TIME COMPRESSED SPONDAIC WORDS AND THRESHOLD ACUITY

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ABSTRACT

TIME COMPRESSED SPONDAIC WORDS AND THRESHOLD ACUITY

By

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Several investigators have suggested that time compressed speech materials can provide potentially useful diagnostic information to differentiate persons with a peripheral auditory disorder from persons with a central auditory disorder. Since the development of the electromechanical technique of time compression, investigators have often used monosyllables for the experimental stimuli. However, spondaic words represent a more temporally and linguistically complex speech stimuli than monosyllables and thus may provide more useful diagnostic information in comparison to monosyllables. The purpose of this study was to develop normative data on the differential effects of time compression, ear presentation, and list presentation on speech reception threshold utilizing List A and List B of the CID W-I spondaic words accelerated to various ratios of time compression.

Two randomizations of 36 spondaic words were time compressed to 40% and 60% of the original time using the Lexicon Varispeech I electronic time compressor. There was also a 0% time compression control condition. This resulted in six experimental conditions.

The subjects were sixty right-handed normal hearing young adults randomly divided into four groups of 15 members each. Each subject within each group received one list of spondaic words compressed at 0%, 40%, and 60% in either the right or the left ear. Time compression conditions were counterbalanced to control for order effects of presentation. The Tillman and Olsen threshold determination procedure was used to establish a speech reception threshold for each subject at each ratio of time compression.

The results revealed that intelligibility minimally decreased as a function of increasing ratios of time compression. No dramatic decrease in intelligibility as a function of time compression was observed. Further investigation of the results revealed neither ear presentation nor list presentation had a differential effect on speech reception threshold.

The results of this study provide the needed normative information relative to the clinical utility and theoretical application of time compressed spondaic words. Theoretical application is discussed in terms of short-term memory and perceptual processes. Clinical utility is discussed in terms of the differentiation of peripheral auditory disorders and central auditory disorders.

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Director of Thesis

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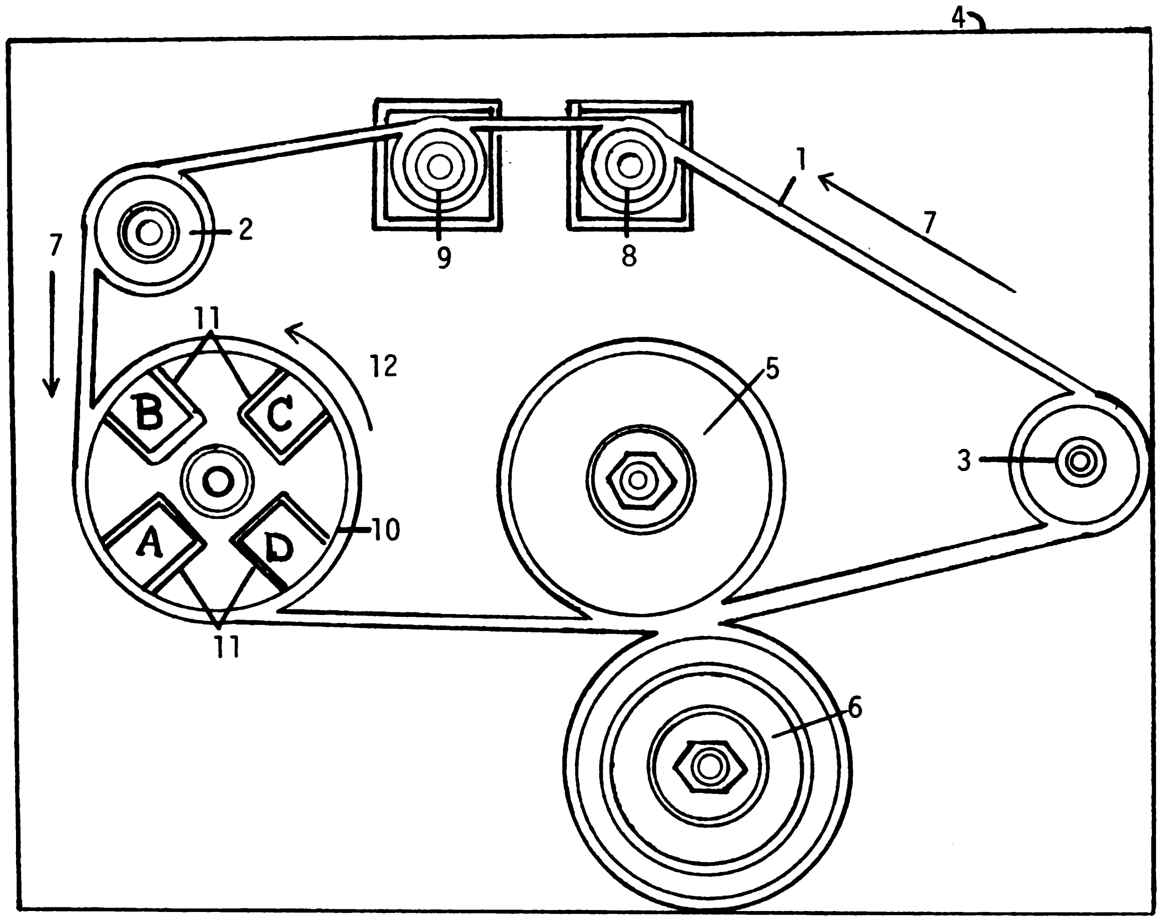
CHAPTER I

INTRODUCTION

In recent years there has been an increasing interest in the applicability of time compressed messages to diagnostic audiology. Investigators have tried various techniques to temporally alter speech messages without distorting the acoustic and prosodic cues associated with the message. Miller (1946), as reported by Cramer (1971), and Miller and Licklider (1950) used an electronic switching system to interrupt speech. Portions of the message were discarded at specified intervals, resulting in what the investigators called a "compressed message". However, the altered message was not reproduced in less time than the original message. As reported by Cramer (1971), Black (1948) applied the same principle as Miller and Licklider (1950) to reproduce speech, but spliced out portions of the taped message, thereby making the total time of presentation less than the original time of presentation. Further, Garvey and Hennemen (1950), using the "cut-splice" method, investigated the intelligibility of time compressed messages. Garvey and Hennemen (1950) found that the speech message remained 90% intelligible to a rate of 2.5 times the input ratio. However, this procedure was reported to be unduly time consuming and tedious. Therefore, Fairbanks, Everitt, and Jaeger (1954) developed the electromechanical sampling method of time compressing.

The presently preferred method of time compressing described by Fairbanks, Everitt, and Jeager (1954) makes use of instrumentation designed to electromechanically vary the temporal characteristics of the spoken message. According to Fairbanks et al., two variables have an important bearing upon the character of the time compressed speech signal: the temporal value of the discarded and retained portions of speech, and the rule by which the speech is sampled. The Fairbanks method used an electromechanical sampling process to automatically accomplish the "cut and splicing" of the recorded speech signal. Cramer (1971) described the Fairbanks technique as follows (see Figure 1):

> Tape loop (1) traveling in the direction shown by arrow (7) passes over erase head (8) and recording head (9). The tape loop (1) then goes over idler (2), down around the rotating head assemble (10), between the tape drive capstan (5) and pressure roller (6), around tension adjusting wheel (3) and back to erase head (8) where it started. When the compressor is in operation, material on the tape is erased at erase head (8) in order to record cleanly at the record head (9). The recorded tape passes the rotation head assembly (10) in the direction shown by arrow (7). The tape moves faster than the rotating head assembly, so that speech recorded on the tape is picked up by any one of the four heads (A,B,C, and D) in the assembly over which it is passing. At the instant when head A leaves contact with the tape, head B contacts the tape. Everything recorded on the tape wrapped around the rotating head assembly between heads A and B will not be scanned or played back by either head A or B and therefore will be discarded. The temporal length of the unscanned material is referred to as the interval discarded (Id), while the



1.- Tape Loop

2.- Idler Wheel

3.- Tension Adjusting Wheel

4.- Mounting Plate

5.- Capstan

6.- Pressure Roller

7.- Direction of Tape Loop Travel

8.- Erase Head

9.- Record Head

10.- Rotating Head Assembly

11.- Playback Heads

12.- Direction of Rotating Head Assembly when compressing.

Figure 1. Schematic of the Fairbanks et al. (1954) electromechanical time compressor (Fairbanks et al., 1959).

