DISCRIMINATION OF TIME-COMPRESSED SPEECH STIMULI: 
A COMPARISON STUDY USING A CLOSED-SET 
TASK WITH OLDER ADULTS 

DISSEbATION 

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Use of time-compressed speech stimuli has been found to be clinically effective in differential diagnosis of lesions of the temporal lobe. However, notably absent from the literature is information concerning performance of adults on time-compressed closed-set speech discrimination tasks. The goal of this study was to compare performance of 12 males and 12 females between age 50 and age 70 on a time-compressed closed-set speech discrimination test against the performance of 12 males and 12 females between age 18 and age 28 on the same task. The Word Intelligibility by Picture Identification test (WIPI) was presented in both non-compressed and time-compressed conditions to all subjects. Previous research suggests that a difference in performance between age groups and between males and females in the older age group should be expected. Average results indicated negligible differences between age or gender groups under any of the conditions tested. Additionally, the test yielded perfect or near perfect scores for all subjects in the non-compressed
condition. Lack of differentiation of results suggests that the Word Intelligibility by Picture Identification (WIPI) may be insensitive to the discrimination disorders expected in older adults, that the subjects included in the study were atypical of older adults in general and therefore such discrimination disorders did not exist in the sample, or that the subjects in the study were able to apply some type of compensatory strategies which resulted in the unexpected performance.
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CHAPTER I

INTRODUCTION

Evaluation of the central auditory nervous system and central auditory processing has become of increasing interest to both audiologists and speech-language pathologists during recent years. As a result of this interest, many different diagnostic tools and/or techniques have been proposed for use in assessment of the structure and function of the central auditory pathway. These differing tools and techniques have met with varying amounts of success. Among them, use of time-compressed speech stimuli is considered to be a beneficial clinical tool in evaluating the central auditory mechanism. Schuknecht (1956), Bocca and Calearo (1963), and Jerger (1973) have suggested that non-altered speech signals and pure tones apparently do not provide sufficient difficulty to make them useful as diagnostic measures in the assessment of the central auditory pathway. However, according to Calearo and Lazzaroni (1957), by time-compressing the speech stimuli and thus decreasing the redundancy in the signal, the difficulty of the material can be increased. Consequently, use of different
time-compressed speech stimuli with a variety of clinical populations has been the focus of much of the research in this area. However, notably absent in the literature are data concerning the use of a time-compressed closed-set speech discrimination task on an elderly population. Also, as Marshal (1981) stated following a review of selected literature concerning aging and auditory processing, "research is still needed on auditory processing in elderly listeners" (p. 236).

Statement of the Problem

This investigation compared the performance of older adult subjects with the performance of younger subjects on a time-compressed closed-set speech discrimination task.

Purpose of the Study

The purpose of this study was to determine if performance of persons over age 50 is substantially different from performance of young, normally hearing adults for the time-compressed closed-set Word Intelligibility by Picture Identification (WIPID) speech discrimination test. The WIPID is a six-alternative forced-choice monosyllabic speech discrimination test that
was originally designed to be used with hearing-impaired children who had limited language abilities (Lerman, Ross, & McLaughlin, 1965). It is, however, frequently used with other persons in a clinical population who have difficulty responding to the standard speech discrimination tasks.

Clinical use of any diagnostic tool presupposes adequate and appropriate normative data. At the present time, adult norms for the time-compressed WIPI have not been established. Prior to establishment of adult norms, it is necessary to determine if age is a significant factor in the performance of adults on the time-compressed WIPI.
The clinical utility of several altered/distorted speech tasks, including time-compressed speech, was discussed by Bocca (1958). According to Bocca, when speech is accelerated from approximately 150 words per minute to approximately 350 words per minute, normal subjects approach 100% correct discrimination with a 10 to 15 decibel threshold shift. A similar threshold shift was reported in temporal lobe tumor patients along with a failure to reach 100% discrimination in the contralateral ear. In aged subjects, Bocca reported "very poor" results for accelerated speech. On the basis of his observations of temporal lobe lesion patients and older patients, Bocca concluded that

The comparative evaluation of the results of our tests in the old age and tumor group of cases is an implicit confirmation that the auditory troubles of old age are mainly cortical in origin, and that insofar as the process of cortical elaboration of the message is concerned, it does not matter whether the cortical
lesions are brought about by compression and invasion, or by primary atrophic and degenerative changes. (1958, p. 307)

Kurdziel, Noffsinger, and Olsen (1976), however, found that time-compressed stimuli were differentially sensitive to various types of cortical lesions in a study comparing performance of 31 temporal lobe lesion or hemispherectomy patients on time-compressed speech stimuli. Stimuli consisted of word lists from the Northwestern University Auditory Test No. 6 (NU 6) which were presented at zero percent (non-compressed), 40%, and 60% time-compression (TC). Results indicated that patients with diffuse unilateral temporal lobe lesions and hemispherectomy patients performed poorly on the 60% TC materials when the stimuli were presented to the ear contralateral to the lesion. Such was not the case for the subjects with discrete temporal lobe lesions who showed no significant ear difference on the time-compressed stimuli. These results led the researchers to conclude that time-compressed stimuli, while being sensitive to diffuse temporal lobe lesions contralateral to the stimulus ear, may not be as sensitive to discrete lesions as previously believed.

The clinical effectiveness of distorted speech in assessment of the central auditory pathway has been
attributed to a decrease in the extrinsic redundancy of the
signal (Calearo & Lazzaroni, 1957). Kurtzrock (1957)
considered the effect of further reducing the redundancy of
the speech signal by altering both the time and frequency
parameters in a study using monosyllabic words as stimuli.
Using six different experimental conditions with various
combinations of time and frequency alterations, he found
intelligibility to be unaffected over a wide range of time
distortion while frequency distortion took its affect more
rapidly. Intelligibility of vowels was found to be more
susceptible to frequency distortion while intelligibility
of consonants seemed to be more adversely influenced by
time distortion. Additionally, specific classes and
subclasses of phonetic elements were shown to differ with
respect to the type of distortion to which they were
subjected. Combinations of time and frequency distortion
were found to be dominated by the frequency parameter but
the effect of duration was also significant.

Similarly, Harris (1960) studied the effect of
combinations of distortion in the perception of speech.
Distortions were achieved both electronically and
"naturally". The two electronic distortions included the
introduction of a four-second reverberation and the
introduction of 50% duty cycle interruptions at the rate of
eight per second to simulating the effect of intermittent
noise. The "natural" distortions consisted of having different talkers produce speech (a) with a swimmer's nose clamp in place, (b) as fast as possible without forfeiting enunciation of each syllable, and (c) while eating a submarine sandwich. Each source of electronic and "natural" distortion was then paired with each other source resulting in a total of 10 paired distortion combinations. Presentation of single-distortion stimuli to "groups of listeners" (N not specified) resulted in comprehension scores between 88.9% and 99.2% correct. From these results, Harris concluded that single sources of distortion permit high intelligibility. Combined distortion results indicated a reduction in intelligibility when compared to results for the single components. Inter-talker differences were also found.

Wingfield (1975) also considered the effect of combinations of distortion on the speech signal by pairing time-compression and altered intonation patterns. Time-compressed sentences were presented either with normal intonation or with intonation patterns which were not representative of the underlying syntactic structure. Wingfield's results indicated a decrease in intelligibility with an increase in time-compression which was worse for sentences with intonation not representative of the underlying syntactic structure than for sentences
with normal intonation.

In a similar study, Wingfield, Lombardy, and Sokol (1984) observed the effect of an additional blow to redundancy by electronically modifying some time-compressed passages to eliminate pitch variation or recording others in "list intonation" to eliminate prosody. Additionally, passages were interrupted either periodically (after every eight words) or at natural syntactic breaks. Results of the study indicated a decrease in intelligibility scores with an increase in time-compression with place of interruption and prosodic pattern also found to be significant.

In addition to the effect of combining types of distortion, other factors affecting the quality and/or perception of the time-compressed speech signal have been considered. Foulke (1970) discussed six methods for increasing the rate of speech for single words or for continuous discourse. Among them was pacing an oral reader at a faster-than-normal rate. The primary advantage of this method was that it required no sophisticated apparatus. It did, however, require a well-trained speaker who was receiving appropriate feedback. Even so, Foulke suggested that this method of rate increase might result in articulatory imprecision and, in connected speech, variations in pitch, intensity, and amount and distribution
of pause time. A second method consisted of recording the stimulus material at one speed with playback at a faster speed. The most notable result of this method was reported to be an increase in frequency (pitch) of the speaker’s voice. Another method Foulke discussed dealt with electromechanically reproducing consecutive samples of a recorded tape. Similarly, it was reported that consecutive sampling could be accomplished by means of a computer. Reported advantages of either of these sampling methods included maintenance of frequency (pitch) and timbre as well as relative pause time and patterns of variation in pitch and intensity in connected speech. Another method discussed pertained to the rate of synthesized speech which can be altered by merely changing the instructions to the speech synthesizer. Finally, Foulke suggested that increased speech rate could be accomplished by means of harmonic compression which divides the frequency while maintaining time and then, in the process of restoring frequency, increases rate.

Calearo and Lazzaroni (1957) reported no significant difference between three different methods used to accelerate speech stimuli. They used sentential stimuli recorded at three different rates: 140 words per minute (considered a normal rate for speaking Italian, the native tongue of the researchers and subjects), 250 words per
minute, and 350 words per minute. The presentation of stimuli was accelerated by using a speaker who was able to accelerate his speaking rate, by increasing the speed of a tape playback, and by using "a special apparatus" (presumably a time compressor) which accelerated the message without altering frequency.

Miron and Brown (1968) evaluated the comprehension of 135 subjects using a technical message altered in terms of stimulus parameters. The parameters considered in the study were: (a) talker rate, (b) selective pause compression at zero percent, 50%, and 100% deletions, and (c) random deletions at zero percent, 30%, 50%, and 70%. Results indicated that subjects exhibited better comprehension for faster rates resulting from pause excision than for slower rates with more normal pause-to-phonation ratios.

Daniloff, Shriner, and Zemlin (1968) compared the distortion effects of time-compression and frequency division on the intelligibility of vowels with results indicating that frequency division more severely affects vowel intelligibility than does time-compression. Even with the time frame electronically restored to normal, the intelligibility of the frequency divided speech signal was not notably improved. The authors concluded that the vowel confusions observed with time-compressed stimuli were
probably related to duration while those observed in the frequency divided stimuli were probably related to perception or misperception of the second vowel formant and somewhat to the first vowel formant.

