaker with prompt and ICRA7 noise from multiple speakers with prompt (p= <.001); and, 4) ICRA7 noise from a single speaker without prompt and ICRA7 noise from multiple speakers without prompt (p= <.001). Results are displayed in Table 3.

Table 2

Descriptive Statistics for the Twelve Test Conditions

Condition	**Mean RTS**	**Standard Deviation**	**Standard Error**	**Lower Bounds of the 95 % Confidence Interval**	**Upper Bounds of the 95 % Confidence Interval**
1	69.42	1.39	.254	68.90	69.94
2	68.91	1.43	.260	68.38	69.45
3	68.54	1.51	.275	67.98	69.10
4	68.79	1.57	.287	68.20	69.37
5	71.13	2.35	.429	70.25	72.01
6	70.82	2.01	.366	70.07	71.57
7	68.70	2.44	.446	67.79	69.61
8	68.84	2.16	.395	68.04	69.65
9	67.53	2.02	.369	66.78	68.29
10	67.82	2.24	.410	66.98	68.66
11	67.07	2.18	.398	66.25	67.88
12	67.30	2.62	.478	66.33	68.28

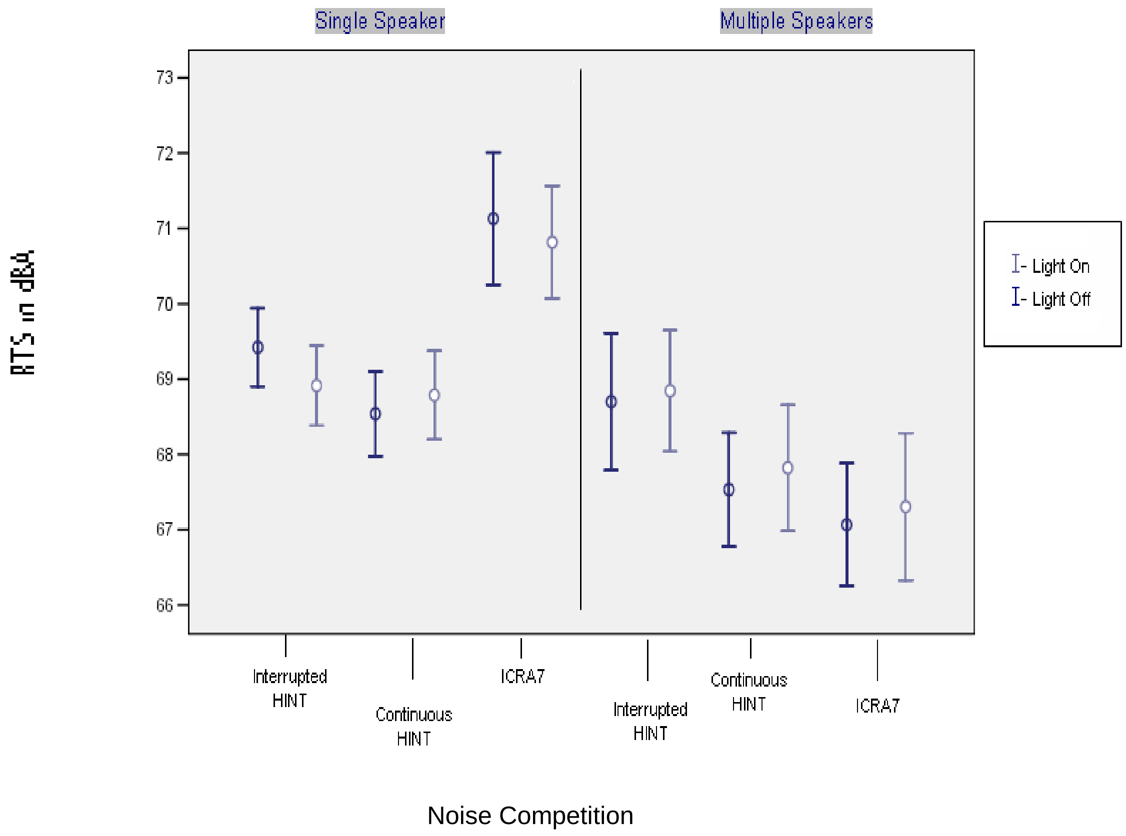


Figure 1. 95% confidence intervals for Reception Thresholds for Sentences.