> part played back by each head constitutes the interval sampled (Is). These two factors can be varied with the Fairbanks equipment so that one may specify either a specified sampling or a discard interval at any given compression ratio. Of the three factors -- compression ratio, discard interval, and sampling interval -- two have to be fixed. (p. 11)

The electromechanical process of time compressing permits the experimenter to control several of the acoustic papameters associated with the speech signal, including intensity, stress, time, and frequency. Thus, it is possible to alter the duration of an original speech message while simultaneously minimizing the alteration of other acoustic and prosodic parameters of the message. Recently, the principles behind the Fairbanks et al. compression procedure have led to the development of solid-state electronic time compressors, such as the Lexicon Varispeech I (Lee, 1972). These developments have permitted investigators to more efficiently study the temporal nature of human perceptual processes by temporally altering speech messages, and to apply the results of these studies to the development of audiometric tests useful in the differential diagnosis of central auditory disorders.

Peripheral Auditory Mechanisms and Central Auditory Mechanisms

Jerger (1974, p. 86) defined the demarcation point between the peripheral auditory mechanisms and the central auditory mechanisms as, "... the synapse between the first- and second-order neurons of the afferent auditory pathway in the dorsal and ventral cochlear nuclei". Therefore, the auditory mechanisms which are distal to the cochlear nuclei, including the middle ear, inner ear, and eighth nerve, were considered to affect the peripheral auditory mechanisms. The auditory mehcanisms proximal to the cochlear nuclei, including the brain stem pathway in the lateral lemniscus up to and including Heschl's gyrus of the temporal lobe and the several auditory areas in the cerebral cortex, were considered to be associated with the central auditory mechanism. Jerger (1974) continued by describing symptoms typically exhibited by persons having a peripheral auditory disorder or a central auditory disorder. Persons with either a conductive, cochlear, or retrocochlear peripheral auditory disorder showed loss of auditory sensitivity, abnormal auditory adaptation, and/or an inability to understand speech presented ipsilaterally. The specific symptoms exhibited in terms of sensitivity, adaptation, and ability to understand speech depended upon the specific type of peripheral auditory disorder. Persons with a central auditory disorder showed normal auditory sensitivity, normal auditory adaptation, and an inability to understand speech presented either contralaterally or in a binaural resynthesis task (Lynn and Gilroy, 1975).

Thus, a person's ability to discriminate speech may be affected if he has either a peripheral auditory disorder or a central auditory disorder. However, persons with a peripheral auditory disorder showed reduced speech discrimination for the ear ipsilateral to the disorder, while persons with a central auditory disorder showed reduced discrimination for the ear contralateral to the disorder. The reduction in speech discrimination for the ipsilateral versus the contralateral ear provided useful information for the differential diagnosis. However, Bocca and Calearo (1963) and Jerger (1960) reported that the auditory mechanisms central to the cochlear nuclei became progressively less definitive the higher they were within the central nervous system, and that adequate diagnosis required the use of increasingly complex speech stimuli. Time compressed speech represented one form of increasing the complexity of the speech stimuli, in that the redundancy of the original message was reduced, therefore suggesting that the use of time compressed speech stimuli to assess central auditory functioning may provide useful differential diagnostic information (Friedman and Johnson, 1968). However, it is essential to accumulate normative data utilizing time compressed materials prior to the application of such a technique in the clinical setting for the differential diagnosis of auditory disorders.

Research Using Time-Altered Speech

Several investigators have assessed the effects of time compression on speech intelligibility with three age groups: children, young adults, and aged adults. Beasley, Maki, and Orchik (1976) using the four lists of the Word Intelligibility by Picture Identification (WIPI) and three lists of the PB-K word lists for children which were compressed to ratios of 30% and 60% of original time, reported that word intelligibility increased as a function of increasing age and decreasing ratio of time compression for normal hearing children. These findings were similar to those obtained by Beasley, Schwimmer and Rintelmann (1972a) who presented the N.U.#6 monosyllables compressed to ratios of 0%, 30%, 40%, 50%, 60%, and 70% of original time to normal hearing young adults. In addition, in the Beasley et al. (1972a) study, intelligibility was found to increase as a function of increasing sensation level for the several ratios of time compression. In a follow-up study, Beasley, Forman, and Rintelmann (1972b), using the same stimulus materials as those used by Beasley et al. (1972a) presented at a 40 dB sensation level also found an inverse relationship between intelligibility and ratio of compression.

Sticht and Gray (1969) using monosyllables compressed to 0%, 36%, 46%, and 59% of the original time by an electromechanical compressor reported that intelligibility decreased as a function of increased age and increased ratios of time compression for both individuals with normal hearing and individuals with sensorineural hearing loss. However, Beasley and Maki (1976) suggested that Sticht and Gray's (1969) conclusions should be considered with caution since certain problems were inherent in the procedures Sticht and Gray (1969) employed. First, they used a small sample, divided into those younger than 60 years and those older than 60 years. This differentiation is questionable in that hearing sensitivity begins to get progressively worse before age 60 in many cases (Jerger, 1973). For example, it is possible that the hearing loss of a 30 year old may have been equated with the hearing loss of a 60 year old. Second, Sticht and Gray (1969) used unusual ratios of time compression, namely 36%, 46%, and 59%, thereby making their results difficult to compare to other studies.

Luterman, Welsh, and Melrose (1966), using monosyllables compressed to 10% and 20% of the original time, found that intelligibility varied as a function of time compression for young and old hard of hearing individuals and for young and old normal hearing individuals. In addition, Luterman et al. (1966) reported that time compression did not differentiate the young from the old individuals. In other words, time compression similarily affected all groups. However, Schon (1970) reported that it was possible to differentiate between the auditory intelligibility performance of young normal hearers, aged normal hearers, young individuals with sensorineural hearing loss, and aged individuals with sensorineural hearing loss by using monosyllables compressed by 30% and 50% of the original time. The difference in opinion between Luterman et al. (1966) and Schon (1970) may be due to the chosen ratios of compression. Luterman et al. (1966) used a maximum compression ratio of 20% whereas Schon (1970) used a maximum compression ratio of 50%. Several researchers (Beasley et al., 1972a; Beasley et al., 1972b) have shown that higher ratios of compression need to be used before a marked decrease in intelligibility will result.

DiCarlo and Taub (1972), using W-22 monosyllables compressed to 30% and 50% of the original time, reported decreased intelligibility as a function of increasing age and increasing ratios of time compression for young and aged aphasic individuals. DiCarlo and Taub (1972) found that the higher ratio of compression (50%) they employed was more effective in differentiating between groups compared to the lower ratio of compression (30%). However, DiCarlo and Taub (1972) suggested that more research is needed to determine if time compressed speech stimuli can differentiate normal hearing individuals from those individuals with sensorineural hearing loss.

Kurdziel, Rintelmann, and Beasley (1975) presented the same experimental stimuli used by Beasley et al. (1972a) and Beasley et al. (1972b) to nine individuals with bilaterally symmetrical noise induced hearing loss. The purpose of this study was to examine intelligibility as a function of sensation level of presentation and ratio of compression for individuals with cochlear pathology. Kurdziel et al. (1975) found that intelligibility decreased as a function of increasing ratios of time compression, and that intelligibility increased as a function of increasing sensation level for individuals with noise induced hearing loss.

The results of the previously discussed studies suggest that the intelligibility of recorded monosyllables increased as a function of age for children between the ages of three and one half years to eight and one half years (Beasley et al., 1976), plateaued in young adult individuals (Beasley et al., 1972a; Beasley et al., 1972b), and then decreased as a function of age for aging adults (Sticht and Gray, 1969; Schon, 1970; DiCarlo and Taub, 1972). These conclusions supported the theoretical bases of speech perception. In addition, all of the above studies reported decreased intelligibility as a function of increasing ratios of time compression. Further, it appears that monosyllables which are compressed to sufficient ratios of time compression (e.g., 50%) are appropriate stimuli to differentiate young persons from old persons with equated hearing and normal hearers from those persons with auditory lesions (DiCarlo and Taub, 1972).

Several investigators have used controlled time compression procedures to temporally alter monosyllables for the evaluation of populations ranging in age from young children to aged adults. However, further research is needed to determine not only how time compressed speech can be applied in the clinical setting, but also to determine which compressed speech materials can provide the most useful information. Spondaic words are more linguistically complex than monosyllables in terms of morphophonemic parameters and are typically used in the clinical setting. Therefore, it may be important to determine the differentiating capabilities of time compressed spondaic words.

Threshold and Intelligibility of Spondaic Words

Spondaic words have been described as a highly homogeneous speech material with respect to audibility compared to other forms of speech materials including monosyllables, sentences, and nonsense syllables (Egan, 1948; Hirsh, 1952; Carhart, 1952). Further, spondaic words are more temporally and linguistically complex than monosyllables, and have been used to estimate pure tone thresholds, to check established pure tone threshold results, or to determine presentation level for discrimination testing. However, it is possible that time compressed spondaic words could be efficiently used in a clinical setting and/or during the differential diagnosis of auditory disorders.

