NORMAL HEARING CHILDREN'S INTELLIGIBILITY ON TIME COMPRESSED CONDITIONS OF THE WIPI

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ABSTRACT

NORMAL HEARING CHILDREN'S INTELLIGIBILITY ON TIME COMPRESSED CONDITIONS OF THE WIPI

By

Paula Jane Shoup

In the area of speech perception, the use of time compressed speech has been the focus of several investigations. The purpose of such studies has been to investigate the effect of temporal alteration, by time compression, upon the auditory perception of speech signals.

Time compressed speech stimuli have recently become an effective diagnostic tool in determining auditory perceptual abilities of various subject populations. Most of this research has provided data for adult listeners. However, a large percentage of the total population seen for speech and language and hearing evaluations is comprised of children. Little information is available to indicate how normal hearing children, as well as other subject populations of children, perform on standard speech discrimination tasks under time compressed conditions.

This study investigated the effect of time compression on normal hearing children's performance using an appropriate standard speech discrimination measure, the Word Intelligibility by Picture Identification (WIPI) test. A total of ninety subjects divided into three age groups (4, 6, and 8 years) were each presented four lists of the WIPI under time compressed conditions of 0%, 30% and 60% at two sensation levels, 32 dB and 16 dB. Each subject received a 0% time compressed

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condition prior to either a 30% or 60% condition. Two lists were presented at 32 dB SL prior to presentations at 16 dB SL. Four practice items preceded each list in order to familiarize each subject to the time compressed stimuli. Stimuli were presented under rearphones, with an equal number of right and left ears tested.

The mean percentage correct scores for each of the three age groups under each condition of time compression and sensation level were computed. Right ear scores and left ear scores were compared. The most frequently missed words for each age group were determined.

General results of the study indicated that scores improved as age increased. In addition, scores decreased as the percentage of time compression increased and as sensation level was decreased from 32 dB to 16 dB. Minimal right versus left ear score differences were found, but no consistent trends were noted. Scores for each of the four lists of the WIPI were compared. Results of the present study were discussed with reference to previous investigations using subject populations of children and time compressed speech stimuli.

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A THESIS

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I would like to thank the many parents and children from the Lansing area for their interest and participation in this study ---- and especially a mischievous four year old who shall long be remembered for his "performance."

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CHAPTER I

INTRODUCTION

The area of time compressed, or accelerated, speech has been the topic of several investigations in the area of speech perception. The primary objective of these studies has been to investigate the effect of temporal alterations via time compression upon the auditory perception of speech signals.

Most of the research dealing with the perception of time compressed speech has provided data for adult listeners. The effect of time compression on the performance of normal hearing adults as well as hearing impaired adult populations and brain damaged adult populations has been determined. Time compressed speech stimuli have become an effective diagnostic tool to determine the auditory perceptual abilities of these populations.

In addition to adults, however, a large percentage of the total population seen for speech and language and hearing evaluations is comprised of children. A paucity of information is available to indicate how normal children perform as compared to adult populations when listening to temporally distorted, or time compressed, speech. No research investigating the effect of time compression upon the auditory perception of hearing impaired, learning disabled, or brain damaged children has been completed. Therefore, no information exists to relate the performance of these populations to a normal population. This thesis concerns the effect of time compression on normal children's performance using a standard speech discrimination measure.

Historical Aspects of Time Compression

Previous investigations have demonstrated that temporal factors affect the listener's auditory perception of speech stimuli (Aaronson, 1967; Beasley and Shriner, 1973). Two of these factors which have been shown to be important in auditory perception are the rate at which stimuli are presented and the duration of the stimuli (Aaronson, 1967). In a time compressed condition, both the rate of presentation and stimulus duration are altered from the original signal in that the rate of signal presentation increases and stimuli duration decreases.

Early attempts to study the effects of time compression resulted in undesirable acoustic characteristics of the speech signal associated with the method of time compression used. For example, one method used was that of speaking at a more rapid rate. Although a simple procedure involving no special equipment, this method resulted in undesirable changes in articulation and inflection. Furthermore, the range of compression was limited, since the average speaker cannot produce intelligible speech at a rate greater than approximately 30% of normal (Calearo and Lazzaroni, 1957; deQuiros, 1964). Additionally, it is difficult for the speaker to speak at a rate which does not fluctuate, especially for long units of stimuli.

An additional method of increasing the rate of speech signal presentation was to tape record the original signal and replay it at a speed faster than the original recording (Fletcher, 1929; Foulke, 1966; Garvey, 1953; Klumpp and Webster, 1961). Again, this was a simple, inexpensive procedure, but it resulted in an undesirable upward shift in frequency.

Sampling methods in which a segment of the original signal is removed have been shown to have the advantage of minimizing the shift in vocal frequency. Miller and Licklider (1950) used a rapid switching arrangement that permitted the speech signal, in this case monosyllabic words, to be turned off and on periodically, thus eliminating a certain percentage of the original signal. They did not remove the silent or "off" periods from their signal, so total presentation time was unchanged, although the actual duration or "on" portion of the stimulus word decreased.

Garvey (1953) used a manual sampling method in which samples of the original signal were removed. He accomplished this by manually splicing out small segments of a taped signal and joining the remaining segments together. Although this method permits a specific portion of the signal to be removed or retained, it was found to be excessively tedious and time-consuming.

An electromechanical means of sampling speech was developed by Fairbanks, Everitt, and Jaeger (1954). This speech compressor made use of a tape loop onto which a signal was recorded. This loop then passed over a rotating head assembly comprised of four record heads, at which point portions of the signal were retained and recorded onto a variable speed tape recorder. This method permitted high quality compression up to 80% time compression with minimal pitch distortion.

Compressors which accomplish a similar effect as the compressor developed by Fairbanks et al. include the Lexicon Varispeech I (Lee, 1972). This portable apparatus uses cassette tapes and is considerably less expensive and easier to operate than the Fairbanks' compressor. Essentially, the Varispeech I is comprised of a Wollensak tape recorder and an analogue mini-computer. The signal is recorded on the Wollensak and compression or expansion is achieved via the mini-computer.

Standard-size computers and speech synthesizers have also been utilized to study the effects of time compression. In addition to the advantages of other electromechanical compressors, this method allows for selective discarding when processing the signal. These methods are, however, very expensive and as yet in the developmental stage.

Intelligibility of Time Compressed Speech: Adults

Two factors of speech and language which have been investigated under time compression are the intelligibility (Garvey, 1953; Fairbanks and Kodman, 1957; Luterman et al., 1966; Daniloff, et al., 1968; Sticht and Gray, 1969; Beasley et al., 1972a, 1972b; and Konkle et al., 1974) and the comprehension (Fairbanks et al., 1957a, 1957b, 1957c; Foulke et al., 1962) of the time compressed speech signal.

Intelligibility is measured by testing the listener's ability to repeat a brief message, usually words or sentences, accurately. This may be tested by an oral or written response and is usually expressed as a percentage of correctly identified items. Comprehension is examined by presenting a selection auditorily at a time compressed rate to the listener and subsequently testing him on the information contained within the selection. Objective tests are generally used to obtain the comprehension score.

Garvey (1953) using the manual sampling, or "chop-splice," method to achieve temporally accelerated speech, investigated the effect of acceleration upon the intelligibility of spondee words. Results indicated that intelligibility scores remained high even at a rapid rate of acceleration. Scores remained above 95% for rates up to two times (50% compressed) the original signal rate. Mean intelligibility scores did not drop below 80% until 67% time compression was achieved, and did not fall below 50% until a 75% time compression rate was attained. Garvey compared these results to those obtained by accelerating the signal by the fast-play method with its associated upward shift in frequency. At two times the original rate, or 50% time compressed, using the fast-play procedures, 65% intelligibility scores resulted (compared to 95% for manually compressed speech). Scores dropped below 10% for 2.5 times the speed of the original message (compared to 93% for manually compressed speech).

Fairbanks and Kodman (1957) also investigated the effect of time compression upon speech intelligibility at rates varying from 40% to 90% time compression. Phonetically balanced (PB) words were processed using the Fairbanks' compressor to achieve the desired experimental conditions. The intervals of discard, that is the duration of the segments removed from the speech signal, were also varied in duration.