Fairbanks, Guttman, and Miron (1957a) used technical messages followed by a test of comprehension in a study using young adult male U.S. Air Force trainees as subjects. The messages, originally taped at 141 words per minute, were presented at zero percent, 30%, 50%, 60%, 70%, or 100% (test-only condition) time-compression. Results indicated that 50% of maximum response could be obtained at the 60% time-compression condition (353 words per minute) and that the response improved to slightly less than 30% at 50% time-compression (282 words per minute). Amount of time-compression, listener aptitude, and message effectiveness were all found to be significant factors in comprehension of the material used in this study.

Fairbanks, Guttman, and Miron (1957b) studied the effect of number of presentations of the stimulus on the comprehension of time-compressed sentence material. Subjects in the study were young adult male U.S. Air Force trainees. They were tested on the content of a technical message presented at either zero percent or 50% time-compression. Part of the subjects received a single presentation of the stimulus material prior to testing
(message, test mode) while the other subjects were in message, message repeated, test mode receiving a double presentation of the material prior to testing. As would be expected, the effect of the number of presentations was found to be significant. However, neither the amount of compression nor an interaction between the amount of compression and number of presentations were significant.

Fairbanks, Guttman, and Miron (1957c) evaluated the auditory comprehension of independent groups of subjects on two versions of a technical message. The second version was created by adding non-repetitive restatements of selected facts to the original version. These augmentative statements were designed to constitute 30% of the words and time of the second version. Each version was then presented at zero percent and at 30% time-compression. The 30% time-compressed augmented version was equal in presentation time to the non-compressed original version but contained more information. These authors found a significant difference between versions within rate.

Voors and Miller (1965) considered the effect of repeated exposure to time-compressed stimuli in a study using 50 college students as subjects. Subjects listened to five different stories which had been recorded and time-compressed. After each presentation, they answered a multiple choice comprehension test. Results indicated a
significant improvement in comprehension of time-compressed stimuli following as little as seven minutes exposure. On the basis of this finding, the authors concluded that practice increased the ability to comprehend time-compressed speech and that the time required to become accustomed to the time-compressed stimulus was relatively short.

Sticht (1968) conducted a three-part study with U.S. Army inductees judged to be low, medium, or high mental aptitude. Two parts of the study dealt with time-compressed stimuli. In one experiment, a passage compressed at zero percent (175 words per minute), 36% (275 words per minute), or 59% (425 words per minute) was followed by a fill-in-the-blank test to assess comprehension. Results indicated a decline in performance of all groups as a function of increased rate with no interaction of rate and aptitude. In the other experiment dealing with time-compressed speech stimuli, 100 words selected from two phonetically balanced word lists were presented at zero percent, 36%, 53%, or 59% time-compression. Subjects were asked to write the words as they heard them through a loud speaker. Results of this experiment suggest that aptitude was a factor in the discrimination of single words with lower aptitude subjects performing more poorly on single word discrimination than
did higher aptitude subjects.

In a similar study, Sticht and Glasnapp (1972) considered the influence of subject aptitude in a study using U.S. Army inductees aged 18 to 25 years. The subjects were divided into two groups defined as "low mental aptitude" and "high mental aptitude" on the basis of a battery of tests normally administered to Army recruits. Two different experiments were included in this study. Experiment I ($n = 204$, 102 per group) evaluated the effect of rate upon immediate retention of material at various difficulty levels. Results of experiment I indicated that low aptitude subjects learned easier material better than difficult material as a function of rate decrease while high aptitude subjects learned best at approximately 175 word per minute regardless of the difficulty of the material. Experiment II ($n = 138$) dealt with an interaction of rate, aptitude, and the association strength of nouns. In this experiment, the performance of high aptitude subjects was poorer than that of low aptitude subjects on low association strength material when rate increased from 175 to 325. The results of this study suggest that differences in performance on speeded speech materials may be due to subject aptitude as well as difficulty of the material.

Beatty, Behnke, and Froelich (1980) studied the
influence of incentive on a time-compressed passage comprehension task. The subjects (n = 180), who were students, were divided into two groups with one group being promised extra credit in a class for good performance in the study. A scale was used to determine that extra credit constituted a sufficient reward for the incentive group. The speech stimuli were recorded by a male speaker at 140 words per minute and compressed to 210 words per minute and 280 words per minute. Results indicated a significant difference for rate and a significant difference for incentive but no interaction between rate and incentive.

Lass and Prater (1973) used 26 female subjects, aged 18 to 36, to study listening rate preference judgments on time-altered oral reading and impromptu speaking stimuli. The speech stimuli were presented at nine different rates ranging from 100 to 300 words per minute with increments of 25 words per minute between presentation rates. The most preferred rate was determined to be 175 words per minute with the least preferred rate being 100 words per minute.

Reid (1968) used an altered version of the Nelson-Denny Reading Test to study the effect of grammatical complexity on the comprehension of time-compressed speech material. The stimuli were presented at two levels of grammatical complexity and at 175 words per minute, 275 words per minute, 325 words per
minute, and 375 words per minute. The 160 subjects (freshman and sophomore psychology students) exhibited better comprehension with the grammatically simplified material and a marked decrease in comprehension at the most compressed (375 words per minute) condition.

Zemlin, Daniloff, and Shriner (1968) considered the effect of talker gender in a study where 40 college students rated the difficulty of time-compressed speech. The stimuli presented by both a male and a female talker were time-compressed to 20%, 30%, 40%, and 50% as well as being presented at a normal rate. Results indicated that beyond 20% time-compression, difficulty increases with the amount of time-compression with 50% time-compression being judged as five times as difficult as normal. Additionally, the female talker was judged as more difficult as the percentage of time-compression increased.

Beasley, Schwimmer, and Rintelmann (1972) considered the effect of varying the sensation level of time-compressed monosyllables in a study using the Northwestern University Auditory Test No. 6 (NU 6) word lists. The NU 6 lists were presented to 96 normal hearing young adults at zero percent, 30%, 40%, 50%, 60%, and 70% time-compression and at sensation levels of eight, 16, 24, and 32 decibels. Presentation ear and list version were counterbalanced. Results indicated a decrease of the
discrimination score as time-compression increased and an increase of the discrimination score as sensation level increased. No ear effect could be demonstrated and results on list effects could be termed inconclusive.

In an expansion of the Beasley, Schwimmer, and Rintelmann (1972) study, Beasley, Forman, and Rintelmann (1972) evaluated 16 subjects on time-compressed monosyllables from the Northwestern University Auditory Test No. 6 (NU 6) presented at 40 dB SL. Stimuli were presented in zero percent, 30%, 40%, 50%, 60%, and 70% time-compression. Results indicated a decrease in intelligibility with an increase in amount of time-compression which was most notable at 70%. A slight right ear advantage was also observed.

Foulke (1968) considered the stimulus variable of rate in a study where he had 350 college students listen to a passage with a presentation rate which was varied from 125 to 400 words per minute in increments of 25 words per minute. A multiple choice comprehension test following presentation of the stimuli yielded no significant differences with rate increases between 125 and 250 words per minute. Beyond 250 words per minute, however, a significant reduction in comprehension was observed as rate increased. Foulke suggested that some critical amount of time is required for perception of speech stimuli and that
a rapid deterioration of comprehension occurs when a rate increase results in an insufficient amount of perception time. This conclusion relates to the results presented by Bocca and Calearo (1956, 1957), cited in Luterman, Welsh, and Malrose (1966) who found a difference in responses of younger and older subjects to rate accelerated phrases and concluded that a lengthened "central acoustic reaction time" results from the aging process.

DeChiccis, Orchik, and Iecca (1981) considered the effect of stimulus material in a comparison of two different open-set speech discrimination tasks with 20 normal hearing listeners serving as subjects. They used commercially available recordings of the CID W 22 Auditory Test (W 22) and the Northwestern Auditory Test No. 6 (NU 6) word lists. The stimuli were presented at zero percent, 30%, 40%, 50%, and 60% time-compression. Performance was found to be consistently worse on the NU 6 material than on the W 22 material reaching significance at 30% and 80% time-compression.

Konkle, Beasley, and Bess (1977) used the Northwestern University Auditory Test No. 6 (NU 6) which is an open-set task to evaluate speech discrimination for time-compressed stimuli with older subjects. Subjects ranged in age from 54 to 84 years. Time-compressed stimuli were presented at varying sensation levels. Results
indicated that intelligibility decreased as age and amount of time-compression increased and sensation level decreased. From these results, the researchers concluded that a relationship appears to exist between changes seen in speech discrimination associated with the aging process and changes in the central auditory system with respect to its temporal resolving abilities.

Aging was also a factor in a study by Schmitt and McCroskey (1981) examining the effect of rate on sentence comprehension of elderly listeners aged 65 to 88 years. Subjects listened to sentences that were presented binaurally at a normal rate, at 140% time-expansion, at 180% time-expansion, and at 60% time-compression and were asked to select pictures matching the sentences they heard. Results indicated statistically significant improvement in performance over that exhibited at the normal rate for both the 60% time-compression and the 140% time-expansion condition. The authors suggest that the improved performance at 60% time-compression may be due to research artifacts such as sentence complexity and novelty of the time-compressed stimuli rather than a true increase in the ability of older listeners to comprehend time-compressed speech stimuli.

Bergman et al. (1976) conducted both cross-sectional and longitudinal studies in which subjects (aged 20 to 79
years) were divided into age groups by decades and evaluated on a variety of altered speech tasks. Except in a non-altered control condition, the speech stimuli were either distorted in some manner (time-compressed, presented dichotically, filtered, periodically interrupted) or presented with some competing message or other competing stimulus. Results indicated a decline in perception of altered speech stimuli beginning with the fifth decade of life and increasing notably in the seventh decade. An interesting exception to this finding was the performance on the time-compressed task which yielded a "relatively small decline" in performance as a function of increasing age. The authors suggest that this result could have been due to an insufficient amount of time-compression (two and a half times faster than the normal rate of 120 words per minute) which they used in their study.

