ABSTRACT

THE PERFORMANCE OF AUDITORY PERCEPTUALLY HANDICAPPED CHILDREN ON TEMPORALLY DISTORTED SENTENTIAL APPROXIMATIONS AND NORMAL SENTENCES

By

Gail Ann Overholt

The effect of temporal characteristics on the intelligibility of the signal has been of interest to researchers and clinicians in recent years. Several investigators have found that distortion of these temporal characteristics increases the load placed on short-term memory resulting in decreased accurate perception of the stimulus. One such method of investigation is to control stimulus duration and vary the silent interstimulus interval using sentential stimuli controlled for length and syntactic and semantic contstraints.

Current theories of perceptual abilities in children with auditory perceptual handicaps suggest that these children do not process auditory stimuli in the same manner as normal children. In turn, children with perceptual problems may demonstrate perceptual strategies different from those used by normal children on a task designed to overload auditory short-term memory and affect information processing strategies.

Gail Ann Overholt

The purpose of this investigation was to study the effect of sentence length, order of sentential approximation, and modified interstimulus interval upon linguistic processing by children with auditory perceptual handicaps. The results were compared to data obtained with the same task on normal children.

In order to increase syntactic and semantic complexity, ten three-word and ten five-word first order sentential approximations, ten three-word and ten five-word second order sentential approximations, and ten three-word and ten five-word normal sentences were constructed. The sentential approximations and normal sentences were read by a male speaker from a Second Level standardized reading list of monosyllabic words. These forty sentential approximations and twenty normal sentences were placed into three experimental conditions, each condition with a specific silent interstimulus interval size. Word duration remained constant (normal speaking rate), but three interstimulus interval sizes (a normal interstimulus interval, 200 msec, and 400 msec) were used.

Twelve elementary school students enrolled in the Remedial Reading Center at Michigan State University served as subjects. All children had normal hearing as assessed by audiological evaluation. Each subject was presented with twenty sentences of each interstimulus interval, twenty sentences of each order of sentential approximation, i.e. synthetic sentences (first order, second order, and normal

sentences), and thirty sentences of each sentence length (three-word and five-word), for a total of 60 sentences per subject. The tape recorded material was presented under earphones to each subject in a two-room, double-walled, sound treated booth.

Examination of responses consisted of the percent correct words recalled. Words substituted for, omitted, or repeated in the wrong order were considered errors. The results of this investigation demonstrated that auditory perceptually impaired children depended upon sentence length, order of sentential approximation, and interstimulus interval size in processing speech and language.

Recall accuracy scores decreased as sentence length increased from three words to five words, as order of sentential approximation decreased from normal sentences to second order and first order approximations, and as the size of the interstimulus interval increased from a normal condition to 200 and 400 msec, respectively.

Interactions of the experimental conditions revealed that for three-word sequences, recall accuracy varied only slightly with increasing sentential approximations and interstimulus intervals. However, there were substantial differences in recall scores for five-word sequences as sentential approximation and interstimulus interval increased. Also, for normal sentences, temporal alteration in either form of increasing sentence length or increasing

interstimulus interval size did not affect recall accuracy, which was near 100 percent.

These findings were discussed in terms of theories of speech and language perception in normal and auditory perceptually impaired children. Particularly important were implications to auditory diagnosis of and language development in auditory perceptually handicapped children.

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INTRODUCTION

Several investigators have shown that the auditory perception of speech is at least in part dependent upon the temporal characteristics of the stimuli (Aaronson, 1967; Beasley and Shriner, 1973; Hirsh, 1959; Shriner and Daniloff, 1970; Speaks and Jerger, 1965). These temporal characteristics include rate and duration, and interact with stimulus frequency and intensity, as well as with the listener's perceptual strategies and memory storage capacities and abilities. The interaction of these several factors affect the intelligibility of the signal, which is necessary before the message can be perceived and comprehended adequately.

It has been found that the perceptual abilities of children are different from those of adults, and that these abilities are developmental in nature (Beasley and Flaherty-Rintelmann, 1976; Beasley, Maki, and Orchik, 1976; King and Weston, 1974; Thompson, 1973). Further, there are some children whose auditory perception is not like that of the majority of children (Katz, 1971; Manning, Johnston, and Beasley, 1975; Lerner, 1971; Rosenthal, 1974). The children in this latter catagory have been labeled auditory perceptually handicapped or specific learning disabled. It has been hypothesized that

the difficulties in auditory perception these children encounter may be due to problems of short-term memory storage (Bryan, 1972; Manning, Johnston, and Beasley, 1975; Senf and Fruendl, 1971). If this is the case, these children would show results that varied from normative data on a test purported to assess short-term memory function. The purpose of this study was to investigate the performance of learning disabled children characterized by auditory perceptual problems on a measure purported to reflect upon the functioning of short-term memory, in which sentence length, word sequence, and interstimulus interval were covaried. This data was compared to data obtained with the same measure on a group of normal children.

A Model of Short-Term Memory

In order for a message (stimulus) to be perceived, it must first enter into a memory storage system of some type. Most current theories of short-term memory discuss the idea that perception occurs in at least two stages (Aaronson,1967; Broadbent, 1958). The first stage, the sensory stage, is a parallel processor, whereby more than one stimulus can be dealt with at one time. Characteristic of this stage is its parallel processing capabilities, large capacity, and rapid storage decay. The second stage, the perceptual stage, is characterized by series processing (that is, stimulus items can enter this stage only one at a time), small capacity, and long storage decay time. Broadbent (1958) hypothesized that stimulus items first enter into the sensory system at a

rapid rate, and then are transferred to the perceptual system at a slower rate. This second stage is believed to occur at higher perceptual levels. Based on this theory, it may be hypothesized that problems in perception arise if items are delayed in the first stage (sensory system) for too long a period of time, since this is a rapid decay system, or if items arrive at the second stage (perceptual system) at too fast a rate to be processed accurately.

Aaronson (1967) reviewed literature which suggested that the temporal aspects of the message have an important effect in short-term memory tasks. From this review she revised Broadbent's short-term memory model. It appeared that varying the stimulus duration alone resulted in fewer number of items being correctly recalled in a listening task. However, when the rate of the message was changed by keeping stimulus duration constant and varying only the interstimulus interval, order of the stimulus items was less correctly perceived for shorter interstimulus intervals. Aaronson, therefore, suggested that the physical qualities of the stimulus were processed in the first stage of short-term memory, simultaneous with stimulus presentation; however, the order in which the stimuli are recalled were processed in the second stage. This second stage was believed to be dependent in part upon the length of the interstimulus interval.

Aaronson, Markowitz, and Shapiro (1971) studied this phenomenon. They kept presentation rate constant, but compressed the stimulus duration by 33%, thereby increasing the

length of the interstimulus interval. Aaronson et al.(1971), found that the number of item errors for the normal stimulus duration condition was similar to the number of item errors in the compressed stimulus duration condition. However, for the normal condition, which had a smaller interstimulus interval, the number of order errors was significantly larger.

Miscik, Smith, Hamm, Deffenbacher, and Brown (1972) also found that an increased interstimulus interval elicited increased recall in a short-term memory task for digits. In another experiment, Miscik et al. again studied the effect of interstimulus interval upon perceptual processing, as well as the type of encoding process used by the subject. They found that when subjects were asked to combine digits into digit pairs and triplets, recall accuracy increased. The authors hypothesized that combining digits in such a manner decreased the number of areas in the central auditory nervous system where this information was stored, and that retrieval from this reduced number of areas was easier than from a larger number of areas.

Some limitations on the capacity of short-term memory were discussed by Miller (1956). He reported that human subjects were able to accurately recall approximately seven presented items or units. When more items were presented, recall accuracy declined. However, even though short-term memory limits could not be extended beyond these seven units, Miller discovered that memory for items could be increased by combining and increasing the item information per unit. He labeled this perceptual strategy "chunking". Miscik

et al. (1972) stated, "Error in short-term recall may be due not only to forgetting caused by inadequate rehersal, for example, but also to inadequacies in the encoding process (p. 151)."

Sentential Stimuli

Assessment of auditory processing abilities using conventional methods has not resulted in adequate measurement of the functioning of the central auditory system. The use of pure tones, clicks, digits, and undistorted word lists appears to be too simple a task for the detection of lesions in the patient with a central auditory problem (Bocca and Calearo, 1963; Calearo and Lazzaroni, 1957; Jerger, 1960; Willeford, 1967). These nonsentential stimuli principally reflect peripheral mechanism functioning, while leaving the central auditory mechanism essentially unassessed. Bocca and Calearo (1963) and Willeford (1967) concluded that pure tones, even when used in a difficult listening situation, were not adequate for the purpose of localization of the site of lesion in a central auditory disorder. They concluded that speech signal tests were more efficient in central auditory functioning assessment.

In identifying the type of stimuli that will adequately assess the central auditory system's functioning, Jerger (1960) discussed two principles. The first is the "sublety principle," that is, as the lesion becomes more centrally located in the central auditory system, the stimuli needed to detect this lesion must necessarily become more complex. The

second principle espoused by Jerger was the "bottleneck principle." He suggested that speech signals encounter a bottleneck in the region of the VIIIth nerve and the lower brain stem. Consequently, if the lesion occurs in this location, or more centrally, the patient will tend to show normal responses to pure tones and clicks, but his ability to understand speech will be dramatically limited.

