PERFORMANCE OF READING IMPAIRED AND NORMAL READING CHILDREN ON TEMPORALLY ALTERED MONOSYLLABLES AND SENTENTIAL STIMULI

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ABSTRACT

PERFORMANCE OF READING IMPAIRED AND NORMAL READING CHILDREN ON TEMPORALLY ALTERED MONOSYLLABLES AND SENTENTIAL STIMULI

By

Barry A. Freeman

The purpose of this study was to investigate the performance of a group of reading impaired and normal reading children on temporally altered monosyllables and sentential approximations to full grammaticality.

Subjects were twenty children who were at least two years behind their equivalent grade level in reading, and twenty normal readers who were matched to the experimental group for age and socioeconomic background. The children ranged in age from 9 to 11 years.

The speech stimuli included four lists of Form B of the Word Intelligibility by Picture Identification (WIPI) test, ten 3- and 5-word normal sentences, ten 3- and 5-word second order sentential approximations, and ten 3- and 5-word first order sentential approximations. The speech stimuli were recorded at 0% and 60% time compression. For the WIPI test the children were randomly divided into two groups. One group received the time compressed WIPI in its standard closed-set picture identification response format. The other group had an open-set format which necessitated verbal

repetition of the stimuli. Each subject also received all orders of either the 3-word or the 5-word sentential stimuli at both 0% and 60% time compression. The WIPI and the sentences were presented through earphones at 24 dB sensation level and 50 dB sensation level, respectively.

The results of this study indicated that the two groups of children could be differentiated by the temporally altered speech stimuli. The normal control group subjects recalled and repeated the first and second order sentential approximations with less difficulty than the reading impaired children. The children were also differentiated by the time-compressed WIPI test but not as effectively as by the sentences.

The results suggested that the reading impaired children did not have the linguistic competence of the normal reading control group. An analysis of errors revealed that the experimental group made both discrimination and omission (i.e., memory) errors. Discrimination errors, however, predominated for the control group. Thus, the two groups processed linguistic stimuli differently.

Based on the results of this study, suggestions were made for diagnostic and therapeutic applications and implications of the stimuli. In addition, the results were discussed in relation to models of perception and reading.

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By

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INTRODUCTION

Adequate diagnosis of auditory perceptual impairments in children has been limited due to the subtlety of such pathologies. An impaired auditory system resulting from excision of a temporal lobe, for example, would be demonstrable only after extensive auditory testing (Jerger, 1969). Traditionally, audiologists have employed tasks that required the recall and repetition of speech stimuli. Processing of these stimuli was facilitated by the extrinsic redundancy of the message and the intrinsic redundancy of the central auditory pathways (Calearo and Lazzaroni, 1957). Jerger (1960) suggested that a reduction in the extrinsic redundancy i.e., cues provided by intonation and stress patterns, syntax and semantic content, would provide for better evaluation of the neuronally complex central auditory nervous system.

Reduction of redundant linguistic cues in a clinical diagnostic evaluation of the auditory pathways has been accomplished by filtering and subsequently allowing for binaural fusion of the stimuli (Willeford, 1974; Matzger, 1959; Smith and Resnick, 1969; Calearo, 1957), binaurally alternating or interrupting the stimuli (Willeford, 1974), presenting the stimuli dichotically (Katz, 1964; Willeford, 1974), and employing speech in noise (Goldman, Fristoe and Woodcock, 1971). The clinical utility of these procedures, however, has been open to question. Calearo (1975), an early investigator of filtered and interrupted speech tasks, concluded that such tasks provide only limited diagnostic information. In addition, he found that performance was positively correlated with IQ score.

Dichotic listening tasks, especially the Staggered Spondaic Word (SSW) test (Katz, 1968), have been among the more popular clinical tests used to predict central dysfunction. Freeman and Beasley (1974), however, rasied some serious procedural questions about the construction of the SSW. In addition, Blumstein et al. (1975) found that dichotic tasks had questionable reliability. Berlin and McNeil (1975) and Speaks (1974) concluded that dichotic listening tasks were research tools, and did not have conclusive clinical utility. Thus, it appears that certain of the audiologic diagnostic tools that have been employed in the diagnosis of auditory perceptual impairments are, at present, of equivocal value.

Temporal Processing

Calearo and Lazzaroni (1957) suggested that the extrinsic redundancy of an auditory stimulus could be reduced by modification of the temporal nature of the speech signal. This concept, however, was based upon the assumption that time played an important role in linguistic processing.

Several investigators have demonstrated that speech is a special case of temporal sequencing. Papcun et al. (1974) found that trained operators and naive listeners processed morse code signals more efficiently in the right ear (left hemisphere) and concluded that speech dominant left hemisphere was superior to the right hemisphere in processing temporal sequences. Efron (1963) found that temporal ordering was primarily localized to the left hemisphere. Jerger et al. (1972) supported Efron's contention when they found that specific auditory disorders were differentiated from aphasia by tests whose format included temporal sequencing.

Time Compression

One method of altering the time domain of the speech signal is via time-compression procedures. Time-compression reduces both the redundancy and the duration of the speech signal by discarding segments of the verbal stimuli. The sampling of speech could occur anywhere within or between linguistic segments and, thus, the discarded segment is random. Calearo (1975) noted that time compression was only negligibly affected by intelligence and appeared to be more sensitive to central auditory pathology than either filtered or interrupted speech tests.

Clinically, this procedure has been employed with children (Shriner and Sprague, 1969; Beasley and Maki, 1975) and adults (Beasley, Schwimmer, and Rintelmann, 1972;

Beasley, Forman, and Rintelmann, 1972), and also has proven sensitive in discerning persons with central auditory pathologies (Kurdziel and Noffsinger, 1973; Konkle, Beasley, and Bess, 1974; Orchik and Oelschlinger, 1974; Manning, Johnston, and Beasley, 1975; Freeman, Beasley, and Overholt, 1975).

Beasley and Maki (1975), Maki (1975) and Shoup (1975) presented a time compressed version of the Word Intelligibility by Picture Identification (WIPI) (Lerman, Ross, and McLaughlin, 1965) monosyllabic speech discrimination test to normal hearing children. They found that children performed almost equally as well at 30% time compression as at 0% time compression, and only 10% poorer at 60% time compression. Manning, Johnston, and Beasley (1975) and Freeman, Beasley, and Overholt (1975) presented time compressed versions of the PB-K 50 (Haskins, 1949) and the WIPI test, respectively, to groups of children with auditory perceptual impairments. The result of both investigations indicated that discrimination performance was reduced as a function of time compression and sensation level for the impaired subjects when compared to the normative data of Beasley and Maki (1975). The results of the Manning et al. and Freeman et al. investigations suggested that time altered speech in the form of time compression could be employed with children to differentiate among auditory processing difficulties. Use of stimuli which are linguistically more complex, such as sentential material, however, may be more sensitive to a centrally based disorder. Speaks and Jerger (1965) devised synthetic sentences through which content and sentence length were controlled, i.e., sentential approximations. Sentential approximations reduced syntactic and semantic cues because each word in a specific sequence was chosen with varying degrees of sequential probability of occurrence. Speaks and Jerger found that as the sentential approximations approached the syntactic and semantic constraints typical of normal sentences, processing of stimuli was facilitated.

Temporally altered sentences have been employed to explore the relationship between word duration and the interval between words (Aaronson, 1967; Aaronson, Markowitz, and Shapiro, 1971; Beasley and Shriner, 1973), to determine the role of intonation and stress patterns in speech perception (Wingfield, 1975), and to determine the adequacy of memory in processing a number of words per unit of time (Schill and Schuckers, 1973; Pantalos, Schuckers, and Hipskind, 1975). Aaronson, Markowitz, and Shapiro (1971) covaried the word durations and inter-stimulus intervals of numerical sequences, and demonstrated that, although both factors were significant in auditory perceptual processing, the interval between the words played a more significant role than word duration. They postulated that at 33% time compression the recall accuracy between normal and compressed stimuli was equivalent because the word duration was adequate for item repetition. Order errors, however, predominated and these were attributed to a reduction in the interval between the stimuli from compression. Aaronson et al. predicated these findings on the theory presented by Broadbent (1957). That is, that there are two stages of memory. Stage one is a large capacity rapid decay system where a modification of word duration would be most effected. Stage two is a small capacity slow decay system where item encoding occurs and, thus, the processing time between items is critical. Beasley and Shriner (1973) evaluated word duration and inter-stimulus interval of sentential approximations. They agreed that word duration and inter-stimulus interval play important roles in recall accuracy, but found that recall accuracy was more dependent on the former. The discrepancy between the two studies regarding inter-stimulus interval and word duration was most probably a result of the different levels of the linguistic content of their stimuli (i.e., digits versus sentential approximations).

Wingfield (1975) presented normal sentences with varied intonation patterns at different levels of time compression to normal adult listeners. He found that sentences with abnormal intonation were affected more by time compression than normally intonated sentences. Schuckers, Shriner, and Daniloff (1973) had children repeat sentences that varied in word length and inter-stimulus interval such that the prosodic and intonational cues were distorted. They found that processing was more dependent upon sentence length than prosodic cues such as duration. Schill and Schuckers

(1973) supported this conclusion when they found that sentences which were seven words or longer were influenced more by temporal alteration than sentences of less than seven words. Pantalos, Schuckers, and Hipskind (1975) covaried the word length and inter-stimulus interval of sentences. They found that more errors were made on sentences having five or more words regardless of the total duration of the sentence. It appears, then, that temporal alteration does affect speech processing. Some confusion, however, remains regarding the importance of the interaction between prosodic cues, sentence duration, word duration, and the total number of words per unit of time.

Sentential Redundancy

In addition to affecting the intonational characteristics of a stimulus, time compression and sentential approximations disrupt the smooth flow of the syntactic and semantic content. Tejirian (1968) found that improved performance from first order to second and third order sentential approximations was due primarily to the addition of the syntactic cues of the stimulus. However, improved recall and repetition of third or higher order sentential approximations was related to the variance in semantic cues. The semantic and syntactic content, then, both enable individuals to process information more efficiently. Carrow and Mauldin (1973) demonstrated that children and adults both use the redundant cues of syntax and semantics in recalling and repeating sentential stimuli. They did find, however, that children age 4 to 7 years could not repeat sentential approximations as proficiently as adults. Carrow and Mauldin suggested that the children did not possess the structural and semantic competence of the older group. McNeil (1970), in fact, found that semantic competence was not present until approximately 5 to 8 years of age.

Menyuk and Looney (1972) had language disabled children repeat meaningful and non-meaningful sentences. More errors were made on the semantically reduced non-meaningful stimuli and Menyuk and Looney concluded that there was a strong dependent relationship between semantic and phonologic rules. Thompson (1973, 1974) found that the repetition of time-compressed sentences was dependent upon syntactic complexity and rate of presentation. She noted that comprehension of semantically and syntactically altered time-compressed and time-expanded sentences improved with age. Thus, as Miller and Isard (1963) have concluded, "...linguistic rules of a non-phonological sort do indeed have measurable effects on our ability to hear and repeat sentences." That is, the inherent extrinsic redundancy of sentences in the form of intonation and stress patterns as well as syntactic and semantic content apparently facilitates the perceptual processing of language.

Reading and Perception

The diagnostic techniques employed for the evaluation of auditory perceptual impairments in children have been related to two prevailing schools of thought. The first contended that perceptual problems were motorically based while the second supported the concept of an auditory disturbance that interfered with linguistic development.