In addition, listeners received training to familiarize them with the vocabulary used during the investigation. For the shorter discard intervals, intelligibility remained at 90% or better for rates of time compression up to nearly 80%. The authors concluded that if intelligibility is to vary primarily as a function of the compressed signal duration, then a discard interval which is short in relation to the signal unit is required.

The effect of time compression with and without frequency distortion was investigated by Daniloff, Shriner, and Zemlin (1968). Stimuli were eleven different vowels produced in the /h-V-d/ context. Experimental conditions were derived using the compressor developed by Fairbanks et al. (1954). Both a male and female speaker were used to determine if speaker-sex differences would occur under the experimental conditions of the study. Time compression values used were 30% to 80%, with each successive condition increasing in 10% steps. Results indicated that time compressed vowels were more intelligible at all conditions than were frequency distorted vowels. In contrast to the Fairbanks and Kodman (1957) study, a rapid decline in intelligibility was noted at 70% time compression instead of the previously reported 80%. However, Fairbanks and Kodman used a discard interval of 10 msec and trained listeners, whereas Daniloff et al. used a discard interval of 20 msec and unsophisticated listeners. In terms of speaker-sex differences, the female speaker was generally more intelligible than the male for all conditions of frequency and time distortion. Similar vowel confusions were noted for both speakers. Results showed that duration was a critical factor in the intelligibility of vowels (i.e., a "long" vowel when time compressed was often mis-identified as a "medium" length or "short" vowel.) In addition, the rapid linear decline of vowel intelligibility in conditions of greater than 30% frequency distortion indicated that frequency is not redundant in the sense that duration is for vowels.

Beasley, Schwimmer, and Rintelmann (1972b) studied the effect of time compression upon the intelligibility of CNC monosyllables. The authors presented to normal adult listeners four lists of Form B of the Northwestern University Auditory Test #6 (NU-6) (Tillman and Carhart, 1966) at 0%, 30%, 40%, 50%, 60% and 70% time compression rates. In addition, four sensation levels (8, 16, 24, 32 dB) were used, and the effect of ear differences was also investigated. Results indicated a gradual decrease in intelligibility scores until the 70% time compression condition, at which point a marked decrease in intelligibility occurred. As sensation level increased, intelligibility also increased. Ear differences were found to be minimal.

A similar study was conducted by Beasley, Forman, and Rintelmann (1972a). Using the same test stimuli (NU-6) and normal listeners as subjects, the effect of a higher sensation level, 40 dB, was investigated under time compressed conditions. Results indicated a slight, non-significant improvement in scores.

In addition to the young adult, normal hearing populations used as subjects in the preceding studies, several investigators have studied the effects of time compression upon aging and/or pathological populations.

Time compressed speech stimuli have been employed in diagnostic audiology in accordance with the 'subtelty principle' presented by Jerger (1960). Jerger hypothesized that as auditory pathways increase in complexity, the stimuli needed to adequately study these pathways must also increase in complexity. Related to this concept are the findings that persons with a damaged auditory cortex may still perform well on standard non-distorted speech discrimination measures and pure tone tasks. These results are due to the intrinsic redundancy of the hearing mechanism as well as the extrinsic redundancy of the signal (Calearo and Lazzaroni, 1957).

To reduce the extrinsic redundancy of the signal, speech has been distorted by various methods, including time compression. The use of time compression is based upon the assumption that time plays a significant role in auditory perception. Results indicating a use for accelerated speech in the diagnosis of lesions in the central auditory pathway were presented by Calearo and Lazzaroni (1957). In addition, an investigation by deQuiros (1964) determined that time compressed speech could be useful in the differential diagnosis of auditory disorders.

Luterman, Welsh, and Melrose (1966) investigated the effects of age and sensori-neural hearing loss upon the intelligibility of time compressed speech using normal hearing adults, young adult sensori-neural impaired, and aging sensori-neural impaired subjects. The CID W-22 test of auditory discrimination was presented at ratios of 10% and 20% compression and 10% and 20% time expansion. Both the time compressed and the time expanded conditions yielded a slight decrease in intelligibility scores. The normal hearing group scored higher than the young sensori-neural group, which, in turn, scored higher than the aging sensori-neural group. The authors suggested, however, that the manner of performance of the aged population was not significantly different from that of the other two groups for the two levels of compression and expansion.

Sticht and Gray (1969) investigated the intelligibility of time compressed words for young (under 60 years) and old (over 60 years) sensori-neural and normal hearing populations. Time compression rates presented were 0%, 36%, 46% and 59%. Stimuli were the words from the CID W-22 lists. Results showed that age, for both the normal and sensori-neural impaired hearing groups, increased the number of discrimination errors. It was determined that the main effects of hearing ability, age and amount of compression were highly significant. The authors concluded that aged populations have special difficulty in discriminating accelerated speech, and additionally that sensori-neural hearing impairment was not a necessary requisite to a decrement in the intelligibility of temporally altered speech for the aged. A similar result was found by Konkle, Beasley and Bess (1974). Konkle et al. studied the effect of time compressed speech upon the intelligibility of different age groups of elderly subjects. Subjects ranged in age from 54 to 74 years and exhibited normal pure-tone hearing thresholds. Word lists of the NU-6 auditory test were presented under conditions of 0%, 20%, 40% and 60% time compression. Three sensation levels (24, 32 and 40dB) were investigated. Results indicated poorer scores as age increased and also as time compression increased. In addition, scores improved as sensation level increased. The authors concluded that, in accordance with the Sticht and Gray results, perceptual difficulty with accelerated speech increases as a function of age.

Although the Beasley et al. (1972a, 1972b) data showed minimal differences between right and left ear scores for normal hearing adult listeners, different results may be expected for certain pathological groups. Kurdziel and Noffsinger (1972) investigated the intelligibility of time compressed speech using adults with cortical brain damage as subjects. Although their data indicated no significant differences between contralateral and ipsilateral ears (re: the cortical brain damage) using conventional pure tone, special pure tone, and non-distorted speech audiometry tests, they did observe that at 60% time compression, scores for the ear contralateral to the damage showed poorer scores, than the ipsilateral ear. These results indicated the usefulness of time compression as a detection method for lesions of the auditory cortex.

These selected studies indicated that not only did the method and rate of time compression affect the resulting intelligibility scores, but that additional factors must also be considered. The subject population, the sophistication of the listeners, the sensation level at which the stimuli are presented, the discard interval, and speaker-sex differences may also influence the resulting intelligibility scores of time compressed speech.

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Intelligibility of Time Compressed Speech: Children

Most of the studies related to the use of time compressed speech in audiological evaluation have used normal hearing young adults as their populations. Investigations using children as subjects have been few in number, yet children comprise a significant percentage of the population seen for audiological and speech and language evaluations. To investigate the effect of time compression upon children's auditory perception of speech, appropriate stimuli must be used.

One measure of speech discrimination frequently used in audiological testing with children is the Word Intelligibility by Picture Identification (WIPI) test (Ross and Lerman, 1970). The test was developed to assess the speech discrimination ability of hearing-impaired children. In developing a test particularly appropriate for children, the authors alleviated problems associated with conventional speech discrimination tests by using words which were familiar to children. Further, a picture-pointing response was required of the child, thus avoiding the problem of articulation errors which could yield a misinterpreted or unintelligible oral response. The entire test consisted of four lists of twenty-five plates of six pictures each with only four of the pictures on each plate used as test stimuli. The other two pictures served as foils. Each test list consisted of different test stimuli arranged so that no stimulus item was used on more than one list.

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discrimination data for normal hearing children using discrimination measures developed for use with children. One of the measures used was the WIPI. Subjects were sixty children grouped by age from 3 1/2 to 11 1/2 years of age with an interval of two years between each group. Sanderson and Rintelmann concluded that the WIPI was particularly appropriate for the 3 1/2 year old group. The authors indicated that tasks requiring an oral response could be used with 5 1/2 year old subjects who demonstrated adequate speech and language abilities.