Table 3

Repeated Measures Analysis of Variance (ANOVA) Comparing the Two Noise Azimuth(s) Within the Same Noise Competition and Light Prompt Condition

Conditions	**F**	**df**	**P-Value**
1 vs. 7	3.40	1,29	.075
2 vs. 8	.035	1,29	.853
3 vs. 9	6.20	1,29	.019*
4 vs. 10	6.65	1,29	.015*
5 vs. 11	32.56	1,29	<.001*
6 vs. 12	25.19	1,29	<.001*

* Statistically significant at p< .05

Repeated measures analysis of variance (ANOVA) comparing the three different noise competitions within the same noise azimuth configuration and the same light prompt conditions was completed. Statistically significant differences were found for nine of the 12 combinations analyzed. Five statistically significant differences were found in the single speaker conditions: 1) interrupted HINT with a prompt and continuous HINT with a prompt (p= .012); 2) interrupted HINT with a prompt and ICRA7 with a prompt (p= <.001); 3) interrupted HINT without a prompt and ICRA7 without a prompt (p= <.001); 4) continuous HINT with a prompt and ICRA7 with a prompt (p= <.001); and, 5) continuous HINT without a prompt and ICRA7 without a prompt (p= <.001). Four statistically significant differences were found in the multiple speakers conditions: 1) interrupted HINT with a prompt and continuous HINT with a prompt (p= .001); 2) interrupted HINT with a prompt and ICRA7 with a prompt (p= .001); 3) interrupted HINT without a prompt and continuous HINT without a prompt (p= .002); and, 4) interrupted HINT without a prompt and ICRA7 without a prompt (p= .002). Results are displayed in Table 4.

Table 4

Repeated Measures Analysis of Variance (ANOVA) Comparing the Three Different Noise Competitions within the Same Noise Azimuth and the Same Light Prompt Conditions

Conditions	***F***	***Df***	***P-Value***
1 vs. 3	7.23	1,29	.012*
1 vs. 5	17.03	1,29	<.001*
2 vs. 4	.190	1,29	.666
2 vs. 6	34.15	1,29	<.001*
3 vs. 5	44.73	1,29	<.001*
4 vs. 6	64.73	1,29	<.001*
7 vs. 9	13.51	1,29	.001*
7 vs. 11	13.17	1,29	.001*
8 vs. 10	11.86	1,29	.002*
8 vs. 12	11.92	1,29	.002*
9 vs. 11	1.13	1,29	.296
10 vs. 12	1.33	1,29	.258

*Statistically significant at p< .05

CHAPTER 5

DISCUSSION

Some researchers have used commercially available software to convolve the interrupted HINT noise into continuous HINT noise for studies involving participants with digital hearing aids. As stated previously, this is done to avoid putting the hearing aids into compression, which would inaccurately represent their effectiveness. Such noise is usually presented uncorrelated through multiple speakers. To date, there remains a paucity of data regarding the relative speech-perception scores across varying noise sources. With these considerations in mind, the purpose of this study was to determine the effects of a visual prompt on the speech-perception abilities of listeners with normal hearing in the presence of various noise sources.

Many studies have reported that improved speech intelligibility in noise occurs when a visual stimuli, be it lip movements, facial expressions, or a static rectangle; accompanies an auditory stimuli (Bernstein et al., 2004; Grant and Seitz, 2000; Sumby and Pollack, 1954). As mentioned earlier, one null hypothesis for this study was that the speech-perception abilities for conditions with and without a visual prompt would be equal. In contrast, the alternative hypothesis stated that the speech-perception abilities for conditions with and without a visual prompt would not be equal. Perhaps the most unexpected finding then was that all findings regarding the visual prompt were in agreement with the null hypothesis. A visual prompt had no significant effects on RTS for the interrupted HINT, continuous HINT, noise or ICRA7 noise test conditions.