Intrinsic redundancy refers to the continual crossing and interaction of neuronal networks in the auditory pathway. In this way, a lesion of the central auditory system would have to be quite severe before any noticable problem in communication would occur. Indeed, it has been stated that an entire temporal lobe could be removed or destroyed, and the effect that this would have on perception would be unnoticed unless a complex auditory task was used to detect the lesion (Willeford, 1967).

Extrinsic redundancy refers to the redundancy of the speech message per se. Harris (1960) defined this as the syntactic and contextual cues of the message, the "....functions of language organization (p. 228)." For example, three or four words may not be heard, but the listener will comprehend the message because he knows the syntactic and semantic constraints of the language. Related to extrinsic redundancy is the concept of multiple-cueing.

Multiple-cueing relates to the physical characteristics of the message. In a complex message, such as speech, there are several characteristics present, including frequency,

intensity, and duration. These characteristics, individually, have a broad range of values that may be present or absent from the speech signal. It is these cues and the interactions of these cues relative to the whole message that are processed by the central auditory system. Distortion or disruption of the physical characteristics of the speech signal would not significantly reduce the intelligibility of the message unless the signal was greatly degenerated (Harris, 1960). When extrinsic redundancy and the effects of multiple-cueing are combined, it becomes possible to process a less than perfect message if the central auditory system is intact.

Distorted Speech Stimuli

The patient with a central auditory lesion (reduced intrinsic redundancy) is able to process speech because of extrinsic redundancy and multiple-cueing. However, when extrinsic redundancy and multiple-cueing are decreased in the speech stimuli, these subjects may show reduced message comprehension.

Investigators have found several ways to reduce redundancy and multiple-cueing. Bocca and Calearo (1963) stated that one method used to reduce redundancy (multiple-cueing) was to filter the speech with high-pass or low-pass filters. Matzker (1962) devised a test in which a high-pass filtered message was presented to one ear and the same message, low-pass filtered, was presented to the opposite ear. The person with an intact brain stem could integrate and understand the message, whereas the patient with a brain stem lesion could

not.

Another method of reducing redundancy is via time-compressed speech. Calearo and Lazzaroni (1957) described three techniques for altering the temporal characteristics of language:

(1) have a speaker talk faster.

(2) play a magnetic tape recording back at a higher speed than was used in the recording process.

(3) use a special device that accelerates speech without changing frequency.

Calearo and Lazzaroni discussed the ability of patients with confirmed temporal lobe desions to comprehend these three types of time-compressed speech. They hypothesized these patients would show an abnormal breakdown in intelligibility of the signal in the ear contralateral to the lesion because the decreased number of interneuronal connections would be insufficient to process information in the message in which redundancy was reduced. Indeed, this effect has been shown to occur (Kurdziel and Noffsinger, 1973).

Speaks and Jerger (1965) discussed the importance of temporal characteristics in the assessment of auditory functioning. They suggested that it was important to use test stimuli of sufficient duration to permit alteration of the temporal characteristics of the speech signal. They concluded that single words were of too short a duration to permit these changes. Speaks and Jerger controlled for sentence length and informational content by devising synthetic

sentences, i.e., sentential approximations. In this way, extrinsic redundancy (as defined by Harris, 1960) was reduced. Syntactic and sematic cues were eliminated because each word in the sequence was chosen with varying degrees of probability of following the previous word. The authors found that as the synthetic sentences approached normal sentences, subjects were more able to accurately recall the approximations.

Beasley and Shriner (1973) reduced extrinsic redundancy by using first and second order sentential approximations. They also varied the amount of time allowed for perception of the stimuli by independently varying the stimulus (word) duration and the length of the interstimulus interval. Using normal adult subjects, they found that the effect of word duration, interstimulus interval size, and order of sentential approximation were independently significant. As the word duration was increased from 200 msec to 400 msec in 100 msec intervals, recall accuracy increased. As interstimulus interval increased in 100 msec steps from 100 msec to 400 msec, recall accuracy increased. Recall accuracy also increased as the order of sentential approximations approached normal sentences (i.e., first order and second order sentential approximations). The authors also found a significant interaction between word duration and interstimulus interval length, and between word duration and order of approximation. The greatest difference between first and second order sentential approximations was in the 300 msec word duration

condition, suggesting that, beyond 400 msec and 200 msec, increases or decreases in word duration, respectively, would result in only minimal changes in recall accuracy. The complex interaction between word duration and interstimulus interval was significant, suggesting that the important factor in speech perception was not either the stimulus duration or interstimulus interval, but rather, the overall rate of speech. Beasley and Shriner found no significant interaction between the length of the interstimulus interval and the order of sentential approximation.

Other investigators have studied the effect of varying interstimulus intervals in sentential stimuli and have obtained results that are consistent with that of Beasley and Shriner. Kuhl and Speaks (1972) compared two kinds of distorted speech stimuli. In comparing time-compressed speech with interrupted speech, the authors found that, at rates of less than 2 words per second, recall accuracy was similar for both conditions. However, at rates of 2 words or more per second, compressed speech was more difficult to understand than interrupted speech. One of Kuhl and Speaks' hypotheses as to why this might occur was that the silent intervals in the interrupted stimuli provided time for the eliminated portions of the signal to be processed, whereas the compressed stimuli provided no interval for processing the deleted portions of the message.

It appears that the length of interstimulus interval influences the accuracy of recall. Aaronson et al. (1971)

and Miscik et al. (1972) found increased recall for digits with increased interstimulus interval. Beasley and Shriner (1973) and Kuhl and Speaks (1972) found this same effect with sentential stimuli. Apparently the interstimulus interval enhanced the possibility for accurate perceptual processing (Broadbent's second stage of short-term memory) to occur. That is, the increased interstimulus interval provided more time for the stimuli to be perceived, resulting in greater recall accuracy.

Auditory Perception in Children

Several investigations have been designed to study auditory perception in children. Beasley, Maki, and Orchik (1976) studied children's perception of time-compressed speech using two measures of speech discrimination: The Word Intelligibility by Picture Identification (WIPI) and the Phonetically Balanced Kindergarten lists (PBK's). Their results were compared with data obtained by Beasley, Schwimmer and Rintelmann (1972) and Beasley, Forman and Rintelmann (1972) for adults using time-compressed Northwestern University Auditory Test Number Six monosyllabic word lists (NU#6's). Beasley et al.(1976) found that children tended to show decreased performance at lower levels of time-compression especially when an open message set response task, such as the PBK's was used. Children showed a major breakdown in scores at 60% time-compression, whereas adults did not show a significant decline until the point at which 70% time-compression was employed. When a closed message set

was used (the WIPI), there was also a breakdown at 60%, however, it was not as dramatic as with the PBK lists. Hodgson (1974) found that the closed message set response task of the WIPI makes up, in part, for the limited linguistic capabilities of children, thereby explaining the WIPI-PBK discrepancy that Beasley et al. found.

Other investigators have studied short-term memory processing of children using sentential stimuli. The effects of time-compressed and time-expanded sentences on sentence discrimination using a closed message set were studied by Thompson (1973). She found that by decreasing presentation rate, the recall accuracy of children increased. However, as age increased, the effect of presentation rate became less significant. She found that younger children tended to perform better under conditions of time-expansion, indicating that younger children need more time to process linguistic information.

Another approach to investigating perception in children has been to study the effect of varying interstimulus interval while keeping stimulus duration constant. Shriner and Daniloff (1970) varied the amount of time between phonemes arranged in meaningful and meaningless CVC units. Performance by children in both first- and third-grades on meaningless stimuli was poorer than their performance on meaningful stimuli. While the children of both grades performed similarly on the meaningless stimuli, for the meaningful stimuli, third-grade children tended to perform better at all

interstimulus intervals. The authors hypothesized this effect was due to increased linguistic capabilities possessed by the older children. Shriner and Daniloff found an interstimulus interval of about 200 msec to be a pivot point. That is, resynthesis of meaningless stimuli remained constant for increasing intervals until 200 msec, at which point, increasing the interstimulus interval brought about a decrease in correct responses. For meaningful stimuli, percentage correct responses declined as the interstimulus interval increased to 200 msec, after which scores remained at the same level for longer interstimulus intervals.

The results of Shriner and Daniloff may be applied to Miller's "chunking" hypothesis (1956), as discussed by Beasley and Beasley (1973). Beasley and Beasley postulated that stimuli with an interphonemic interval of less than 200 msec was processed as a single word. With the slight increase in scores observed at the 400 msec interphonemic interval condition, Beasley and Beasley hypothesized the CVC units were processed as three separate phonetic units. At interphonemic intervals of intermediate duration (greater than 100 msec but less than 400 msec), it was difficult for the children to decide whether the stimuli should be processed as one unit or as three separate units; therefore, scores were depressed.

Beasley and Beasley used this same measure to compare short-term memory functioning of Black and White children from an inner-city environment. They obtained results

similar to those of Shriner and Daniloff (1970); that is, third-grade children performed better than first-grade children on the meaningful stimuli, although there was no grade difference on the meaningless stimuli. Beasley and Beasley also found a major breakdown in the 200 msec interphonemic interval condition. Since the results of Beasley and Beasley did not differ from those of Shriner and Daniloff, the former authors concluded that short-term memory functioning was not culturally based.