Beasley et al. (1975) studied the effect of time compression upon normal hearing children's perception of verbal stimuli using the WIPI and an additional speech discrimination measure. Three conditions of time compression, 0%, 30% and 60%, presented in sound field at two sensation levels, 16 dB and 32 dB, were investigated using sixty subjects divided into three age groups (4, 6 and 8 years). Results indicated that time compressed speech discrimination ability increased as age increased and as sensation level increased. Discrimination ability was found to decrease as the percentage of time compression increased for both sensation levels. At 30% time compression scores were slightly lower than those at 0%; however, a marked decrease in scores, especially for the more difficult 16 dB SL condition, occurred at 60% time compression. Scores at 32 dB SL, as compared to 16 dB SL, were generally improved, with the greatest improvement found at the 60% time compression condition. An exception to this effect was noted for the 8 year old subjects where the higher sensation level resulted in increased scores by approximately the same amount for all rates of time compression. As time compression increased, age groups were divided by increasingly larger amounts. However, more differences occurred between the 4 and 6 year old groups than between the 6 and 8 year olds. Overall, the greatest score differences occured between the 6 and 8 year olds at 16 dB SL at 60% time compression.

Additional research is warranted to further investigate normal children's perception of time compressed speech stimuli. Additional factors, such as right/left ear differences, should be included to determine if ear advantages exist in normal hearing children. Populations of hearing-impaired, learning disabled, and brain damaged children should be included as subject groups in studies of time compression to determine differences in their performance as compared to normal populations.

Statement of the Problem

Several investigations have determined the effects of temporally distorted stimuli upon normal hearing adults, hearing-impaired adults, and adult populations with cortical brain damage (Beasley et al., 1972a, 1972b; Fairbanks et al., 1957a, 1957b, 1957c; Garvey, 1953; Klumpp and Webster, 1961; Konkle et al., 1974; Kurdziel and Noffsinger, 1972; Luterman et al., 1966 and Sticht and Gray, 1969).

A minimal amount of research regarding the effects of time compression with normal hearing children exists in the literature (Beasley et al., 1975). General results of the Beasley et al. study show that discrimination scores decrease as a function of time compression but increase as a function of age and sensation level.

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In comparing their scores under the 0% time compressed condition with those of Sanderson and Rintelmann (1971), Beasley et al. found their results to be lower. One explanation suggested by Beasley et al. for the lower scores was the different procedures for determining SRT values. Sanderson and Rintelmann's procedure resulted in a greater number of words being presented, possibly leading to fatigue and a higher SRT score. The SRT procedures used in the present study were the same as those of Beasley et al. to allow for the presentation of fewer spondee words, thus lessening the chance for fatigue and resulting in an inaccurate SRT value.

The random presentation order of both sensation level and time compressed conditions used in the Beasley et al. study probably resulted in undue variability of results. Procedures of the present study were more like those normally used in a clinical setting. The WIPI, a closed set discrimination measure, was presented since this discrimination task has been shown to be particularly appropriate for the ages of the subject population of the present study especially under time compressed conditions (Beasley et al., 1975). No subject received more than four lists of the WIPI, thus eliminating any repetition of lists. Additionally, each subject received a zero percent time compressed condition prior to either a 30% or 60% condition. Subjects received two lists at 32 dB SL prior to presentations at 16 dB SL. Four practice items preceding each list were included to familiarize each subject to the time compression stimuli.

Subjects were presented stimuli under earphones rather than in sound field as in the Beasley et al. study. Equal numbers of right and left ears were tested. Although the Beasley et al. (1972a, 1972b) data indicated minimal differences between right and left ear scores for normal hearing adult listeners, different results may be expected for certain pathological groups, as indicated by the Kurdziel and Noffsinger (1972) study. Data for children responding to time compressed speech under earphones have not been established; therefore, normative data do not exist as a comparative measure. Nor have data been reported to show differences, if they exist, between scores obtained from the right and left ear.

In summary, the purpose of this study was to determine the effect of time compression upon normal hearing children's intelligibility of a closed set speech discrimination measure. Stimuli were presented under earphones at two sensation levels.

Specifically, the following questions were investigated:

1. What effects would time compressed conditions of 0%, 30% and 60% have upon normal hearing children's speech intelligibility scores using a standard speech discrimination measure (WIPI)?
2. Would these effects differ for age level (4, 6 and 8 year olds), sensation level (16 and 32 dB), and/or right and left ear?
3. How would the results of the present study compare to previous findings with normal hearing populations using time compressed conditions?

CHAPTER II

EXPERIMENTAL PROCEDURES

Ninety normal hearing children in three age groups were presented the Word Intelligibility by Picture Identification (WIPI) speech discrimination measure under earphones at three conditions of time compression (0%, 30%, and 60%) and two sensation levels (16 dB and 32 dB).

Subjects

Ninety normal hearing children with normal intelligence were the subjects of this study. Thirty children each comprised the following groups: Group I, age 3 years-6 months to 4 years-6 months ($\bar{M}$ = 4 years-0 months); Group II, age 5 years-6 months to 6 years-6 months ($\bar{M}$ = 6 years-0 months); Group III, age 7 years-6 months to 8 years-6 months ($\bar{M}$ = 8 years-0 months).

In order to qualify as a subject for the experiment, each child was given individually a bilateral pure tone air conduction screening test at 20 dB (re: ISO 1964) for the following frequencies: 125, 250, 500, 1000, 2000, 4000, and 8000 Hz. Any child who did not pass all frequencies for each ear was not included in the study.

The experimenter conversed with each child prior to the determination of the Speech Reception Threshold (SRT) so that any deviant articulations could be noted and did not affect those responses accepeted as correct. In addition, the University of Akron Articulation Identification

Test was also administered to each subject to determine articulation errors.

Preparation of Experimental Tapes

The four lists of the Word Intelligibility by Picture Identification (WIPI) test of speech discrimination were recorded by a male, General American, experienced speaker. The speaker exhibited normal fundamental frequency ($f_{o_{avg}}$ = 105) and speaking rate (155 wpm reading rate).

The tapes were recorded on an Ampex AG 440-B tape recorder (frequency response ± 2 dB 50-15,000 Hz). The speaker was seated in a single-walled recording booth with a two-way window. An Electro Voice (Type 635A) microphone was used throughout the recording procedures.

A VU meter was positioned inside the recording booth so that the speaker was able to note the level at which he was speaking. This VU meter was adjusted to correspond to the reading of the VU meter of the Ampex AG 440-B tape recorder. Two experienced observers monitored the level of each speech production as indicated on the VU meter of the Ampex recorder.

Each item of the WIPI was produced three times by the speaker. The carrier phrase "Show me..." preceded each test item. The speaker was instructed to peak his productions of the carrier phrase between 0 and -2 dB, and then produce the stimulus word using natural prosodic cues. If either of the two observers or the speaker was not satisfied with at least one of the three productions, the speaker reproduced the item until a satisfactory production was achieved. Four practice items and identifying information for each list of the WIPI, as well as for each test condition, was also recorded. (Practice itmes for each list are indicated in Appendix A.)

Prior to the recording of the test stimuli, a sweep tone (50-15,000 Hz) and a 60 sec 1000 Hz calibration tone were recorded onto the master experimental tape. A Bruel and Kjaer Sine-Random Generator (Type 1024) was utilized for this procedure. The recording of the calibration tone and the test stimuli was monitored by TDH 39 headphones with MX 41/AR cushions connected to the Ampex AG 600-2 recorder.

To record the test stimuli, the tape was auditorially and visually monitored by two observers using earphones and a Bruel and Kjaer Electronic (Voltmeter (Type 2409) to select the most appropriate test stimuli from each group of the recorded items. These items were copied from an Ampex AG 440-B tape recorder, via the Bruel and Kjaer Electronic Voltmeter, to an Ampex AG 600-2 tape recorder (frequency response ± 2 dB 50-15,000 Hz) in order to create the experimental master tape.

The master tape was then recorded from the Ampex AG 600-2 recorder to a cassette tape using a Sony Solid State/Cassette-Corder (Type TC 180 AV). The three test conditions of 0%, 30%, and 60% time compression were made from the cassette tape using the Lexicon Varispeech I time compressor (Lee, 1972).