Bocca and Calearo (1963) and Jerger (1960) reported that the auditory mechanisms central to the cochlear nuclei become progressively less definitive. Jerger (1960) reported that application of a complex stimulus material was necessary to detect lesions within this less definitive portion of the central nervous system. Aaronson et al. (1971) reported that the duration of the stimulus material is an important factor in the early stage of memory processing, known as the sensory stage. Therefore, it would follow that altering the temporal characteristics of a speech message would yield a stimulus material complex enough to tax the less definitive portions of the central nervous system. This statement is based on two assumptions: First, that the perception of auditory sequences is temporally biased (Aaronson et al., 1971) and, second, that the interstimulus interval is sufficient to allow for identification encoding which is the second stage of perceptual processing (Aaronson et al., 1971). Thus, any form of compressed speech materials would be considered more complex than the noncompressed version of the speech material since the redundancy of the compressed message would be shortened.

Spondaic words are considered more temporally complex due to the increased time required for their production and due to the temporal relationship between the two syllables of spondaic words. Spondaic words are considered more linguistically complex in terms of increased phonemic and morphophonemic content in comparison to monosyllables. Therefore, when a compressed spondaic word is presented to an individual, more perceptual encoding must occur within a shorter length of time in comparison to the encoding required for the perceptual processing of a monosyllable.

Clinically, the results of compressed spondaic words would have several advantages over the use of the traditional compressed monosyllable discrimination test. First, speech reception threshold is typically established prior to discrimination testing. Results of compressed spondaic words could possibly alert the clinician sooner in the audiologic evaluation to the possible existence of a central auditory pathology. Second, since research has not confirmed the diagnostic capability of compressed monosyllables, it is possible that more conclusive diagnostic information would be gathered if presentation level was determined from speech reception threshold found using compressed spondaic words rather than noncompressed spondaic words. Further, it is possible that time compressed spondaic words alone may provide useful differential diagnostic information since spondaic words are more temporally and linguistically complex compared to monosyllables. Third, if research consistantly showed that all individuals performed equivalently when compressed spondaic words were used, then compressed spondaic words could be substituted for noncompressed spondaic words in the typical hearing evaluation. Conserving time clinically is especially important when dealing with the difficult to test patient including children, multiply handicapped, and geriatric populations.

Garvey (1953) used the speed changing technique and the cut-splice technique to temporally alter the PAL Auditory Test No. 14 spondaic words to accelerations between 1.5 through 4.0 times of the original time. He presented these compressed spondiac words to normal hearing young adults at a constant presentation level of 44 dB SL, and found that intelligibility remained high (above 90%) for accelerations of 1.5, 1.67, 1.75, 2.0, and 2.5 the original time. Intelligibility dropped to 78% at the 3.0 acceleration rate and to 50% at the 3.0 and 4.0 acceleration rates for spondiac words compressed via the cut-splice technique. Comparison of these results to the data obtained using the speed changing technique showed that the attendant frequency shift significantly decreased intelligibility for acceleration rates of 1.75, 2.0, and 2.5 times the original time. Acceleration rates to levels greater than 2.5 were not produced using the speed changing method, therefore comparison could not be made between the intelligibility scores obtained with the accelerations above 2.5 times the original time using the speed changing method and the intelligibility scores obtained with accelerations above 2.5 times the original time using the cut-splice method. Garvey (1953) concluded that spondaic words remain 90% intelligible through acceleration rates of 2.5 times the original time if the words are accelerated via the cut-splice technique.

To date, Garvey's (1953) study represents the available literature on time compressed spondaic words, however, it is difficult to interpret his results in the framework of recent time compression research. For example, Garvey (1953) used various numerical acceleration rates of the original time which are difficult to equate with time compression ratios used today. In addition, he utilized the speed changing technique and and cut-splice technique of time compression which are less efficient and less effective than the electromechanical techniques used today. Thus, it is impossible to validly compare Garvey's (1953) findings to the recent time compression research.

Summary and Statement of Problem

Traditionally, the intelligibility of time compressed stimuli has been studied using various ratios of time compressed monosyllables presented at suprathreshold levels. In general, results indicated that intelligibility for time compressed monosyllables increased as a function of age for children between three and one half years and eight and one half years (Beasley et al., 1976), plateaued in young adult individuals (Beasley et al., 1972a; Beasley et al., 1972b) and decreased as a function of age for aged adults (Sticht and Gray, 1966; Schon, 1970; DiCarlo and Taub, 1972; Bocca and Calearo, 1963; Konkle, Beasley, and Bess, 1975). Luterman et al. (1966) reported time compression did not differentiate young from old individuals, but Luterman et al. (1966) used a maximum compression ratio of 20% of the original time which would not be expected to differentiate individuals (Beasley et al., 1972a; Beasley et al., 1972b). In all cases, intelligibility decreased as a function of increasing ratios of time compression.

Garvey (1953) reported that intelligibility for time compressed spondaic words remained very high (90%) through accelerations of 2.5 times the original time, and became progressively worse at successive acceleration rates through 4.0 times the original time for normal hearing young adults. However, Garvey (1953) used the speed changing and the cut-splice techniques for time compressing and acceleration rates which can not be validly compared to ratios of recent research utilizing time compressed materials.

Spondaic words are typically used in the clinical setting to estimate pure tone thresholds, to check established pure tone thresholds, or to determine presentation level for discrimination testing. In addition, spondaic words represent a more complex speech stimuli than monosyllables in that spondaic words are more temporally and linguistically complex than monosyllables. Therefore, temporally altering spondaic words should yield a speech stimulus that provides the complexity required to detect lesions in the less definitive portions of the central auditory pathway, since the perceptual encoding of a stimulus is temporally biased (Aaronson et al., 1971). It appears necessary, then, to investigate how various ratios of time compressed spondaic words will differentially affect speech reception thresholds. This is necessary to determine the differential capabilities of time compressed spondiac words.

The purpose of this study, then, is to investigate the differential capabilities of spondiac words which have been electronically time compressed to 0%, 40%, and 60% of the original time. The differential capabilities of time compressed spondaic words will be assessed using individuals, aged 19 through 24 years inclusive, whose peripheral auditory mechanisms are considered to be within normal limits.

CHAPTER II

EXPERIMENTAL PROCEDURES

Sixty subjects were assigned to one of four experimental groups including one right ear List A of CID W-I spondaic words group, one right ear List B of CID W-I spondaic words group, one left ear List A group and one left ear List B group. The experimental conditions included two randomizations of standardized spondaic word lists presented at three ratios of time compression. Amount of time compression was counterbalanced within groups to control for presentation order effects.

Subjects

The subjects were 60 normal hearing adults, aged 19 through 24 years, selected from the Michigan State University student population. The subjects were naive listeners randomly assigned to one of four groups containing fifteen subjects each.

Each subject was required to complete a case history form (refer to Appendix A) containing questions pertaining to hearing status. Each case history was examined to determine if each subject had any history of hearing loss. Each subject was required to pass a conventional pure tone screening test at a Hearing Threshold Level (HTL) of 20 dB for all frequencies at octave intervals ranging from 250 Hz through and including 8000 Hz using a Beltone Audiometer (Model 10D) calibrated within ANSI standards. Each subject was further required to obtain a score of at least 90% on a standard speech discrimination test using the Northwestern University Auditory Test Number Six (N.U.#6) monosyllables presented at 40 dB HTL. Standard instructions (refer to Appendix B and Appendix C) were read to each subject prior to both pure tone screening and discrimination testing.

Stimulus Generation

The experimental stimuli used in this study were two randomizations (Lists A and B) of the Central Institute for the Deaf (CID) W-I spondaic words (Hirsh et al., 1952). Each list consisted of 36 spondaic words. The original word lists were recorded by a white male (W.F. Rintelmann) who spoke with a general American dialect and who was experienced in controlled recording procedures. All effort was made during recording to maintain normal pitch, intensity, and vocal qualities, except that stressing was approximated across syllables. The stressing patterns of the recordings were validated by observation using a graphic level recorder (Bruel and Kjaer, Model 2305).

Each randomized list of spondaic words was time compressed, using an electronic time compressor (Lexicon

Varispeech I) to 0%, 40%, and 60% of the original time. This process yielded three tapes of List A compressed to 0%, 40%, and 60% and three tapes of List B compressed to 0%, 40%, and 60% of the original time.