The motor theories of learning (Kephart, 1967; Cratty, 1974; Getman, 1974) have relied upon the hypothetical basis that the development of cognition was provided primarily through visual inputs which were integrated and correlated with motor activity. These theorists suggested that a child who had poor motor skills or balance problems would have difficulty learning to read. They have tended to ignore the role of speech and language in the development of reading. Mattingly (1972), however, stated that reading was a deliberately acquired language based skill which was dependent upon the awareness of certain aspects of basic linguistic activity in speaking and listening. Further, Mattingly contended that reading was an automatic behavior related to verbal language and cognition. In support of this contention, Norman (1969) theorized that visually presented linguistic material was received initially by a visual sensory storage system and subsequently was decoded, integrated and processed in auditory form. LaBerge and Samuels (1974) provided a theoretical framework for reading based upon the concept of automaticity. They suggested that visual stimuli were processed semantically after passing through visual, phonologic and episodic memory systems (see Figure 1). Processing at each stage

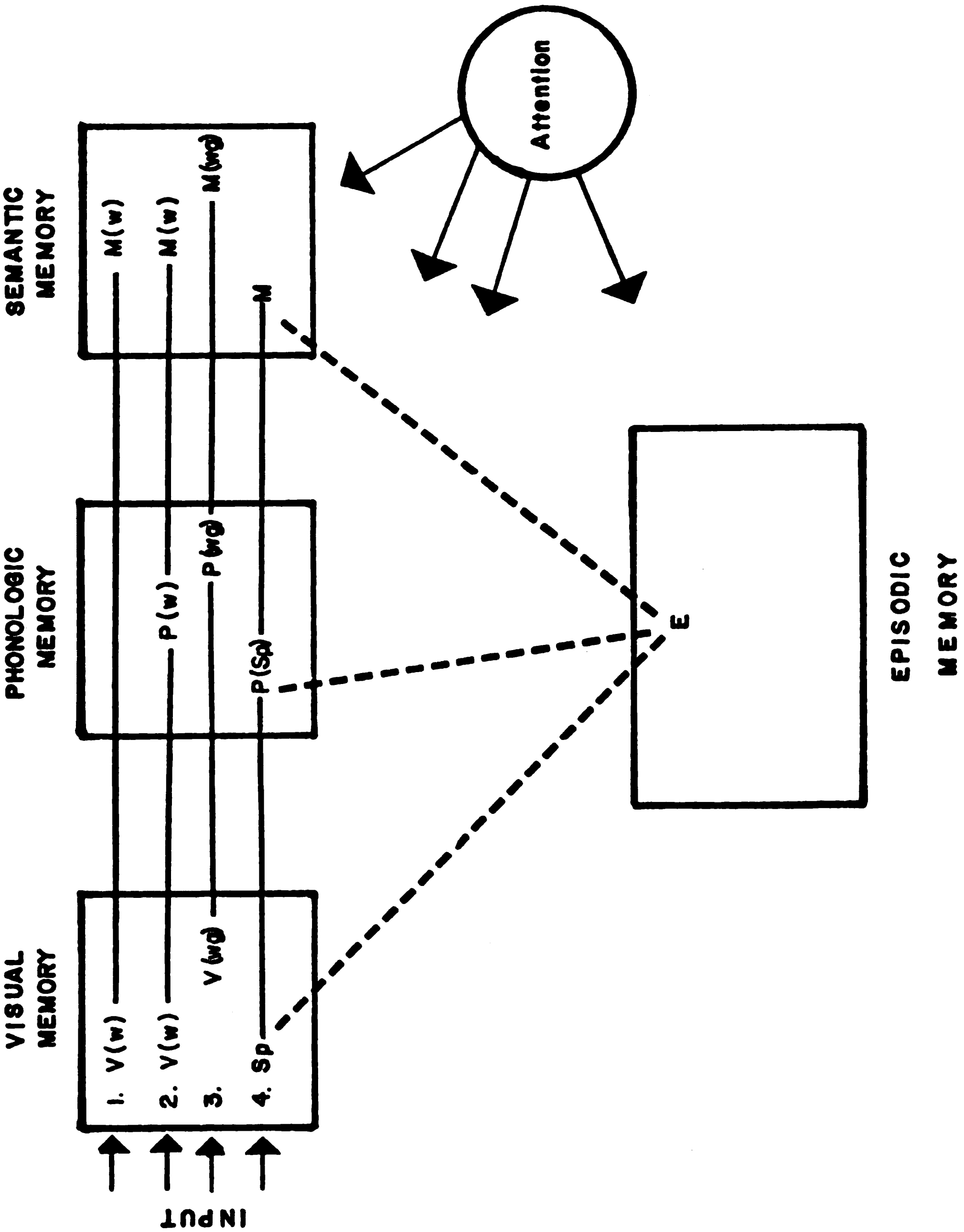

Figure 1. A Model of Reading

required learning and experience and these, in turn, were dependent upon accuracy and automaticity. The role of attention was explained as a necessity for accuracy but not automaticity.

The visually presented word in the LaBerge and Samuels model could take one of several alternative routes to reach the final stage of processing, namely, the activation of meaning codes. These included:

1. the graphemic stimulus was automatically coded into a visual word (V(w)) representation. This automatically activated the meaning word (M(w)) code (e.g., bare or bear);

2. the graphemic stimulus was automatically coded into a visual word (V(w)) representation. This automatically activated the phonologic word (P(w)) code which then automatically excited the meaning code (e.g., any word not coded in example one);

3. the graphemic stimulus was automatically coded into a visual word group (V(wg)) code. This then automatically activated the phonologic word group (P(wg)) which then activated meaning word group (M(wg)) (e.g., apres-ski or beef-stew);

4. the graphemic stimulus was automatically coded into a spelling pattern (sp). This then activated phonologic (P(w)) and/or episodic (e) codes. Episodic codes which provided experiential input were activated only when the stimulus was not at a level of automaticity and conscious experiences had to be related to the stimulus (e.g., skylab). This may also have demanded more attention because of the reduced level of automaticity. Attention then excites the meaning code (M(w)).

LaBerge and Samuels assumed that attention could be directed to only one item at a time for accurate processing, but that automaticity enabled processing of several items simultaneously with minimal attention. In the development of reading, parallel automatic processing of subskills was necessary in order to build towards the final goal of fluent reading. This level of automaticity was dependent on the development and interaction of three coding networks: graphemic, phonologic and semantic memory systems.

On a graphemic level it was thought that word segments were encoded with regard to the distinct features of the letters that composed the word, i.e., the lines, angles and curves. The recall of all of the features of each letter, however, would place a tremendous burden on memory (Miller, 1956). It seemed more reasonable to assume that analysis was a shape, letter or spelling pattern level or some combination of those features. LaBerge and Samuels stressed that despite the exact nature of the code, practice was important to the development of automaticity.

It has been suggested that visual and acoustic input both require phonologic recoding (Rubenstein et al., 1971). LaBerge and Samuels assumed in their model that input to the phonologic system came from visual memory, response memory, semantic memory, auditory stimulation, and articulatory response feedback. The activation of a phonologic spelling pattern or word code was required for the activation of a response system. For example, to respond to a word, attention must be given to its phonologic components so that they can be automatically fed to the final response mode. The coordination of several of these patterns had to be learned to a level of automaticity for generalization.

LaBerge and Samuels suggested that the learning of phonologic word codes appeared to be facilitated through experiences and communication which, in turn, aided in the learning of semantic codes. If this semantic system was learned to the automatic level, then the primary task in reading would become decoding. In conclusion, LaBerge and Samuels hypothesized that reading skills were dependent upon the development of an adequate semantic base capable of processing graphemic codes at an automatic level. Any factor which might interfere with this development would inhibit the learning of an associated task.

Reading Disability

Reading has been suggested to be a linguistic decoding task that requires the integration of several perceptual modalities and systems including vision, audition, memory, and discrimination. A deficit in any one of these areas could result in a reading disability.

Reading skills are obviously dependent upon an intact peripheral visual mechanism to discriminate graphemic stimuli. Linguistic recoding of the visual input, however, necessitates visual-auditory integration and, therefore, intact auditory and visual pathways. Vellutino, Steger and Kandel (1972) and Vellutino, Pruzek, Steger and Meshoulam (1973) suggested that reversals and inversions during reading were not misperceptions but rather misreadings, which, in turn, were not a cause of reading disability, but rather an effect. They concluded that reading problems were cognitively based and related to an impairment in the organization of visually based linguistic material. The converse of these results would suggest that reading disabilities could be the result of a deficient auditory-visual integration system. Yet, the effects of audiologic diagnostic tests that required discrimination of auditory stimuli by pointing to pictures are still undefined with this population.

Locke (1968) suggested that language and reading disabilities resulted from poor short term memory processing abilities, and any associated auditory discrimination loss was a consequence and not a cause of such problems. Savin and Perchonock (1965) found that negative and passive transformations of a sentence were encoded apart from the words of a sentence. They concluded that more than one immediate memory system was activated during the encoding of linguistic stimuli. Consequently, according to Savin and Perchonock, a deficiency in memory could result in an encoding disability. Menyuk and Looney (1972) used a sentence repetition task with children and found that sentence structure was more important for repetition tasks than sentence length. They suggested that there was a deficit in memory that was interfering with proper decoding of the stimuli.

The theory that deficient linguistic decoding is a result of a memory impairment has been disputed by several researchers. Wickelgren (1969) suggested that the coding of items that enter short term memory may be adversely affected by auditory discrimination impairments. Saxman and Miller (1973) expanded upon the results of Marquardt and Saxman (1972) who suggested that linguistic deficiencies were a result of discrimination problems. Saxman and Miller evaluated a group of children with defective articulation. They presented strings of random digits and words, and sentences of varying length to a group of children with defective articulation and a normal control group. More substitution and omission errors were made by the deficient articulation group but there was no correlation between sentence length and articulation errors. They concluded that an impairment to short term memory and poor auditory discrimination may coexist but were not necessarily related. Thus, there are at least three possible explanations for processing problems of visually presented linguistic stimuli, i.e., visual-verbal confusions, deficient short term memory, and poor auditory discrimination.

Statement of the Problem

The stimuli necessary to diagnose auditory perceptual impairments in children must be within the linguistic processing abilities of the children (Carrow and Mauldin, 1973; McNeil, 1970) and yet be sufficiently complex to tax the central auditory processing system (Jerger, 1969; Calearo, 1957; Willeford, 1974). Temporally altered sentential stimuli seem to fulfill these requirements.

There appears to be little doubt that auditory perceptual processing is temporally-based (Efron, 1963; DiSimoni, 1974; Aaronson, 1967), and that temporal alteration of stimuli by time compression can assist in the discernment of individuals with auditory perceptual impairments (Kurdziel and Noffsinger, 1973; Manning, Johnston, and Beasley, 1975; Freeman, Beasley, and Overholt, 1975). Sentential stimuli are of sufficient duration to permit temporal alteration via time compression and still provide syntactic, semantic and intonational cues which aid in processing (Carrow and Mauldin, 1973; Tejirian, 1968; Speaks and Jerger, 1965).

Reading impairment appears to be a linguistic decoding task that requires an intact auditory processing system (Norman, 1972; Mattingly, 1972; LaBerge and Samuels, 1974). Diagnosis of this impairment, then, would be best achieved by employing distorted linguistic stimuli that would have reduced redundancy and would tax the central auditory nervous system. Thus, the purpose of this study was to determine if children with auditorily based reading impairments could be differentiated from normal reading children by temporally altered speech stimuli. Specifically, the purposes of the present investigation were:

1. To determine if a series of time compressed monosyllabic words and sentential stimuli were sufficiently sensitive to differentiate a group of normal reading and reading disabled children.

2. To determine if recall of sentences was affected by temporal alteration and modification of syntactic and semantic content.