Luterman et al. (1966) used the CID 22 Auditory Test (W 22) to consider the effect of slight time-compression and slight time-expansion on the speech discrimination scores of three groups of male subjects. The subject groups represented older males, aged 79 to 87 years, who were Spanish-American War veterans, younger normal hearing males (aged 20 to 38 years), and younger hearing impaired males (aged 20 to 40 years) who exhibited a high frequency hearing loss similar to that of the older subjects. The
CID W 22 Auditory Test word lists, presented at 10% and 20% time-compression and at 10% and 20% time-expansion, yielded no significant difference in any condition or for any subject group. It is important to note, however, that maximum time-compression or time-expansion condition considered in this study was 20 percent.

Schon (1970) also used the CID W 22 Auditory Test (W 22) to consider the effect of both time-compression and time-expansion. His study used male subjects divided into five groups on the basis of age and hearing loss. The Campbell revision of the CID W 22 Auditory Test was presented to all subjects in a non-compressed, non-expanded condition (zero percent time-compression, zero percent time-expansion), at 30% and 50% time-compression, and at 30% and 50% time-expansion. Results indicated significantly poorer performance in the time-compression condition in young subjects with hearing loss, older subjects with hearing considered normal for their age and gender, older subjects with sensory-neural loss when compared to normal hearing young subjects. Such was not the case for the time-expanded condition where older subjects with normal hearing for age and gender did not differ significantly from young normal hearing subjects.

Schmitt (1983) also used older subjects when investigating the auditory comprehension of time-altered
passages. Subjects in the study were divided into two groups: "young-old" aged 65 to 74 years and "old-old" aged 75 to 84 years. Subjects were asked to respond to questions after listening to passages which were presented at the normal rate or which had been time-compressed 60%, time-expanded 140%, or time-expanded 180%. Results indicated no significant difference between the two groups when stimuli were presented at a normal rate and a reduction in performance in both groups at the 60% time-compression condition. A difference between groups was observed in the time-expanded conditions which became more pronounced as the time-expansion increased.

Schmitt and Carroll (1985) assessed comprehension of passages with the material presented at normal rate, 60% time-compression, and at two time-expansion conditions. Fourteen men and 14 women, aged 65 to 74 years, served as subjects. These researchers found rate to be a significant factor in comprehension with scores lowest in the 60% time-compression condition. Neither gender nor rate-by-gender were found to be significant. Additionally, the expansion conditions did not yield a significant improvement in results.

Sticht and Gray (1969) evaluated 14 normal hearing-subjects and 14 hearing-impaired subjects using time-compressed CID W 22 Auditory Test (W 22) word lists.
The subjects were divided into two groups: "old" (over age 60) and "young" (under age 60) with equal numbers of hearing-impaired and normal hearing subjects in each group. The open-set stimuli were presented at zero, 36, 46, and 59% time-compression. Results indicated that performance was not affected differentially as a result of the subjects' hearing abilities. Performance did differ as a result of age with older subjects offering poorer performance than younger subjects in the time-compressed conditions. This difference increased as the amount of time-compression increased.

Similarly, Grimes, Mueller, and Williams (1984) compared discrimination scores on the Northwestern University Auditory Test No. 6 (NU 6) of 28 normal hearing subjects and 28 subjects determined to have a sensory-neural hearing loss. The NU 6 lists were presented at 60% time-compression and yielded significant list effects with only list I and list IV being equivalent for both groups. Additionally, a significant learning effect was observed which was greater for the normal hearing subjects.

Results of normal hearing and hearing-impaired subjects were also compared in a study by Harris, Haines, and Myers (1960). The hearing-impaired subjects exhibited losses of varying severity beginning at either 2000 Hertz
or at 3000 Hertz. The authors used a speeded sentence comprehension measure and found that subjects with hearing losses beginning at 3000 Hertz showed a significant decrement in performance when compared to normal subjects. Additionally, subjects with losses beginning at 2000 Hertz showed results that approached normal more quickly as presentation speed was reduced.

Similar results were found by Harris (1965) when he considered the effect of pure tone acuity on four different distorted speech tasks. Fifty-two subjects with sensory-neural losses were evaluated on speech tasks where the talker wore a nose clamp, where the speech was speeded, where the stimuli were interrupted, or where the stimuli were reverberated. Results indicated a high correlation between hearing sensitivity at 1000, 2000, and 3000 Hz and performance on the distorted speech tasks suggesting that acuity at these frequencies is important in the perception of distorted speech.

Di Carlo and Taub (1972) compared the performance of young and older aphasic subjects (with demonstrated left hemisphere CVA) on time-altered speech tasks. The mean age of the young group was 25.0 years while the mean age of the older group was 64.6 years. Subjects were presented with two time-expansion conditions (30% and 50%) and with two time-compression conditions (30% and 50%). Data from this
study were also compared with previous results obtained for young and older subjects and for older subjects with sensory-neural hearing loss. Results indicated a significant difference with respect to both age group and diagnostic category group (aphasic, sensory-neural, normal) for the non-altered condition (zero percent time-compression/zero percent time-expansion) with the young normal subjects performing best followed by the older normal subjects, young aphasic subjects, the older aphasic subjects, and finally by the older sensory-neural subjects. This rank order of performance was maintained for both time-expansion conditions. With the exception of the older normal subjects falling below the young aphasic subjects on performance for both the 30% time-compression and 50% time-compression conditions, the rank order was also maintained for the time-compressed stimuli. Based on these results, the researchers concluded that performance on time-altered stimuli was affected primarily by age and that the introduction of distortion conditions did not have a greater effect on performance for aphasic subjects than for normal subjects.

Orchik, Walker, and Larson (1977) also evaluated aphasic subjects using a time-compressed closed-set speech discrimination task. The Word Intelligibility by Picture Identification (WIPI) speech discrimination task was
time-compressed to zero, 30, and 60% for use in this study. Subjects in the Orchik et al. (1977) study were eight aphasics ranging in age from 44 years to 65 years and eight non-aphasics who were matched with the aphasic subjects in terms of age, sex, and hearing loss. Results indicated that the average performance of the aphasic subjects was significantly poorer than that of the non-aphasic subjects in the 60% time-compression condition. These researchers did suggest that the number of subjects examined in their study precluded generalization of the data.

Beasley, Maki, and Orchik (1976) also used the time-compressed WIPI in addition to the time-compressed PR-K 50 word lists as stimuli in their study of 60 children aged three and one-half to eight and one-half years. Their results indicated that the open-set PR-K 50 task was consistently more difficult for all subjects under all conditions than was the closed-set WIPI task. They also found that performance improved as a function of increasing age and also as a function of increasing sensation level. Conversely, as amount of time-compression increased, performance decreased.

Berry and Erickson (1973) used a trained speaker who recorded the receptive portion of the Northwestern Syntax Screening Test (NSST) at varying rates of presentation.
Using 50 kindergarten children and 50 second grade children as subjects, these researchers found that "presentations at rates of utterance which are slower than normal adult rates appeared quite consistently to result in greater comprehension than did those presentations at normal or faster rates" (p. 371). Significant differences were found when slower speaking rates were compared with faster speaking rates. When results were analyzed by grade, no significant difference was found. Additionally, the researchers indicated that no difference in comprehension results was seen between sexes. They did, however, suggest that control of speaking rate which was defined in terms of syllables per second might have influenced results.

Woodcock and Clark (1968) evaluated comprehension of elementary school children on time-compressed and time-expanded narrative passages. Presentation rates ranged from 78 words per minute (wpm) to 428 words per minute (wpm). Subjects were divided into three groups on the basis of grade level and intelligence levels (sixth grade children with "low" IQ, fifth grade children with "average" IQ, and third grade children with "high" IQ). Subjects were trained initially and then asked to listen to time-altered passages followed by a multiple choice test designed to assess comprehension of the passage. Subjects were also evaluated after one week to determine the effect
of time delay on retention. Results indicated improved performance at rates of 228 to 328 wpm as compared to performance at the normal rate of 178 wpm.

Goldhaber (1970) evaluated the performance of two groups of subjects differing in academic grade level (and consequently, by age) on a time-compressed speech comprehension task. Subjects were 40 college students enrolled in a basic speech course and 40 junior high school students (aged 12 and 13) enrolled in a basic English course. A passage concerning the history of radio and television was compressed at different rates. Subjects listened to a practice passage time-compressed at the same rate as the experimental passage and took a practice test before being presented with the experimental stimuli followed by a multiple choice comprehension test. Results indicated a significant difference in comprehension as a factor of academic level with the junior high school students performing better and a significant difference in comprehension as a factor of rate with better performance on the slower presentation. Interestingly, no significant interaction effect between rate and academic level could be demonstrated. The researcher did not attribute the significantly better performance of the younger subjects to an increased ability of those subjects to comprehend time-compressed speech. Rather, he suggested that the
interest factor of the stimulus passage might have been more in line with that age group or that the younger subjects might have been more eager to learn and/or to participate in the study than the older subjects.

The difference between closed-set and open-set performance was one of the factors considered by Freeman and Beasley (1978) in their study of children with and without reading impairment. The subjects were presented with time-compressed three-word and five-word sentential approximations and with the time-compressed WIPI in the traditional closed-set format (with pictures) and in an open-set format (without pictures). Results indicated that reading-impaired children had more difficulty with the stimuli as linguistic complexity and amount of time-compression increased than did the normal-reading control group. Additionally, the use of an open-set format on the WIPI did not to adversely affect the performance of the normal subjects. Such was not the case for the reading-impaired subjects however.

Children with and without articulation disorders served as subjects for a study by Orchik and Oelschlaeger (1977) using the time-compressed WIPI. Subjects were divided into three groups: those with no articulation errors, those with one to three errors, and those with four or more errors. Performance was significantly poorer in
children with four or more errors than in either of the other two groups. Based on their results, these researchers suggested sensitizing the measure for clinical use through a weighting formula which evaluates the subjects relative change in performance.

Manning, Johnson, and Beasley (1977) time-compressed the PB-K 50 word lists to evaluate 20 children with auditory perceptual disorders. Results indicated that these subjects diagnosed as having auditory perceptual disorders had worse performance in the zero percent and 60% time-compression conditions than the norms for children would suggest. These subjects did, however, have similar results to the suggested norms in the 30% time-compression condition. These researchers theorized that this apparent "normal" performance at the 30% time-compression condition might be related to memory problems seen in children with auditory perceptual disorders. They suggested the 30% time-compression condition provided a shorter message which was easier for subjects with memory problems to remember and thus process. It is important to note that performance of these subjects at 30% TC was not better than normal but rather did not show as great a decrement in performance when compared to normal as did the zero percent and 60% results.