Several procedures were used to check the accuracy of the tapes and the calibration of the instrumentation. The 0% compression tapes were processed through the Lexicon to control for any acoustic and prosodic variations due to the Lexicon instrument itself. A graphic level recorder (Bruel and Kjaer, Model 2305) was used to check the accuracy of tape compression by yielding a visual representation of the actual duration of each tape. This duration was compared to the expected duration which was calculated via the following formula (Konkle et al., 1975a): $f = \frac{100 \times 1000}{x}$

where f = the expected frequency
x = 100 - (desired level of compression)

The graphic level recorder speed was checked via a stop watch (Westclock 1/10 second) which was checked via an electric watch (Lago quartz digital). The tape recorder (Ampex, Model AG 600-2) was checked for frequency, intensity, and total harmonic distortion using the Bruel and Kjaer Frequency Analyzer (Model 2107) and the Beckman Eput and Time Counter (Model 6148). The Lexicon was calibrated using the Beckman Eput and Time Counter (Model 6148) by comparing the actual frequency read-out to the calculated expected value. The accuracy of the pitch corrector of the Lexicon was assessed by using the Beckman Eput and Time Counter (Model 6148) to evaluate recorded calibration tones at each level of time compression. Finally, the Beckman Eput and Time Counter (Model 6148) was assessed via expected calibration read-out as designated in the manual.

Presentation Procedure

The 60 subjects were randomly divided into four groups of fifteen subjects each. Each subject within each group heard one randomized list (either List A or List B) of spondaic words at each level of time compression in either the right or the left ear. Within each group, presentation order of time compression was counterbalanced. More specifically, ratio of time compression was rotated with subjects number 1, 4, 7, 10, and 13 hearing 0% first and 60% last, subjects number 2, 5, 8, 11, and 14 hearing 40% first and 0% last, and subjects number 3, 6, 9, 12, and 15 hearing 60% first and 40% last. Such a format attempted to control for order effect associated with ratio of time compression.

All subjects were seated in the center of a prefabricated double-walled sound suite (IAC, 1200 series) with a Dynamic Microphone (Model 560) placed approximately two feet from the subject's mouth. The experimenter and the experimental apparatus were located in an adjacent control room. The ambient noise level in the test suite was checked with a Bruel and Kjaer Sound Level Meter (Type 2204) and condensor microphone (Type 4145) to insure sufficiently low noise levels. Table 1 displays the recommended and obtained

Table 1. Noise levels in octave bands, re: .0002 dyne/cm^2 in the test room and the proposed standard for maximum allowable sound pressure levels in dB for ambient noise levels in the test room (ANSI, 1969).

Frequency	125	250	500	1000	2000	4000	8000
Octave Band	75/150	150/300	300/600	600/1200	1200/2400	2400/4800	4800/9600
Noise Level Obtained	11 ± 1	5	9	6	8	9	8
ANSI Level* Recommended	31	25	26	30	38.5	51	55.5

* corrected to conform to ANSI 1969 standards (Melnick, 1971).

ambient noise levels.

Standard instructions (see Appendix D) were read to each subject while each subject simultaneously read a printed copy of the instructions. In addition, the subjects were familiarized with the test word vocabulary by reading an alphabetized list of the spondaic words. The experimental testing began with the presentation of the experimental tapes played via a Tanberg Tape Recorder (Model 3300 X) through a Grason-Stadler Speech Audiometer (Model 162) and TDH-39 earphones mounted in the MX 41/AR cushions. The Tillman and Olsen (1974) procedure for obtaining SRT was employed. More specifically, the first spondaic word was presented at 40 dB HTL, and the second spondaic word was presented at a level 10 dB lower than the first level. This process continued until an incorrect response was obtained. Once an incorrect response occurred, a second spondaic word was presented at the same level. If this second spondaic word was missed, the intensity was increased by 4 to 6 dB and the experimental test task was initiated. If the second spondaic word was not missed, the intensity was attenuated 10 dB until two spondaic words were missed consecutively. At that point, the threshold testing began with the presentation of two spondaic words at 4 to 6 dB SL (re: the last missed spondaic word). At the beginning of the testing procedure, five of the first six spondaic words had to be correctly repeated before the threshold procedure could begin. The intensity was continually attenuated by 2 dB and two spondaic words were correspondingly presented at each level. This process continued until five of the last six spondaic words were missed.

Scoring or determination of speech reception threshold was accomplished by using the following formula (Tillman and Olsen, 1974):

SRT = beginning intensity level - (the number of correct responses - one)

Several procedures were employed to control the accuracy of the threshold testing. First, the experimenter's hearing acuity was monitored to insure normal thresholds for that individual. This was relevant since the presentation level of each spondaic word was dependent upon the subject's previous responses. The experimenter listened to each response and then appropriately adjusted the presentation level. Second, both the beginning level and the ending level of the threshold testing intervals were recorded (refer to Appendix E). This permitted the experimenter to double check the attenuation intervals by comparing the number of presented spondaic words within the threshold interval to the number of spondaic words which should have been presented within the threshold interval. For example, if the beginning level was 10 dB and the ending level was 0 dB, there should have been two responses at each 2 dB attenuation level between 0 dB and 10 dB. Therefore, eight spondaic words should have been presented between 0 dB and 10 dB. Correspondingly, the answer sheet should have portrayed eight spondaic word presentations by either a correct response (√) or an incorrect response (X).

Analysis

The data were hand-scored by the experimenter, in that SRT was determined for each subject at each compression ratio, and mean SRT was determined for each group of subjects. This permitted the experimenter to determine the average shift in SRT across ratio of time compression. Effects of ear presentation and lists upon SRT were also determined.

CHAPTER III

RESULTS

The results of this study revealed that inter-list differences of List A and List B of the CID W-I spondaic words showed a .05 dB difference in obtained speech reception thresholds as a function of list presentation. Further, ear differences were found to be .79 dB. These results are reported in Tables 2 and 3 and depicted in Figures 2 through 6.

Time Compression Effects

Table 2 and Figures 2, 3, 4, 5, and 6 indicate a decrease in intelligibility as a function of increasing ratios of time compression. In addition, the decrease in intelligibility is greater between the 40% and 60% compression ratios in comparison to the decrease in intelligibility between the 0% and 40% compression ratios. This difference is illustrated in Figure 5 which depicts a 1.39 dB difference between the speech reception thresholds obtained with a 0% compression ratio and the speech reception thresholds obtained with a 40% compression ratio. Further, Figure 5 depicts a 2.51 dB difference between the speech reception thresholds obtained with a 40% compression ratio and the speech reception

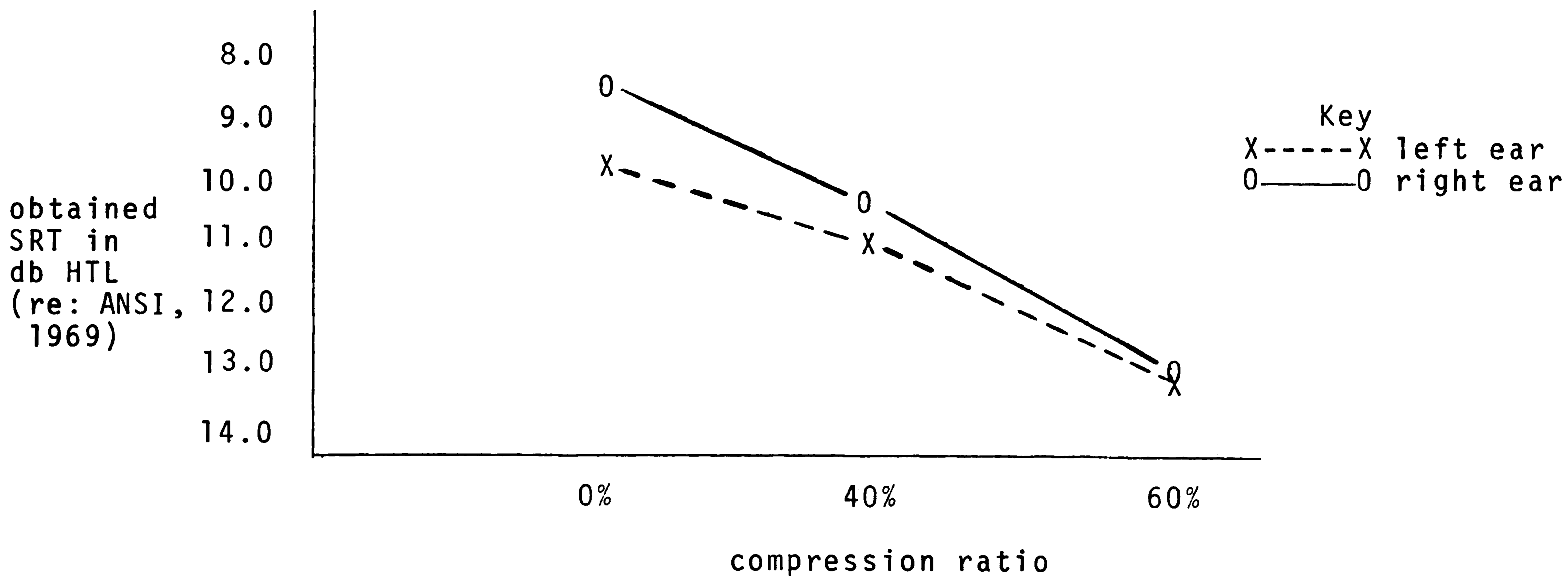


Figure 2. Mean speech reception thresholds for right and left ear presentations collapsed across list.