A Beckman 6148 Eput and Timer (frequency counter) was connected to the Lexicon Varispeech I to determine the frequency of the pure tone recording on the cassette tape. Frequency values for each percentage of compression were determined according to the following formula:

$$\frac{100 - \%\ \text{time compression}}{1000} = \frac{1000}{x}$$

Therefore, when using a 1000 Hz pure tone for calibration, the appropriate frequency reading was 1000 Hz at 0% time compression, 1428 Hz at 30% time compression, and 2500 Hz at 60% time compression. The appropriate frequency count for each of the rates of time compression was maintained for at least eight of ten readings displayed on the Beckman instrument.

The pitch-restoring computer of the Lexicon Varispeech I time compressor was not activated during this calibration procedure so that a higher frequency output resulted as the percentage of compression increased from 0%.

Following the calibration procedures, the time compressed stimuli were recorded onto magnetic tape using the Ampex AG 600-2 tape recorder from the Lexicon Varispeech I. In order for the frequency (pitch) to be restored to normal during the time compression procedures, the computer of the Lexicon Varispeech I was activated.

Following the completion of the above recording procedures, the intervals between stimulus items of the time compressed conditions were spliced from the tape. Between each item the magnetic tape was removed and replaced with leader tape. Each section of leader tape spliced onto the tape was approximately 30 inches long, equivalent to four seconds in duration when played at a speed of 7 1/2 inches per second. Color coded leader tape was spliced between the three time compression conditions and between each of the WIPI lists in order to permit the experimenter easy identification and location of each list and each condition.

Testing Procedures

Each subject was tested in a two-room double walled, sound treated audiometric suite (IAC series 1200). The rooms of the testing suite were divided by a window which allowed the subject and the examiner to be in view of each other.

A Beltone Model 15C Clinical Audiometer was used for pure tone screening. For each test presentation, the taped signal was directed from an Ampex AG 600-2 tape recorder through a Grason-Stadler Model 162 Speech Audiometer to the accompanying TDH 39 earphones with MX 41/AR cushions. The 1000 Hz calibration tone of the recording was adjusted so that the VU meter of the speech audiometer indicated a reading of 0 dB. Preceding each testing day, the Beltone and Grason-Stadler audiometers were calibrated to meet established standards (ANSI, 1969). (Calibration procedures and instrumentation are included in Appendix B).

Following the hearing screening test, the Speech Reception Threshold (SRT) for either right or left ear of each subject was determined using earphones. The same earphone was used for both right and left ears. A recorded list of the Utley Children's Spondees (Utley, 1951) was used for this procedure. The taped spondees were directed from an Ampex AG 600-2 tape recorder through the Grason-Stadler Model 162

Speech Audiometer to the accompanying earphone. Prior to the establishment of the SRT, each subject was instructed to repeat each spondee word as the examiner read the list. A short screening test of articulation was also given, and the examiner determined if articulatory production would affect test responses.

Directions read to each subject before obtaining the SRT were as follow:

> I'm going to say some words and I'd like to have you say the words after me... Now you'll hear the words coming from here (experimenter points to the earphone). Some of the words will be very soft so listen carefully and say the word you think the man said. I will be sitting in the next room, but I can still hear you.

Following these directions, any questions the subject had were answered.

The SRT for each subject was determined according to the following procedures as described by Beasley et al. (1975):

> The intensity level for presentation of the spondees was set at 20 dB to 30 dB HL initially and was decreased in 4 dB steps following word presentations at each level. Initially, two words were presented at each level until the point where the subject began to respond incorrectly. From that point a maximum of four words was presented at each level. In this manner, determination was made of the lowest intensity level at which the subject could repeat 50% of the words presented, that is, at least two out of four words presented.

Subject responses for the SRT were monitored through an earphone connected to the speech audiometer.

Following these procedures, the experimental conditions were presented. The subjects were randomly assigned to either a right ear or left ear condition. Each subject received the following instructions.

> Here are some pages that have pictures on them. In a few minutes you will hear a man telling you what pictures to show me on the page. Some of the time he may sound funny or different but look at the pictures on the page then point to the picture he tells you to show me.

For each list under each time compressed condition, four practic items preceded the actual test stimuli so that the subject was familiarized with listening to each percentage of time compression presented.

During the presentation of the experimental tape, the examiner remained in the room with the subject. An assistant controlled the tape recorder, stopping the presentations temporarily if the subject needed a longer time to respond between stimuli.

The following six experimental conditions were presented in this study:

0% time compression at 16 dB SL
30% time compression at 16 dB SL
60% time compression at 16 dB SL
0% time compression at 32 dB SL
30% time compression at 32 dB SL
60% time compression at 32 dB SL

The values for the 16 and 32 dB SL conditions were determined from each subject's SRT score.

Each age group of subjects received presentations at both 16 and 32 dB SL. In addition, each subject in each of the groups received two time compressed conditions, either 0% and 30% or 0% and 60%, so that each list of the WIPI was used a maximum of one time per subject. The 0% condition was always presented first to each subject, as this is the clinical procedure generally used. Each subject received two lists of the WIPI at the 32 dB SL condition prior to the presentation of lists at 16 dB SL. Order of presentation of the four test lists was rotated.

Individual data sheets were completed for each subject listing basic identifying information, SRT scores, experimental conditions presented, and scores for each experimental condition. (See Appendix C) A response sheet was also completed for each subject, indicating correct responses and incorrect responses (See Appendix D.)

The mean percentage scores for each of the three subject groups under each condition of time compression, age and sensation level were computed. Scores obtained by right and left ears were compared to see if any differences resulted. The ten most frequently missed words for each age group were also determined. Data were compared with previous investigations.

CHAPTER III

RESULTS

Results of the study showed that scores decreased as the percentage of time compression increased. The 32 dB SL presentation resulted in better scores than presentations at 16 dB SL. Higher scores were found as age increased from four to eight years. Minimal right versus left ear differences were found, but no consistent trends were observed. Scores by list were compared, and the ten most frequently missed test words for each age group were computed. The results of the study can be found in Tables one through six.

Time Compression and Sensation Level

As the rate of time compression increased from 0% to 60%, the mean percent scores decreased under both sensation levels (See Table 1). For both sensation levels, only a slight decrease in scores was noted at 30% time compression. However, at 60% time compression, the mean scores were generally much poorer, particularly at the 16 dB sensation level.

Scores increased at all three time compression conditions as the sensation level was increased from 16 to 32 dB, a finding similar to that of Beasley, Maki, and Orchik (1975). However, Beasley et al. found that there was a major improvement in scores at the 60% time

TABLE 1. Mean intelligibility scores in percent on the WIPI for each age level, sensation level, time compression percentage and right and left ear presentations.

16 dB SL	Time Compression											
	0%			30%			60%			Total		
Age	Left	Right	Total	Left	Right	Total	Left	Right	Total	Left	Right	Total
4	81.1	80.8	80.9	79.5	78.8	79.2	69.1	61.5	65.0	76.6	73.7	75.0
6	88.8	91.2	90.0	89.5	87.4	88.5	74.8	77.0	76.0	84.4	85.2	84.8
8	92.3	89.6	90.9	90.0	90.8	90.4	89.7	85.0	87.2	90.6	88.4	89.5
Total $\overline{M}$	87.4	87.2	87.2	86.3	85.7	86.0	77.8	74.5	76.0	83.8	82.4	83.1

32 dB SL	Time Compression											
	0%			30%			60%			Total		
Age	Left	Right	Total	Left	Right	Total	Left	Right	Total	Left	Right	Total
4	90.1	90.4	90.2	82.0	86.3	84.0	65.7	77.5	72.0	79.2	84.7	81.9
6	95.5	96.3	95.8	93.5	93.1	93.3	88.0	89.5	88.8	92.3	93.0	92.6
8	97.6	97.9	97.7	97.5	97.7	97.6	89.7	95.0	92.5	94.9	96.8	95.9
Total $\overline{M}$	94.4	94.8	94.6	91.0	92.4	91.6	81.1	87.3	84.4	88.8	91.5	90.1

compression condition with an increase in sensation level, whereas the results of the present study indicated a similar increase for all levels of time compression. The mean difference scores between sensation levels for the three rates of time compression and each age group are indicated in Table 2.

TABLE 2. Mean difference scores on the WIPI between 16 dB SL and 32 dB SL for each age group and each time compression condition of the present study (P). The Beasley et al. (B) and the Sanderson and Rintelmann (S) results are also shown for comparison purposes.