Regarding the interrupted HINT noise, to some extent these findings were expected because a prompt was given each time the interrupted HINT noise was used, be it audibly (onset of noise) or visually (light prompt). Regarding the continuous HINT and ICRA7 noise, these findings were not expected at all because a prompt was only given during light on conditions. Interestingly enough, through out all 12 test conditions many participants commented on the visual prompt; while some reported that it seemed helpful others reported that it seemed distracting. So based upon the anecdotal reports from the participants of the present investigation, one must wonder if the reasoning behind no effects for the visual prompt in any condition is due to an overly distracting light. It is possible that the number of participants that the visual prompt helped may have been approximately equal to the number of participants that the visual prompt distracted. Indeed, if this were the case, the poorer RTS scores of the test conditions with a light prompt (due to distraction of visual prompt) and better RTS scores of the test conditions with a light prompt (due to helpfulness of visual prompt) would have averaged out and equaled RTS scores of the test conditions without a light prompt.

Another null hypothesis was that speech-perception abilities for conditions presented from 0^o azimuth (single speaker configuration) or from 45^o, 135^o, 225^o, and 315^o azimuth (multiple speakers configuration) would be equal. The alternative hypothesis was that speech-perception abilities for conditions presented from single speaker configuration or from multiple speakers configuration would not be equal. The differences found when comparing the two noise azimuth(s) within the same noise competition and light prompt condition were in disagreement with the null hypothesis with the exception of two conditions: interrupted HINT with visual prompt and interrupted HINT without visual prompt. These findings may be due to the interrupted HINT noise being presented correlated from multiple speakers while ICRA7 and continuous HINT noise were presented uncorrelated from multiple speakers. Uncorrelated spatially separated noise has been shown to have greater masking effects on speech materials than correlated noise for individuals with and without hearing loss (Sperry, Wiley, & Chial, 1997). Based upon these findings it makes sense that uncorrelated continuous HINT and ICRA7 noise yielded significant differences in RTS between the two noise routing conditions because these two types of noise likely masked more of the HINT sentence material than did the interrupted HINT noise, thus making sentence recognition more difficult. These findings are consistent with previous research (Sperry, Wiley, & Chial).

A third null hypothesis was that speech-perception abilities for conditions in continuous HINT, interrupted HINT, and ICRA7 noise would be equal. The alternative hypothesis was that speech-perception abilities for conditions in continuous HINT, interrupted HINT, and ICRA7 noise would not be equal. Findings are in disagreement with the null hypothesis with the exception of three conditions: 1) ICRA7 noise without prompt in the single speaker condition compared with continuous HINT noise without prompt in the single speaker condition; 2) continuous HINT noise with prompt in the multiple speakers condition compared with ICRA7 noise with prompt in the multiple speakers condition; and, 3) continuous HINT noise without prompt in the multiple speakers condition compared with ICRA7 noise without prompt in the multiple speakers condition. Nine significant differences were noted between noise competitions with ICRA7 noise yielding the poorest RTS scores in the single speaker configuration and the best RTS scores in the multiple speakers configuration. Although ICRA7 noise most closely resembles speech, it still served as a competing background noise in this study. Given this information, these findings are not surprising being that previous literature reported on the advantages for SRT in spatially separated speech and noise (Gelfand, Ross, and Miller, 1988).

Limitations of the Study

Since all of the participants were in their twenties and the majority of them were recruited from the Towson University Au.D. program, it is important to note that the differences found for RTS do not reflect the speech-perception abilities of the general population. Another limitation to note is that a certain amount of error in timing may have occurred when the examiner turned on and off the light prompt. An additional limitation to this investigation was that the participants did not necessarily need to rely on the light prompt after the first test condition was presented since the timing in between sentences was uniform through out all 12 test conditions.