Beasley and Flaherty-Rintelmann (1976) assessed short-term memory functioning in children by varing sentence length (three-word and five-word), order of sentential approximation (first order, second order, and normal sentences), interstimulus interval (an unaltered interval, and 200 msec, and 400 msec), and grade level (second-grade and fourth-grade). Using a recall task, results indicated that fourth-grade children were better able to recall the sentences than second-grade children. As sentence length increased from three words to five words, the number of errors increased, except in the normal condition, where accuracy in both three- and five-word recall was near 100 percent over all interstimulus interval and sentence length conditions. As a general trend, recall accuracy increased as order of sentential approximation increased, whereby first order sentential approximations showed the greatest number of recall errors and normal sentences showed the least number of recall errors. Greatest recall accuracy was obtained with an

unaltered interstimulus interval, which was determined to be the shortest interstimulus interval. The 400 msec condition produced the largest number of recall errors. The intermediate condition of 200 msec was shown to have an effect on recall accuracy somewhere between the unaltered condition and the 400 msec condition. Beasley and Flaherty-Rintelmann stated that temporal characteristics such as the interstimulus interval might be important in the processing of auditory stimuli at lower, more peripheral neural centers. As the stimuli became more linguistically meaningful, it was analyzed at higher levels of the central auditory system and temporal alteration of the stimuli did not affect recall accuracy.

All of these studies dealing with auditory processing capabilities of children have tended to show two main characteristics of the children's ability to process information:

(1) auditory perception in children tends to be different from that of adults. In general, they are not able to process temporally distorted stimuli as well as adults.

(2) auditory perception appears to be developmental in nature. Ability to use linguistic strategies and to chunk stimulus items increases with age, thereby increasing short-term memory recall accuracy.

Learning Disabled Children

Senf and Freundl (1971) investigated short-term memory function in learning disabled children. Three visual-auditory digit pairs were presented in a simultaneous condition and in two alternating conditions, the visual digit being presented first in both conditions. Subjects, eighteen learning disabled males matched for age and intelligence quotient with eighteen children who did not possess learning problems, were directed to recall the digits in one of two manners:

(1) directed pair: subjects were to recall the digits in their order of arrival, beginning with the first visual digit.

(2) directed modality: subjects were to recall the digits by modality; that is, the three visual digits first, followed by the three auditory digits.

Both gross number of errors and order errors were analyzed. For the directed pair conditions, there was no difference among conditions (simultaneous or alternating presentation). The learning disabled children differed from the control group of children, showing poorer recall scores in the auditory error analysis, while performing similarly to the control group with the visually presented digits. For the directed modality condition (recall by modality), learning disabled children performed significantly lower than the control group on all conditions (visual and auditory

modality, simultaneous and alternating conditions, and gross number and order errors). Presentation conditions showed a significant difference only with visual gross errors. The authors concluded that these results were not due to problems in cross-modal integration (from visual to auditory stimuli and vice versa), but rather, to inadequate higher-order (short-term memory) functioning in the learning disabled children.

Rosenthal (1974) proposed a theory based on his research of auditory perceptual difficulties in children with language disorders. In his theory, Rosenthal stated that the specific perceptual disorder, whether it be auditory or visual, interferes with accurate processing of incoming linguistic stimuli. If the disorder is an auditory perceptual impairment, then the incoming signal is speech, and, because the speech signal is not perceived accurately, the child is not able to internalize language. The consequence is delayed language development.

McCrosky and Thompson (1973) studied the effect of time-compression, time-expansion, and a normal presentation rate using children from the ages of 5 through 17 years who demonstrated difficulty in understanding spoken messages, but whose auditory sensitivity was within normal limits. The authors time-compressed and time-expanded simple declarative sentences and presented them in a discrimination task. Significant differences were obtained only for the younger grade-school-age children. What was found was that as

presentation rate decreased (that is, as the speech message was expanded) the accuracy of performance of these children increased, suggesting that those children with auditory perceptual handicaps needed more time to process incoming information. The older children showed no differences in perception of the varied presentation rates. This may be because their knowledge of linguistic rules was such that they were able to obtain enough information from the syntactic and semantic constraints, ignoring the temporal factors involved.

The inability of auditory perceptually handicapped children to adequately process time-compressed stimuli was also studied by Manning, Johnston, and Beasley (1975). They found that these children tended to show decreased accuracy scores at a lower sensation level and percent level of time-compression than children without auditory processing problems (Beasley et al., 1976). Using time-compressed PBK's, a speech discrimination measure, Manning et al. found that scores of the impaired children agreed with those of the normal children at 0% and at 60%; however, at 30% time-compression, the impaired children showed significantly lower scores. This would again suggest that auditory perceptually impaired children process speech at a slower fate than normal children.

Freeman, Beasley, and Overholt (1975) found this same effect with a learning disabled population using the WIPI speech discrimination test. Again, the learning disabled

children performed more poorly at lower sensation levels and lower levels of time-compression than normal children. As well, Freeman et al. studied the performance of learning disabled children in recalling sentential stimuli of varying word length, order of sentential approximation, and interstimulus interval size. Results indicated that learning disabled children had more difficulty than normal children (Beasley and Flaherty-Rintelmann, 1976) in processing temporally altered first and second order sentential approximations. Also, those learning disabled children with auditory perceptual problems did significantly worse than learning disabled children without auditory perceptual problems, whose performance agreed with the normative data.

As Broadbent's theory of short-term memory is stated, by decreasing presentation rate, more time is available to process the stimuli, thereby increasing recall accuracy. Research results have shown that in children with learning disabilities short-term memory functioning is inferior to that of normal children. Since these children cannot adequately process linguistic stimuli until these stimuli are presented at a slower rate, they may be having problems transferring information from Broadbent's sensory processing stage of short-term memory to the perceptual stage.

Statement of the Problem

It has been found that the temporal characteristics of the speech signal play an important role in auditory perception of speech. Normative data has been obtained on a task

that varies interstimulus interval, as well as controlling for grammaticalness, for both adults (Beasley and Shriner, 1973) and children (Beasley and Flaherty-Rintelmann, 1967).

Theories as to how children who are labeled specific learning disabled process speech stimuli have been postulated. Although there is a paucity of research in this area, it is generally believed that these children demonstrate a breakdown in the speech processing mechanisms of the central auditory pathways (Willeford, 1974). If this is true, performance by these children on a speech processing task that purports to measure a major characteristic of the functioning of the central auditory system should show a significant difference from responses of normal children. This difference may be important in the detection and subsequent remediation of children with auditory perceptual problems.

The purpose of this investigation was to determine the perceptual processing strategies of auditory perceptually handicapped children using a task of sentential stimuli, controlling for syntactic and sematic constraints, and sentence length. The effects of modifying the sentence length, order of sentential approximation, and interstimulus interval size on auditory perception of children with auditory perceptual problems were investigated.

Specifically, the following questions were asked:

(1) what effect would variations in sentence length have on recall accuracy of auditory perceptually handicapped children?

(2) what effect would various orders of sentential approximation and normal sentences have on recall accuracy of these children?

(3) what effect would varying interstimulus intervals of a normal condition, 200 msec, and 400 msec have on recall accuracy of the stimuli by these children?

(4) what would be the effect of interactions of the above factors on recall accuracy of auditory perceptually handicapped children?

(5) how would the performance of auditory perceptually handicapped children compare with the performance of children without such handicaps?

CHAPTER II

EXPERIMENTAL PROCEDURES

Twelve reading impaired children were presented with a temporally altered linguistic test. There were four subjects per condition of sentence length by sentential approximation by interstimulus interval, for a total of 36 subjects for each sentence length (three-word and five-word), 24 for each order of sentential approximation (first order, second order, and normal sentences), and 24 for each interstimulus interval (a normal condition, 200 msec, and 400 msec). (See Figure 1.)

Subjects

Twelve children with an age range of 8.5 years to 11.7 years and a mean age of 10.1 years who were enrolled in the Remedial Reading Center at Michigan State University served as subjects. These children were chosen as subjects because theories have been postulated (Norman, 1969; Mattingly, 1972) and research has shown (Birch and Belmont, 1965; McGrady and Olsen, 1970) that visual stimuli are processed auditorilly. Therefore, children who indicate reading difficulties would likely also manifest auditory perceptual problems (de Hirsch, 1973; Freeman and Beasley, 1976; Stark, 1975). None of the children evidenced any other known