	Time Compression								
	0%			30%			60%		
	S	B	P	S	B	P	S	B	P
Age									
4	13.0	-	9.3	-	-	4.8	-	-	7.0
6	3.3	11.2	5.8	-	9.6	4.8	-	17.6	12.8
8	3.4	6.8	6.8	-	8.8	7.2	-	8.8	5.3

The mean scores obtained in this study were slightly poorer than those of Sanderson and Rintelmann (1971) but were somewhat better than those of Beasley et al. (1975). The greatest mean score differences between the present study and the Beasley et al. study were found at 60% time compression for both sensation levels. The mean scores associated with the several levels of time compression, sensation level, and age can be found in Table 3.

TABLE 3. Mean percent scores on the WIPI for each condition of time compression and sensation level for age groups 4, 6, and 8, for the present study (P). The Beasley et al. (B) and the Sanderson and Rintelmann (S) results are also shown for comparison purposes.

16 dB SL									
Age*		4			6			8	
	S	B	P	S	B	P	S	B	P
Time Compression									
0%	78.7	-	80.9	94.0	83.6	90.0	95.3	90.8	90.9
30%	-	-	79.2	-	82.4	88.5	-	87.6	90.4
60%	-	-	65.0	-	64.4	76.0	-	78.0	87.2
Total $\overline{M}$			75.0		76.8	84.8		85.5	89.5

32 dB SL									
Age		4			6			8	
	S	B	P	S	B	P	S	B	P
Time Compression									
0%	91.7	86.8	90.2	97.3	94.8	95.8	98.7	97.6	97.7
30%	-	80.8	84.0	-	92.0	93.3	-	96.4	97.6
60%	-	68.0	72.0	-	82.0	88.8	-	86.8	92.5
Total $\overline{M}$		78.5	82.0		89.6	92.6		93.6	95.9

* The mean age for each group in years and months for each study was as follows: Sanderson: 3-6, 5-6 and 7-5; Beasley et al.: 4-1, 6-2 and 8-2; and the Present Study: 4-0, 6-0 and 8-0.

Effect of Age

As indicated in Table 1, mean percentage scores increased for both sensation levels and all time compression conditions as age increased. The greatest score differences were obtained between the four year old group and the six year old group. In general, scores for the six year olds were only slightly poorer than scores for the eight year olds. The greatest score difference between four and six year olds occurred at 60% time compression under 32 dB SL. while the greatest difference between six and eight year olds was found at the 60% time compression condition under 16 dB SL. This trend of differences between the four and six year old groups and also the six and eight year old groups at both sensation levels was similar to the results of Beasley et al.*

Score differences between age groups in the present study were generally less for all age groupings than those reported by Beasley et al. Table 4 indicates score differences between age groups for the present study and as reported by Beasley et al.

Ear Differences

Mean scores obtained from presentations of the WIPI to both left and right ears are found in Table 1. No consistent ear advantages were found for any age group.

*Beasley et al. did not present the stimuli at a 16 dB sensation level to the four year old group.

TABLE 4. Mean difference scores on the WIPI in percent between ages 4 and 6 and between 6 and 8 for each time compressed condition. Beasley et al.'s (1975) values are indicated in ( ).

16 dB SL

Age	4 and 6	6 and 8
Time Compression		
0%	9.1	.9 (7.2)
30%	9.3	1.8 (5.2)
60%	10.9	11.2 (14.6)
Total $\overline{M}$	9.7	4.6 9.0

32 dB SL

Age	4 and 6	6 and 8
Time Compression		
0%	5.6 (8.0)	1.8 (2.8)
30%	9.3 (11.2)	4.3 (4.4)
60%	16.8 (14.0)	3.7 (4.8)
Total $\overline{M}$	10.6 (11.0)	3.3 (4.0)

List Differences and Analysis of Errors

Mean scores for each list for all groups at each sensation level and time compression condition are included in Table 5. In general, scores obtained with each list were similar. However, overall mean scores obtained from List IV were slightly lower for both sensation levels, particularly at 60% time compression. Beasley et al. also noted a similar trend for List IV.

Table 6 indicates the ten most frequently missed words for each age level across all levels of time compression and both sensation levels. It was noted that List IV contained at least two times as many of the most frequently missed words when compared to each of the other three lists.

For each age level, each group of the ten most frequently missed words was analyzed to determine what percentage of the total errors it comprised. For the four year old group, the ten words with the greatest total errors accounted for 31.75% of all errors. For the six year old group, 35.5% of all errors occurred within the ten most frequently missed words, and for the eight year old group 47.5% of all errors were found within this group.

TABLE 5. Mean percent correct scores for each list of the WIPI for all age groups combined at each time compression condition for the present study (P) and for the Beasley et al. study (B) for 6 and 8 year olds at 16 dB SL.

16 dB SL	Time Compression													
	0%				30%				60%				Total	
List	P	n	B	n	P	n	B	n	P	n	B	n	P	B
I	86.0	23	83.0	4	87.0	14	93.0	4	77.7	9	65.0	4	83.6	80.3
II	89.9	20	89.1	7	88.5	13	86.7	6	78.5	9	64.0	5	85.6	79.9
III	90.2	24	88.8	5	89.0	5	85.3	3	81.3	15	81.1	7	86.8	85.1
IV	83.1	25	86.0	4	80.6	13	78.9	7	70.3	12	69.0	4	78.0	77.9
Total $\overline{M}$	87.3		86.7		86.2		86.0		76.9		69.8		83.5	80.8

32 dB SL	Time Compression													
	0%				30%				60%				Total	
List	P	n	B	n	P	n	B	n	P	n	B	n	P	B
I	95.3	24	96.0	5	89.5	6	92.0	11	89.8	14	84.0	9	91.5	90.7
II	96.0	24	95.5	8	93.6	13	92.6	7	85.1	11	68.0	5	91.6	85.4
III	92.6	22	90.6	11	89.1	14	89.1	7	85.0	10	80.0	5	88.9	86.6
IV	94.0	20	92.0	6	89.0	11	81.6	5	74.8	9	79.2	11	85.9	84.3
Total $\overline{M}$	94.4		93.5		90.3		88.8		83.6		77.8		89.4	86.7

TABLE 6. The ten most frequently missed words on the WIPI at all levels of time compression and both sensation levels for each age group.

4 Year Olds

Word	List	Times Missed	Times Presented	% Missed
Crown	3	22	30	73
Spring	3	21	30	70
Gum	4	21	30	70
Wing	1	20	30	66
Beet	4	19	30	63
Bowl	2	18	30	60
Pear	4	17	30	56
Bow	4	17	30	56
Red	2	16	30	53
Pan	1	16	30	53

6 Year Olds

Word	List	Times Missed	Times Presented	% Missed
Bowl	2	15	30	50
Beet	4	15	30	50
Gum	4	12	30	40
Bow	4	12	30	40
Pan	1	11	30	36
Pear	4	10	30	33
Lip	4	9	30	30
Wing	1	9	30	30
Spring	3	8	30	26
Box	3	7	30	23

8 Year Olds

Word	List	Times Missed	Times Presented	% Missed
Bow	4	14	30	46
Pear	4	11	30	36
Crown	3	11	30	36
Spring	3	10	30	33
Gum	4	10	30	33
Lip	4	10	30	33
Mouth	4	9	30	30
Bee	4	8	30	26
Broom	2	8	30	26
Bowl	2	7	30	23

CHAPTER IV

DISCUSSION

Results of the present study indicated that for all three age groups tested, intelligibility decreased as time compression increased. In addition, scores improved as a function of increasing sensation level and increasing age. No consistent ear effect differences were found. In determining the ease of each list of the WIPI, it was found that lower scores were often associated with List IV, and further, of the words missed most frequently by each age group, a greater percentage was contained in List IV. Caution should be used in interpretation of list results, since the number of subjects per list in each time compressed condition is small.

Overall, the scores and trends found in the present study were similar to those reported by Beasley, Maki and Orchik (1975). The present study differed somewhat in procedures from the Beasley et al. study in that a different male speaker was used to record the test stimuli, testing was done under earphones with only one ear receiving the test stimuli (as opposed to sound field), and four taped practice items preceded each test list. In addition, each of the two higher time compressed conditions was preceded by a 0% compressed condition, whereby the first presentation was always at 32 dB SL, followed by either the 30% or 60% compressed condition at 32 db SL. The last two lists received by each subject were presented at 16 dB SL at 0% time compression followed by a 30% or 60% time compressed condition.