Future Research

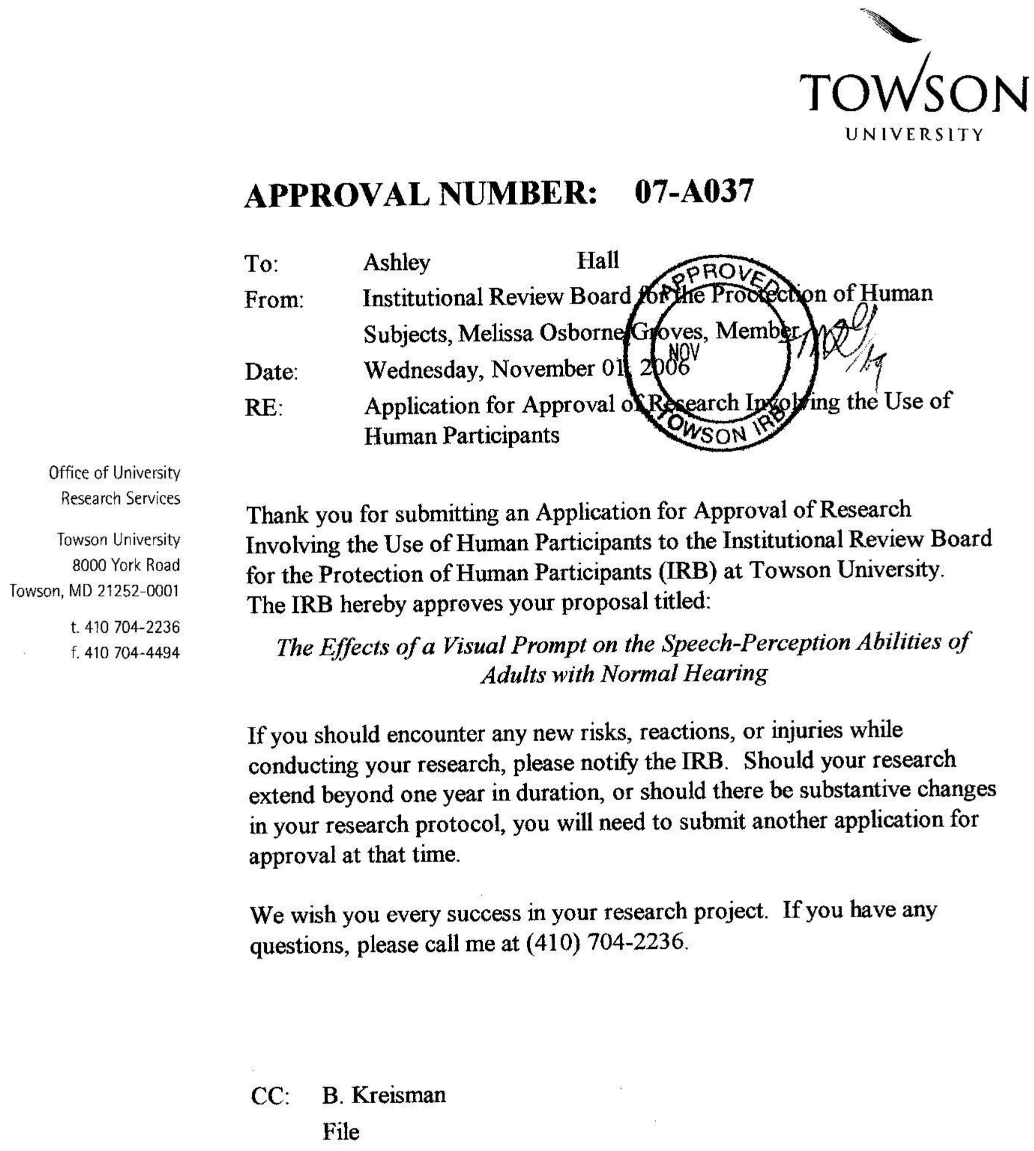
While all of these findings in mind, further research is still necessary to determine if results would be the same if a different visual prompt were used. It is unlikely that many differences would be found since participants would still be aware of the timing difference between sentences. However, altering the time interval between sentences so that participants did not have an auditory cue would be very interesting and may yield very different results than the present investigation found. Assessing whether the visual prompt might be more useful for other populations, such as the elderly with normal hearing, or young and/or elderly individuals with sensorineural hearing loss is also a venue that future research could explore. In addition, evaluating the speech-reading abilities of participants or assessing whether participants are more attuned to visual versus auditory cues would be worth noting when analyzing results and making statistical comparisons.