McNutt and Li (1980) evaluated the ability of 10
normal children and 10 learning disabled children to comprehend time-compressed and time-expanded sentences. The subjects were required to repeat sentences presented at normal rate (zero percent time-compression/expansion), at 30% and 60% time-compression, and at 30% and 60% time-expansion. Results indicated that the normal subjects performed equally well in all conditions and also with greater accuracy than the learning disabled subjects. The only notable difference in the performance of the learning disabled subjects was a decrease in accuracy in the 60% time-compression condition. The authors suggested the observed results might be due to a processing deficit of a semantic or syntactic nature rather than a memory deficit.

McCroskey and Thompson (1973) used declarative sentences presented at normal rate (3.6 syllables per second), two compressed rates (5.0 and 6.8 syllables per second), and two expanded rates (2.3 and 2.9 syllables per second) in a study to determine the effect of rate on message comprehension in learning disabled children. The subjects ranged in age from five years to 17 years. They were asked to select, from three choices, the pictorial representation of the sentence they heard. Pooled data did not reveal any difference in comprehension with respect to rate. However, when data from the 10 youngest subjects were analyzed separately, a significant difference in
comprehension was observed as a function of rate of speech.

Foulke (1966) used 123 blind children in grades 7 to 9 as subjects for a study to determine if compression method and/or word rate affected speech comprehension. Groups of subjects listened to a story which was compressed either by using an electronic sampling method or by playing a recording at a faster speed and which was presented at 253, 300, or 350 words per minute. Word rate was found to be significant in comprehension of the time-compressed speech stimuli. Method of compression did not have a significant effect on comprehension.

Zucker and D'Alonzo (1981) evaluated the ability of 20 educable mentally retarded subjects to comprehend time-compressed speech. Stories presented at a normal rate and at a "compressed rate of 1.5 times normal" were followed by a short multiple choice test of comprehension. Results indicated no significant difference in performance on normal versus compressed speech.

Lovitt (1968) compared listening rate preferences of 10 normal males (aged 11 to 12) and 10 retarded males (aged 10 to 13). A story stimulus was presented at 90 words per minute (wpm), 120 words per minute, 180 words per minute (defined as normal rate), 240 words per minute, and 360 words per minute. None of the retarded subjects preferred
the normal rate with one selecting 360 wpm, three selecting 240 wpm, two selecting 120 wpm, and three selecting 90 wpm as their preferred rates. Of the normal subjects, five chose the normal rate as the rate of preference while three chose 240 wpm and one chose 120 wpm. Responses of two subjects (one from each group) were reported to be inconsistent and therefore not included in the data analysis.

Presbycusis

Evidence exists to suggest that physiological changes occur in the aging auditory pathway and that these changes accompany an audiometric symptom complex referred to as presbycusis (Crowe, Guild, & Polvolgt, 1934, cited in Schuknecht, 1955; Saxen, 1952; Schuknecht, 1955; Arneson, 1982). Presbycusis has been defined as "the gradual reduction of hearing with advancing age" (Sataloff, 1966, p. 124). If a presbycusis loss does occur, it has been reported that it will (a) be present in the sixth decade of life (Powers & Powers, 1978), (b) affect the higher frequencies first (Bunch, 1929; Ciocca, 1932), and (c) result in a reduction of speech discrimination scores, (Goetzinger, Proud, Dirks, & Embrey, 1961; Blumenfeld, Bergman, & Millner, 1969; Feldman & Reger, 1967).
Hinchcliffe (1962) listed the audiologic features of presbycusis as:

a) impairment of auditory threshold sensitivity, b) lowering of upper tone limit, c) impairment of frequency discrimination, d) impairment of auditory temporal discrimination, e) impairment of sound directionalization, f) impairment of auditory perceptual judgment, g) impairment of speech discrimination, h) decrease in the intelligibility of distorted speech, i) decrease in the ability to recall long sentences. (p. 301)

He also reported that a histological study of the human auditory mechanism indicated some structural changes associated with increasing age. These included some atrophy of the external auditory meatus, calcification of the basilar membrane of the cochlea in the basal turn, and neural degeneration in the cochlea, cochlear nerve, and brain. On the basis of his observations, Hinchcliffe concluded that the manifestations of presbycusis are primarily dependent on degenerative changes in the brain.

Glorig and Nixon (1962) described three types of change in hearing as a result of age. They stated that a hearing loss due to physiological aging should be termed "presbycusis" while a reduction in hearing sensitivity due to "wear and tear" should be termed "sociocusis."
Additionally, they did allow for reduced auditory thresholds as a result of an occupationally induced hearing loss. They also reported average hearing levels for five age groups which were generally within normal limits with a few exceptions. For the age group termed 54.5 years old, a threshold of 25.9 decibels was reported at 6000 Hertz while for the 64.5 year-olds, reductions to 29.6 decibels at 4000 Hertz and 37.2 decibels for 6000 Hertz were reported. The oldest age group (74.5 years) had thresholds of 23.5 decibels at 2000 Hertz, 34.5 decibels at 3000 Hertz, 40.0 decibels at 4000 Hertz, and 50.8 decibels at 6000 Hertz. It might be important to note that auditory thresholds below 1000 Hertz and above 6000 Hertz were not reported.

Hinchcliffe (1959) determined thresholds for 50 males and 50 females in the age group 18 to 24 years and for 30 males and 30 females in age groups 25 to 34 years, 35 to 44 years, 45 to 54 years, 55 to 64 years, and 65 to 74 years. Potential subjects who had evidence of outer or middle ear disease, history of a reported incident which might affect hearing, history of vertigo accompanied by tinnitus, or history of ear surgery were excluded. Results indicated a significant gender difference for all age groups at 3000, 4000, and 6000 Hertz. For older subjects a difference was also observed at 2000 and 8000 Hertz.

Corso (1959) also found a gender difference in a study
examining audiometric thresholds of subjects aged 18 to 49 years divided into four age groups: 18 to 24 years, 26 to 32 years, 34 to 40 years, and 43 to 49 years. Both male and female subjects were evaluated. Results indicated no notable ear difference. A gender difference was demonstrated, however, with women having better auditory thresholds than men especially in the higher frequencies. The gender difference observed was independent of age. An age difference was also demonstrated with a decrease in hearing sensitivity occurring with an increase of age. The hearing loss observed was more pronounced in the higher frequencies and spread to the lower frequencies with increasing age. Men were found to have a greater degree of impairment beginning at an earlier age than women. On the basis of his results, the researcher suggested that audiometric norms be specified independently for men and women according to particular age levels.

In a later study, Corso (1963) reported a gender difference when comparing pure tone thresholds of male and female subjects between the ages of 18 and 65 years. All subjects received an ear, nose, and throat examination (primarily otologic) and had a case history including a hearing environment questionnaire administered to them. Corso found only minor differences in average sensitivity between right and left ears. He did, however, find that
women's hearing, on the average, to be more acute than men's with less intersubject variability. This held true in all but the two oldest groups where women had poorer low frequency hearing (below 1000 Hertz) with more variability and men had poorer hearing and greater variability in the higher frequencies (3000 Hertz and higher). A gender difference was most notable at frequencies greater than 1000 Hertz. In both men and women, a decrease in acuity with a progressive spread of loss from high to low frequencies was observed with increasing age. Gorso also observed that the onset of presbycusis was later in women than in men but proceeded at a faster rate. Similarly, the rate of deterioration as a function of age was observed to be uniform in women and to occur in discrete steps of approximately 15 years in men.

Crowe et al. (1934), cited in Schuknecht (1955), studied clinical and pathological findings in 79 human ears with high frequency hearing loss. Classification of results yielded two categories. One category was characterized by an abrupt high frequency loss with atrophy of the organ of Corti at the basal turn. The other category was characterized by a gradual high frequency loss with partial atrophy of the cochlear nerve supply in the basal turn. Some cases of unknown etiology were also reported.
Schuknecht (1955) suggested that histologically observed changes in the auditory mechanism result in presbycusis. He stated that the: "classical manifestation of cochlear aging is high tone deafness caused by atrophic changes in the basal coil" (p. 402). Studying cats and one human ear, he determined that one type of presbycusis was characterized by atrophic changes in the membranous labyrinth beginning at the basal end and moving toward the apex. He termed this "epithelial atrophy." A second type of presbycusis was reportedly characterized by a decrease in the number of neurons in the auditory nervous pathway. This was termed "neural atrophy."

In a later study, Schuknecht (1964) identified four distinct types of presbycusis based on clinical findings and histologic studies: sensory presbycusis, neural presbycusis, metabolic presbycusis, and mechanical presbycusis. Sensory presbycusis resulted in an abrupt high frequency loss and was characterized by atrophy of the organ of Corti and auditory nerve at the basal turn of the cochlea. Neural presbycusis was characterized by a loss of neurons in the auditory pathways and cochlea and resulted in a decrease in speech discrimination that is not commensurate with the amount of hearing loss (phonemic regression). Schuknecht also reported that neural presbycusis occurs late in life. Metabolic presbycusis was
reported to produce a slowly progressive flat hearing loss which was attributed to a defect in the physical and chemical processes which produce energy and make it available to sense organs. Specifically, in the auditory system, this was reported to take the form of atrophy of the stria vascularis. Mechanical presbycusis was the fourth type of presbycusis Schuknecht reported, resulting from stiffening of the basilar membrane and producing a sloping audiometric curve.

Gaeth (1948), cited in Pestalozza and Shore (1955), outlined the characteristics of phonemic regression stating that it: (a) occurs with perceptive-type losses, (b) may be more prevalent in moderate to severe losses, (c) is of unknown etiology, (d) results in an inability to hear and repeat common words at suprathreshold levels, (e) appears to be associated with poor pitch discrimination, and (f) may be complicated by low vocabulary scores. In a study he conducted, Gaeth found that older people with greater hearing loss had poorer discrimination. He stated that persons with a discrimination score greater than 69% had a mean hearing loss between 35 and 39 decibels while persons with a discrimination score less than 68% had a mean hearing loss of 51 decibels. Two possible interpretations of this finding were suggested: (a) that phonemic regression accompanies more severe hearing loss with both
deficiencies springing from a common cause or (b) phonemic perception is more easily disturbed beyond a certain degree of hearing loss severity. Additionally, Gaeth did not rule out the effect of other confounding health problems in the population.