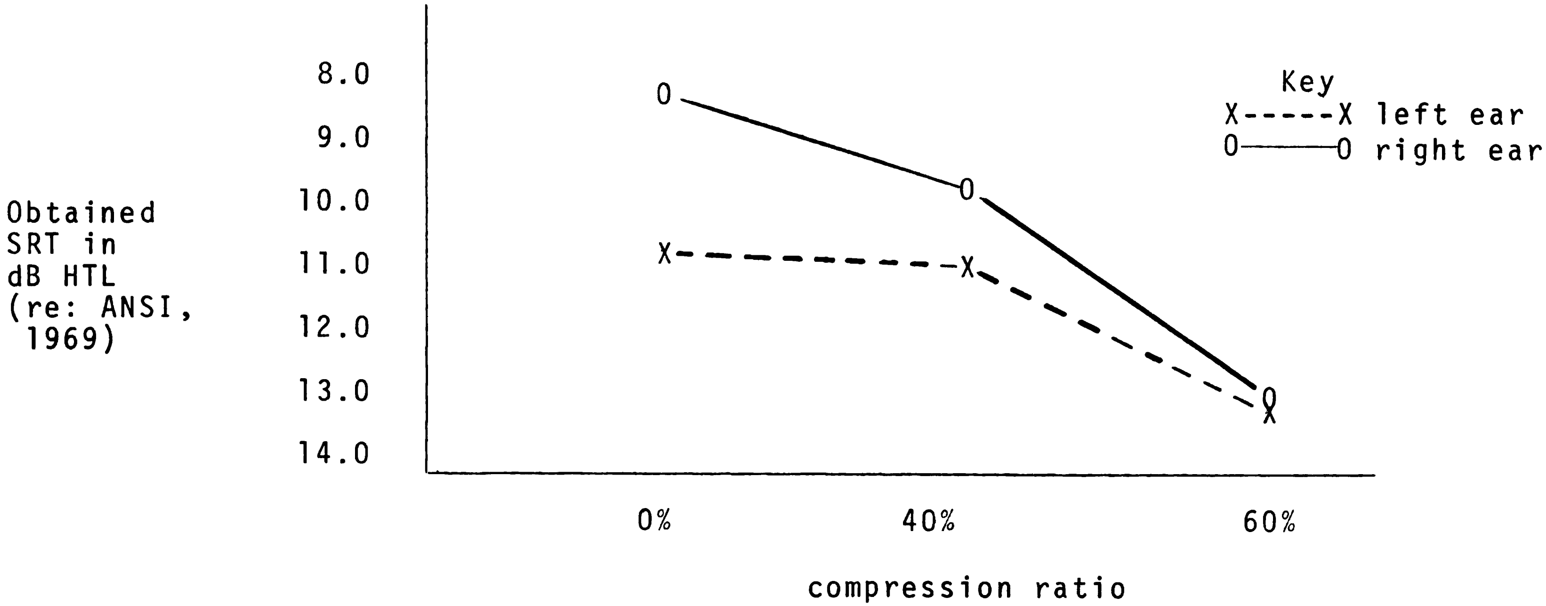


Figure 3. Mean speech reception thresholds for right and left ear presentations: List A.

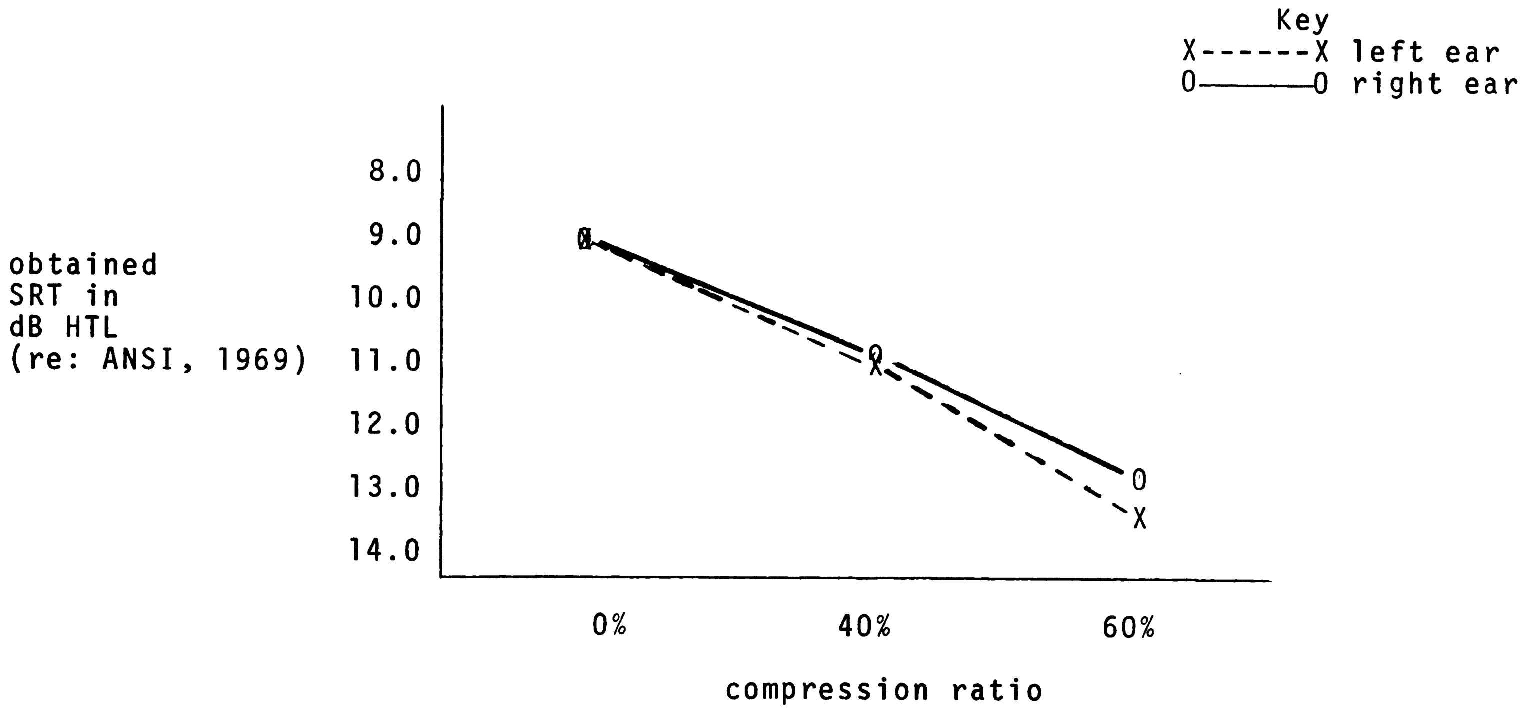


Figure 4. Mean speech reception thresholds for right and left ear presentations: List B.

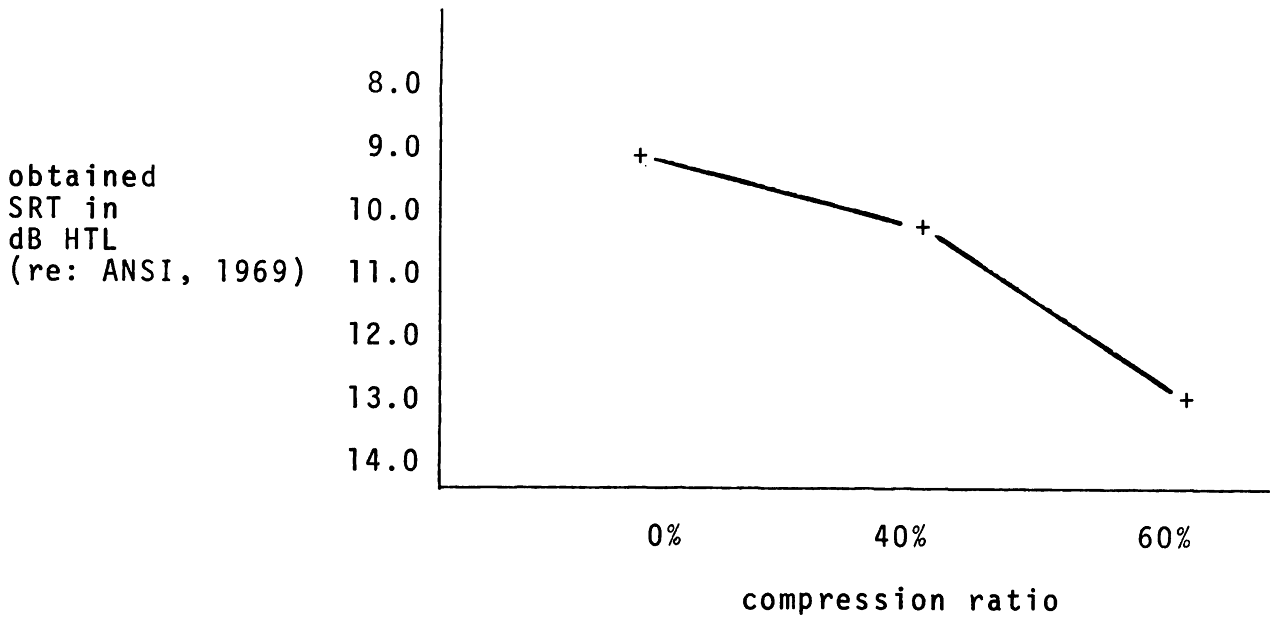


Figure 5. Mean speech reception thresholds collapsed across ear presentation and list.