3. To determine if reading problems were more related to auditory discrimination difficulties or short term memory impairments.

4. To determine if children with reading problems have more difficulty integrating the visual-auditory modality than do normal reading children.

EXPERIMENTAL PROCEDURES

For this study, twenty normal reading and twenty reading impaired children participated in a temporally altered linguistic test. Each subject was required to recall fifty time compressed monosyllables in either an open-set or closed-set response format and to recall and repeat sixty time compressed 3- or 5-word sentential approximations (see Figure 2).

Subjects

Forty children who ranged in age from 8.2 years to 11.2 years with a mean age of 9.4 years were the subjects of this study. The children were classified into two groups based upon two criteria. The first was a performance index developed by the Lansing School District (see Appendix A). Every child in the system was evaluated in six areas: reading readiness, vocabulary skills, word analysis ability, reading comprehension, study skills, and ability to interpret reading material. The school system established a standard grade level score for each area. The twenty subjects in the experimental group performed at least two years behind their grade equivalent, whereas the twenty children in the control group scored at their grade level or better.

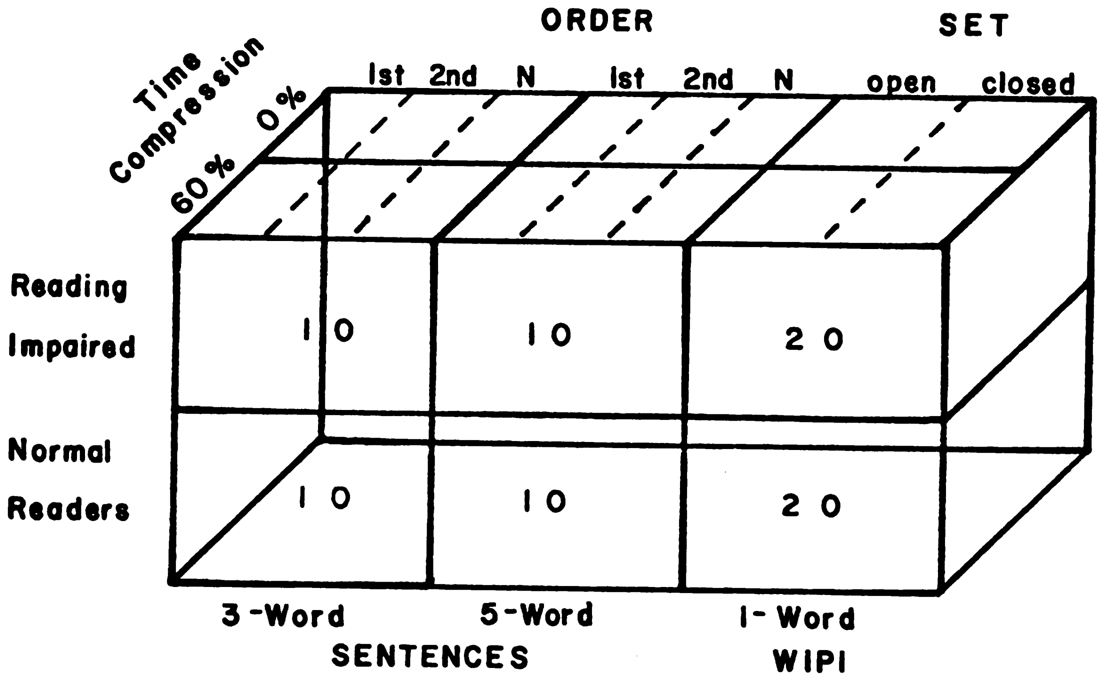

Figure 2. Experimental Design.

All children were selected from the same elementary school and were matched for age.

Following classification into the two groups, the children were evaluated with the Lindamood Auditory Conceptualization (LAC) test. This test involved the manipulation of colored blocks to indicate the children's conceptualization of speech sounds. The test purports to measure auditory discrimination and memory skills. The reading impaired children scored at least two years below their chronological age, whereas the normal reading children obtained chronological age equivalents.

Each of the forty children was given a pure tone air conduction screening test bilaterally prior to the experimental test session. The screening was administered at 15 dB HTL (re: ANSI, 1969) at the octave frequencies from 250 Hz through 8000 Hz. In addition, a speech reception threshold was established for each child using a tape recorded version of the CID W-1 word lists. This threshold was obtained in a manner described by Jerger, Carhart, Tillman, and Peterson (1959).

<u>Experimental Stimuli</u>

The stimuli consisted of four experimental tapes:

1. Ten three-word and ten five-word first order sentential approximations, each time compressed to ratios of 0% and 60%;

2. Ten three-word and ten five-word second order

sentential approximations, each time compressed to ratios of 0% and 60%;

3. Ten three-word and ten five-word normal sentences time compressed to ratios of 0% and 60%;

4. Four lists of Form B of the Word Intelligibility by Picture Identification (WIPI) test at 0% and 60% time compression.

The sentential approximations to full grammatical sentences were ordered in a manner described by Beasley and Flaherty-Rintelmann (1975) and Speaks and Jerger (1965). The sentences were constructed using 100 monosyllabic words which were randomly selected from the Basal Vocabulary of the primary reader workbook <u>On We Go</u> (Teacher Edition, Second level) (Houghton Mifflin, 1966). For first order three- and five-word sentences, the words simply were randomly ordered. The construction of the second order sentences was accomplished by the random selection of a word from the monosyllabic word list. Then another individual was asked to choose a word from the list that may follow word one in a sentence. Word three was supplied by a third individual who, without knowing word one, chose a word to follow word two. The process was continued until all of the sentences were constructed.

The WIPI test, as described originally by Lerman et al. (1966), is a monosyllabic auditory discrimination test. The test was originally intended for hearing impaired children but the time compressed versions have been employed to evaluate the auditory discrimination abilities of normal hearing, hearing impaired, learning impaired and articulatory deficient children (Beasley and Maki, 1975; Maki, 1975; Freeman, Beasley, and Overholt, 1975; Manning, Johnson, and Beasley, 1975; Orchik and Oelschlinger, 1974).

The WIPI was designed to be presented in a closed-set picture pointing response format. Each stimulus picture was presented with five foils and the child was required to recall and point to the correct picture after hearing the stimulus auditorily. The present investigation also presented the WIPI test in an open-set format. That is, the child was required to recall and repeat the stimuli without the aid of visual cues.

Recording and Stimulus Generation

All of the stimuli were recorded onto a master tape via a tape recorder (Ampex, model 440B, frequency response = 50 Hz to 15000 Hz $\pm$ 2 dB) at 7.5 inches per second by a male who spoke general American speech and was trained in phonetics. A description of the stimulus generation procedure has been provided by Beasley and Flaherty-Rintelmann (1974).

This master tape was then copied from the same tape recorder to a cassette tape recorder (Advent, model 201, frequency response = 50 Hz to 15000 Hz $\pm$ 3 dB). Subsequently, the cassette tape was processed through a time compressor/expander (Lexicon Varispeech I) at 0% and 60%

time compression and re-recorded on a tape via the Ampex tape recorder. The desired levels of time compression were determined in a manner described by Konkle, Freeman, Riggs, Riensche, and Beasley (1975). That is, a recorded 1000 Hz pure tone was played back through the time compressor/expander. A frequency counter (Beckman, model 6148) which was connected to the output of the time compressor/expander monitored the variations in the output frequency of the 1000 Hz pure tone recording which, in turn, resulted from a change in the variable playback speeds of the Lexicon Varispeech I. For example, when the playback speed was equal to the record speed the expected readout on the frequency counter was 1000 Hz or 0% time compression. Conversely, when the frequency output was 2500 Hz, the level was 60% time compression.

A ten second response interval was placed between each sentential stimulus. A five second inter-stimulus interval was provided for subject response during the monosyllabic WIPI test. The carrier phrase "Number ____" preceded all stimuli.

Presentation Procedures

Each experimental condition consisted of ten three-word and ten five-word first order sentential approximations, ten three-word and ten five-word second order sentential approximations, ten three-word and ten five-word normal sentences, and four twenty-five word lists of Form B of the WIPI test, each stimulus condition time compressed to 0% and 60% of the original time. Ten children from each of the two groups, experimental and control, were presented the WIPI test auditorily in an open-set response format. That is, recall of the stimulus words was required without the aid of pictures. The remaining ten children in each group received the WIPI auditorily and in a closed-set format, where the subjects were required to select the presented test item from among six pictorial choices (see Figure 2).

Each subject was seated in a double-walled test suite (IAC 1200 series) which had an ambient noise level of 43 dBC. The pure tone screening stimuli were presented via a clinical audiometer (Beltone, model 15C). The tape recorded stimuli were generated through a tape recorder (Ampex, model 600-2, frequency response = 50 Hz to 15000 Hz ± 2 dB) to a speech audiometer (Grason-Stadler, model 162) which were located in the control room. The attenuated stimuli were then transduced to the test suite via an earphone (TDH-39-10z) mounted in a biscuit type cushion (Mx 41/AR). The sentential approximations were presented at 50 dB sensation level and the monosyllables at 24 dB sensation level. The presentation ear was counterbalanced.

The experimental equipment was calibrated in accordance with the procedures recommended in the American National Standard Specifications (ANSI) for audiometers (S 3.6-1969). These included measurements for output, reference threshold levels, distortion, linearity and background noise. Periodic calibration checks were made throughout the investigation to monitor the equipment's stability.

Analysis of Data

The responses of the subjects to each item of the sentential approximations were hand-scored by the experimenter. A subjective analysis of errors for the sentential stimuli included discrimination errors which were defined as inaccurate recall of the words, each of which was scored independently. Omission errors were any items which were not repeated in the sentence and addition errors were any words that were added beyond those required. Any sentence that was repeated in the incorrect order was also scored incorrect. Thus, a maximum of four and six errors were possible of the 3- and 5-word sentences, respectively. The monosyllabic WIPI stimuli were scored as being correct or incorrect and only scored as discrimination errors.

The sentential data were placed in a four factor (2X2X2X3) analysis of variance. The monosyllabic WIPI test results were placed in a three factor (2X2X2) analysis of variance. To further explore the interactions of possible significant main effects and interactions, a Duncan Multiple Range test was used as a post-hoc statistical procedure.

RESULTS

The results of this study support the contention that normal reading and reading impaired children can be differentiated by time compression, sentential order, and/or sentence length. The results also support the thesis that reading impaired children had more difficulty with sentences when the constraints upon the semantic and syntactic order were reduced, as evidenced by the lower scores of these children when the sentences were time compressed and when the sentential order was varied. The results of an analysis of variance performed on the data can be found in Appendix D. In addition, the significant main effects and interactions were further investigated using the Duncan Multiple Range test for post-hoc statistical comparisons.

Sentential Stimuli

A four-factor analysis of variance with repeated measures was performed upon the scores of the sentential stimuli. There was a significant main effect ($F=37.8$; $df=1$; $p < 0.0005$) for the factor of subjects, whereby the reading impaired children showed more difficulty recalling and repeating the sentential stimuli. There were also significant main effects associated with word length ($F=12.4$;

df=1; p=0.001), time compression (F=131.2; df=1; $p < 0.0005$), and sentential order (F=42.6; df=2; $p < 0.0005$). These indicated that scores decreased as stimulus complexity increased as a function of increasing word length and time compression, respectively, and decreasing sentential order to full grammaticality. The results are depicted in Figure 3.