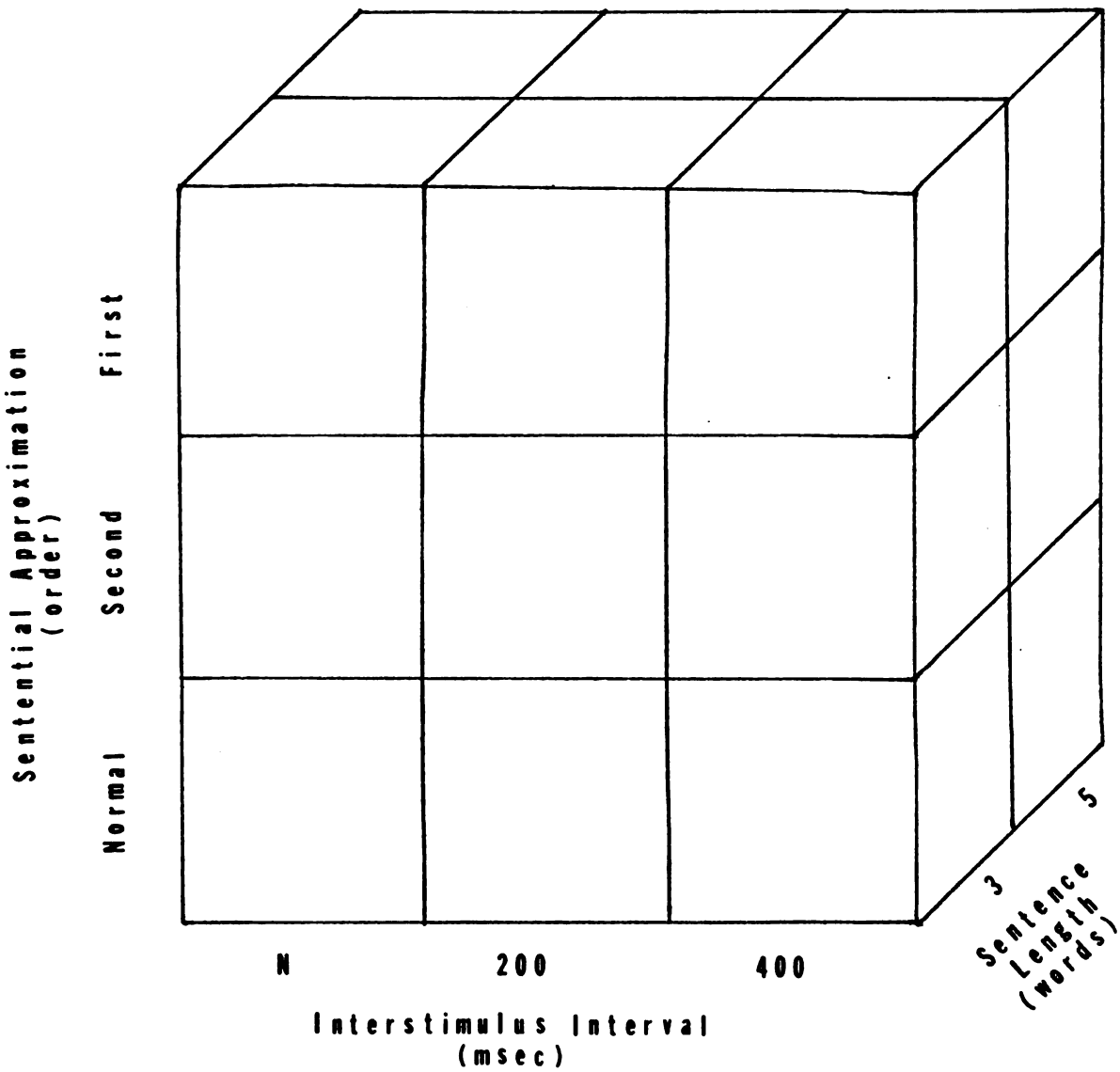

Figure 1. Experimental design.

handicaps. All children received a thorough audiologic evaluation and exhibited normal hearing. (See Appendix A.)

Each subject was presented 20 first order sentential approximations (ten three-word and ten five-word), 20 second order sentential approximations (ten three-word and ten five-word), and 20 normal sentences (ten three-word and ten five-word). Also, each subject received 20 sentential stimuli (ten three-word and ten five-word) with an unaltered interstimulus interval (an interstimulus interval of normal speaking rate), 20 sentential stimuli (ten three-word and ten five-word) with a 200 msec interstimulus interval, and 20 sentenial stimuli (ten three-word and ten five-word) with a 400 msec interstimulus interval. The two experimental conditions of sentential approximation and interstimulus interval were counterbalanced to minimize possible interactions and randomized to reduce any effect that might be due to learning.

Stimuli

The stimulus materials used here were taken directly from those used by Beasley and Flaherty-Rintelmann (1976) in a previous investigation of short-term memory function in second- and fourth-grade children. The stimuli consisted of three separate experimental conditions:

(1) order of approximation: 20 first order sentential approximations (ten three-word and ten five-word), 20 second order sentential approximations (ten three-word and ten five-word), and twenty normal

sentences (ten three-word and ten five-word).

(2) interstimulus interval: all sixty sentential approximations and sentences produced with a 200 msec interstimulus interval, a 400 msec interstimulus interval, and an unaltered interstimulus interval (normal speaking rate).

(3) sentence length: ten first order sentential approximations, ten second order sentential approximations, and ten normal sentences, each consisting of three words, as well as ten first order sentential approximations, ten second order sentential approximations, and ten normal sentences of five-word length.

The sentential approximations to full grammaticality were constructed in a manner similar to a procedure described by Speaks and Jerger (1965), based on the probability of one word following another in a normal sentence. The words used in the sentential approximations for this investigation were taken from the Basal Vocabulary of the primary reader workbook, ON WE GO (Teacher Edition) (Second Level) (Houghton Mifflin, 1966). One hundred monosyllabic words were chosen from the ON WE GO list and randomized into a new list. (See Appendix B.)

For the first order sentential approximations, words were chosen randomly from the revised list and constructed into ten three-word and ten five-word sentential stimuli.

Construction of the second order sentential approximations was achieved by randomly choosing the first word from the revised list. The second word was then chosen from the revised list such that it might follow the first word in a normal sentence. The third word was chosen, without the knowledge of word one, to follow the second word in a similar manner. This procedure was continued until ten three-word and ten five-word second order sentential approximations were constructed.

Recording and Stimulus Generation Procedures

For the experimental tape recordings, sixty sentential stimuli (ten three-word and ten five-word first order approximations, ten three-word and ten five-word second order approximations, and ten three-word and ten five-word normal sentences) were recorded onto a master tape recording by a male speaker who spoke general American English and was trained in phonetics. The speaker used an Electro-voice 635A microphone and an Ampex AG 440-B tape deck. The recordings were made at conversational pitch and effort level with minimum inflection in a sound treated recording suite. Minimum inflection was used to reduce prosodic cueing effects that might influence the stimuli. The speaker monitered his vocal intensity on a VU meter. Peaking occured between words in order to facilitate the location of the initiation and termination of each word for splicing purposes.

Two copies of the master tape recording were made at 7½ ips (inches per second) using Ampex 601 and Ampex 600 tape recorders. Each of these copies was prepared as experimental stimuli by varying the interstimulus interval size (200 msec and 400 msec, respectively). To prepare the 200 msec condition, the acoustic initiation and termination points of each word were determined aurally by using a playback record head coupled to a pre-amplifier and an amplifier/speaker. These points were marked and then manually severed. The existing interval between words was discarded and a length of magnetic recording tape ascertained to be 200 msec in length (1.5 inches of tape) was spliced between each word. This same procedure was followed in the preparation of the 400 msec condition stimuli. For this condition, a length ascertained to be 400 msec (3 inches of tape) was used.

These experimental tapes were played through a Bruel and Kjaer Type 2305 high speed graphic level recorder (paper speed=30 mm/sec, writing speed=250 mm/sec, 50 dB, 20 Hz). The silent interstimulus intervals were hand measured in millimeters and converted to milliseconds. Any silent interstimulus interval in error by more than approximately ±30 milliseconds was reprocessed.

These stimulus tapes (used by Beasley and Flaherty-Rintelmann, 1976) were rerecorded and reordered for counterbalancing and randomization procedures used in the present investigation. The stimuli were copied from an Ampex AG

440-B tape deck to an Ampex AG 601 tape recorder, and the carrier phrase, "Number ___" (the number of the sentence for a given condition) was inserted in front of each sentential stimuli.

Counter-Balancing and Randomization Procedures

The condition of order of sentential approximation (first order, second order, and normal sentences was combined with the interstimulus interval condition (an interval associated with normal speaking rate, 200 msec and 400 msec) and sentence length (three-word and five-word). This resulted in eighteen experimental conditions. (See Figure 1.)

These experimental conditions were arranged such that each subject would receive two conditions of each order of approximation (first order, second order, and normal sentence), two conditions of each interstimulus interval (200 msec, 400 msec, and an unaltered interstimulus interval), and three conditions of each sentence length (three-word and five-word). Among subjects, these conditions were counterbalanced to offset any effect that might be due to the interaction between sentence length,sentential approximation, and length of interstimulus interval. All of the counterbalanced conditions were randomized to minimize any effect due to practice that might occur.

Presentation Procedures

Each child was presented with 30 sentences of each sentence length (three-word and five-word), 20 sentences of each order of sentential approximation (first order,

second order, and normal sentences), and 20 sentences of each interstimulus interval (normal, 200 msec, 400 msec) for a total of 60 sentences per subject.

The listeners were seated in a chair in a two-room, double-walled IAC 1200 series sound-treated testing suite. The pure-tone air- and bone-conduction tests were presented via a Beltone 15C clinical audiometer. The clinical tape recordings for speech reception threshold (SRT) (Central Institute for the Deaf - CID W-1) and speech discrimination (Northwestern University Auditory Test Number Six - NU#6) and the experimental tapes were generated through an Ampex 600-2 tape recorder to a Grason-Stadler 162 speech audiometer located in the control room. The experimental stimuli were presented at 7½ ips binaurally, through TDH-39 earphones housed in MX-41/AR cusions. The intensity level was set at 50 dB HL (re: ANSI, 1969).