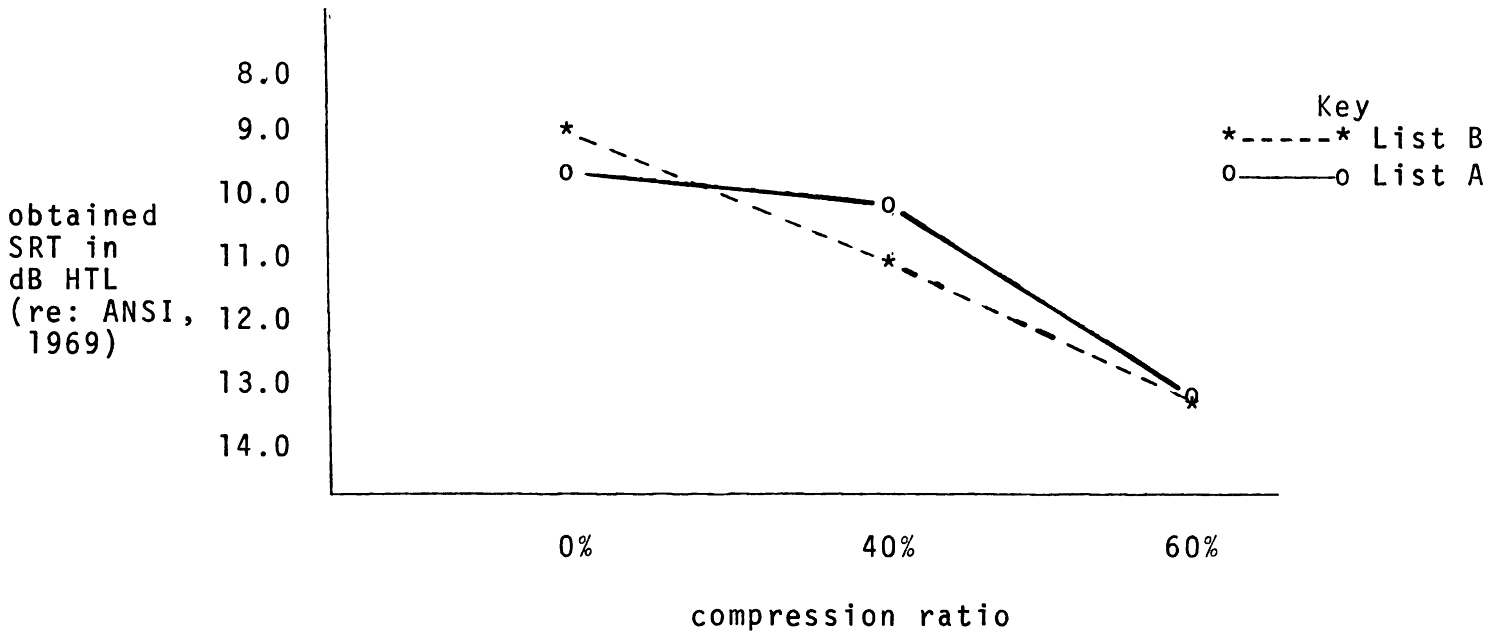


Figure 6. Mean speech reception thresholds collapsed across ear presentation.

Table 2. Average speech reception thresholds for each ratio of time compression, ear presentation, and list presentation.

		Ear		
	List	Left	Right	Total
0%	A	10.87	8.47	$\bar{X}$A 9.67
	B	9.0	9.0	$\bar{X}$B 9.0
	$\bar{X}$	9.93	8.73	$\bar{X}$T 9.33
40%	A	11.0	9.73	$\bar{X}$A 10.37
	B	11.13	11.0	$\bar{X}$B 11.07
	$\bar{X}$	11.07	10.37	$\bar{X}$T 10.72
60%	A	13.27	13.07	$\bar{X}$A 13.17
	B	13.67	12.93	$\bar{X}$B 13.30
	$\bar{X}$	13.47	13.0	$\bar{X}$T 13.23
Total	$\bar{X}$	11.49	10.70	$\bar{X}$ 11.09

thresholds obtained with a 60% compression ratio. Figure 5 also depicts a 3.90 dB difference between the speech reception thresholds obtained with a 0% compression ratio in comparison to speech reception thresholds obtained with a 60% compression ratio. Thus, the data support a shift in speech reception threshold as a function of ratio of time compression that is considered minimal by the experimenter. The shift in speech reception threshold is consistantly in the downward direction (poorer speech reception threshold) for all list presentations and ear presentations. The lack of a marked shift in speech reception threshold as a function of increasing ratios of time compression may be due to the relatively low ratios of time compression. It is possible that a 70% compression ratio needs to be used before a dramatic shift in speech reception threshold will result.

Ear Effects

Tables 2 and 3 and Figures 2, 3, and 4 illustrate the average effects of ear presentation across three ratios of time compression. These data suggest a difference in speech reception thresholds as a function of spondaic word presentation to either the right or left ear that is considered minimal by the experimenter.

Table 2 reports average speech reception thresholds in terms of ratio of compression, ear presentation, and list presentation. Considering ear presentation while simultaneously disregarding list presentation, the data portrayed a 1.20 dB difference in speech reception threshold between the right and left ear presentations for 0% time compression, a .70 dB difference for 40% time compression, and a .47 dB difference for 60% time compression. Thus, the data cumulatively portray a .73 dB range (.47 to 1.20 dB) in terms of the differences between right and left ear presentations across the various compression ratios when collapsed across list presentation. Further, the data indicate a .79 dB average difference in speech reception threshold across ratios of time compression as a function of ear presentation. Together, the range across compression ratios (.73 dB) and the average difference in speech reception threshold between

Table 3. Average speech reception threshold across ear presentation and list presentation disregarding ratio of time compression.

	Ear		
List	Right	Left	Total
A	10.42	11.71	11.07
B	10.98	11.27	11.12
Total	10.70	11.49	11.09

the right and left ear presentations (.79 dB) respectively indicate minimal difference between right and left ear presentations across ratios of time compression, and minimal shift in speech reception threshold as a function of ear presentation within ratios of time compression.

Table 3 depicts average speech reception thresholds in terms of ear presentation and list collapsed across ratio of compression. These data also indicate a minimal (.79 dB) shift in speech reception threshold as a function of ear presentation.

Figure 2 depicts right and left ear presentations across ratios of time compression while simultaneously disregarding list presentation. These data depict a portion of the data reported in Table 2. Again, as ratio of time compression increased, speech reception threshold exhibited a similar downward shift with either right or left ear presentation.

Finally, Figures 3 and 4 depict average speech reception threshold for right and left ear presentations of List A and List B respectively. Figures 3 and 4 indicate that ear presentation effects were slightly greater for List A than for List B. Specific differences in speech reception threshold for right and left ear presentations of List A and List B are reported in Table 2.

Cumulatively, the data indicate differences in speech reception threshold due to ear presentation at all ratios of time compression that are considered minimal by the experimenter. However, Figures 2, 3, and 4 portray a slight, but consistent right ear superiority at all ratios of time compression.

List Effects

Tables 2 and 3 and Figure 6 illustrate average speech reception thresholds in terms of list presentation. These data suggest differences in speech reception threshold as a function of list presentation that are considered minimal by the experimenter.

Table 2 shows speech reception threshold in terms of ratio of compression, ear presentation, and list presentation. Considering list presentation while simultaneously disregarding ear presentation, the data portrayed a .67 dB difference in speech reception threshold between spondaic word presentations of List A and B of the CID W-I lists for 0% time compression, a .70 dB difference for 40% time compression, and a .13 dB difference for 60% time compression. Thus, the data indicate a .50 dB average difference in speech reception threshold as a function of list presentation while simultaneously disregarding ear presentation.

Reference to Table 3 reveals a .05 dB difference in speech reception threshold as a function of list presentation while simultaneously disregarding ear presentation and ratio of time compression.