The factor of subjects interacted significantly with word length (F=7.8; df=1; p=0.008), time compression (F=32.9; df=1; $p < 0.0005$) and sentential order (F=15.6; df=2; $p < 0.0005$). The normal reading children showed no difference in scores as a function of increasing word length (3-word= 97.9%; 5-word=97.2%), whereas the scores for the reading impaired children showed a significant decrease (p=0.05) as word length increased (3-word=94.9%; 5-word=89.3%). Further, there was a significant difference (p=0.05) in time compression conditions for the normal and reading impaired subjects. This effect was more pronounced for the reading impaired subjects (0% time compression=97.0%; 60% time compression= 95.9%). Finally, the significant subjects by order interaction (p=0.05) demonstrated that reading impaired subjects (first order=86.7%; second order=90.6%; normal=98.9%) were more affected by decreasing sentential order to full grammaticality than the normal readers (first order=96.1%; second order=97.3%; normal=99.2%).

There was a significant word length by sentential order interaction (F=7.2; df=2; p=0.001). Scores for both the

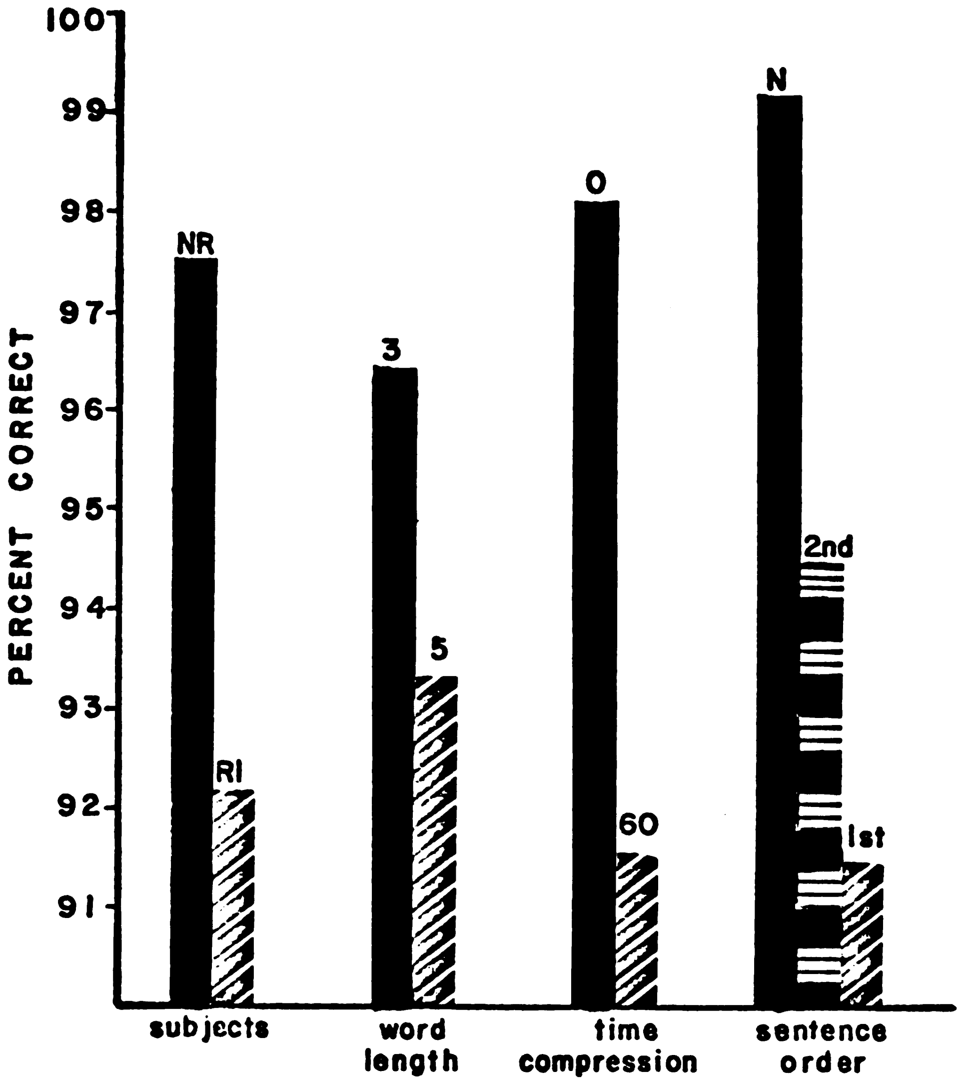

Figure 3. Main effects of subjects, word length, time compression, and sentence order.

first order (3-word=94.1%; 5-word=88.8%) and second order (3-word=96.3%; 5-word=91.6%) sentential approximations differed significantly (p=0.05) from normal sentences for both the 3-word (98.8%) and 5-word (99.4%) sentence lengths. In addition, the first and second sentential order stimuli for the 3-word condition differed significantly for the respective 5-word conditions.

A significant three-way interaction (F=8.5; df=2; $p < 0.0005$) between subject groups, time compression, and sentential order was found as shown in Figure 4. These results demonstrated that the subjects' scores increased significantly as sentential order approached full grammaticality and temporal redundancy was maintained.

Monosyllabic Stimuli

A three-factor analysis of variance with repeated measures was performed upon the scores of the Word Intelligibility by Picture Identification (WIPI) test. A significant main effect was found for the factor of subjects (F=4.1; df=1; p=0.05) whereby the normal readers had less difficulty recalling the stimuli than the reading impaired subjects. A significant main effect was also associated with the levels of time compression (F=7.3; df=1; p=0.01). These indicated that, as with the sentential stimuli, the scores decreased as the stimuli complexity increased as a function of time compression. Significant main effects were also obtained for presentation procedure (F=13.4; df=1; $p < 0.005$)

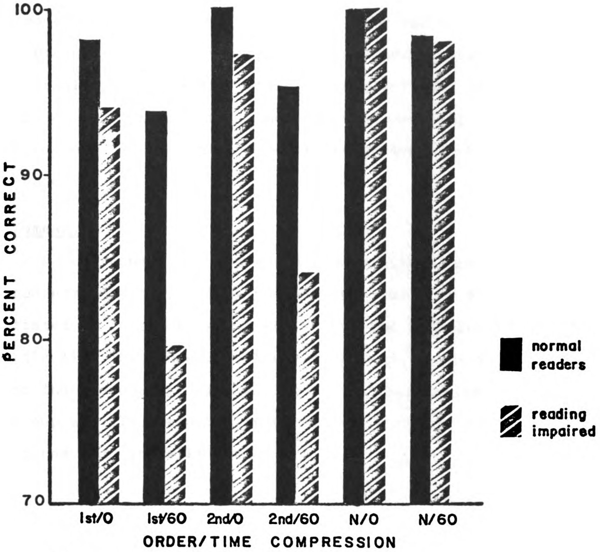

Figure 4. Mean percent correct scores of subjects per level of time compression and sentence order.

as the subjects obtained lower scores with the open-set non-visual condition. In addition, there was a significant difference for the interaction of subjects and presentation procedure (F=5.76; df=1; p=0.05). Both subject groups performed poorer on the open-set non-visual condition (normal readers=89.4%; reading impaired=77.4%) than the closed-set visual format (normal readers=92.8%; reading impaired=93.8%). These results are presented in Figures 5 and 6.

Summary

The results of this study demonstrated that normal readers and reading impaired children could be differentiated by time compressed sentential and monosyllabic stimuli. The sentences, however, appeared more sensitive to the processing difficulties of the reading impaired group and also resulted in consistently higher performance scores than the WIPI test.

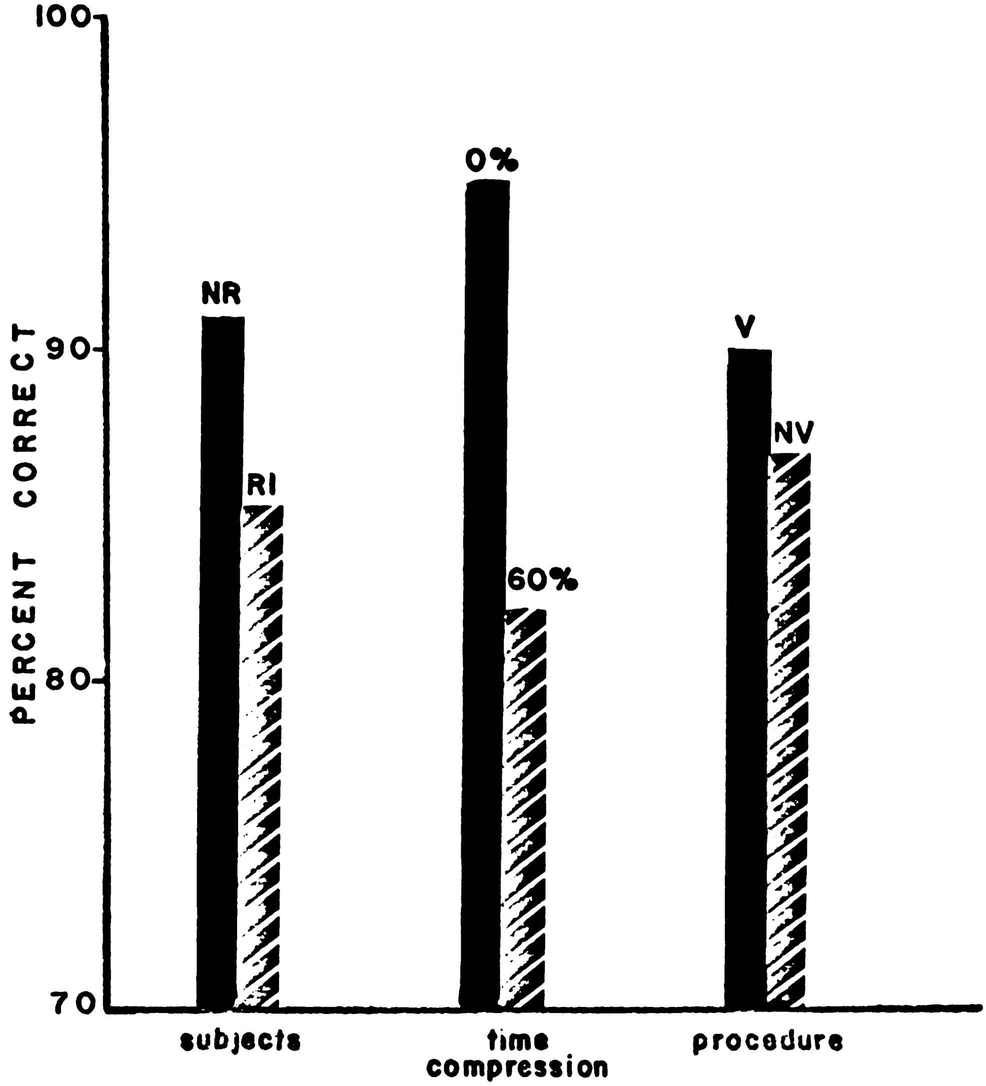

Figure 5. Mean percent correct scores of subjects (normal readers (NR), reading impaired (RI)) per level of time compression (0%, 60%) and presentation procedure (visual closed-set (V), non-visual open-set (NV)) for the WIPI test.