Saxen (1952) reported physiologic changes in the cochlea associated with the aging process. He observed atrophy of the spiral ganglion reported to be a "process of wear" and an angiosclerotic degeneration of the inner ear. He suggested that the angiosclerotic degeneration was a result of sclerosis of the corresponding blood vessels and possibly of a general toxic influence.

Arneson (1982) found evidence of involvement of the cochlear nuclei in the presbycusis process. Results from six human brains of geriatric patients diagnosed as presbycusis prior to death (cause of death either pneumonia or heart disease) indicated a statistically significant loss of neurons (50%) in presbycusics when compared to previously established norms. On the basis of this, Arneson concluded that presbycusis was not only the result of degeneration of the cochlea but also of the cochlear nuclei.

In a similar study, Hansen and Reske-Nielsen (1965) determined pure tone thresholds for 12 patients over 60 years of age and completed a histologic study of their
temporal bones and central auditory pathways. They reported that most patients exhibited a symmetrical high frequency loss with one patient exhibiting an additional conductive component in one ear resulting in a unilateral mixed loss and one patient exhibiting total unilateral deafness. They also reported that most patients exhibited histologic deviation in the basal end and of the cochlea and in the central auditory pathway.

There is evidence to suggest that some of the redundancy in the auditory system may be compromised by age. Kirikae, Sato, and Shitara (1964) reported the results of a histopathologic study on 11 brains selected at random from 500 autopsies of aged people. Results indicated a decreased number of ganglion cells, shrinkage of nerve cells and accumulation of pigment in nerve cells at the level of the ventral cochlear nucleus. They also noted a decrease in size and a loss of distinct shape in ganglion cells, changes in cell nuclei, and some increase in pigmentation in cells at the level of the superior olivary complex. At the level of the inferior colliculus, they found an irregularity of shape of medium sized cells, occasional cell atrophy, and an increase in the ratio between the size of the nucleus and the cell body in small sized cells. Additionally, they observed a reduction in cell number, evidence of cell shrinkage, the loss of
distinct shape of some cell bodies, and increased pigmentation of cells at the level of the medial geniculate body. In discussing these results, Kirikae et al. suggested that auditory sensation was the result of excitation of a given number of nerve fibers and that the typical presbycusic high-frequency loss occurred as the result of a reduction in the number of nerve fibers. High frequencies were reportedly more affected since the original number of nerve fibers which transport high frequency information was smaller.

Kirikae et al. (1964) additionally compared the performance of older subjects to that of younger subjects on frequency- and time-distorted speech tasks. Frequency-distorted speech was accomplished by means of a low pass filter. The time-distorted speech tasks consisted of a monaural presentation of interrupted speech and binaural fusion condition where interrupted speech was alternated between ears. Results indicated that older subjects had greater difficulty with both types of distorted speech tasks than did younger subjects.

Bauer (1965) found evidence of physiologic changes as a result of aging in a study of the auditory reaction time and brain wave period of 137 adults. The subjects were aged 23 to 87 years with all subjects reported to have normal electroencephalograms. Results of the study
indicated a .49 millisecond increase of brain wave period per year of advancing age. Similarly, a 24 millisecond increase in auditory reaction time per year of advancing age was also observed.

Auditory reaction time was one of the several auditory and non-auditory tasks included in a study by Feldman and Reger (1967). They compared the responses of 20 males, aged 20 to 28 years, to those of 36 males, aged 50 to 89 years, on pure tone air conduction thresholds from 250 to 8000 Hertz, speech reception thresholds, speech discrimination using the CID W 22 Auditory Test, and reaction time for auditory stimuli. The non-auditory tasks included in the study consisted of reaction time for visual and tactile stimuli. Subjects exhibited impaired pure tone sensitivity, impaired speech reception thresholds, poorer speech discrimination, and an increase in reaction time as age increased.

Goetzinger et al. (1961) obtained a variety of audiometric results on 45 men and 45 women, aged 60 to 90 years who were equally divided into 3 age groups. Tests administered included pure tone air conduction and bone conduction thresholds, speech reception thresholds, speech discrimination, Carhart tone decay, and tests for recruitment. Results included a decrease in hearing sensitivity for pure tones and speech stimuli as a function
of increasing age, no gender or ear effect on the speech reception threshold, a decrease in discrimination ability with increasing age, and no significant tone decay.

Stevenson (1975) obtained pure tone thresholds and results on a variety of speech audiometry tasks. Subjects for the study included 32 elderly persons (five males, 27 females) aged 62 to 90 years. For some tasks, small numbers ($n = 11$, $n = 4$) of young adults with normal hearing were also tested. Based on the results obtained in the study, Stevenson concluded that there may be a reduction in the number of or availability of phoneme categories which older persons can utilize successfully.

Grady, Pikus, et al. (1982) evaluated 36 male subjects (aged 21 to 83 with a mean age of 50.1) using a variety of auditory tests. In addition to obtaining the subjects' pure tone thresholds, speech reception thresholds, speech discrimination scores, middle ear pressures, middle ear compliances, and acoustic reflexes, the researchers also evaluated subjects' abilities on a low-pass filtered speech task and a binaural fusion task. Results indicated a significant correlation between age and pure tone thresholds for all frequencies in both ears. No correlation between age and any of the other measures could be demonstrated. On the basis of their results, Grady, Pikus, et al. concluded that many auditory functions are
not compromised by age in spite of known physiological changes in the system.

In a related study, Grady, Grimes, et al. (1984) suggested that reduced performance of older subjects on speech tasks reported previously may be due to the effect of a peripheral hearing loss. Grady, Grimes, et al. found a statistically significant correlation between age and pure tone thresholds for all frequencies they tested. However, they could establish no correlation between age and results on any of the speech tasks they tested (except for low pass filtered speech in the left ear) when the effect of peripheral hearing loss was taken into account. On the basis of their results, these authors state: "Our findings suggest that the aging process in healthy man is not necessarily accompanied by deficits in the processing of speech stimuli beyond those which are due to peripheral hearing loss" (Grady, Grimes, et al., 1984, p. 109).

These results are in disagreement with the results of Palva and Jokinen (1970) who evaluated 149 adults aged from 20 to 89 years using pure tone threshold testing, undistorted speech audiometry, and filtered speech tasks. They found that intelligibility of filtered speech decreased as a function of age before changes in pure tone results could be observed. Additionally, they noted an asymmetry of results in subjects over age 60 with poorer
performance in the right ears. The asymmetry of results was attributed to the "effect of cerebral dominance becoming evident in the degenerated central auditory pathways" (p. 232). These authors also stated that this occurs after age 60 because prior to that time "the compensatory mechanism of the centrencephalic system apparently prevents the effect of cerebral dominance" (p. 232) in filtered speech tasks.

A factor which may affect the performance of older subjects on auditory tasks was suggested by Potash and Jones (1977). They examined the performance of a young group of subjects (aged 18 to 22 years) and an older group of subjects (aged 55 to 64 years) on a signal detection task to determine if response bias/decision criteria differed as a function of age. The subjects, using a confidence rating scale, were required to report the detection of a pure tone set at intensities of 35, 50, or 65 dB SPL embedded in a noise stimulus. Results indicated "perfect sensitivity" to the tone at the various intensity levels by the younger subjects while sensitivity increased as a function of intensity in the older subjects. A second group of younger subjects was then tested using stimuli tones presented at lower intensity levels (20 and 30 dB) in attempt to make the tasks more comparable and thereby more accurately assess response bias. A comparison of the
Performance of the second group of younger subjects against that of the older subject group revealed that the older subjects were more conservative in their responses than the younger group even with a task of comparable difficulty.

Pestalozza and Shore (1955) evaluated 24 adults diagnosed as presbycusics with a variety of auditory tests and studied the records of 185 other elderly patients. On some auditory tests, the results of young hearing-impaired persons were also considered. The audiometric evaluation included pure tone thresholds, spondee thresholds, speech discrimination, a sentence threshold, a hearing aid evaluation, and a monaural loudness balance procedure to test for recruitment. They found a "very severe" discrimination loss in all older subjects with a positive relationship between hearing loss and discrimination loss. This relationship was not significantly affected by the presence of other health problems (cardiovascular disease, hypertension, metabolic disorders) or by a familial history of deafness. Similarly, in the younger patients, a positive relationship between hearing loss and discrimination loss was found but discrimination results of younger patients were better than those of older patients with the same amount of loss. Discrimination results were found to be independent of audiometric configuration in older patients but in younger patients, an increasing slope
on the audiogram resulted in poorer discrimination results. Audiometric configuration was reported to affect the agreement between pure tone average and speech reception threshold in patients with a steep audiometric slope but not in patients with flat or mildly sloping audiograms. Also, the relationship between pure tone results and speech reception thresholds was reported to be better in younger patients than in older patients where spondee thresholds were worse than pure tone thresholds. The discrimination problems exhibited by the older patients were also reported to extend to easier speech materials. No relationship was found between poor discrimination and hearing aid satisfaction nor was there a relationship between hearing aid satisfaction and gains observed using sentence material. No clear correlation was found between recruitment and poor discrimination. The authors did feel, however, that poor discrimination could more likely be predicted from the presence of recruitment than fair or good discrimination could be predicted from the absence of recruitment.

Glorig and Davis (1961) compared the audiometric results of adults at a variety of ages and with and without history of noise exposure to determine the relationship between noise exposure and aging. Results indicated that both aging and noise exposure could result in decreased
hearing sensitivity. However, they found the aging process to be independent of injury by noise stating that the "age effect continues during the development of the noise effect and after the noise effect is complete" (p. 566-567). They also suggested that once a worker had completed his permanent threshold shift, which they felt occurred after about 10 years, further damage by the precipitating noise or a less intense noise would not occur but exposure to a more intense noise would further increase the permanent threshold shift. Additionally, they found that a progressive high frequency loss beginning in middle life could be observed in some but not all individuals. Finally, they observed an absence of recruitment in what they termed "inner ear" presbycusis.