Time Compression and Sensation Level

For each age group at each sensation level presented, highest scores were obtained at the 0% time compressed condition, with a slight decrease at 30% time compression and a major decrease at 60% time compression. As sensation level increased from 16 dB to 32 dB, an increase in scores was observed at all levels of time compression for each age group.

The scores obtained in this study were similar to those of Beasley et al. (1975), but were somewhat higher under the 30% and 60% time compressed conditions at 16 dB SL and 60% time compressed condition at 32 dB SL.

The improved scores of this study were a probable result of the procedure in which the test stimuli were presented to the subjects. Prior to each test list four taped practice items were presented at the same rate of compression as the test list to follow. Presentations of practice items allowed the subject time to adjust to the time compressed rate and the sensation level of the stimuli. Each subject received a 0% time compressed condition prior to receiving either the 30% or 60% condition at each sensation level, and, in addition, all subjects received two 32 dB SL conditions prior to receiving any lists at 16 dB SL. These procedures resulted in the easiest conditions being presented first, then progressing to more difficult conditions at a lower sensation level.

The procedures allowed the subjects additional time to become familiar with the task prior to receiving the more difficult listening conditions. Beasley et al. did not hold constant the sensation level or time compression rate presented initially to each subject, thus the most difficult sensation level and highest compression rate were sometimes the first condition presented.

Effect of Age

As age increased, intelligibility scores improved for all time compression conditions and both sensation levels. Results showed that both the eight and six year olds achieved higher scores at the more difficult 16 dB sensation level than the four year olds at the easier 32 dB sensation level. The exception to this trend was found at the 0% time compressed condition where four year olds at 32 dB scored equivalent to six and eight year olds at 16 dB SL. This poorer scoring trend by the four year olds may indicate that younger children who have less language experience need the temporal redundancy of non-compressed words to achieve maximum intelligibility.

In comparing the results of the 0% time compressed conditions with those results obtained by Sanderson and Rintelmann (1971), those scores reported by Sanderson were higher at both the 16 and 32 dB sensation levels. A similar result, in comparison to Sanderson and Rintelmann's findings, was found by Beasley et al. (1975).

Two possibilities were suggested by Beasley et al. (1975) for the higher scores obtained by Sanderson and Rintelmann. One possibility for the differing results is the manner in which the test stimuli were generated. The tapes used in the Beasley et al. and present study were processed at 0% time compression using a time compressor, resulting in the presence of some compressor noise. The Sanderson and Rintelmann tapes were not generated using a time compressor. An investigation using tapes generated by both procedures to achieve a 0% time compressed condition could be undertaken to determine if intelligibility scores are affected by the manner of stimulus generation.

A second and more likely possibility suggested by Beasley et al. was the effect of differences in mean SRT scores. Table 7 shows the mean SRT scores for comparable age groups in the present study as compared to those of Sanderson and Rintelmann and Beasley et al. SRT values for the Beasley et al. study and the Sanderson and Rintelmann study were obtained in sound field with speakers at 0° azimuth. The SRT values of the present study were obtained under earphones. The mean SRT scores obtained by Sanderson and Rintelmann were higher in almost all instances than those of either the Beasley et al. study or the present investigation.

Dirks, Stream and Wilson (1972), in reviewing the literature on speech audiometry, compared speech reception thresholds for spondees obtained under earphones and in sound field. Results of the studies selected indicated that SRTs obtained under earphones were usually 3.5 dB poorer than those obtained in sound field when the speakers were placed at a 0° azimuth. Thus, it would be expected that those

TABLE 7. Mean SRT scores in dB according to age groups for the present study, Beasley et al. (1975) and Sanderson and Rintelmann (1971).

	Ages					
	4		6		8	
Sanderson and Rintelmann	12.8	(6 to 18)	8	(2 to 10)	4.5	(-2 to 12)
Beasley et al.	6.3	(-2 to 16)	2	(-2 to 8)	2.3	(-2 to 10)
Present Study	9.5	(0 to 20)	6.3	(2 to 12)	5	(-6 to 12)

mean values for SRTs found in this study would have been lower (better) if obtained in a sound field condition at 0° azimuth. If this trend was actually observed, the SRT values in the sound field condition would have been more similar to those found by Beasley et al., suggesting that the Sanderson and Rintelmann procedures for obtaining SRTs may be clinically inappropriate.

Beasley et al. also suggest that those differences in SRT scores may be the result of procedural differences in obtaining the SRT values. The present study followed the same procedures as Beasley et al., initiating presentations of the spondees at an intensity level of approximately 30 dB HL. Intensity levels were decreased in 4 dB steps following word presentations. Initially, two words were presented at each intensity level until the point where each subject missed the first word. From that point a maximum of four words was presented at each intensity level until the lowest point was reached at which the subject could repeat 50% of the words presented. Sanderson and Rintelmann's procedure began with an initial intensity level 10 to 20 dB above the estimated threshold and decreased in 2 dB steps. Four words were presented at each sensation level. Thus, the Sanderson and Rintelmann procedure would allow for a greater number of word presentations, possibly increasing the likelihood of subject fatigue and ultimately resulting in a higher SRT value than the actual value. If this were true, then the sensation level of the test word presentations would actually be higher than the level indicated. By using the SRT procedures of the present study and presenting test items at higher sensation levels it could be determined if the difference between intelligibility scores in these three studies was a result of differing SRT scores.

Ear Differences

It has been recognized that a cerebral hemisphere dominance exists for speech processing. Research using dichotic listening tasks has shown that verbal material is better perceived by the right ear-left hemisphere (Kimura, 1961; 1963; Shankweiler, 1966; Studdert-Kennedy and Shankweiler, 1970), whereas non-verbal environmental sounds were found to be more accurately perceived by the left ear-right hemisphere (Knox and Kimura, 1970). Since contralateral auditory pathways to the cerebral hemispheres have been shown to be stronger than the ipsilateral pathways (Kimura, 1961), the results of this previous research imply a left cerebral hemisphere dominance for verbal processing.

Recent research has suggested that ear advantage is less evident when monotic speech tasks are presented (Dirks, 1964). Dirks presented filtered phonetically balanced words in both dichotic and monotic conditions to normal hearing listeners. A significant right ear advantage was found only in the dichotic situation, with a greatly reduced advantage with the right ear observed in the monotic situation.

The present study, involving a monotic task, resulted in no consistent ear advantages. The greatest difference in ear scores was a right ear advantage observed at a 32 dB sensation level under 60% time compression for the four year old group. However, at the same time compression rate and at 16 dB SL, a slight left ear advantage was observed for the four year olds. No explanation is offered for this occurrence. Additional research is warranted to study ear differences with children under time compressed conditions, as no research on this topic, other than the present study, has been reported.

Although no additional information on ear differences under time compressed conditions with children is available, Beasley, Schwimmer, and Rintelmann (1972b) and Beasley, Forman and Rintelmann (1972a) reported minimal ear differences for adults under time compressed conditions using a monotic speech task.

List Differences and Analysis of Errors

Overall mean scores for List IV were somewhat lower than the other lists of the WIPI. The remaining three lists resulted in similar mean scores. In computing the ten most frequently missed words for each age group, it was found that List IV contained at least twice as many of the most frequently missed words in comparison to the other three lists. List IV, therefore, represents the most difficult speech discrimination task of the four WIPI lists and may be expected to result in poorer scores.

Several errors resulted from apparent confusions or non-recognition of the drawings of the WIPI. For example, the test word "skirt" appears on the same plate as the foil picture of a girl wearing a dress. Subjects frequently pointed to the skirt of the girl's dress rather than the pictured skirt. Across all age levels the selection of "girl" comprised 66.6% of the total errors on the test word "skirt."

A picture of a glass of milk, apparently representing a dish for some children, appears as a foild on the plate with the test word "dish." Again, the foil accounted for a high percentage of the total errors on the test item.

In presenting the WIPI, problems with items associated with such confusions may be alleviated by asking the child to repeat the word heard, if the pictures on the plate appear to be ambiguous. A more comprehensive task would be to have the pictures currently in use revised.