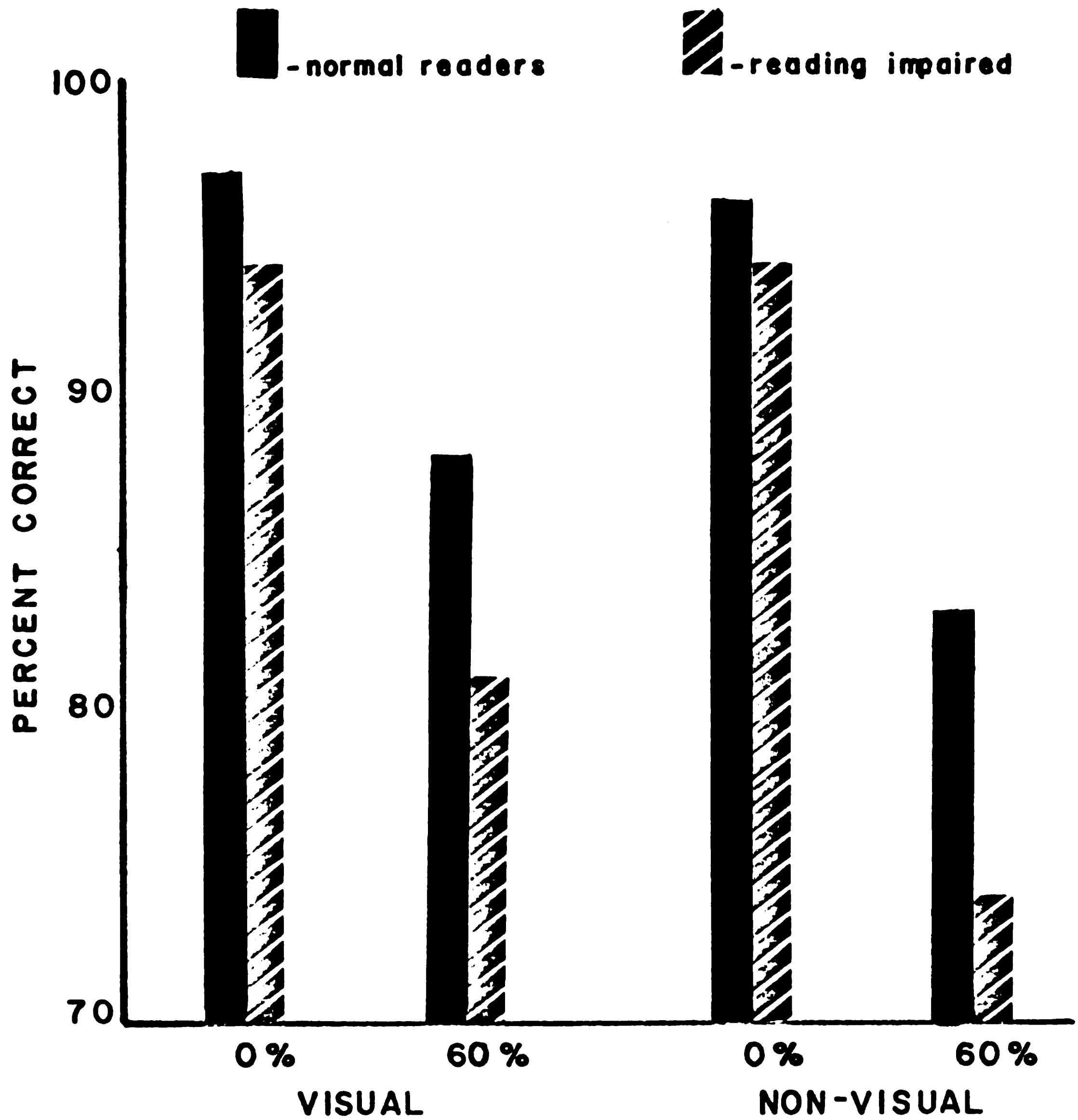

Figure 6. Interaction between presentation procedure (VISUAL, NON-VISUAL) and time compression (0%, 60%) for the WIPI test.

DISCUSSION

The results of this study indicated that order of sentential approximations to full grammaticality, sentence length and level of time compression all contributed to the recall accuracy of the reading impaired and normal reading subjects. These findings supported significant implications for both the diagnosis of auditory perceptual impairments and contributed to the theoretical speculations pertaining to the perceptual processing of language by children.

Differentiation by Sentences and Monosyllables

The two groups of subjects in this study were differentiated on the basis of the interaction between the variables of sentence length, sentential order and level of time compression. No variable seemed to be the dominant one. Although a single factor was at times differentiating, a combination of the three was more effective as is evidenced by the fact that the difference between groups was maximized at 60% time compression of the 5-word first order sentences.

It has been demonstrated that time compression reduces the extrinsic redundancy, the perceptual cues of intonation and stress patterns, and the syntactic and semantic cues of a stimulus (Wingfield, 1975). Carrow and Mauldin (1973) found that a reduction in the syntactic and semantic content by varying sentential order interfered with sentence recall. An individual with an intact auditory pathway enabling the development of a normal linguistic system, however, should be capable of overcoming the limitations imposed by time compression and varied sentential order (Wingfield, 1975; Pantalos et al., 1975; Beasley and Flaherty-Rintelmann, 1975; Bratt, 1975; Thompson, 1974). The results of the present study supported this contention, in that the normal readers had no difficulty recalling the sentences. The reading impaired subjects, however, demonstrated significantly more difficulty than the control group subjects on all of the sentential stimuli, with the exception of the full grammatical sentences.

The repetition of monosyllabic words is a linguistically based discrimination task that does not require as much dependence upon syntax, semantics and the memory constraints imposed by 3- and 5-word sentences. The time compressed WIPI test was presented with an open-set non-visual and closed-set picture-pointing response format. The open-set task necessitated recall and verbal repetition of the stimuli, whereas the closed-set task required that the subject point to one picture that most closely resembled the stimuli out of a set of six choices. The closed-set format was categorized as the visual task because it required the transformation of an auditory stimulus into a visual response.

Both the visual and non-visual conditions of the WIPI test showed clinically significant differences between groups at 60% time compression. Hodgson (1974) low-pass filtered the WIPI test at 1560 Hz and presented it to normal hearing children in both an open- and closed-set response format. He found that the mean difference between the two conditions was 10 percent, with the open-set being the more difficult of the two. The normal subjects of the present study also performed better on the visual task (92.8%), but when compared to the non-visual task (89.4%) this difference was not significant when the stimuli were temporally distorted. The 4 percent difference between the Hodgson study and the present investigation was probably attributable to the two distortion techniques employed, i.e., filtering versus time compression. Significant differences between visual (93.8%) and non-visual (77.4%) presentation were obtained for the reading impaired subjects, suggesting that these children had more difficulty with auditory-visual integration than did the normal readers. Thus, differences do exist between visual and non-visual presentation of the WIPI test and interpretation of discrimination scores should be with regard to the method of presentation.

Maki (1975) suggested that a sensitive indicator of perceptual impairment was obtained by comparing the closed-set discrimination scores at 0% and 60% time compression.

She found that normal hearing and hearing impaired children with no apparent perceptual impairments obtained discrimination scores at 60% time compression which were approximately 8 percent poorer than their performance at 0% compression. The normal readers in this study were within the limits established by Maki for the visual condition. The open-set WIPI, however, is more difficult because of the interaction of two variables, i.e., presentation procedure and time compression, and, therefore, the 13 percent difference between 0% and 60% time compression for the present study was not unexpected. The reading impaired subjects, however, demonstrated a 12.4 percent difference for the visual stimuli compared to an 8 percent difference for normal readers. A 20.4 percent difference between scores was obtained for the reading impaired subjects on the nonvisual stimuli as compared to the 13 percent difference for the normal readers on the same condition. This procedure of comparing the scores of 0% time compression and 60% time compression, then, might provide more diagnostic information than just computing the percentage of correct responses at a specific level of time compression.

The complexity of the auditory system necessitates that diagnosis of auditory pathology be based on a test battery that would assess the various levels of processing. Figures 7 and 8 present the results of the subjects' performance in the present study on the sentences and monosyllables. All but one of the control group subjects

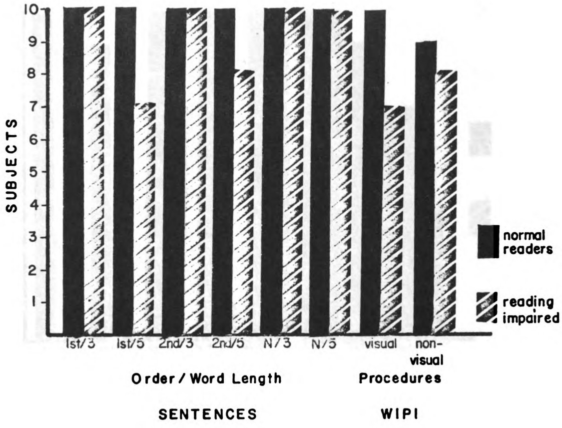

Figure 7. Number of subjects scoring 90 % or better on the sentences and WIPI test at 0 % time compression.

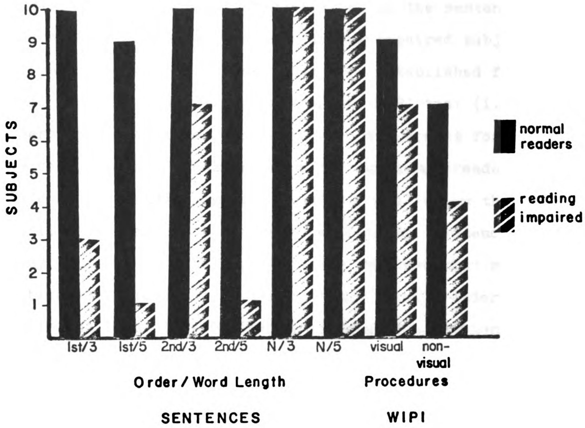

Figure 8. Number of subjects scoring 90% or better on the sentences and WIPI test at 60% time compression.

achieved 90 percent or better scores on the time compressed sentential stimuli (the one subject scored 87 percent on the 5-word first order sentences at 60% time compression). The reading impaired group, however, presented a much wider array of scores, particularly at 60% time compression of the 5-word first and second order sentential approximations. The WIPI test as not as differentiating as the sentences because both normal readers and reading impaired subjects fell below the cut-off scores that were established for the limits of normal performance on the WIPI test (i.e., 90 percent for 0% time compression and 80 percent for 60% time compression). However, none of the normal readers and twelve of the reading impaired subjects fell below the established norms on two or more tests (i.e., sentences or monosyllables). Of the eight reading impaired that met the established performance criteria of the normal readers, six were in the less differentiating three word condition. A feasible diagnostic recommendation, then, would be to evaluate subjects on a test battery that would include temporally altered 5-word first and second order sentential approximations and the non-visual WIPI test. Of the reading impaired children that were randomized into these recommended test conditions, each one failed at least two tests, and more than half failed three or more tests. Thus, temporal alteration of sentential and monosyllabic stimuli did appear to have value in the diagnosis of auditorily based reading impairments.

Memory and Discrimination

Conclusive objective data regarding the contributions of memory and discrimination to linguistic processing is still unavailable. It was, for example, suggested that children with poor articulation had an associated memory deficit but that their primary impairment was related to poor discrimination (Saxman and Miller, 1973; Orchik and Oelschlinger, 1974). The reading impaired subjects in the present study also evidenced impaired discrimination in addition to an associated memory deficit.

An analysis of errors on the sentential stimuli (Figure 9) revealed that discrimination errors accounted for more than half of the reading impaired inaccuracies. Omission errors, which have been referred to as an index of memory storage efficiency (Carrow and Mauldin, 1973) and are indicative of the constraints upon memory (Scholes, 1969), represented nearly a third of the recall errors for the reading impaired group. By contrast, 77 percent of the normal reading control group errors were discrimination, whereas only 10 percent were omission errors. Although the percent of omission errors differed for the two groups, similar trends were found (see Figures 10 - 13). That is, there were more omission errors at 60% time compression than at 0% compression; errors were more prevalent for the 5-word sentences than for the 3-word sentences; and, fewer errors were made as the sentences approached full grammaticality.