After a brief greeting period, the hearing evaluation was performed. For the experimental portion of the testing, standard verbal instructions (Appendix C) were given to each subject. If there were any questions, they were answered. Each subject was tested individually.

The oral responses of the subjects were recorded by the examiner on the response forms (Appendix D).

Analysis

The data were hand scored. The percent of words correctly recalled was the score for each subject. Three types

of errors were possible:

(1) discrimination errors consisted of words inaccurately recalled.

(2) omission errors consisted of any word not recalled within the sequence.

(3) any words that were repeated in the wrong order were considered to be order errors.

CHAPTER III

RESULTS

The results of this study supported the contention that speech perception is dependent, at least in part, on the syntactic, semantic, and temporal constraints imposed upon sentential stimuli. Overall results indicated that sentence length, order of sentential approximation, and interstimulus interval all affect recall accuracy of auditory perceptually handicapped children. In general, recall accuracy decreased as sentence length increased. As the order of sentential approximations rose to full grammaticality, recall accuracy scores increased. Recall accuracy decreased as the silent interstimulus interval was increased. (These effects, discussed below, can be seen graphically in Figure 2 and in Tables 2 and 3 in Appendix E.)

Effect of Sentence Length

Figure 2 shows the main effect of sentence length; that is, as sentence length increased from three words to five words, recall accuracy was reduced.

The interaction between sentence length and order of sentential approximation is illustrated in Figure 3A. As can be seen from the graph, the three-word stimuli provided for better recall accuracy. This is true across order of sentential approximation. However, as the order of

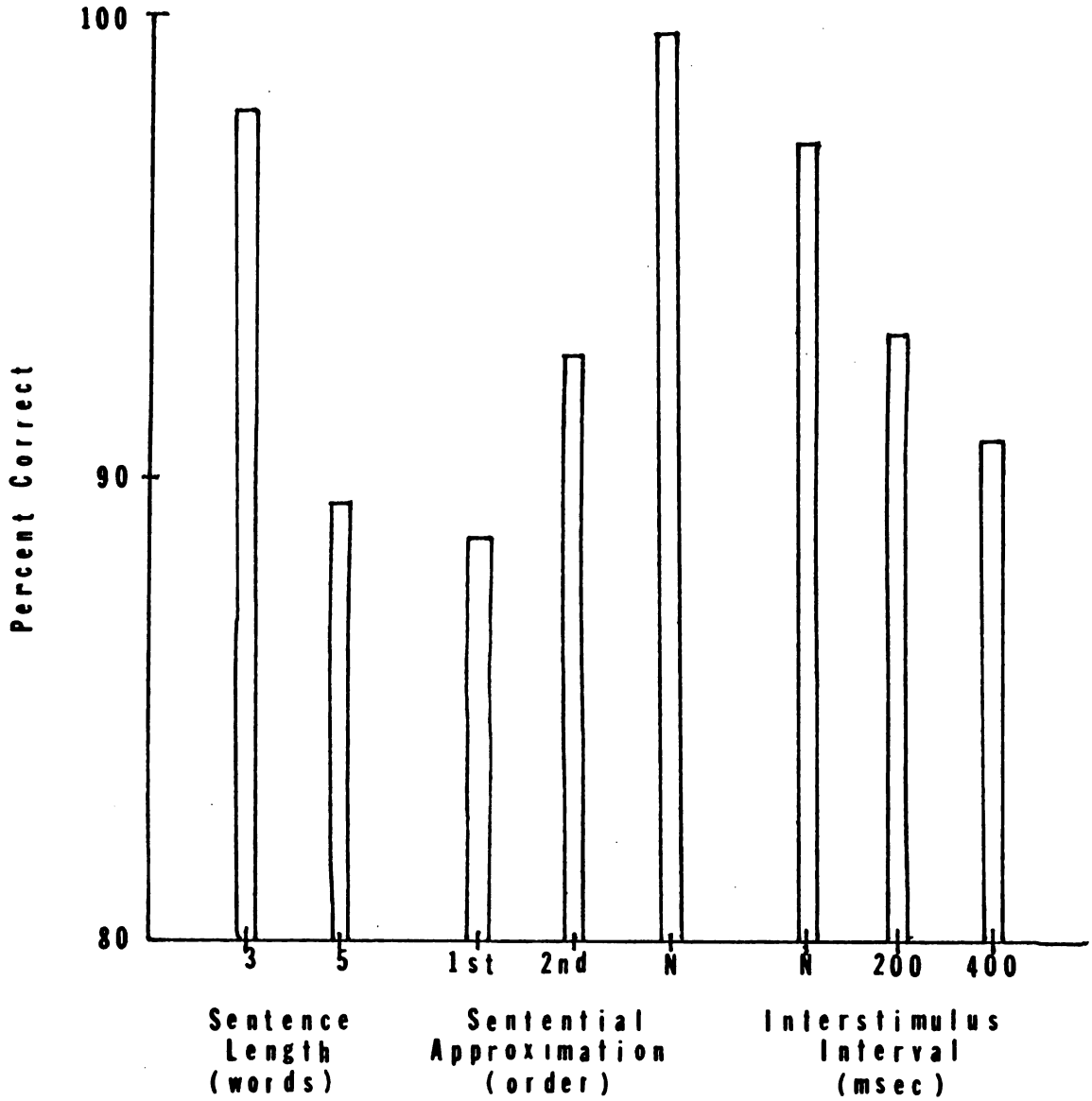

Figure 2. Main effects of sentence length, sentential approximation, and interstimulus interval.

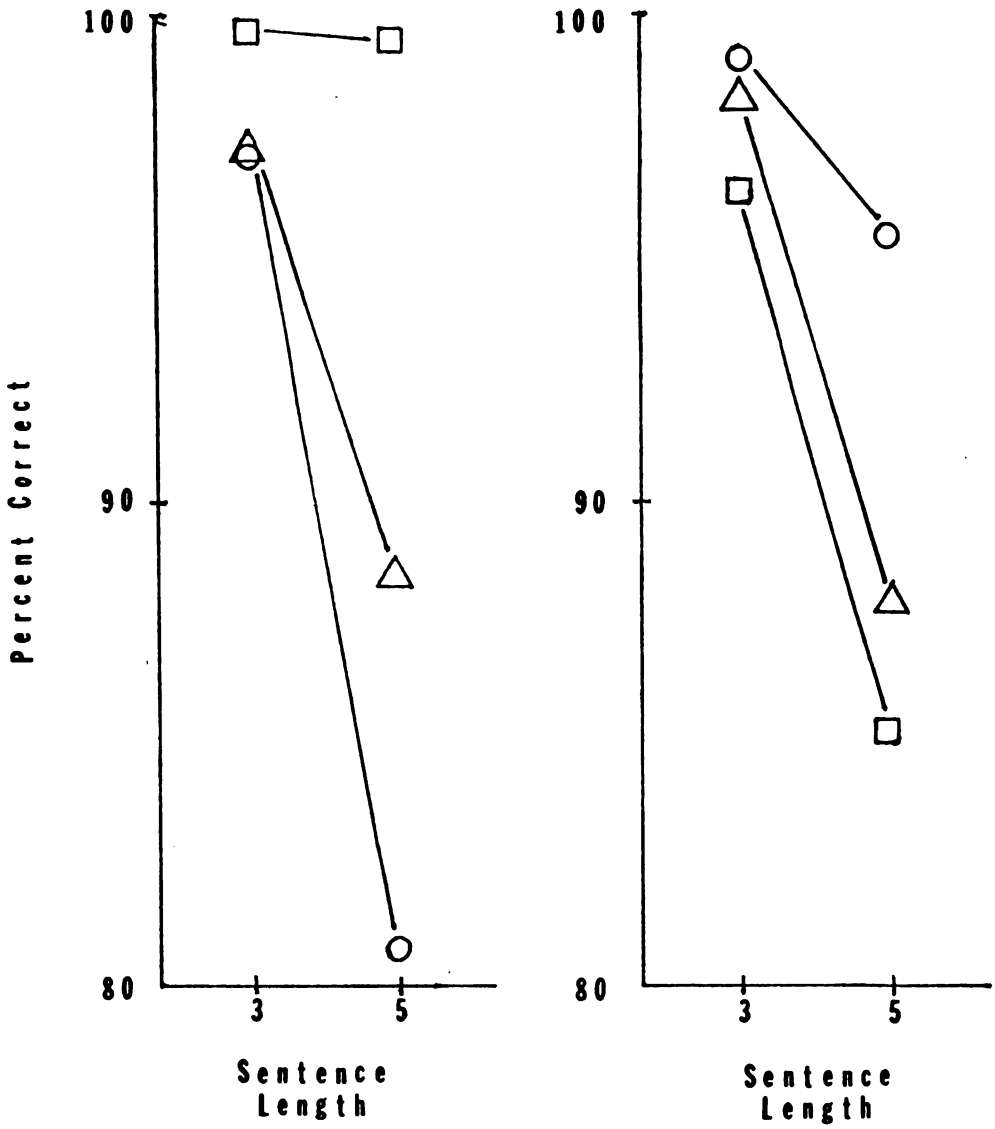

Figure 3A

Figure 3B

Figure 3A. Mean percent correct scores per sentence length and sentential approximation (O - first order; △ - second order; □ - normal sentence).