Clinical Implications

Results of this study indicate that, in order to achieve optimal scores on time compressed conditions of the WIPI, several procedures should be followed. Practice items should be administered at the same rate of time compression as the test stimuli that follow. Higher sensation levels should be presented before the more difficult lower sensation levels, and a 0% time compressed condition should precede higher compression rates at each sensation level presented. Deviations from these procedures may be expected to produce lower scores.

For the normal hearing population of this study no ear advantage was noted; therefore, presentation of the test stimuli could be to either ear with minimal intelligibility score differences.

Results similar to those of this study, in terms of intelligibility scores, were reported by Beasley et al. (1975). Test stimuli were presented in sound field rather than under earphones as in the present study. Particularly for younger children, sound field presentation would be recommended as some of the younger children in the present study showed an aversion to wearing earphones.

Of the four WIPI lists, List IV was the most difficult and resulted in the lowest mean scores. This was particularly evident at 30% and 60% time compression rates at the more difficult 16 dB sensation level. Therefore, if a slightly more difficult speech discrimination measure is desired in comparison to the other test lists, List IV could be presented.

The most frequently missed words overall for each age group were computed. Future research efforts may wish to compare word errors by sensation level, time compression and age in addition to total overall errors.

The present study presents normative data for normal hearing white children on time compressed conditions of the WIPI. Additional studies are needed to supply comparable data for other populations of children, such as the learning disabled, brain damaged, and hearing-impaired, to provide information about the speech discrimination abilities of these populations under time compression.

Comparative information is needed to distinguish the performance of other populations of children from that of normal hearing children. Ear advantages should be investigated with other populations to determine if they exist. Future research efforts should be directed at determining for what populations of children the time compressed WIPI would be an effective diagnostic tool.

CHAPTER V

SUMMARY

The purpose of this study was to determine the effect of time compression upon normal hearing children's intelligibility of a closed set speech discrimination measure. Stimuli were presented under earphones at two sensation levels. The stimuli used in this study were the words from the Word Intelligibility by Picture Identification (WIPI) speech discrimination measure. Stimuli were processed using a Lexicon Varispeech I time compressor. Ninety normal hearing children were the subjects of the study.

The results of the study provided normative data on the Word Intelligibility by Picture Identification speech discrimination measure for normal hearing children aged 4, 6, and 8 years. Data were included for 0%, 30% and 60% time compression and 32 dB and 16 dB sensation levels.

Results showed that discrimination scores decreased as the percentage of time compression increased. Also, better scores resulted as age and sensation level increased. Minimal right versus left ear differences were found, and no consistent trends were observed. Scores by list were compared, and the ten most frequently missed test words for each age group were computed.

Clinical application of the procedures was discussed. Results were compared with results of previous studies.

APPENDICES

APPENDIX A

PRACTICE ITEMS BY LIST

PRACTICE ITEMS

LIST ONE

1. Bat
2. Cat
3. Glass
4. Grass

LIST TWO

1. Rat
2. Cap
3. Bat
4. Glass

LIST THREE

1. Grass
2. Rat
3. Cap
4. Cat

LIST FOUR

1. Cat
2. Grass
3. Bat
4. Rat

APPENDIX B

CALIBRATION PROCEDURES AND INSTRUMENTATION

CALIBRATION PROCEDURES AND INSTRUMENTATION

Audiometers used during testing procedures were calibrated to meet those standards established by ANSI (1969).

BELTONE MODEL 15C CLINICAL AUDIOMETER

1. INTENSITY OUTPUT of the audiometer was calibrated for each test earphone (TDH 39 with MX 41/AR cushions) by using a Bruel and Kjaer Type 4152 artificial ear with a Bruel and Kjaer Type 4144 microphone attached to a Bruel and Kjaer sound level meter Type 2204.
2. HARMONIC DISTORTION was calibrated using the test earphones with a Bruel and Kjaer Type 4152 artificial ear with a Bruel and Kjaer Type 4144 microphone attached to a Bruel and Kjaer Audio Frequency Spectrometer Type 2112.

GRASON-STADLER MODEL 162 SPEECH AUDIOMETER

1. ATTENUATOR LINEARITY was calibrated by directing a 1000 Hz tone from an Ampex AG 600-2 tape recorder into the speech audiometer. The attenuator of the audiometer was initially set at 100 dB HTL and was subsequently attenuated down in 10 dB steps. The signal output from the audiometer was directed through the test earphone (TDH 39 with MX 41/AR cushions) to a Bruel and Kjaer Type 4152 artificial ear with a Bruel and Kjaer Type 4144 microphone attached to a Bruel and Kjaer Type 2112 AudioFrequency Spectrometer.

2. ELECTRICAL NOISE was calibrated by using the same instrumentation as indicated for attenuator linearity. The signal output from the tape recorder was directed through the speech audiometer. Readings from the spectrometer were taken first with the tape recorder on with no signal being played and then with a 1000 Hz tone being played. With the attenuator of the audiometer at 100 dB HTL, the dB SPL level when there was no 1000 Hz signal output was required to be 50 dB SPL below the reading for the 1000 Hz tone output.
3. ACOUSTIC FIDELITY was calibrated by directing pure tones of 200, 300, 400, 700, 1500, 2000 and 4000 Hz from a Hewlett Packard 4204A Oscillator into the speech audiometer. The same test earphone, artificial ear, microphone, and spectrometer as was indicated for attenuator linearity were also utilized for this calibration. The spectrometer reading for each of the above frequencies could not differ from the reading of the 1000 Hz tone by more than ten dB to meet calibration standards.
4. INTENSITY OUTPUT was calibrated by directing a 1000 Hz tone from the Ampex AG 600-2 tape recorder into the speech audiometer. The VU meter of the audiometer was peaked at 0 dB and the HTL level of the attenuator was set at 60 dB. Again using the same calibration instrumentation, the SPL output could not differ from the established standards by more than 3 dB.

APPENDIX C

INFORMATION SHEET

SUBJECT NO.________

INFORMATION SHEET

Date of Testing:______________________ Sex: M F Age: 4 6 8

Name:________________________________ Birthdate:_______ C.A.____

Address:____

Phone:____

Parents:____

HEARING SCREENING (20 dB RE: ISO 1964)

RE 125____ 250____ 500____ 1000____ 2000____ 4000____ 8000____

LE 125____ 250____ 500____ 1000____ 2000____ 4000____ 8000____

ARTICULATION ERRORS NOTED

Distortions Substitutions Omissions

TEST EAR: Right Left

SRT = __________dB

16 dB SL = ______

32 dB SL = ______

TIME COMPRESSED CONDITIONS RECEIVED

0% and 30% ______

0% and 60% ______

LIST ORDER RECEIVED: 1234 2341 3412 4123

WIPI SCORES:

16 dB: 0%____ List____ 30%____ List____ 60%____ List____

32 dB: 0%____ List____ 30%____ List____ 60%____ List____

APPENDIX D

WIPI SCORE SHEET

SUBJECT NO.______________

WIPI SCORE SHEET

Name________________________________DOB__________Date________

List Order: 1234 2341 3412 4123 Ear: R L %: 0, 30 0, 60

LIST ONE	LIST TWO	LIST THREE	LIST FOUR
SL_____	SL_____	SL_____	SL_____
TC_____	TC_____	TC_____	TC_____
school____	broom____	moon____	spoon____
ball_____	bowl_____	bell_____	bow_____
smoke____	coat_____	coke_____	goat_____
floor____	door_____	corn_____	horn_____
fox_____	socks____	box_____	blocks____
hat_____	flag_____	bag_____	black____
pan_____	fan_____	can_____	man_____
bread____	red_____	thread____	bed_____
neck_____	desk_____	nest_____	dress____
stair____	bear_____	chair____	pear_____
eye_____	pie_____	fly_____	tie_____
knee_____	tea_____	key_____	bee_____
street____	meat_____	feet_____	beet_____
wing_____	string____	spring____	ring_____
mouse____	clown____	crown____	mouth____
shirt____	church____	dirt_____	skirt____
gun_____	thumb____	sun_____	gum_____
bus_____	rug_____	cup_____	bug_____
train____	cake_____	snake____	plane____
arm_____	barn_____	car_____	star_____
chick____	stick____	dish_____	fish_____
crib_____	ship_____	bib_____	lip_____
wheel____	seal_____	queen____	green____
straw____	dog_____	saw_____	frog_____
pail_____	nail_____	jail_____	tail_____
SCORE _____%	_____%	_____%	_____%

APPENDIX E

INDIVIDUAL DATA

Individual data for 4 year olds who received the WIPI at 0% and 30% time compression conditions.