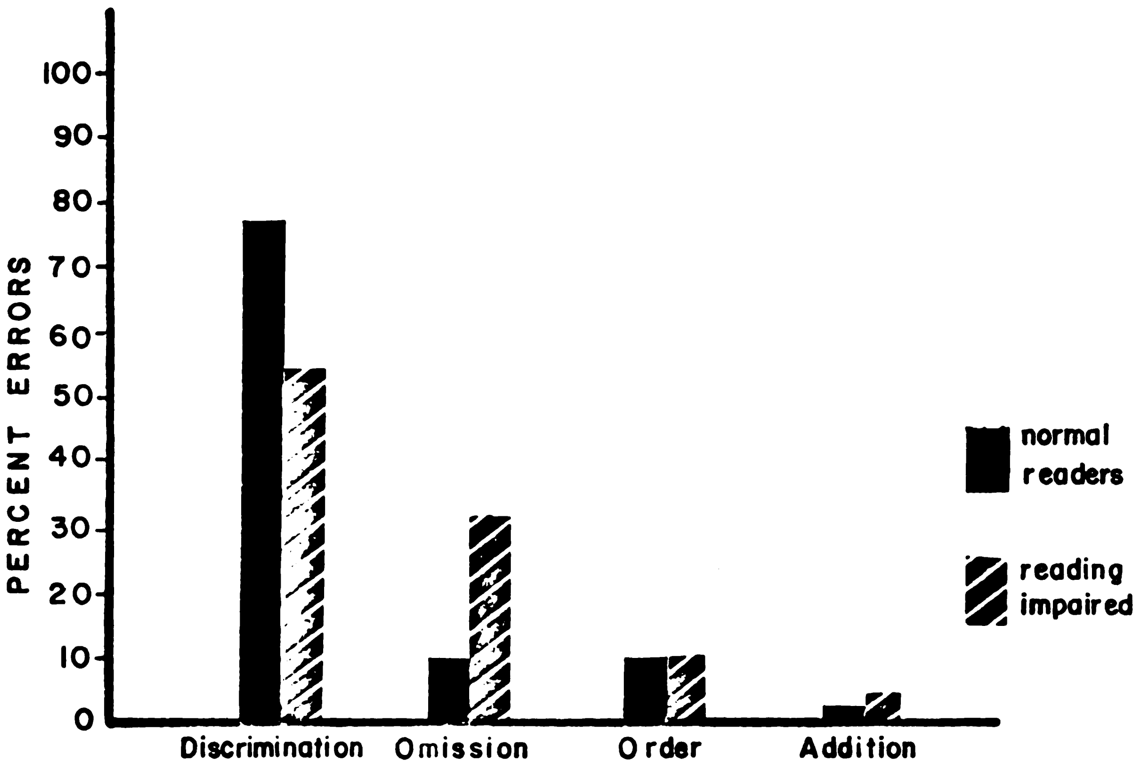

Figure 9. Mean percent errors made by subjects on sentential stimuli.

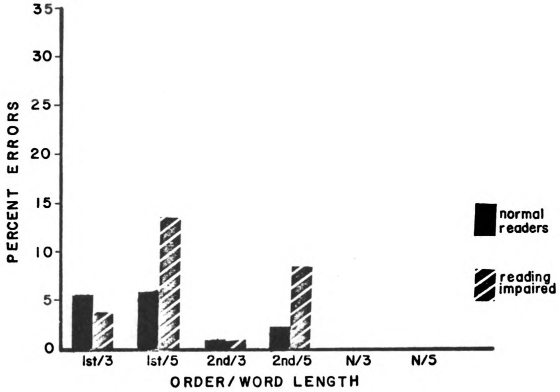

Figure 10. Percent of discrimination errors made at 0% time compression on the sentential stimuli.

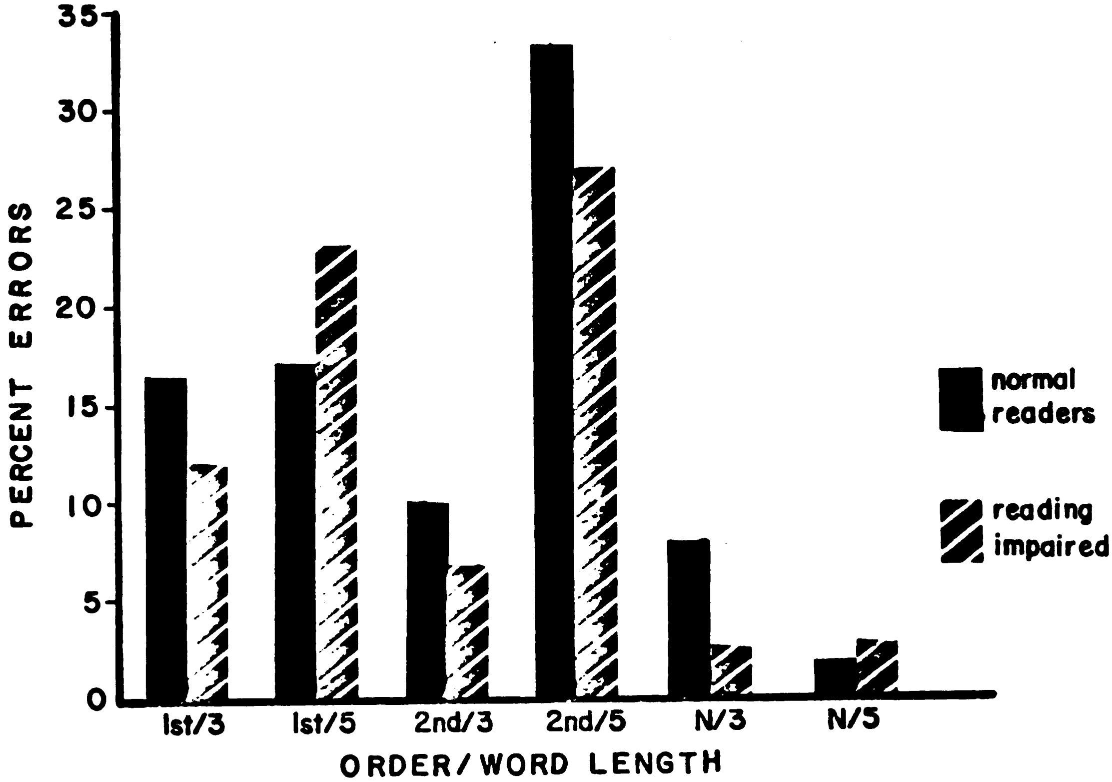

Figure 11. Percent of discrimination errors made at 60% time compression on the sentential stimuli.

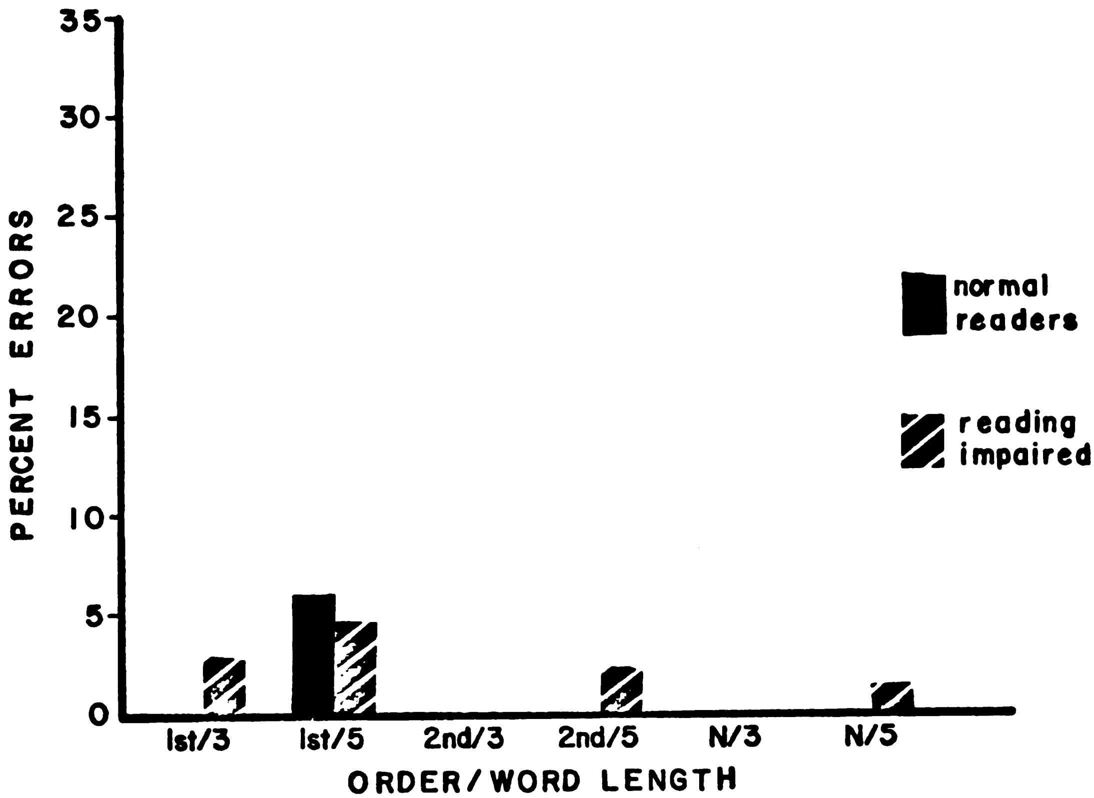

Figure 12. Percent of omission errors made at 0% time compression on the sentential stimuli.

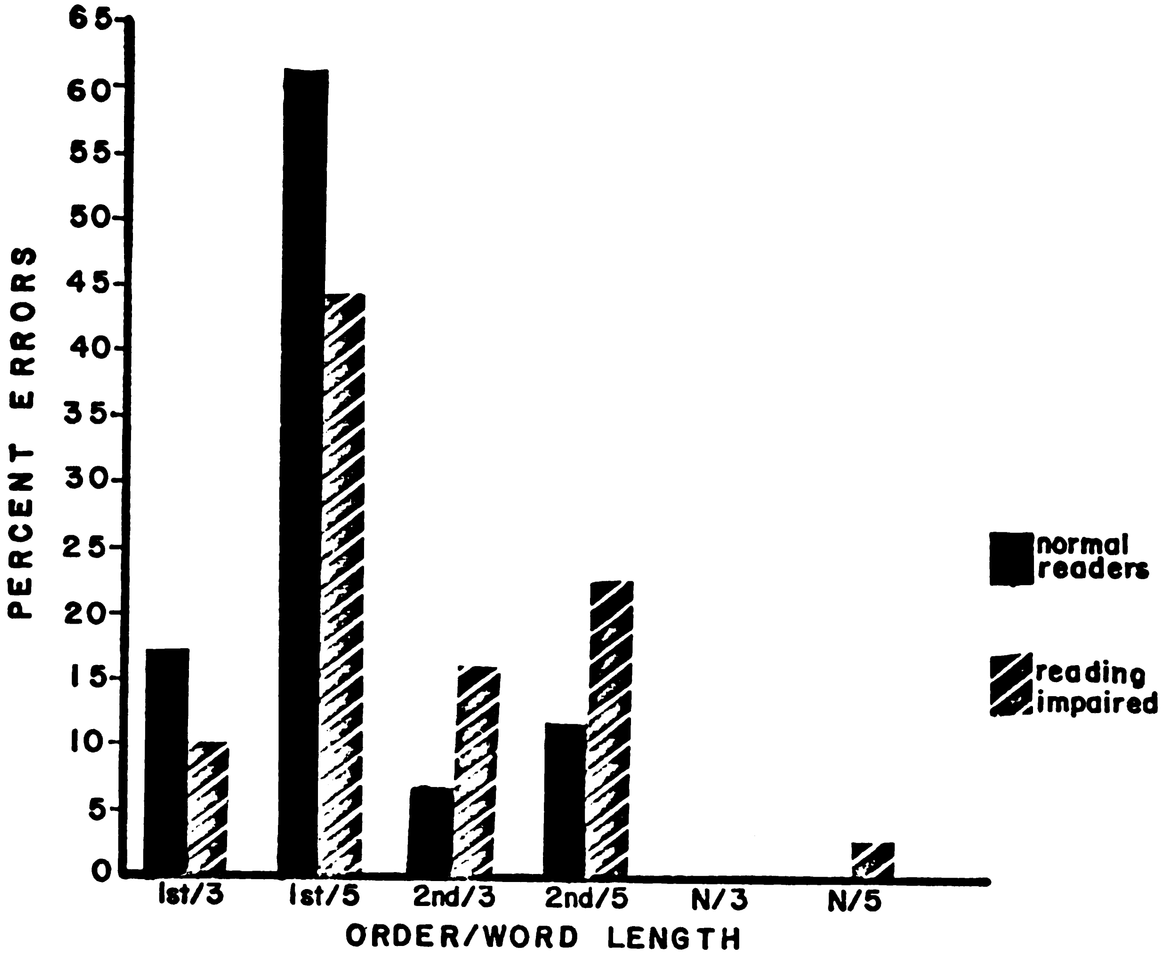

Figure 13. Percent of omission errors made at 60% time compression on the sentential stimuli.