Conclusions

The current investigation examined the effects of a visual prompt on the speech-perception abilities of listeners with normal hearing. Results suggested no significant differences between conditions with and without the light prompt. Despite this finding, further research is needed on other visual prompts and other populations. Since the HINT sentences already have an auditory timing cue, it is likely that findings would indicate that the RTS for interrupted and continuous HINT noise is equivalent. This finding would be very useful both clinically and in research settings because the effectiveness of digital hearing aids could be examined without worrying if the hearing aids had been put into compression due to the onset and the offset of interrupted HINT noise. Rather, continuous HINT noise could be used to measure RTS (i.e., the effectiveness of digital hearing aids).

APPENDICES

APPENDIX A



TOWSON
UNIVERSITY

APPROVAL NUMBER: 07-A037

To: Ashley Hall
From: Institutional Review Board for the Proctection of Human Subjects, Melissa Osborne Groves, Member
Date: Wednesday, November 01, 2006
RE: Application for Approval of Research Involving the Use of Human Participants

APPROVED
NOV
TOWSON IRB

Office of University
Research Services

Towson University
8000 York Road
Towson, MD 21252-0001

t. 410 704-2236
f. 410 704-4494

Thank you for submitting an Application for Approval of Research Involving the Use of Human Participants to the Institutional Review Board for the Protection of Human Participants (IRB) at Towson University. The IRB hereby approves your proposal titled:

The Effects of a Visual Prompt on the Speech-Perception Abilities of Adults with Normal Hearing

If you should encounter any new risks, reactions, or injuries while conducting your research, please notify the IRB. Should your research extend beyond one year in duration, or should there be substantive changes in your research protocol, you will need to submit another application for approval at that time.

We wish you every success in your research project. If you have any questions, please call me at (410) 704-2236.

CC: B. Kreisman
File

APPENDIX B

TOWSON UNIVERSITY
INFORMED CONSENT FORM

Title of Study: The effects of a visual prompt on the speech-perception abilities of adults with normal hearing

Principal Investigator: Ashley Hall
Dept. of Audiology, Speech-Language Pathology and Deaf Studies
8000 York Road
Towson, MD 21252-0001
(410) 236-9227

Faculty Sponsor: Brian M. Kreisman, Ph.D., CCC-A, FAAA
109B Van Bokkelen Hall
Towson University
Dept. of Audiology, Speech-Language Pathology and Deaf Studies
8000 York Road
Towson, MD 21252-0001
(410) 704-3620

Purpose of the Study:
The purpose of this investigation is to examine the effects of a visual prompt on the speech-perception abilities of listeners with normal hearing.

Participants:
Adult volunteers (ages 18-30) with normal hearing (thresholds screened at 15 dB HL from 250 Hz – 8000 Hz) will serve as participants for this investigation. All participants will meet the following criteria:

1. hearing within normal limits (-10 to 15 dB HL) as determined through a hearing screening;
2. normal visual acuity or wear corrective lenses;
3. no central auditory processing disorders or psychiatric disorders as self reported;
4. no know hearing loss or middle ear dysfunction;
5. native speaker of English;
6. willingness to participate in the study.

Procedures:
After the consent document is signed, each participant will receive a hearing screening. The hearing screening will be conducted by a licensed audiologist or by a student who is directly supervised and observed by a licensed audiologist. If the participant passes the hearing screening, they will be asked to sit in a sound-treated booth. A series of sentences will be presented through speakers inside the sound-treated booth. The participant will be asked to repeat a series of sentences with background noise present and without a visual prompt. The noise used will be calibrated at 65 dB SPL, which is considered to be a level of loud conversational speech, well below levels that are considered potentially harmful. The light will be an every day 60-watt light-bulb which is not considered potentially harmful to the human eye.