Figure 3B. Mean percent correct scores per sentence length and interstimulus interval (O - normal interval; △ -200 msec; □ -400 msec).

sentential approximation increased from first through second order to full grammaticality, the effect of sentence length decreased, so that at the normal sentence condition, there was only a negligible difference between three-word and five-word length.

Sentence length also interacted with interstimulus interval, as seen in Figure 3B. It appears that recall accuracy decreased as sentence length increased; and, further, that this occurred over all interstimulus intervals. Also, as the interstimulus interval condition increased from a normal speaking rate to 200 msec and 400 msec, the difference between recall accuracy for the three-word and five-word sentence lengths increased. (This is also illustrated in Figure 5A.)

Effect of Order of Sentential Approximation

As can be seen in Figure 2, there was a main effect for order of sentential approximation. In general, as the order of approximation increased from first order to second order to full grammaticality, the scores in recall accuracy increased.

There was an interaction between sentential approximation and sentence length (Figure 4A). While the effect of increased recall accuracy with increasing order of sentential approximation occurred over both conditions of sentence length (three-word and five-word), the effect was much greater for the five-word stimuli. Also, for normal sentences, recall accuracy scores of three- and five-word

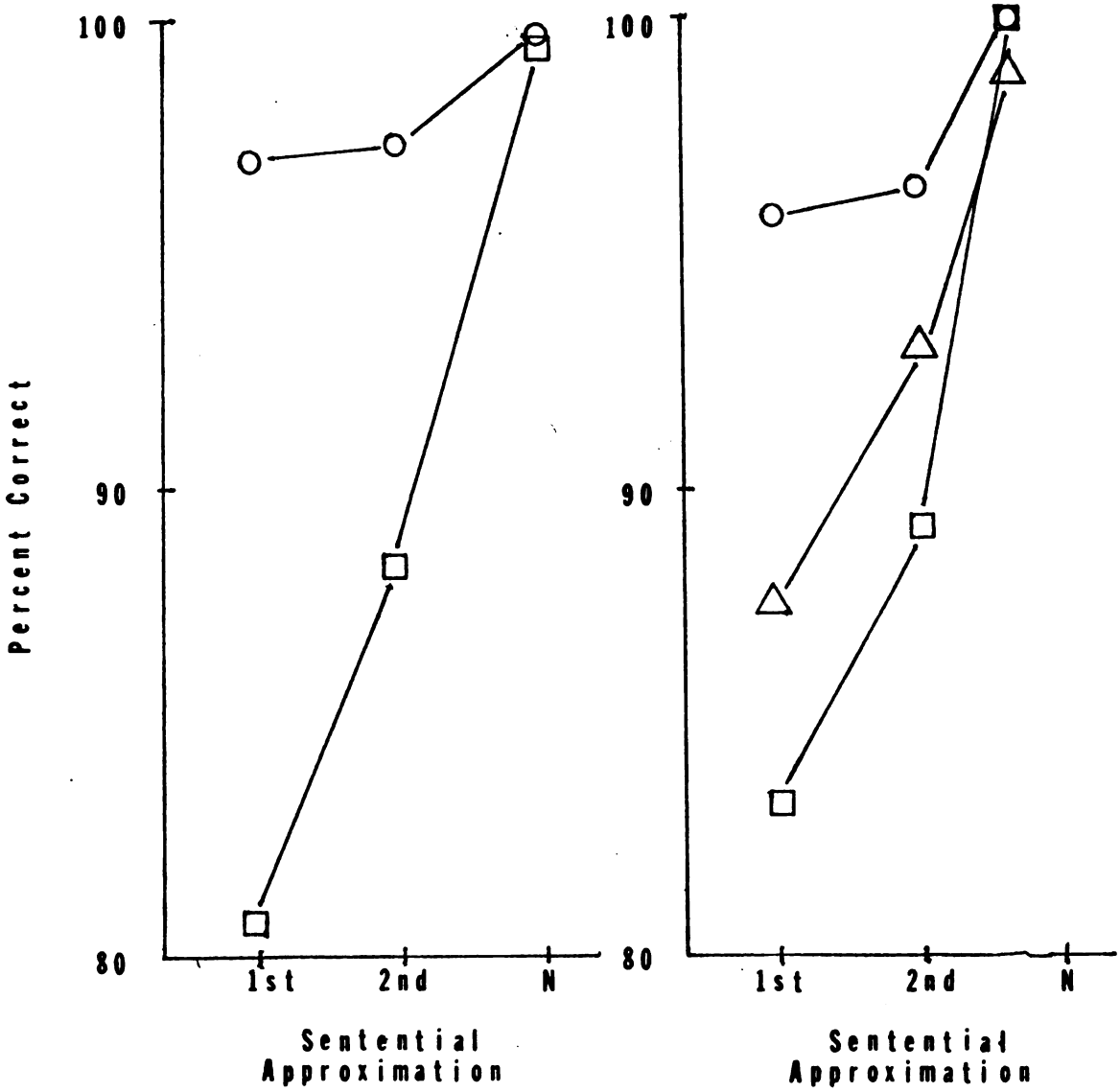

Figure 4A

Figure 4B

Figure 4A. Mean percent correct scores per sentential approximation and sentence length (○ - three words; □ - five words).

Figure 4B. Mean percent correct scores per sentential approximation and interstimulus interval (○ - normal interval; △ - 200 msec; □ - 400 msec).

stimuli were essentially equal and approached 100 percent accuracy.

Order of sentential approximation also interacted with interstimulus interval (Figure 4B). Again, recall accuracy scores can be seen to increase as the sentential approximations approach full grammaticality. As well, at the lower orders of approximation (first and second order), the interstimulus interval had a greater effect on recall scores than at the normal sentence condition. With the normal sentence stimuli, variations in recall due to changes in interstimulus interval were negligible.

Effect of Interstimulus Interval

The main effect of interstimulus interval is shown in Figure 2. The graph shows that as the silent interstimulus interval (ISI) increased from a normal ISI (determined to be the shortest ISI--approximately 100 msec in length) to 200 msec and 400 msec, scores in recall accuracy decreased.

The length of the interstimulus interval interacted with sentence length to produce an effect on recall accuracy (Figure 5A). Recall accuracy decreased as the interstimulus interval increased for both three-word and five-word stimuli. However, this effect was greater for the five-word stimuli than for the three-word stimuli.

Figure 5B shows the interaction of interstimulus interval and sentential approximation. For first and second order sentential approximations, as the interstimulus interval increased, the main effect of decreased recall