The remaining errors of addition and order were similar for both subject groups.

When the stimuli were time compressed, subjects had to use certain linguistic strategies to overcome the reduced temporal redundancy that resulted from time compression. The superior performance by both subject groups on higher order time compressed sentential approximations suggested that these strategies were performed upon the syntactic and semantic content of the sentences. However, when these syntactic and semantic cues were also reduced by varying sentential order, then the load placed upon the storage system was increased. The reading impaired subjects were less able than the normal readers of this study to overcome the constraints placed on the sentences by the interaction of both time compression and sentential order.

These results can be explained in terms of a model of processing suggested by Aaronson, Markowitz, and Shapiro (1971) whereby items initially entered a large capacity sensory storage system and were, then, selected one at a time to be processed by a small capacity perceptual mechanism. In reference to this model of perception, it was possible that memory was being overloaded at 60% time compression and that the reading impaired children did not have an adequate linguistic foundation to develop strategies to overcome this overload. Their inefficient memory system would, therefore, have been unable to retain the input to the storage system long enough for it to be transferred to higher perceptual processing stages for accurate recall. Since a higher proportion of errors at 60% time compression were of the discrimination type, it was also possible that the successive words in the sentential stimuli might be acting as maskers to the preceding item (Aaronson, 1967). This concept of forward and backward masking was supported in part by the fact that a higher percentage of discrimination errors were noted on sentential stimuli at 60% time compression than with the time-compressed monosyllables.

The contention that distorted input resulting in discrimination and memory storage difficulties was responsible for the processing differences between the two groups of subjects was supported by the fact that the errors of this study were not consistent with those found by Aaronson et al. (1971). In their study, item (i.e., discrimination) and order errors predominated when subjects were required to recall sequences of normal and time compressed digits. A higher percentage of order errors were found and the authors suggested that recall order was not entirely dependent upon presentation order, but by a "...probability distribution over accumulated unidentified items" (p. 339). This concept was based upon the assumption that the subject had some prior linguistic awareness of the stimuli or its component parts. The college students who served as subjects for Aaronson et al. were presumably familiar with digits which are a serial recall task, the items of which can be recalled one at a time with a minimal degree of linguistic processing and awareness. Thus, the digit task was less of a test of discrimination and more of a strain on memory for order. The predominance of order errors in the recall of the digits then would be expected. In the present study, however, item or discrimination errors predominated, suggesting that the subjects were used to processing sentences with regard to an expected grammatical order. This anticipation of a specific order by the subjects existed because of the linguistic constraints of normal language that limit the number of possible responses for a fully grammatical sentence. Thus, there was no difficulty recalling the normal sentences. However, a modification of sentential order increased the probability of errors because of a corresponding increase in the number of possible response selections.

The results suggested that the processing of the linguistic stimuli by the two subject groups differed as a result of poor discrimination and limited memory storage capacity of the reading impaired children. In reference to the model of reading suggested by LaBerge and Samuels (1974), the significant differences between the scores of 3-word and 5-word sentential stimuli could be attributed to a greater peripheral sensory input which resulted in additional phonologic components. In order to by-pass phonologic memory, and correctly recall and repeat the sentences, less attention had to be given to the stimuli. This becomes increasingly more difficult for longer sentences because of the greater amount of stimuli to be processed. In addition to increased stimulus complexity from word length, significant differences were observed between the sentential orders. The fully grammatical sentences presented no difficulty for any of the subjects. Presumably, these were processed automatically from the sensory input stage directly to semantic memory. The first and second order sentential approximations, however, necessitated more attention because the processing cues related to semantics and syntax were modified. Thus, these sentences passed through more stages of memory in the LaBerge and Samuels model than did the fully grammatical sentences.

The significant differences in processing at the two levels of time compression may be related to the distorted prosodic and intonational cues which facilitate the automatic processing of the stimuli. Again, more attention was necessary for recall accuracy when the stimuli were distorted and, therefore, the 60% time compressed stimuli passed through more stages of memory than the undistorted (0% time compression) stimuli.

The significant differences in the recall accuracy between the subject groups suggested that the reading impaired subjects did not have the linguistic competence to automatically process the linguistic cues that were still available after temporal distortion and/or modification of sentential order. Therefore, the reading impaired subjects needed to devote more attention than the normal readers to the stimuli for recall accuracy. This, then, suggests that the stimuli presented to the reading impaired children had to pass through more stages of memory than the stimuli which was prcessed automatically by the normal readers. Additional processing time then was required by the reading impaired subjects than the normal readers for recall and repetition and, thus, there was more chance for memory errors. This may account for the differences in omission errors between the two subject groups.

Summary, Conclusions and Implications for Future Research

It is apparent from the results of this study that temporally altered sentential stimuli and monosyllabic words were capable of differentiating reading impaired subjects from normal readers. The time compressed monosyllabic Word Intelligibility by Picture Identification (WIPI) test has been standardized on both normal hearing and hearing impaired populations (Beasley and Maki, 1975; Maki, 1975). Those results in addition to the findings of Manning et al. (1975) and the present investigation with learning impaired and reading impaired children, respectively, warrant the inclusion of the time compressed WIPI test in a differential diagnostic test battery.

The limited population and the fact that the time compressed sentential stimuli of this study have never been employed previously, makes it impossible to make any conclusive statements as to general clinical application of the sentences. Kurdziel, Rintelmann, and Beasley (1975) and

Beasley and Maki (1975) have demonstrated that time compression adversely affects performance scores of subjects with peripheral hearing impairments on time compressed monosyllabic word tests. They have suggested that, with monosyllables, a difference between performance at two levels of time compression might provide more clinical diagnostic information than a comparison of baseline scores to normative data. This suggestion was supported by the results of the present investigation for the monosyllables but should be investigated with the sentential stimuli.

The results of this study also suggested that there were linguistic processing differences between the normal readers and reading impaired subjects. These differences may in part have been related to a lower level of automaticity by the reading impaired subjects which necessitated the activation of more stages of memory. Although 60% time compression appeared to be quite taxing to the linguistic system, it might be of interest to evaluate the performance of these children at lower levels of time compression. Aaronson et al. (1971) found that immediate recall of the digits by her subjects was enhanced at 33% time compression as compared to non-compressed digits. It is possible that the apparent memory impairments of the reading impaired children can be overcome if the stimuli were presented at levels below 60% time compression. Thus, time compressed stimuli appear to have both diagnostic and therapeutic implications.

LIST OF REFERENCES

Aaronson, D. Temporal factors in perception and short term memory. Psychol. Bull. 67:130-140 (1967)

Aaronson, D., Markowitz, N. and Shapiro, H. Perception and immediate recall of normal and "compressed" auditory sequences. Perception and Psychophys. 9:338-344 (1971)

Beasley, D.S., Forman, B. and Rintelmann, W.F. Perception of time-compressed CNC monosyllables. J. Aud. Res. 12:71-75 (1972)

Beasley, D.S., Schwimmer, S. and Rintelmann, W.F. Intelligibility of time-compressed CNC monosyllables. J. Speech Hearing Res., 15:340-350 (1972)

Beasley, D.S. and Shriner, T. Auditory analysis of temporally distorted sentential approximations. Audiology. 12:262-271 (1973)

Beasley, D.S. and Flaherty-Rintelmann, A. Children's perception of temporally distorted sentential approximations of varying length. Audiology. In press (1975)

Beasley, D.S. and Maki, J. Children's perception of time compressed speech on two measures of speech discrimination. J. Speech Hearing Dis. In press (1975)

Berlin, C.I. and McNeil, M.R. Dichotic listening. In Contemporary issues in experimental phonetics. Ed. Lass, N. (1975)

Blumstein, S., Goodglass, H., Tartter, V. The reliability of ear advantage in dichotic listening. Brain and Language. 2:226-236 (1975)

Bratt, G. Performance of subjects on time-compressed sentential stimuli. Unpublished Master's Thesis. Michigan State University (1975)

Calearo, C. Binaural summation in lesions of the temporal lobe. Acta Otolaryng. 47:392-395 (1957)

Calearo, C. Verbal tests of central audition. Audiology. 14:300-311 (1975)

Calearo, C. and Lazzaroni, A. Speech intelligibility in relation to the speed of the message. Laryngol. 67:410-419 (1957)

Carrow, E. and Mauldin, M. Children's recall of approximations to English. J. Speech Hearing Res. 16: 201-212 (1973)

Cratty, B.J. Motor activities and learning disabilities, A look ahead. Proceedings of a conference on Learning Disabilities: the decade ahead. Ed. Krasnoff, M.J. ISMRRD, U. Michigan (1974)

DiSimoni, F.G. Some preliminary observations on temporal compensation in the speech of children. J. Acous. Soc. Amer. 56:697-699 (1974)

Efron, R. Temporal perception, aphasia and deja vu. Brain. 86:403-424 (1963)

Freeman, B.A. and Beasley, D.S. Lead and lag affects associated with the staggered spondaic word test. J. Speech Hearing Res. In press (1975)

Freeman, B.A., Beasley, D.S. and Overholt, G.A. Performance of learning disabled children on temporally altered speech stimuli. Unpublished manuscript. Michigan State University (1975)

Getman, G.N. Concepts of vision in relation to perception. Proceedings of a conference on Learning Disabilities: the decade ahead. Ed. Krasnoff, M.J. ISMRRD, U. Michigan (1974)

Goldman, R., Fristoe, M. and Woodcock, R. Goldman-Fristoe-Woodcock test of auditory discrimination. Am. Guidance Serv. (1970)

Haskins, H. A phonetically balanced test of speech discrimination for children. Master's Thesis. Northwestern University (1949)

Hodgson, W.R. A comparison of WIPI and PB-K discrimination test scores. Paper presented at American Speech and Hearing convention (1974)

Jerger, J., Weikers, N.J., Sharbrough, F.W. and Jerger, S. Bilateral lesions of the temporal lobe. Acta Otolaryng. Suppl. 258 (1968)

Jerger, J., Lovering, L. and Wertz, M. Auditory disorder following bilateral temporal lobe insult: report of a case. J. Speech Hearing Dis. 37:523-535 (1972)