Benefits:
It is hoped that the results of this study will provide normative data on how individuals perceive speech in the presence of background noise, and whether or not a visual prompt can

improve speech-perception abilities. Furthermore, it is hoped that results from this study can be used to compare to results of future studies for different populations, such as individuals with hearing loss and individuals with hearing loss who wear hearing aids.

Risks:

There are no known risks associated with participation in this study. Standard audiological testing techniques will be employed. The sound intensity levels will be carefully monitored, and will be no louder than the level of loud conversational speech. Should the assessment become distressing to the participant, it will be terminated immediately.

Cost Compensation:

1. Each participant will receive a free hearing screening as part of the study.

Rights as a Participant:

1. Subject's participation in this study will remain strictly confidential. Only the principal investigator will have access to the identities of the subjects and information associated with their identities. Any data collected through the computer system will be labeled using a code number, which will be randomly assigned to the subject. This computer will be password protected and all other information related to the study will be held in a locked cabinet in the principal investigator's office. Although the information gathered may be published or presented, at no time will identifying information regarding subjects be used.
2. Participation in this study is voluntary. At any time prior to or during the study, the participant or his/her parent/guardian are free to discontinue participation. A decision not to participate or to withdraw from the study will have no effect on the individual's status or any current or future services he/she may be receiving at the Towson University Speech-Language-Hearing Clinic.
3. The participant is free to ask questions regarding the study and/or the test procedures. The principal investigator will answer these questions.
4. If any questions should arise regarding this study, please contact the principal investigator, Ashley Hall, at phone (410) 236-9227, Dr. Brian Kreisman, Assistant Professor, at phone (410) 704-3620, or the Institutional Review Board Chairperson, Dr. Patricia Alt, Office of University Research Services, at phone (410) 704-2236.

Informed Consent:

_____ I have read and understood the information on this form.

_____ I have had the information on this form explained to me.

____ ____________________
Subject's Signature Date

____ ____________________
Witness to Consent Procedures** Date

____ ____________________
Principal Investigator Date

**If investigator is not the person who will witness participant's signature, then the person administering the informed consent should write his/her name and title on the "witness" line.

THIS PROJECT HAS BEEN REVIEWED BY THE INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN PARTICIPANTS AT TOWSON UNIVERSITY.
IRB Approval Number: ______07-A037_____.

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CURRICULUM VITA

NAME: Ashley S. Hall

PERMANENT ADDRESS: 13 Clearlake Court, Parkville, Maryland, 21234

PROGRAM OF STUDY: Audiology

DEGREE AND DATE TO BE CONFERRED: Doctor of Audiology, May, 2008

Collegiate institutions attended	Dates	Degree	Date of Degree
The University of Maine	2000-2004	B.A.	May, 2004
Towson University	2004-2008	Au.D.	May, 2008

Major: Audiology

Clinical Experience:

Chesapeake Hearing Centers, February 2007-Present
Graduate Clinician
- Adult and pediatric hearing evaluation and hearing aids
- Electronystagmography testing

Greater Baltimore Medical Center, February 2007-May 2007
Graduate Clinician
- Adult and pediatric cochlear implant assessment and mapping

Maryland Audiology, June 2006-December 2006
Graduate Clinician
- Adult and pediatric hearing evaluation and hearing aids
- Electronystagmography testing
- Otoacoustic emission testing

Baltimore City Public School Systems, February 2006-May 2006
Graduate Clinician
- Pediatric hearing evaluation and hearing aids
- Personal and sound field FM system assessment
- Otoacoustic emission testing

Towson University, February 2005-February 2006
Graduate Clinician
- Adult and pediatric hearing evaluation and hearing aids
- Auditory brainstem response testing
- Otoacoustic emission testing