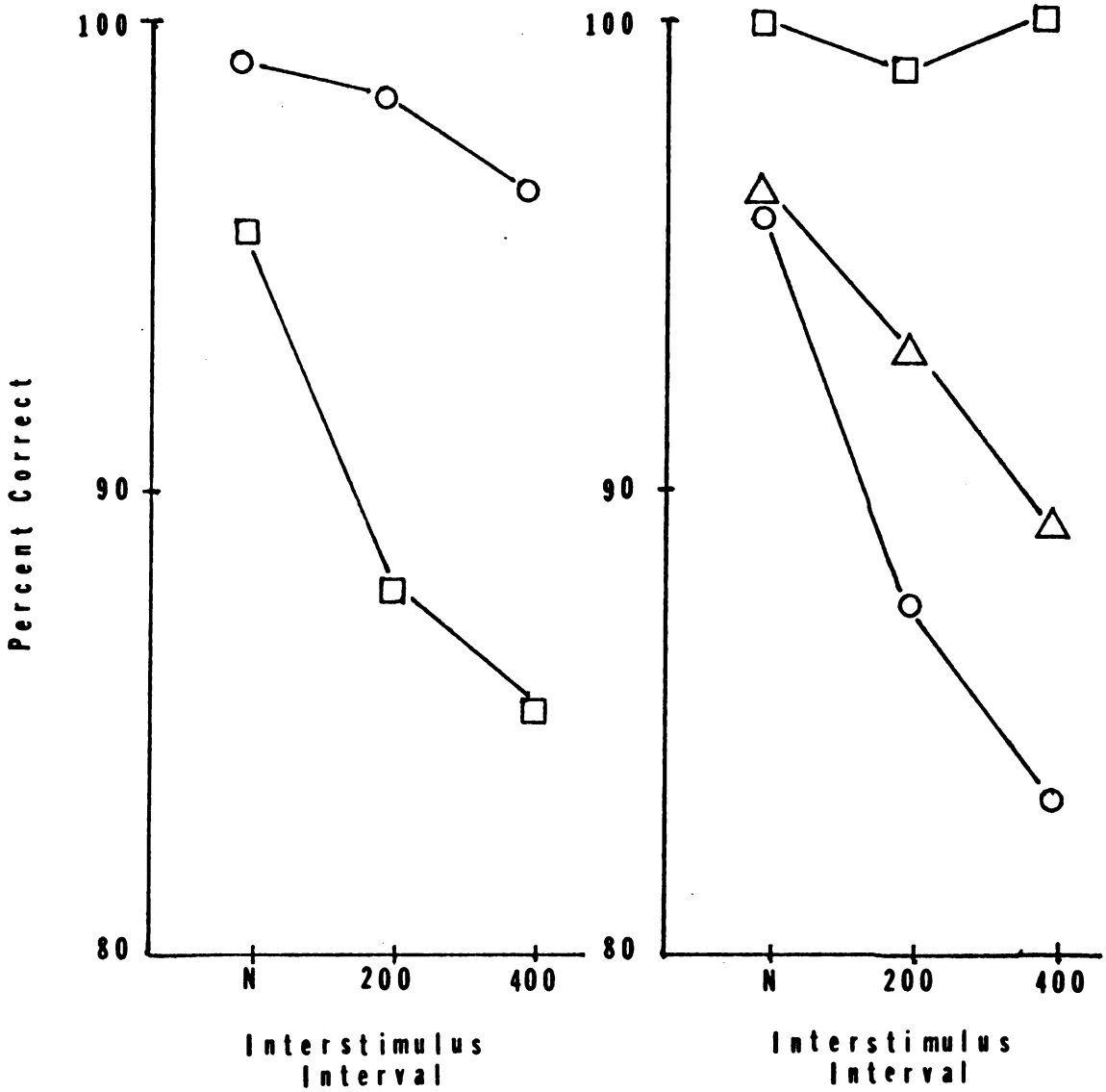

Figure 5A

Figure 5B

Figure 5A. Mean percent correct scores per interstimulus interval and sentence length (O - three words; □ - five words).

Figure 5B. Mean percent correct scores per interstimulus interval and sentential approximation (O - first order; △ - second order; □ - normal sentence).

accuracy scores was observed. However, for the normal sentence condition, the length of the interstimulus interval appeared to have a negligible effect.

A three-way interaction is illustrated in Figure 6. This graph shows the interaction of sentence length, sentential approximation, and interstimulus interval. Both decreased sentential approximation and increased interstimulus interval had a slight effect on the three-word stimuli, resulting in decreased recall accuracy; however, this effect was more easily seen for five-word stimuli. The normal sentences were not affected greatly by sentence length or interstimulus interval. Recall for all normal sentences was near 100 percent. It can be seen from Figure 6 that recall accuracy decreased as sentence length increased, as order of sentential approximation decreased, and as interstimulus interval size increased.

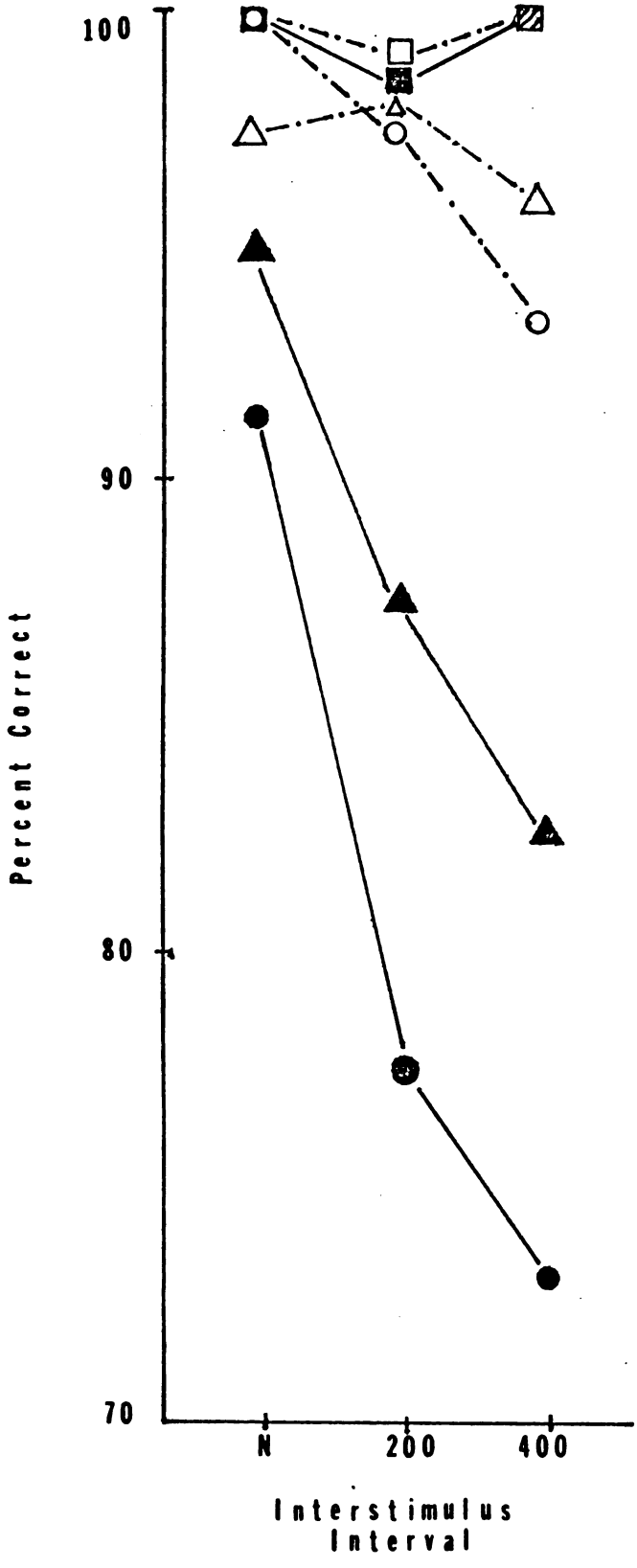

Figure 6. Mean percent correct scores per interstimulus interval, sentence length (open symbols - three words; filled symbols - five words), and sentential approximation (circles - first order; triangle - second order; square - normal sentence).

CHAPTER IV

DISCUSSION

The results of this study indicated that recall accuracy in auditory perceptually handicapped children is affected by the conditions of sentence length, order of sentential approximation, and length of silent interstimulus interval independently. These three conditions also interacted at various levels. In certain instances specific variables took precedence over others in affecting the recall accuracy. These findings, along with the results of previous investigations, support implications which may be important in both discussing the theoretical aspects of auditory processing and language aquisition in children and in diagnosing auditory perceptual impairments.

Comparison of Trends to Previous Investigations

In reviewing the main effects of the three experimental conditions in this study, the results support the findings of previous investigators.

As sentence length increased, recall accuracy decreased. Previous studies on sentence length and short-term memory have all shown this effect (Giattino, 1973; Pantalos, Schuckers, and Hipskind, 1972; Schuckers, Shriner, and Daniloff, 1973; Smith and Beasley, 1973). As the number of

items in a string approaches and exceeds the limits of short-term memory, the subject is not able to process all the items correctly, and consequently makes more errors in recall. Miller (1956) found this number of items to be seven, plus or minus two. From the results of this and other studies, it appears that, for children, three items is well within the limits of short-term memory, while five items approaches and, in some cases, exceeds short-term memory limits.

Results of the present study were consistent with those of earlier studies in showing that increased sentential approximation resulted in increased recall accuracy (Beasley and Shriner, 1972; Carrow and Mauldin, 1973; Speaks and Jerger, 1965; Tejirian, 1968). As the sentential approximations increased from first order to second order to full grammaticality, the syntactic and semantic constraints on the stimuli increased, thereby abetting perceptual processing by multiple-cueing and extrinsic redundancy (Harris, 1960). These effects aided in increasing the amount of information per chunk (Miller, 1956), resulting in more complete auditory processing and increased recall accuracy.

The trend for recall accuracy to decrease with increasing interstimulus interval size supports other studies utilizing sentential stimuli with children (Beasley and Flaherty-Rintelmann, 1976). While other investigators found that increased interstimulus interval size resulted in increased recall for digits (Aaronson et al., 1971; Miscik et al.,

1972) , Beasley and Shriner (1973) discussed results which indicated that when linguistic stimuli were used, the rate of speech was more important than the length of the interstimulus interval itself for auditory processing.

Comparison of Interactions to Previous Investigations

While Beasley and Flaherty-Rintelmann (1976) obtained normative data using the same stimuli as used in the present study, a direct comparison cannot be made due to differences in the experimental procedures. In that study, children were tested in the field; but in the present investigation, children were tested in a sound-treated testing suite. However, for both normal second- and fourth-grade children and for auditory perceptually handicapped children (as defined by reading impairment), similar trends can be seen for all experimental conditions. In both investigations, recall accuracy decreased as sentence length increased, as order of sentential approximation decreased, and as interstimulus interval increased. Consequently, similar interactions of experimental conditions can be seen in both investigations. Three-word stimuli were very nearly 100 percent correctly recalled in both instances. The five-word stimuli were found to be more sensitive than the three-word stimuli to the short-term memory limits of both normal and auditory perceptually handicapped children. Normal sentences were recalled with greater accuracy than first order approximations (which were found to be least correctly recalled) and second-order approximations, and were less

affected by temporal alterations than either order of sentential approximation.