Knight and Margolis (1984) also could not demonstrate recruitment in older subjects. They studied five adults, between 20 and 42 years of age, with asymmetrical sensory-neural hearing losses of unknown etiology to determine that magnitude estimation and the Alternate Binaural Loudness Balance (ABLB) test yielded similar results of loudness growth (recruitment). They then compared 10 young normal subjects (aged 19 to 29 years) and 15 presbycusis subjects (aged 58 to 78 years) on a magnitude estimation task. The results indicated that the presbycusis subjects had steeper loudness functions than
the normal subjects but the difference only reached significance at 6000 Hertz. They, therefore, concluded that presbycuscics do not display notable loudness recruitment.

Blumenfeld et al. (1969) reported the results of 55 adults aged 27 to 82 years on a speech discrimination task presented in quiet and in noise. The Rhyme Test was presented monaurally to the subjects in quiet and in noise with a signal-to-noise ratio of zero. Additionally, a hearing handicap scale was also administered. Results indicated a reduction in speech discrimination skills with an increase in age, especially over age 60, but with little difference between the quiet and noise conditions. These authors also found a correlation between self-estimate of degree of hearing handicap and speech discrimination results.

McCroskey and Kasten (1982) evaluated older subjects on an auditory fusion task and on a rate-altered speech task. Auditory fusion results showed a decrease in performance as a result of age, beginning in the fifth decade. Rate-altered speech results indicated best response to stimuli presented at a slower than normal rate (125 words per minute vs. 175 words per minute). Results also indicated that second best response was to speech presented at an accelerated rate (231 words per minute).
These results were observed in elderly subjects who lived independently. With subjects who lived in nursing homes, a 20% improvement was observed for the 125 words per minute condition as compared to the 175 words per minute condition with no difference between the 175 and the 291 words per minute conditions. These researchers also reported a difference in performance as a result of age and type of stimulus material.

Yanz and Anderson (1984) used 10 young (aged 20 to 30 years) subjects and 10 older subjects (aged 65 to 75 years) to compare subjects' responses with their confidence ratings of the responses on a speech discrimination task. The stimuli consisted of the Northwestern Auditory Test No. 6 (NU 6) presented at 40 dB SL (re: SRT) in the presence of broadband noise at a signal-to-noise ratio of either zero (S/N = 0) or plus-five decibels (S/N = +5). Subjects gave written responses and rated their confidence in the accuracy of each response on a six-point scale with "1" being labeled "positive I'm correct" and "6" being labeled "positive I'm incorrect." An estimate of decision criterion based on previously established computational methods was also determined. Results indicated no difference between age groups on percentage correct on the speech discrimination task or on decision criterion. Young adults did show a significant improvement in the ability to
correctly judge accuracy of response as the task became easier (i.e., from $S/N = 0$ to $S/N = +5$); older adults did not. On the basis of this, the researchers concluded that "young subjects are more able than older subjects to adapt to and take advantage of an improvement in the acoustic environment" (p. 134).

Novak and Anderson (1982) determined masking level differences using a 500 Hertz signal presented binaurally in phase, 180 degrees out of phase, in phase in noise, and 180 degrees out of phase in noise. Five groups of subjects were included in the study: young normal hearing adults, old normal hearing adults, metabolic presbycusics, sensory presbycusics, and neural presbycusics. Results indicated that, compared to other groups, neural presbycusics had masking level differences which were significantly larger in quiet and significantly smaller in noise. This result led the authors to suggest that elevated internal noise levels may accompany neural presbycusics.

Nash and Wepman (1973) used adult males between 19 and 84 years of age as subjects in a study that considered the relationship(s) between age, status of hearing, auditory comprehension, memory, and "intelligence." Subjects, defined as having normal hearing, a conductive hearing loss, or a sensory-neural hearing loss, were evaluated using the Nash Auditory Comprehension Test. Auditory
memory was evaluated by the digit span subtest of the Wechsler Adult Intelligence Scale (WAIS). The authors considered years of education as a "rough approximation" of intelligence. Results of the study showed that age significantly correlated with education, auditory memory, and auditory comprehension. No correlation was observed between age and type of hearing loss. However, results did indicate a difference between type of hearing loss with age correlating with auditory comprehension, education, and memory at the .01 level for conductive loss. For sensory-neural loss, age correlated with auditory comprehension at the .01 level and with education at the .05 level. No correlation was observed between age and auditory memory for sensory-neural loss. The authors concluded that auditory comprehension is significantly related to age and more closely related to age than to education and/or memory. They also concluded that auditory comprehension declines with age even in the presence of an intact end organ.
CHAPTER III

PROCEDURES FOR COLLECTION OF DATA

Research Questions

The preponderance of evidence suggesting that the aging auditory system differs in both structure and function from the young auditory system, the indications that onset and progression of presbycusis differ according to gender, and the lack of normative data concerning the performance of older subjects on a closed-set time-compressed speech discrimination task have led to the following questions:

1. Does the performance of older subjects differ significantly from the performance of younger subjects on a closed-set time-compressed speech discrimination task?

2. Is there a significant gender difference which can be observed in the performance of older subjects on a closed-set time-compressed speech discrimination task?

3. If a significant gender difference does occur, can it be extended to include younger subjects also?
Significance of the Study

The use of any clinical tool in the diagnostic process necessitates the existence of data concerning expected performance for any population which might be evaluated with that given tool. As a clinical tool, time-compressed speech discrimination tasks have been found to be sensitive to disorders of the central auditory pathway, specifically to lesions in the temporal lobe contralateral to the test ear (Bocca, 1958). Traditionally, whether in a non-compressed or a time-compressed condition, speech discrimination skills of adults have been evaluated using an open-set, verbal response task. However, tasks requiring a verbal response may not be appropriate for all clients/patients.

The WIPI is a closed-set, forced-choice speech discrimination task which requires the client/patient to select a picture from a six-picture response matrix. Therefore, it is a useful clinical tool in evaluating speech discrimination skills of persons for whom a verbal response is not the best alternative. However, the WIPI was originally designed for use with hearing-impaired children and thus extensive data are not available concerning the performance of adults. This is especially true for the time-compressed version of the WIPI. The
proposed study could be considered significant in that it will provide preliminary data concerning the performance of older and younger adults of both genders on the time-compressed WIPI. These data can be considered prerequisite to the future development of adult norms for the time-compressed WIPI. If no significant age or gender differences exist, age and gender factors will not need to be considered when adult norms are established.

Definition of Terms

Many different methods have been used to present speech stimuli in a reduced amount of time and, as a result, speeded speech stimuli have been described in a variety of ways. Since it is the desire of this researcher to simulate use of time-compressed speech under clinical conditions, the time-compressed speech signal will be described in terms generally used in a clinical setting. Therefore, for the purposes of this study, the following definitions relating to time-compression will be used:

1. Time-compressed speech signals will be those which have been electronically altered to present the stimuli in a reduced amount of time without changing frequency information.

2. Zero percent time-compression refers to signals
which have not been time-compressed.

3. Thirty percent time-compression refers to signals which are delivered in 30% less time than the original signal.

4. Sixty percent time-compression refers to signals which are delivered in 60% less time than the original signal.

Basic Assumptions

It is assumed that the Word Intelligibility by Picture Identification (WIPI) is a valid and reliable instrument for evaluation of speech discrimination skills and that the four lists are equivalent (Lerman et al., 1965; Ross & Lerman, 1970, 1971). Additionally, it is assumed that since each subject serves as his own control, amount of hearing loss does not need to be considered as a variable. It is also assumed that since the stimulus words on the WIPI were selected to be appropriate for a preschool language level, subjects' language skills and/or amount of formal education need not be considered a variable. Finally, it is assumed that commercially available time-compressed versions of the WIPI are prepared in such a manner that they are hi-fidelity representations of the material and that the reported time-compression values are
accurate.

Subjects

Twenty-four individuals between the ages 18 and 38 and 24 individuals between the ages 50 and 70 served as subjects. There were 12 males and 12 females in each age group. Subjects were volunteers recruited from and through the student, faculty, and staff population of Arkansas State University. The mean age of the younger subjects was 27.7 years while the mean age of the older subjects was 58.9 years. Table 1 shows mean age for each subgroup: older males, older females, younger males, younger females.

Table 1

Subjects' Mean Age As a Function of Age Group and Gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Older</th>
<th>Younger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>58.3</td>
<td>27.3</td>
</tr>
<tr>
<td>Female</td>
<td>59.5</td>
<td>28.1</td>
</tr>
<tr>
<td>TOTAL (n=48)</td>
<td>58.9</td>
<td>27.7</td>
</tr>
</tbody>
</table>
Subjects were asked to fill out a one-page hearing history questionnaire (Appendix A) prior to participation in the study. Potential subjects with a history of ear surgery within the past year or with a history of noise exposure or ear infections within the past month were eliminated from the sample since these conditions might have resulted in fluctuating hearing levels. Potential subjects who reported previous extensive exposure to time-compressed speech stimuli or substantial experience with the WIPI were also eliminated from the sample. A total of seven potential subjects were eliminated from the sample: one for history of ear surgery, three for recent ear infections, one for recent noise exposure, and two for substantial experience with the WIPI and/or time-compressed speech.

Pure tone thresholds for the octave frequencies between 250 and 8000 Hz were obtained bilaterally on all subjects using the modified Hughson-Westlake method. Additionally, bilateral speech reception thresholds (SRT) using standard clinical procedures with monitored live voice were obtained for each subject. The responses of all subjects ranged between -10 decibels and 25 decibels with only one subject presenting SRT results at 25 decibels. The mean speech reception thresholds for both the older and the younger age groups were well within the clinically
accepted normal limits. The average pure tone thresholds for the test ear (selected on the basis of SRT results) for both younger subject subgroups were within clinically accepted normal limits at all frequencies tested. Figures 1 and 2 show average audiometric thresholds for the test ear for the two younger subgroups. The average pure tone thresholds for the older female subgroup were also within clinically accepted normal limits at all frequencies tested except 8000 Hertz. Figure 3 shows average pure tone audiometric thresholds for the older female subgroup. Similarly, the average thresholds for the older male
Figure 2. Average test ear pure tone thresholds for young female subjects.