Jerger, J. Audiological manifestations of lesions in the auditory nervous system. Laryngol. 70:417-425 (1960)

Katz, J. The SSW test: an interim report. J. Speech Hearing Dis. 33:132-146 (1968)

Kephart, N.C. The slow learner in the classroom. E. Merrill Co. (1960)

Konkle, D.F., Beasley, D.S. and Bess, F. A study of time-compressed speech on an elderly population. Paper presented at American Speech and Hearing convention (1974)

Konkle, D.F., Freeman, B.A., Riggs, D., Riensche, L.L. and Beasley, D.S. Calibration procedures for time-compressed/expanded speech. <u>Proceedings of Third Louisville Conference on Rate Controlled Speech</u> (1975)

Kurdziel, S. and Noffsinger, D. Performance of cortical lesion patients on 40% and 60% time-compressed speech materials. Paper presented American Speech and Hearing Association convention (1973)

Kurdziel, S.A., Rintelmann, W.F. and Beasley, D.S. Performance of noise induced hearing-impaired listeners on time-compressed consonant-nucleus-consonant monosyllables. J. Am. Aud. Soc. 1:54-60 (1975)

LaBerge, D. and Samuels, S.J. Toward a theory of automatic information processing in reading. Cognitive Psychol. 6:293-323 (1974)

Lerman, J., Ross, M. and McLaughlin, R. A picture-identification test for hearing-impaired children. J. Aud. Res. 5:273-278 (1965)

Locke, J. Discrimination learning in children's acquisition of phonology. J. Speech Hearing Res. 11:428-434 (1968)

Maki, J. Speech discrimination and response latency of normal hearing and hearing-impaired children as a function of time compression. Dissertation. Michigan State University (1975)

Manning, W.J., Johnston, K.L. and Beasley, D.S. The performance of children with auditory perceptual disorders on a time-compressed speech discrimination measure. Paper presented at American Speech and Hearing Association convention (1975)

Marquardt, T.F. and Saxman, J.H. Language comprehension and auditory discrimination in articulation deficient kindergarten children. J. Speech Hearing Res. 15: 382-389 (1972)

Mattingly, I.G. Reading, the linguistic process, and linguistic awareness. In Language by ear and by eye. Ed. Kavanaugh, J.F. and Mattingly, I.G. (1972)

Matzger, J. Two new methods for the assessment of central auditory functions in cases of brain disease. Ann. Otol. 68:1185-1197 (1959)

McNeil, D. The acquisition of language (1970)

Menyuk, P. and Looney, P.L. Relationship among components of the grammar in language disorder. J. Speech Hearing Res. 15:395-406 (1972)

Miller, G.A. The magical number seven, plus or minus two: some limits on our capacity for processing information. Psychol. Rev. 63:81-97 (1956)

Miller, G.A. and Isard, S. Some perceptual consequences of linguistic rules. J. Verb. Learning Beh. 2:217-228 (1963)

Newcombe, F. and Marshall, J.C. Stages in recovery from dyslexia following a left cerebral abscess. Cortex. 9:329-332 (1973)

Norman, D.A. Memory and Attention (1969)

Orchik, D.J. and Oelschlaeger, M.L. Time-compressed speech discrimination: its relationship to articulation ability. Paper presented at American Speech and Hearing Association convention (1974)

Pantalos, J., Schuckers, G.H. and Hipskind, N. Sentence length-duration relationships in an auditory assembly task. J. Comm. Dis. 8:61-74 (1975)

Papcun, G., Krashen, S., Terbeek, D., Remington, R. and Harshman, R. Is the left hemisphere specialized for speech, language, and/or something else. J. Acous. Soc. Amer. 55:319-327 (1974)

Rubenstein, H., Lewis, S.S. and Rubenstein, M.A. Evidence for phonemic recording in visual word recognition. J. Verb. Learning and Verb. Beh. 10:645-647 (1971)

Rubino, C.A. and Minden, H.A. An analysis of eye movements in children with a reading disability. Cortex. 9: 217-220 (1973)

Savin, H.B. and Perchonock, E. Grammatical structure and the immediate recall of English sentences. J. Verb. Learning and Verb. Beh. 4:348-353 (1965)

Saxman, J.H. and Miller, J.F. Short term memory and language skills articulation-deficient children. J. Speech Hearing Res. 16:721-730 (1973)

Schill, H.J. and Schuckers, G.H. Auditory assembly of non-prosodic sentences by children. J. Comm. Dis. 6:70-74 (1973)

Scholes, R.J. The role of grammaticality in the imitation of word strings by children and adults. J. Verb. Learning and Verb. Beh. 8:225-228 (1969)

Schuckers, G.H., Shriner, T. and Daniloff, R. Auditory assembly of segmented sentences by children. J. Speech Hearing Res. 16:116-127 (1973)

Shoup, J. Performance of children to the time-compressed WIPI test. Master's thesis. Michigan State University (1975)

Shriner, T.H. and Sprague, R.L. The effects of time-compressed speech signals on identification accuracy and latency measures. J. Exp. Child Psych. (1969)

Speaks, C. and Jerger, J. Method for measurement of speech identification. J. Speech Hearing Res. 8:185-194 (1965)

Speaks, C. Dichotic listening: a clinical or research tool. In Proceedings of a symposium on central auditory processing disorders. University of Nebraska (1974)

Tejirian, E. Syntactic and semantic structure in the recall of orders of approximations to English. J. Verb. Learning and Verb. Beh. 7:1010-1015 (1968)

Thompson, N.W. Comprehension of rate controlled speech of varying linguistic complexity by normal children. Paper presented at American Speech and Hearing convention (1973)

Thompson, N.W. (Nelson) Comprehension of standard English at varied speaking rates by children whose major dialect is black English. Paper presented at American Speech and Hearing convention (1974)

Vellutino, F.R., Steger, J.A. and Kandel, G. Reading disability: an investigation of the perceptual deficit hypothesis. Cortex. 8:240-250 (1972)

Vellutino, F.R., Pruzek, R.M., Steger, J.A. and Meshoulam, U. Immediate visual recall in poor and normal readers as a function of orthographic-linguistic familiarity. Cortex. 9:370-386 (1973)

Wickelgren, W.A. Auditory or articulatory coding in verbal STM. Psychol. Rev. 76:232-235 (1969)

Willeford, J. Central auditory function in children with learning disabilities. Paper presented at American Speech and Hearing convention (1974)

Wingfield, A. Acoustic redundancy and the perception of time-compressed speech. J. Speech Hearing Res. 18: 96-104 (1975)

APPENDIX A

LANSING SCHOOL DISTRICT
READING RECORD

LANSING SCHOOL DISTRICT READING RECORD (EXCERPT)

Readiness

Describe objects
Fold paper
Specific directions
Oral directions
Same beginning letter
Print first name
Name, letter, orally
Identify differing parts
Circle word different

Vocabulary Development

Identify--different
Same letter opp. case
Aural stimuli
3 step oral directions
Draw figure memory
Name basic colors
Identify common obj.
Name body parts
Respond to question
Color names
Dolch pp. or p. or one

Word Analysis

Print initial consonant
Give word initial consonant
Say word--initial consonant--context
Supply word final consonant
Mark beginning blend
Circle yes-no vowel sounds
Supply long vowel
Supply short vowel
Rhyming word--picture
Singular--plural word form

Comprehension

Sentences--similar ideas
Retell story--sequence
Main idea
Best title
Select conclusion

Study Skills

Alphabetize first letter
Alphabetize second letter
Table of contents

Interpretive

Read orally--mood

APPENDIX B

SENTENTIAL WORD LISTS

NORMAL

Subject____________

Condition__________

1.	I	will	play	
2.	the	cat	played	
3.	I	know	you	
4.	stop	the	car	
5.	you	work	late	
6.	I	am	big	
7.	I	eat	here	
8.	I	like	milk	
9.	I	like	her	
10.	Lock	the	door	

NORMAL

Subject____________

Condition__________

1.	we	went	to	the	zoo
2.	that	girl	is	not	good
3.	she	ran	to	the	store
4.	we	play	in	the	snow
5.	you	do	like	the	snow
6.	that	boy	is	with	me
7.	I	was	a	good	boy
8.	that	boy	will	play	here
9.	five	men	came	to	work
10.	you	take	that	cat	out

SECOND ORDER

Subject___________

Condition_________

1.	men	will	do
2.	that	man	of
3.	snow	time	will
4.	dog	nest	girl
5.	wish	with	her
6.	good	girl	work
7.	like	good	one
8.	up	and	to
9.	man	zoo	food
10.	do	hot	wish

SECOND ORDER

Subject___________

Condition_________

1.	I	put	up	to	like
2.	here	all	of	stop	tree
3.	stop	egg	run	with	good
4.	feet	is	big	ten	good
5.	nest	milk	one	sun	said
6.	man	sun	eat	with	milk
7.	late	time	to	wish	you
8.	is	said	five	feet	pop
9.	I	milk	pop	come	zoo
10.	eat	egg	take	up	ten

FIRST ORDER

Subject__________

Condition__________

1.	go	girl	zoo
2.	take	hot	girl
3.	food	jar	wish
4.	jar	sand	man
5.	red	toy	us
6.	wish	pop	milk
7.	egg	call	ten
8.	up	jar	said
9.	nest	ring	sun
10.	name	will	jar

FIRST ORDER

Subject____________

Condition__________

1.	men	zoo	pop	nest	is
2.	red	play	late	I	call
3.	snow	take	play	big	man
4.	name	milk	good	girl	sun
5.	time	all	sun	pop	tree
6.	snow	pop	dish	is	name
7.	pop	zoo	cry	food	milk
8.	tree	up	yes	me	word
9.	me	play	wish	milk	nest
10.	dog	cat	high	man	hot

APPENDIX C

WORD INTELLIGIBILITY BY PICTURE IDENTIFICATION (WIPI) WORD LISTS

LIST ONE	LIST TWO	LIST THREE	LIST FOUR
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	teeth
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

APPENDIX D

ANALYSES OF VARIANCE

ANALYSIS OF VARIANCE TABLE FOR SENTENTIAL STIMULI

Source	Mean Square	df	F	P
Subjects	1782.2	1	37.8	< 0.0005
Word Length	582.8	1	12.3	0.001
Time Compression	2561.1	1	131.8	< 0.0005
Sentence Order	1218.9	2	42.6	< 0.0005
Subjects x Word Length	370.0	1	7.8	0.008
Subjects x Time Compression	640.3	1	32.9	< 0.0005
Word Length x Time Compression	35.3	1	1.2	0.186
Subjects x Word Length x Time Compression	24.1	1	1.2	0.273
Subjects x Sentence Order	445.3	2	15.6	< 0.0005
Word Length x Sentence Order	206.1	2	7.2	0.001
Subjects x Word Length x Sentence Order	74.4	2	2.6	0.081
Time Compression x Sentence Order	350.2	2	19.9	< 0.0005
Subjects x Time Compression x Sentence Order	148.6	2	8.5	< 0.0005
Subjects x Word Len. x Time Compression x Sentence Order	3.5	2	0.2	0.818

ANALYSIS OF VARIANCE TABLE
FOR SENTENTIAL STIMULI

Source	Mean Square	df	F	P
Subjects	604.8	1	4.1	0.05
Time Compression	1065.6	1	7.2	0.01
Procedure	1960.0	1	13.4	< 0.005
Subjects x Time Compression	273.8	1	1.9	
Subjects x Procedure	845.0	1	5.8	0.05
Time Compression x Procedure	192.2	1	1.3	
Subjects x Time Compression x Procedure	16.6	1	0.1	