In general, the data indicate differences in speech reception threshold as a function of list presentation at all ratios of time compression that are considered minimal by the experimenter.

CHAPTER IV

DISCUSSION

It has been reported that persons with central auditory disorders typically show normal sensitivity and an inability to understand speech contralaterally, whereas persons with a peripheral auditory disorder typically show sensitivity loss, distortion, abnormal adaptation, and inability to understand speech ipsilaterally (Jerger, 1974). In addition, it has been suggested that persons with central auditory disorders can not sufficiently synthesize stimulus materials which have been temporally altered (Bocca and Calearo, 1963; Calearo and Lazzaroni, 1957). Bocca and Calearo (1963) and Jerger (1960) reported that the auditory mechanisms central to the cochlear nuclei became progressively more diffuse and less definitive, and suggested that complex stimuli were required to detect lesions within the higher portions of the central auditory system.

Bocca and Calearo (1963) and Calearo and Lazzaroni (1957) suggested that time compressed speech materials, wherein inherent temporal redundancy was reduced, could be used in the detecting of lesions of the central auditory system. Calearo and Lazzaroni (1957), using short sentences recorded at 140 wpm, 250 wpm, and 350 wpm reported that intelligibility decreased as a function of increasing rates of presentation for patients with temporal lobe tumors. In addition, accelerated stimuli presented to the ear contralateral to the lesion yielded poorer discrimination scores than accelerated stimuli presented to the ear ipsilateral to the lesion. Thus, it appears that accelerated speech stimuli can provide useful differentiating data in terms of decreased intelligibility in ears contralateral to neurological lesions in central auditory disorders.

The use of time compressed speech stimuli during a differential evaluation has several inherent advantages over the use of other forms of distorted speech tests, for example, filtered speech tests. Aaronson (1967) and Aaronson et al. (1971) postulated that the perception of auditory stimuli was temporally biased and that the perceptual encoding was dependent in part upon stimulus duration. However, the temporal alteration associated with time compressed stimuli is not associated with filtered speech tests. In addition, controlled temporal acceleration of speech messages does not eliminate relevant spectral information which would be adversely affected by frequency filtering.

Time Compression Effects

The results of the present study indicate a gradual decrease in intelligibility of spondaic words as a function of increasing ratios of time compression which ranged from 0%

through 60% of the original time. These findings were generally in agreement with the results of Garvey (1953) who also found a gradual decrease in intelligibility of spondaic words as a function of increasing ratios of time compression. However, several inherent problems existed with the comparison of this study to Garvey's (1953) study.

Garvey (1953), using normal hearing young adults, presented spondaic words accelerated from 1.5 to 4.0 times the speed of the original message at a constant level of 44 dB SL. He used both the speed changing and the cut-splice technique of time compression to produce the compressed spondaic words used in his study. In addition, Garvey (1953) reported his results in terms of percent correct at a specific ratio of time compression which, in turn, represented the intelligibility score for the specific ratio of compression. In comparison, this study presented spondaic words compressed to ratios between 0% and 60% of the original message to normal hearing young adults utilizing the Tillman and Olsen (1974) threshold determination procedure. The time compression ratios were obtained using an electronic processor (Lexicon Varispeech I) and the results were reported in terms of speech reception threshold. Therefore, differences between the two studies exist in terms of ratios of compression, presentation level, and compression technique.

Garvey (1953) concluded that spondaic words accelerated up to speeds of 2.5 times the original speed using the cut-splice technique yielded scores portraying less than a 10%

decrease in intelligibility. However, a gradual decrease in intelligibility was also reported for spondaic words compressed to speeds between 1.5 and 2.5 times the original speed, with a marked decrease in intelligibility when acceleration rates of 3.0 through 4.0 times the original speed were used. Statistically significant differences were reported between the intelligibility scores obtained with the cut-splice technique and the intelligibility scores obtained with the speed changing technique, in that spondaic words compressed using the speed changing technique consistantly showed a lower percentage of intelligibility.

To summarize, the results of this study indicate a gradual decrease in intelligibility of spondaic words as a function of increasing ratios of time compression. The lack of a marked decrease in intelligibility as a function of time compression may in part be due to the relatively low ratios of time compression used. Further investigation is needed, however, to assess the intelligibility of spondaic words at higher ratios of time compression.

Test Ear Effects

The same speech materials were used during the experimental evaluation of both the right and left ears. The use of identical stimuli to evaluate either ear was based on the underlying assumption of all audiometric testing that normal ears will react similarily when stimulated by identical materials (Schwimmer, 1971). However, if in fact intelligibility varies as a function of ear presentation, separate tests would have to be devised to assess each ear.

Research using dichotic and/or monotic presentation of auditory stimuli has not only suggested that either ear will similarily respond to identical stimuli, but has also suggested a laterality effect associated with specific forms of auditory stimuli. Kimura (1961a), using individuals with epileptic foci in various areas of the brain, found that both temporal lobes participate in auditory activity. However, the left temporal lobe was particularily important for the identification of verbal material (digits) under dichotic listening conditions. Milner (1962), using individuals with temporal lobe lesions and the Seashore Measures of Musical Talents, found that a left temporal lobectomy did not affect time judgements in terms of duration, timbre judgements, or tonal memory. However, time judgements, timbre judgements, and tonal memory were adversely affected by a right temporal lobectomy. Thus, it appears that the identification of verbal material is more adversely affected by left temporal lobectomy, whereas the identification of musical materials is more adversely affected by right temporal lobectomy. In essence, the above studies support a cerebral dominance for specific forms of auditory stimuli. However, it is important to recognize the relationship between cerebral dominance information and ear preference information.

Kimura (1961a) reported that extensive amounts of research have shown that contralateral neural pathways from the ear to the cerebral cortex of animals (dogs, cats, monkeys) were more abundant than ipsilateral neural pathways. In addition, Kimura (1961a) reported evidence to support a similar central auditory organization in human beings. Specifically, Kimura (1961a), using dichotic presentations of digits, found that both right or left temporal lobectomy impaired perception of digits arriving at the ear contralateral to the lobectomy. In another study, Kimura (1961b) studied the contralateral ear effect in individuals with speech represented in the right hemisphere rather than the usual left hemisphere. The dominant hemisphere was determined by injecting sodium amytal into the internal carotid artery of one side of the brain, thereby temporally disrupting the function of that hemisphere. Dysphasia resulted only when the dominant side for speech received the injection of sodium amytal. Kimura (1961b) found that digits arriving at the ear contralateral to the dominant hemisphere was more efficiently recognized than digits arriving at the ear ipsilateral to the dominant hemisphere. These results suggest not only that the contralateral pathways are more abundant than the ipsilateral pathways, but also that the dominant hemisphere is important for the identification of verbal stimuli whether it is represented in the right or the left hemisphere.

Studies using monotically presented stimuli have questioned whether monotic auditory stimulation will yield results similar to those studies using dichotically presented stimuli. In other words, if the hemispheres are stimulated unilaterally will each hemisphere still show a dominance for specific stimuli?

Dirks (1964), using filtered monosyllables found a significant right ear superiority under dichotic listening conditions and a nonsignificant right ear superiority (58.8% for the right ear and 58.6% for the left ear) under monotic listening conditions for normal hearing young adults. Dirks (1964) concluded that assymetry between the hemispheres resulted only under dichotic listening conditions. Therefore, under monotic stimulation the hemispheres portrayed a symmetrical relationship. Beasley et al. (1972a), using time compressed monosyllables, also found a minimal right ear superiority under monotic listening conditions for young normal hearing individuals.

Kimura (1967), using monosyllables, found a nonsignificant left ear superiority (86% for the left ear and 81% for the right ear) under monotic listening conditions for normal hearing adults. Thus, a difference exists between the reported findings of Dirks (1964) and Beasley et al. (1972a) in comparison to the reported findings of Kimura (1967) in terms of ear superiority under monotic listening conditions. However, only Kimura (1967) did not report a right ear superiority under monotic listening conditions, and all studies reported nonsignificant advantages under monotic listening conditions for either the right or left ear advantages that did occur. Thus, these findings support two conclusions: First, if an ear advantage does exist under monotic listening conditions, it is probably for the right ear and second, it is probably not a statistically significant advantage. Glorig (1958) supports this contention by reporting a minimal right ear superiority for both pure tones and speech stimuli for 3,515 individuals. In addition, the present study reported minimal effect favoring the right ear as a function of ear presentation. Therefore, the results of the present study suggest that this monotic test of time compressed spondaic words can be validly used to assess either the right or the left ear without a corresponding laterality effect.

List Effects

The present data suggested that both List A and List B of the CID W-I spondaic words yielded essentially similar results at all ratios of time compression (see Figure 6). List A and List B were composed of identical spondaic words, but differed in that the order of the spondaic words is different for each list (see Appendix F). Therefore, the results of the present study suggest that at various ratios of time compression the presentation order of the spondaic words will not differentially affect speech reception threshold.