Figure 3. Average test ear pure tone thresholds for older female subjects.
subgroup were also within clinically accepted normal limits at all frequencies tested with the exception of 4000 and 8000 Hertz. Figure 4 shows average audiometric thresholds for the older male subgroup. The older male subjects yielded average pure tone thresholds that were 5 to 15 decibels better than the older female subjects in the low frequencies, equal to the older female subjects at 2000 Hertz, and 10 to 15 decibels worse at 4000 and 8000 Hertz.

![Graph showing average audiometric thresholds](image)

**Figure 4.** Average test ear pure tone thresholds for older male subjects.

These results were consistent with the gender difference trends reported by Corso (1963). This suggests that, although the subject selection was non-random and therefore
not a true sample of the presbycusic population, the older subjects in this study displayed hearing loss trends reported by Corso to occur in a presbycusic population.

Since each subject served as his own control in each of the time-compression conditions, amount of hearing loss was not considered a variable in this study. However, potential subjects with an ear difference marked enough to require masking to ensure valid testing were not included in the study since the addition of masking noise, when necessary, could add a confounding variable for those subjects. Only one potential subject had to be eliminated on the basis of this criterion.

Limitations of the Study

The sample for this investigation is a non-random convenience sample. It is intended that maximum control of the collection and analysis of the data will overcome the study deficiencies due to lack of a random sample. Regardless, the results may not be generalizable to a population.

Equipment and Materials

Commercially prepared recordings of the Word
Intelligibility by Picture Identification (WIPI) speech discrimination test at zero percent, 30%, and 60% time-compression were employed as stimuli. The taped time-compressed stimuli were presented monaurally to subjects through TDH 49 headphones from a Madsen OB 822 Clinical Audiometer coupled to a Sony Model TC 377 reel-to-reel tape recorder. Calibration of the audiometer was checked against the ANSI, 1973 standards at regular intervals throughout the study to ensure that uniform presentation levels were maintained. A double-walled Tracoustics Model RS-254 sound-treated room with an acoustic environment suitable for threshold measurement according to the ANSI, 1977 standards provided the test environment.

The Word Intelligibility by Picture Identification (Ross & Lerman, 1971) consists of 100 different monosyllabic words divided into four lists of 25 words each. Stimulus words were selected on the basis that they be appropriate for the language skills of pre-school aged children. Only words that could be "adequately represented pictorially" were included. Subjects respond to an auditory presentation of a stimulus word by selecting the appropriate pictorial representation from a six-picture matrix. The stimulus book includes a practice plate and 25 test plates, each with a six-picture format. Each test
plate contains a pictorial representation of one of the stimuli from each of the four test lists plus two decoy pictures. The test stimuli and the decoys on any given plate are in some way acoustically similar (e.g. rhyming words, words containing the same vowel or words containing the same initial and/or final consonants). A sample test form including the four lists of test stimuli is found in Appendix B. A sample stimulus plate is found in Appendix C.

The WIP1 is reported to have test-retest reliability coefficients ranging from .87 to .94 for the four lists with standard error of measurement results for the four lists ranging from 4.74 to 7.74. The test authors state that "these results indicate that all four lists of the test are highly reliable with comparable reliabilities for all four lists" (Ross & Lerman, 1971, p. xi). The test authors also evaluated list equivalency by comparing means and standard deviations of the four lists and also determining Pearson product-moment correlation coefficients of the four lists. The only statistical significant difference in the comparison of means was found between lists III and IV at the .05 level. According to Ross and Lerman (1971), this 2.8 percent difference represents less than a one-word variation in the final score and thus, should not be considered clinically significant.
Additionally, the authors also found negative Pearson product-moment correlation coefficients between WIPI list scores and speech reception thresholds ranging from -.60 to -.65. These results are reported to be similar to those found with other speech discrimination tasks suggesting that the WIPI does "reflect valid differences in discrimination ability" (Ross & Lerman, 1971, p. xiii).

Procedures

All testing took place in the sound-treated booth via the TDH 49 headphones coupled to the Madsen OB 822 Audiometer. All instructions were given to the subjects at a comfortable listening level binaurally through the headphones. Each subject received bilateral pure tone threshold and speech reception threshold (SRT) testing initially. Time-compressed test stimuli were presented monaurally to the better ear as determined by the SRT. In instances where SRT results were identical for both ears, selection of test ear was based on pure tone results. For 20 subjects, the right ear was selected as the test ear. For the remaining 28 subjects, the left ear served as the test ear. Since no consistent ear effect has been demonstrated in the literature, no attempt was made to test an equal number of right and left ears.
Once the test ear had been determined, the subject was questioned to determine most comfortable loudness (MCL). The subjects were divided into two groups. Each group had six younger female subjects, six younger male subjects, six older female subjects, and six older male subjects. One group received the time-compressed (TC) WIPI stimuli in the following order: zero percent TC, 30% TC, 60% TC, zero percent TC. The other group received the stimuli at zero percent TC, 60% TC, 30% TC, and zero percent TC. Presentation of each of the four lists of the WIPI was alternated so that each subject received a different list in each of the time-compression conditions. Order of list presentation was counterbalanced so that no subject received the exact same combination of stimuli list and time-compression sequence as any other subject in the group. Every attempt was made to simulate standard clinical procedures in presentation of the time-compressed test stimuli and determination of pure tone and speech reception thresholds. Therefore time-compressed stimuli were presented at 40 dB SL (re: SRT) to the test ear. Since no subject indicated a tolerance problem for the stimuli at that presentation level, it was not necessary to alter presentation level to MCL for any subject.

For pure tone threshold testing, subjects were instructed to raise their hands each time they heard a tone
even if the tone was very soft. Pure tone thresholds were established using a modified Hughson-Westlake procedure recommended by Carhart and Jerger (1959) due to its simplicity to administer and its intratest reliability. For SRT testing, subjects were instructed to repeat the word they heard even if they had to guess. Pure tone and speech reception thresholds were recorded in a standard audiogram format. A copy of the form to be used in the study is found in Appendix D. A copy of the instructions given to the subjects is found in Appendix E.

Subjects listened to the taped WIPI stimuli presented to the designated ear and responded by pointing to the stimulus in the book of response plates which accompany the test. Responses were recorded on the standard WIPI test form. For the WIPI speech discrimination testing, subjects again were instructed to respond even if they had to guess. Additionally, however, they were told that some of the lists of words had been speeded up. A copy of the instructions given to the subjects concerning the WIPI is also found in Appendix E. The entire testing protocol (pure tone thresholds, SRT, MCL, WIPI) took between 30 and 45 minutes.
CHAPTER IV

RESULTS

Responses of each subject to the four WIPI lists were tabulated and a raw score from a possible 25 correct for each test condition (two time-compressed conditions and two non-compressed conditions) was determined. In Tables 2, 3, and 4 are mean scores on each of the four WIPI presentations by age, gender, and age and gender, respectively. A simple perusal of the results shows very little difference in mean scores between older and younger subjects collapsed across gender (Table 2) or between the male and female subjects collapsed across age (Table 3).

Table 2

Mean Scores of Subjects by Age On the Four WIPI Presentations

<table>
<thead>
<tr>
<th></th>
<th>0% TC</th>
<th>30% TC</th>
<th>60% TC</th>
<th>0% TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Older</td>
<td>24.8</td>
<td>24.6</td>
<td>20.3</td>
<td>24.9</td>
</tr>
<tr>
<td>Younger</td>
<td>24.9</td>
<td>24.3</td>
<td>22.4</td>
<td>25.0</td>
</tr>
</tbody>
</table>
Table 3

**Mean Scores of Subjects by Gender On the Four WIPI Presentations**

<table>
<thead>
<tr>
<th></th>
<th>0% TC</th>
<th>30% TC</th>
<th>60% TC</th>
<th>0% TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>24.7</td>
<td>24.2</td>
<td>20.8</td>
<td>25.0</td>
</tr>
<tr>
<td>Female</td>
<td>24.9</td>
<td>24.6</td>
<td>21.9</td>
<td>24.9</td>
</tr>
</tbody>
</table>

Similarly, very little difference was evidenced when the mean scores were considered by subgroups (Table 4). In no instance was the difference between age groups, between

Table 4

**Mean Scores of Subjects by Age and Gender On the Four WIPI Presentations**

<table>
<thead>
<tr>
<th></th>
<th>0% TC</th>
<th>30% TC</th>
<th>60% TC</th>
<th>0% TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Older</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>24.6</td>
<td>24.2</td>
<td>19.2</td>
<td>25.0</td>
</tr>
<tr>
<td>Female</td>
<td>25.0</td>
<td>24.9</td>
<td>21.4</td>
<td>24.9</td>
</tr>
<tr>
<td>Younger</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>24.9</td>
<td>24.2</td>
<td>22.4</td>
<td>25.0</td>
</tr>
<tr>
<td>Female</td>
<td>24.9</td>
<td>24.4</td>
<td>22.4</td>
<td>25.0</td>
</tr>
</tbody>
</table>
gender groups, or between age and gender subgroups greater than 3.2. This translates into a 12% difference as discrimination scores are generally interpreted in a clinical setting and would be considered at the upper limits of normal test-retest differences clinically.

In general, the average performance of the subjects appeared to decrease slightly as time-compression increased to 60% with changes in the 30% time-compressed condition and in the second non-compressed condition being negligible.

Initially, results from the second non-compressed condition (zero percent TC) were compared to results from the first non-compressed condition (zero percent TC) to determine if altered performance was present at the end of the session since the possibility of fatigue as a confounding factor, especially with the older subjects, had not been ruled out. A comparison of scores from presentation one and presentation four (the two non-compressed conditions) indicated that 87.5% of the subjects (n = 41) obtained identical perfect scores on the both non-compressed conditions with 10.4% (n = 5) obtaining an improvement to a perfect score on the second non-compressed condition. Based on an assumption that if fatigue were a factor it would result in a decrement of performance on the last presentation of the testing
protocol (the second zero percent TC condition), it seems unlikely that fatigue was a factor in subject performance in this study. Additionally, none of the subjects missed more than two items in either of the non-compressed conditions. This suggests that either subjects in this study had excellent speech discrimination or that the non-compressed version of the WIPI may not be a sensitive measure of speech discrimination in adults.
CHAPTER V

DISCUSSION AND CONCLUSIONS

Discussion

An examination of the data revealed several general trends. First, the average performance of all groups and subgroups in both non-compressed conditions was perfect or near perfect. Therefore, if differences in discrimination of non-compressed speech stimuli occurred in this sample, it was not evident on the basis of performance on this test.