					Discrimination Scores in Percent Correct							
					16 dB SL				32 dB SL			
Subject #	Sex	C.A.	SRT	Ear	0%	List	30%	List	0%	List	30%	List
2	M	3-8	12	L	76	4	92	1	96	2	72	3
3	F	4-4	4	R	84	3	68	4	92	1	92	2
4	M	3-6	6	R	84	3	64	4	88	1	80	2
5	M	4-1	10	R	72	1	76	2	88	3	96	4
7	F	4-4	8	L	80	1	80	2	84	3	84	4
8	F	3-8	8	L	84	3	76	4	92	1	84	2
9	F	4-3	8	R	92	1	88	2	84	3	92	4
13	M	4-3	8	L	84	3	88	4	92	1	88	2
16	M	4-4	0	L	68	4	60	1	92	2	64	3
19	F	4-0	8	L	84	1	84	2	92	3	80	4
23	M	3-11	6	L	72	4	72	1	84	2	88	3
25	M	4-0	12	L	80	3	84	4	100	1	96	2
26	M	4-1	8	R	76	4	92	1	92	2	80	3
27	M	3-8	8	R	76	2	84	3	88	4	88	1
30	M	3-9	20	R	80	1	80	2	80	3	76	4

Individual data for 4 year olds who received the WIPI at 0% and 60% time compression conditions.

					Discrimination Scores in Percent Correct							
					16 dB SL				32 dB SL			
Subject #	Sex	C.A.	SRT	Ear	0%	List	60%	List	0%	List	60%	List
1	M	4-1	12	L	84	4	60	1	100	2	80	3
6	F	3-6	12	R	88	2	80	3	88	4	68	1
10	F	3-9	16	R	84	3	72	4	96	1	84	2
11	M	4-4	6	R	92	2	84	3	92	4	72	1
12	M	3-6	12	R	80	4	56	1	100	2	84	3
14	F	4-6	8	R	76	4	48	1	100	2	80	3
15	F	3-7	6	R	72	2	60	3	84	4	88	1
17	F	4-6	12	L	80	1	60	2	88	3	52	4
18	F	4-0	8	R	92	2	64	3	96	4	80	1
20	F	4-0	8	L	76	1	76	2	76	3	36	4
21	F	3-6	12	L	80	1	64	2	80	3	60	4
22	F	3-11	8	R	64	3	28	4	88	1	64	2
24	F	4-3	18	L	88	2	68	3	92	4	96	1
28	F	4-4	6	L	92	4	88	1	96	2	76	3
29	M	3-7	14	L	88	3	68	4	88	1	60	2

Individual data for 6 year olds who received the WIPI at 0% and 30% time compression conditions.

					Discrimination Scores in Percent Correct							
					16 dB SL				32 dB SL			
Subject #	Sex	C.A.	SRT	Ear	0%	List	30%	List	0%	List	30%	List
1	F	5-10	12	R	100	3	92	4	100	1	96	2
4	M	6-4	6	L	88	4	96	1	96	2	92	3
5	F	6-5	8	R	88	3	80	4	100	1	96	2
6	M	5-10	8	R	88	1	88	2	100	3	88	4
7	F	5-7	6	R	88	1	88	2	96	3	88	4
8	F	5-10	10	L	100	1	96	2	96	3	88	4
9	M	6-1	6	L	88	3	84	4	100	1	96	2
14	F	6-1	2	L	64	1	96	2	96	3	92	4
16	F	6-6	2	L	84	4	80	1	96	2	100	3
17	M	5-10	4	L	100	3	72	4	84	1	92	2
19	F	5-6	10	R	96	4	80	1	96	2	92	3
20	F	6-2	8	R	92	1	92	2	100	3	92	4
21	M	5-10	4	L	92	4	96	1	100	2	96	3
25	M	5-10	4	L	88	4	96	1	96	2	92	3
26	M	6-0	12	R	96	4	92	1	96	2	100	3

Individual data for 6 year olds who received the WIPI at 0% and 60% time compression conditions.

					Discrimination Scores in Percent Correct							
					16 dB SL				32 dB SL			
Subject #	Sex	C.A.	SRT	Ear	0%	List	60%	List	0%	List	60%	List
2	F	5-8	2	L	96	2	80	3	100	4	92	1
3	M	6-4	2	R	96	3	88	4	100	1	96	2
10	M	6-5	6	R	100	3	88	4	100	1	100	2
11	M	5-6	6	R	84	2	80	3	92	4	92	1
12	F	6-0	2	R	88	1	76	2	92	3	88	4
13	F	5-7	2	R	68	1	76	2	100	3	84	4
15	M	5-6	4	L	80	4	84	1	96	2	88	3
18	F	6-2	6	L	88	2	92	3	96	4	84	1
22	M	5-10	10	L	96	3	68	4	96	1	88	2
23	M	6-6	4	L	84	2	64	3	96	4	96	1
24	F	5-6	10	R	92	3	44	4	88	1	84	2
27	M	6-2	12	R	100	2	84	3	96	4	88	1
28	F	6-6	6	L	88	4	68	1	88	2	80	3
29	M	6-0	12	R	92	2	80	3	88	4	84	1
30	M	6-4	4	L	96	2	68	3	96	4	88	1

Individual data for 8 year olds who received the WIPI at 0% and 30% time compression conditions.

					Discrimination Scores in Percent Correct							
					16 dB SL				32 dB SL			
Subject #	Sex	C.A.	SRT	Ear	0%	List	30%	List	0%	List	30%	List
1	F	7-11	4	L	100	3	88	4	100	1	100	2
2	M	7-10	6	R	92	3	84	4	100	1	96	2
6	F	8-6	-6	L	52	4	92	1	96	2	92	3
7	M	7-8	6	R	92	2	92	3	100	4	96	1
8	F	8-0	0	R	88	4	92	1	100	2	96	3
9	M	7-10	2	L	88	2	88	3	100	4	100	1
11	F	7-8	0	L	92	1	92	2	96	3	100	4
12	F	7-10	2	R	92	4	88	1	96	2	96	3
13	F	7-9	10	L	100	1	92	2	96	3	92	4
15	F	8-4	4	L	100	1	92	2	100	3	100	4
18	F	8-5	0	R	80	4	96	1	96	2	100	3
21	F	7-6	6	R	92	2	96	3	100	4	100	1
23	F	7-7	8	L	92	3	76	4	96	1	96	2
26	M	8-0	6	R	92	3	88	4	100	1	100	2
30	M	8-5	10	L	100	2	100	3	92	4	100	1

Individual data for 8 year olds who received the WIPI at 0% and 60% time compression conditions.

					Discrimination Scores in Percent Correct							
					16 dB SL				32 dB SL			
Subject #	Sex	C.A.	SRT	Ear	0%	List	60%	List	0%	List	60%	List
3	M	7-11	6	R	92	4	84	1	96	2	88	3
4	F	7-9	4	R	92	2	100	3	100	4	100	1
5	F	8-3	4	L	80	4	88	1	100	2	80	3
10	M	7-7	10	R	88	4	100	1	100	2	96	3
14	F	7-9	0	L	96	3	84	4	100	1	96	2
16	F	8-2	6	R	100	3	72	4	100	1	96	2
17	F	7-9	10	L	96	1	100	2	92	3	88	4
19	M	7-11	6	R	92	1	80	2	92	3	84	4
20	F	7-9	4	L	100	1	96	2	100	3	88	4
22	M	7-7	6	R	80	1	96	2	100	3	96	4
24	M	8-5	4	R	88	4	84	1	96	2	100	3
25	F	7-8	12	L	92	2	92	3	100	4	96	1
27	F	8-5	10	R	84	3	64	4	92	1	100	2
28	F	8-4	8	L	100	2	92	3	100	4	96	1
29	F	8-4	4	L	96	3	76	4	96	1	84	2

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