Implications for Future Research

The present study represented the only research to date using spondaic words which were time compressed via the electronic technique. Future research should employ higher ratios of time compression to assess the differential capabilities of time compressed spondaic words, since only a minimal shift in speech reception threshold was obtained in this study. Beasley et al. (1972a) using time compressed monosyllables found a marked decrease in intelligibility did not occur until compression ratios of 70% were used. Even though monosyllables cannot be equated with spondaic words, it is possible that a similar time compression effect would be obtained with spondaic words. In other words, a time compression ratio of 70% may be required before a marked decrease in intelligibility is observed.

If in fact higher compression ratios yield a marked decrease in intelligibility then additional implications exist for future research. Specifically, the effects of time compressed spondaic words on subjects with peripheral auditory disorders including conductive pathology, cochlear pathology, and retrocochlear pathology and subjects with central auditory disorders need to be evaluated to assess the efficiency of time compressed spondaic words in differentiating peripheral auditory disorders from central auditory disorders. In order for time compressed spondaic words to be useful as a differential tool in the diagnosis of central auditory lesions, research needs to provide evidence supporting the assumption that when utilizing time compressed spondaic words as a stimuli, individuals with any form of peripheral auditory disorder will respond similarly to normal hearers, whereas individuals with central auditory disorders will respond atypically. This underlying assumption of central and peripheral differentiation must be well supported by research prior to the clinical application of time compressed spondaic words.

Another potential area of investigation is the comparison of responses to time compressed spondaic words to the responses to other forms of distorted speech stimuli designed to differentiate peripheral auditory disorders from central auditory disorders. Future research is needed to determine the specific site within the central auditory system which is taxed by time compressed stimuli. Bocca and Calearo (1963) indicated that time distorted materials are useful in identifying lesions at the level of the second order neurons, whereas frequency distorted materials are useful in identifying lesions above the third order neurons. However, other research has suggested time distorted materials are useful in identifying lesions above the third order neurons within the diffuse areas of the central auditory system (Calearo and Lazzaroni, 1957). Thus, future research should attempt to differentiate the site within the central auditory mechanism being taxed when utilizing temporally distorted materials. Such information would be useful in terms of developing a test battery for the diagnosis of central auditory disorders. If it is established that specific areas of the central auditory system are responsible for the identification of time distorted speech, then the clinical utility of time compressed speech materials as a diagnostic tool will improve significantly.

A further area of investigation suggested by the results obtained in this study is concerned with ear effects. Research has not confirmed the clinical utility of monotic speech tests in terms of ear superiority. However, the present study and other studies (Beasley et al., 1972a; Dirks, 1964; Glorig, 1958) have reported a minimal right ear superiority for various forms of auditory stimuli, and it is important for future research to consider ear effects. Equal numbers of right and left ears should be used during the testing procedures so that ear effects can be examined. Thus far, it appears that ear presentation will not confound results obtained utilizing time compressed speech materials. However, as mentioned, future research should include controls to examine the possibility of laterality effects in the identification of time compressed materials.

Finally, another potential area of research would be the applicability of time compressed spondaic words as a reference for determining presentation level for time compressed monosyllables. Traditionally, time compressed monosyllables presented at suprathreshold levels have been used as the experimental stimuli in controlled time compression research. However, sensation level was determined from speech reception thresholds using noncompressed spondaic words. It is possible that time compressed spondaic words represent a more appropriate stimulus than noncompressed spondaic words for the establishment of presentation level for compressed monosyllables.

In summary, then, several potential areas of research exist not only for the utilization of time compressed spondaic words, but also for the utilization of other forms of time compressed speech materials. The data reported thus far in the literature suggests valuable diagnostic implications for the use of time compressed speech materials during the differential diagnosis of auditory disorders. However, several areas related to the differential capabilities of time compressed speech materials need to be investigated further.

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APPENDICES

APPENDIX A

CASE HISTORY INFORMATION

CASE HISTORY INFORMATION

SUBJECT__________________

Do you think you have normal hearing?________ AGE______

Have you ever worked in a noisy place?_____ Did you have to shout in order to be heard by a person less than 3 feet away?_____ Did you wear ear protectors?_____

Have you ever used guns?_____, snowmobiles?_____, noisy power equipment?_____

Do you have difficulties hearing the telephone ring when you are in another room?_____

Do you have difficulties hearing the doorbell ring when you are in another room?_____

Do you watch people's lips in order to understand their speech?_____

Have you ever had a hearing test before?_____

Do you get dizzy?_____

Do you have any numbness in your face?_____

How much aspirin do you take every day?_____

What other medication do you take?_________________________

Have you ever been hit on the head and knocked out?_____ Explain____

Have you ever taken any of the following drugs? Kanamycin?____, Quinine?____, Streptomycin?____, Dihydrostreptomycin?____

Did you notice any difficulties hearing after measles____, mumps____, scarlet fever____, chicken pox____?

If you have had earaches, how old were you?____ Were they medically treated?____

Have you ever had surgery on your ears?____

Which hand do you write with?_______

Additional information relating to hearing or ears:

APPENDIX B

PURE TONE SCREENING INSTRUCTIONS

PURE TONE SCREENING INSTRUCTIONS

You are going to hear some beeps of different frequencies. Raise your finger or your hand each time you hear a beep. First I will test your right ear and then I will test your left ear. Do you have any questions?

APPENDIX C

DISCRIMINATION TESTING INSTRUCTIONS

DISCRIMINATION TESTING INSTRUCTIONS

Now you are going to hear a list of words. Write each word you hear on this answer sheet. If the words come too fast, please signal me. Do you have any questions?

APPENDIX D

INSTRUCTIONS FOR EXPERIMENTAL TESTING

INSTRUCTIONS FOR EXPERIMENTAL TESTING

You are going to hear some words that have two parts; words like airplane, cowboy, hotdog. Some of the words will sound as though they are being said very quickly, and some of the words will sound as though they are being said at a normal rate. All of the words will get softer and softer. Just repeat as many of the words as you can. If you are not sure of a word, don't be afraid to guess. Do you have any questions?

APPENDIX E

RECORDING SHEET

RECORDING SHEET

STARTING LEVEL: 40 DB HTL. 40

LEVEL IN DB OF FIRST INCORRECT RESPONSE . . . . ________

LEVEL IN DB OF SECOND INCORRECT RESPONSE. . . . . . . ________

LEVEL IN DB WHERE THRESHOLD TESTING BEGAN . . . . . . ________

RESPONSES ONCE THRESHOLD TESTING BEGAN. . . . . ________

________, ________, ________, ________

________, ________, ________, ________

________, ________, ________, ________

________, ________, ________, ________

________, ________, ________, ________

LEVEL IN DB WHERE FIVE OF SIX LAST SPONDEES WERE MISSED. . . . . ________

NUMBER OF CORRECT RESPONSES. . . . . ________

OBTAINED SRT ________

APPENDIX F

LISTS A AND B OF CID W-I SPONDAIC WORDS

LISTS A AND B OF CID W-I SPONDAIC WORDS

1.	greyhound	1.	playground
2.	schoolboy	2.	grandson
3.	inkwell	3.	daybreak
4.	whitewash	4.	doormat
5.	pancake	5.	woodwork
6.	mousetrap	6.	armchair
7.	eardrum	7.	stairway
8.	headlight	8.	cowboy
9.	birthday	9.	oatmeal
10.	duckpond	10.	railroad
11.	sidewalk	11.	baseball
12.	hotdog	12.	padlock
13.	padlock	13.	hardware
14.	mushroom	14.	whitewash
15.	hardware	15.	hotdog
16.	workshop	16.	sunset
17.	horseshoe	17.	headlight
18.	armchair	18.	drawbridge
19.	baseball	19.	toothbrush
20.	stairway	20.	mushroom
21.	cowboy	21.	fairwell
22.	iceberg	22.	horseshoe
23.	northwest	23.	pancake
24.	railroad	24.	inkwell
25.	playground	25.	mousetrap
26.	airplane	26.	airplane
27.	woodwork	27.	sidewalk
28.	oatmeal	28.	eardrum
29.	toothbrush	29.	greyhound
30.	fairwell	30.	birthday
31.	grandson	31.	hothouse
32.	drawbridge	32.	iceberg
33.	doormat	33.	schoolboy
34.	hothouse	34.	duckpond
35.	daybreak	35.	workshop
36.	sunset	36.	northwest

APPENDIX G

ANSWER FORM FOR DISCRIMINATION SCREENING

ANSWER FORM FOR DISCRIMINATION SCREENING

N.U. #6 SCREENING

SUBJECT________________