Second, there was virtually no difference between the zero percent and the 30% time compression conditions for any group or subgroup. As with the case of the two non-compressed conditions, this suggests that either the test is not sensitive to discrimination differences resulting from time-compressing the signal 30% or that such differences did not occur. Third, as time-compression increased to 60% the mean performance of all subject groups and subgroups decreased but not to a magnitude that would be considered clinically significant in most cases. Further, it appeared very likely that subjects would obtain a perfect score in the second non-compressed condition.
regardless of what they scored in the first non-compressed condition. Only two subjects failed to obtain perfect scores in the second non-compressed condition and each of those only missed one item. Again, this suggests that (a) the subjects in this study had excellent speech discrimination for non-compressed speech stimuli, (b) the WIPI may not be a sensitive measure of discrimination in adults, or (c) a slight learning effect took place. The occurrence of a learning effect is the least likely explanation, however, since most subjects performed nearly as well in the first non-compressed condition. Finally, no age or gender differences could be demonstrated in performance on the WIPI in either the non-compressed or the time-compressed conditions. Although slight differences did exist between groups and subgroups (primarily in the performance of the older male subjects), it is doubtful that clinical interpretation of the results would find differences of this magnitude clinically significant.

There are several possible factors that might account for the results observed in this study. The most obvious would be lack of sensitivity of the instrument. Based on the information in the literature concerning the speech discrimination abilities of presbycusis adults, at least a slight decline in performance by the older subjects was to be expected. Since this decline in speech discrimination
did not occur, the sensitivity of the WIPI to detect expected decrements in performance of the older subjects must be questioned.

Another factor might be the subjects included in the study. First, the n may not have been sufficient for either the groups or the subgroups to demonstrate differences even if they were present. Second, the older subjects included in this study were overall well-educated and in excellent health. These factors may have made them atypical of older adults in general. Additionally, their hearing history was basically unremarkable. Although, only recent noise exposure and ear infections were controlled for during subject selection, very few of the subjects had notable histories of noise exposure and/or ear infections even in the distant past. This again may have made them atypical of older adults in general. Consequently, even with the average pure tone thresholds of the older subjects in this study being consistent with the trends found by Corso (1983), it is still possible that the hearing abilities which the subjects displayed were not sufficiently representative of the types and extent of hearing difficulties to be expected in presbycusis.

Also, results of the older subjects may have been influenced by the inclusion of subjects ranging in age from 50 to 60 years. As stated previously, Powers and
Powers (1978) have suggested that if presbycusis occurs, it is present by the sixth decade. However, it is possible that a presbycusis hearing loss in subjects in that age range may not have progressed to such an extent that speech discrimination skills have been compromised. Therefore, inclusion of these subjects may have resulted in average performances for the older group that skewed the data.

Additionally, there was no attempt to control for type of presbycusis. Generally, by definition, a reduction in speech discrimination abilities is included in the symptom complex described as presbycusis. However, in Schuknecht’s (1964) categorization of presbycusis into four types, only neural presbycusis was characterized by a decrease in speech discrimination not commensurate with the amount of hearing loss. Thus, if Schuknecht’s categories are considered, it is seemingly possible that the subjects in this study did not include a sufficient number of neural presbycusics for a reduction in speech discrimination skills to be expected.

Finally, it is possible that because of their experiences and/or educational backgrounds, the subjects in the sample were able to perform better than expected on the task. First, as occurs in an educational setting, many of the subjects had previous experience conducting or serving as subjects in research studies. Since subjects were
controlled for experience with time-compressed speech and/or with the WIPI but not for experience with research protocols in general, it is possible that previous research experience may have altered their response criteria and strategies. For example, the WIPI is a closed-set task with 25 response plates and only six choices per plate. Each plate contains one stimulus word from one of the WIPI lists plus two decoy items. Use of each plate is repeated if the subject receives more than one list. Since, new items are not added with subsequent uses of the same plate, the resulting effect is a decrease of the possible choices with each subsequent use of the response plate. Thus, while a test-wise subject may have a one-in-six chance of selecting the correct response with the first list presented, he may consciously or subconsciously realize that with the second presentation of the plate, the number of possible choices has been reduced to five. If such is the case, by the time the test-wise subject receives the fourth list presentation, each response plate may represent only a one-in-three choice. Second, most of the subjects in the study had daily experience in an educational situation which consists mainly of and relies heavily on the spoken word. It is possible that these experiences may have sharpened the subjects' listening and speech discrimination strategies by providing them with more
frequent opportunities for compensating for less than ideal speech signals. Finally, it is again possible that the test instrument was simply too easy for adults who have had the benefit of years of language experience.

Conclusions

The primary conclusion resulting from the perusal of the data is that the sensitivity of the Word Intelligibility by Picture Identification test in either a time-compressed or a non-compressed condition as a measure of discrimination in adults is questionable. Additional conclusions concerning the performance of adult subjects on a time-compressed closed-set speech discrimination task would be imprudent until the issue of sensitivity of the instrument has been resolved. This does, however, offer implications for future research.

Initially, performance of adults on the WIPI in both the non-compressed and the time-compressed conditions should be compared against their performance on another speech discrimination task which has already been normed with an adult population either to confirm or rule out the lack of sensitivity issue. Then, if the instrument is determined to be sensitive to discrimination differences in adults, results of a larger number of subjects with more
clearly defined age groups, more varied medical histories, and a wider variety of educational and life experiences should again be compared in an attempt to answer the research questions generated in this study.

If the issue of instrument sensitivity of the WIPI cannot be resolved, then future research should include attempts to develop a closed-set speech discrimination task that would be sensitive to speech discrimination disorders in adults and yet appropriate for adults whose language skills require a non-traditional method of assessing speech discrimination. Certainly, the difficulty of the task could be enhanced by increasing the number of response options from six to ten or twelve. Also, the difficulty of the task could be enhanced by selecting stimulus words which were more difficult. As stated previously, stimuli for the WIPI were selected to be picturable and appropriate for preschool children. Although the stimuli still need to be picturable and thus concrete, it seems plausible that words that are more difficult and therefore appropriate for older subjects could be selected as stimuli.

Finally, the issue of possible listening strategies of adults should be considered. It cannot be disputed that the older subjects in this study performed better than should be expected. If the test instrument is found to be sufficiently sensitive for an adult population, then the
subjects themselves must be examined to attempt to explain why their performance differed from the expected norm. Either the expectations for this age group are inappropriate, the subjects were atypical of their age group, or the subjects were able to apply strategies to this situation which had been developed under different circumstances.
APPENDIX A

Hearing History
<table>
<thead>
<tr>
<th>Question</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever been diagnosed as having a hearing loss?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, explain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you had a previous hearing test?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, explain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you been exposed to loud noise (heavy machinery, gunfire, loud music, etc.) in the past month?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you ever been exposed to loud noise?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, when and what type?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you had an earache or ear infection in the past month?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you have a history of earaches/ear infections?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, explain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you ever had ear surgery?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, when and what type?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you had any experience with time-compressed speech?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, explain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are you familiar with the Word Intelligibility by Picture Identification test?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, explain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do your ears ring?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, explain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you ever had any dizziness?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, explain</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX B

WIPI Score Sheet
<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>school</td>
<td>broom</td>
<td>moon</td>
<td>spoon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>bowl</td>
<td>bell</td>
<td>bow</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>smoke</td>
<td>coat</td>
<td>coke</td>
<td>goat</td>
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<td>fan</td>
<td>can</td>
<td>man</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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Score: __________  __________  __________
APPENDIX C

Sample Stimulus Plate from WIPI
PRACTICE SET
APPENDIX D

Audiogram Form
ARKANSAS STATE UNIVERSITY
CLINICAL SERVICES
P.O. BOX 489
STATE UNIVERSITY, ARKANSAS 72467-0489

AUDILOGIC EXAMINATION

NAME: ____________________________ AGE: ______ CASE NO: ______
TESTED BY: ________________________ DATE: __________ REFERRAL SOURCE: __________

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SOUND FIELD

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| Left           | SL  |%

SUMMARY

DNT = Did Not Test
CNT = Could Not Test
NR = No Response
AR = No Response

AIR CONDUCTION MASKING LEVEL

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BONE CONDUCTION MASKING LEVEL

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APPENDIX E

Instructions Given to Subjects
Instructions Given to Subjects

**Pure Tone Thresholds:** You are going to hear some tones. Some of them will be loud. Some will be very soft. Raise your hand every time you hear a tone, no matter how soft. Do you understand?

**Speech Reception Thresholds:** You are going to hear some words. They will be getting softer. Repeat the word you hear. It is OK if you have to guess. Do you understand?

**Time Compressed WIPI:** You are going to hear some lists of words. The words will be presented one at a time. Point to the picture of the word you hear. After you have chosen a picture, turn the page. Some of the lists are going to be very fast. If you have to guess, that is OK. Don’t worry if you are unsure of the word you heard, just select a picture that you think it might be. You will be given plenty of time between word presentations to make your selection. Do you understand?
To All Subjects:

You have been asked to participate in a study to determine the feasibility of clinical use of a speech discrimination test originally designed for use with children. Your participation is totally voluntary and there will be no penalty for refusal to participate or for withdrawal from the study at any time.

As part of the study, you will receive routine audiological testing (pure tone thresholds, speech reception thresholds, and speech discrimination). In addition, you will be asked to listen to lists of words which have been speeded up (also a standard audiomeric procedure). The entire procedure will take approximately 1 to 2 hours to complete (average time 1 hour, 20 minutes). All information obtained in the study will be strictly confidential. You will be verbally informed of the results of the hearing evaluation at the time of the testing. You may also have written copies of the hearing test results placed in the files at ASU Clinical Services, if you wish. They will then be available for you to obtain a copy or have copies sent to other persons or agencies.

Any questions concerning this study should be directed to Karen Patterson, Department of Special Education & Speech Pathology, Arkansas State University (Office: ED 341, Ext. 3061).

I have read and understand the above informed consent statement.

Signature Date

OPTIONAL

I wish to have a copy of my hearing test results placed in the clinic files at ASU Clinical Services. I understand that these results will be treated with the same confidentiality as all clinical records kept at ASU Clinical Services and that they will not be released to anyone without my written permission.

Signature Date

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