Freeman and Beasley (1976) employed reading impaired subjects, sentential stimuli, and experimental procedures similar to those used in the present investigation. Results of these two studies compared favorably. Both investigations were concerned with auditory processing via temporal alteration of the speech signal in reading impaired children. Freeman and Beasley time-compressed the stimuli; whereas, in the present investigation, the interstimulus interval was altered without varying word duration. The condition of 0% time-compression in the Freeman and Beasley study was comparible to the normal interstimulus interval condition used in the present study. Table 1 shows a breakdown of scores for normal readers and reading impaired children in the Freeman and Beasley study, as well as the scores of the subjects in this study. The significant main effects of sentence length and order of sentential approximation can be seen. The table also shows that as syntactic and semantic constraints were reduced on the stimuli (i.e., as sentential order decreased from normal sentences to first order approximations), the normal reading children were not affected greatly, while the reading impaired children in both investigations showed a decline in recall accuracy. Also, the normal readers in the Freeman and Beasley study were not as greatly affected by temporal alteration (time-compression) of the stimuli as the reading impaired subjects.

Table 1. Mean percent correct scores of normal reading (NR-BAF) and reading impaired children (RI-BAF) in the Freeman and Beasley (1976) study and of subjects in this study (RI-GAO) for the main effects of sentence length (three-word (3) and five-word (5)) and sentential approximation (first order (1), second order (2), and normal sentences (N)).

Subjects	Sentence Length		Sentential Approximation		
	3	5	1	2	N
NR-BAF	97.8	95.5	91.5	99.5	100.0
RI-BAF	97.3	89.5	87.3	94.0	99.0
Total- BAF	97.6	92.5	89.2	96.8	99.5
RI-GAO	97.8	89.5	88.8	92.8	99.6

Further, time-compression did not greatly affect the recall scores for either normal readers of reading impaired children when the sentential stimuli were normal sentences.

Based on the Freeman and Beasley data that the normal reading children did not make as many errors as the reading impaired children on temporally altered sentential stimuli, it can be speculated that, using similar stimuli and experimental design as was used in this study, children without auditory perceptual impairments (or normal reading children) would show greater recall accuracy scores than children with auditory perceptual (or reading) problems (i.e., the children who served as subjects in this study). However, due to differences in the experimental procedures between the

present study and that of Beasley and Flaherty-Rintelmann (1976), the above statement can only be hypothesized.

Type of Errors

An error analysis performed on the data showed that 32 percent of the errors in recall were errors in intelligibility, while 36 percent were memory errors (ommissions), and 32 percent of the errors were order errors. This breakdown of error types was due primarily to the five-word sequences. For three-word sequences the errors were 93 percent intelligibility errors and only 7 percent memory errors. Errors made on the five-word sentences were 26 percent intelligibility, 39 percent memory, and 35 percent order errors. These trends compare favorably with the Freeman and Beasley data, which found 45 percent intelligibility errors and 40 percent memory errors in the reading impaired population, while the normal readers showed 75 percent intelligibility errors and only 10 percent memory errors. For first and second order sentential approximations and for all interstimulus interval sizes, the distribution of error types was equal over the three catagories; that is approximately 1/3 of the errors were intelligibility, approximately 1/3 were memory (ommission),and the final 1/3 were order errors. For normal sentences, there were 50 percent intelligibility and 50 percent order errors. This finding tends to suggest that the children used the syntactic and semantic cues to effectively chunk information (Miller, 1956),

thereby avoiding omitting words. The order errors in the normal sentence condition tended to consist of changing a sentence to a question or vice versa. (I.e., you do like the snow was repeated as do you like the snow.)

Theoretical Implications

In three investigations using sentential stimuli with normal and reading impaired (or auditory perceptually handicapped) children (Beasley and Flaherty-Rintelmann, 1976; Freeman and Beasley, 1976; and the present investigation), similar trends have been found. It appears that as the sentential stimuli approach full grammaticality (i.e., normal sentences), temporal alterations of the signal did not affect auditory perception to a great extent. In this study, normal sentences were recalled with near 100 percent accuracy regardless of sentence length or interstimulus interval. Freeman and Beasley found that normal sentences were correctly recalled by both normal reading and reading impaired children in both the 0% and the 60% time-compression conditions. These findings suggest that once the stimuli has reached sophisticated levels of syntactic and semantic constraints, temporal alterations has little effect on recall accuracy. This may indicate that highly constrained stimuli are analyzed at a very high level of auditory processing, and that temporal alteration affects only stimuli processed in the lower, more peripheral, neural centers.

Another interesting trend of this investigation can be seen in Figure 6. Normal sentences were recalled with 100

percent accuracy in the normal interstimulus interval (ISI) condition and in the 400 msec ISI condition. However, a slight drop in recall accuracy can be seen in the 200 msec ISI condition for both three-word and five-word sentences. Beasley and Beasley (1973) hypothesized that a 200 msec interphonemic interval might be a pivot point for auditory processing. The trend in the present study, along with the findings of Beasley and Beasley, suggest that children may not be able to effectively chunk information in the 200 msec ISI condition. At the normal ISI condition, children may be processing the whole sentence as one unit. At the 400 msec ISI condition they may be processing five separate words. However, the 200 msec condition may be too slow for the children to process the sentence as a whole and too rapid for the words to be processed individually, thus resulting in a slight reduction in recall accuracy scores.

Implications for Audiology

It appears that conventional auditory tests are not sensitive enough to evaluate auditory functioning in auditory perceptually handicapped children. These tests evaluate the status of the peripheral mechanism (outer and middle ear, chochlea, and the VIIIth cranial nerve), but lack the complexity necessary to tax the central auditory system. Since this system is responsible, hypothetically, for temporal integration at the lower neurological levels and structural organization at the higher, more cortical, levels, it would seem reasonable to assume that temporally altered

speech, if not highly syntactically and semantically organized, will aid in diagnosing the presence or absence of a lesion in the lower central auditory nervous system. In order to adequately assess this area of the auditory system, the stimuli must be of sufficient length to permit temporal alteration; however, the stimuli must simultaneously be controlled for structural organization. Sentential approximations have been found to effectively reduce the syntactic and semantic constraints of speech (structural organization) and yet maintain the temporality needed to assess central auditory system functioning.

Implications for Language Development

Normal language acquision and development has been hypothesized to depend upon the auditory processing of speech, and such processing, in turn, is dependent, at least partially, upon the temporal patterns and the organization of the speech signal. As the speech stimuli become more complex, auditory perception becomes more difficult. Children exhibiting specific learning disabilities, or auditory perceptual impairments, are unable to temporally integrate and organize stimuli in such a manner as to adequately process the stimuli. Therefore, auditory perceptually impaired children are unable to internalize the temporal and organizational characteristics of speech. Consequently, if the child does not possess these characteristics, he will be unable to effectively use them in his expressive speech. The result of this inability to internalize the temporal

and organizational characteristics of speech is delayed language development, since language acquisition and development is indeed dependent upon these characteristics. In auditory perceptually handicapped children, the central auditory pathways do not exhibit enough intrinsic redundancy to overcome the reduced extrinsic redundancy and multiple-cueing effects of time-altered and unorganized speech. In order for this child to properly perceive speech, the signal must be highly organized and/or of short enough duration that the child will process the entire message.

Implications for Future Research

While findings indicate, at least tentatively, that temporally altered sentential stimuli may be of significance in diagnosing auditory-based perceptual handicaps, more information should be obtained. Specifically, a normative population should be evaluated in a clinical setting for direct comparison to these results. Also, more information may be obtained by varying and increasing the number of experimental conditions (sentence length, sentential approximation, and interstimulus interval size). Information as to what takes place during auditory misperception might be hypothesized from more complete item, error, and subject analyses than was possible in the present study.

CHAPTER V

SUMMARY AND CONCLUSIONS

Temporal characteristics of the speech signal have been found to play an important role in auditory processing. In the past, investigators used digits and word lists to study short-term memory and auditory processing. Only very recently have linguistic stimuli been used to assess central auditory system functioning. These stimuli, however, are not subtle enough to be useful unless extrinsic redundancy and the effects of multiple-cueing are reduced. First and second order sentential approximations have been found to accomplish this task. Temporal alteration of these approximations would then be subtle enough for central auditory testing.

It has been hypothesized that children with auditory perceptual disorders manifest problems of reduced intrinsic redundancy (i.e., an inability to integrate distorted stimuli). Therefore, these children would not be able to adequately process speech stimuli from which extrinsic redundancy has been reduced and temporality has been altered.

The purpose of this study was to examine auditory perceptual processing in children with specific learning disabilities (auditory perceptual impairment) by controlling

for sentence length, order of sentential approximation, and interstimulus interval size.

Specifically, the following questions were investigated:

(1) what would be the recall accuracy of auditory perceptually impaired children on sentential stimuli of various sentence lengths?

(2) what would be the recall accuracy of these children on variations in order of sentential approximation?

(3) what would be the recall accuracy of these children on interstimulus interval sizes of normal duration, 200 msec, and 400 msec?

(4) what would be the effects of interactions of these above factors on recall accuracy of auditory perceptually impaired children?

(5) what would be the recall accuracy of auditory perceptually impaired children compared to normal children?

Overall results indicated that the main conditions of sentence length, order of sentential approximation, and length of silent interstimulus interval all affected recall accuracy. Recall accuracy was near 100 percent for the three-word stimuli, but as sentence length increased to five words, recall accuracy decreased. As order of sentential approximation rose from first order to second order to full grammaticality (normal sentences), recall accuracy increased. Recall for normal sentences was very nearly 100 percent

correct over all other conditions. Increased interstimulus interval (ISI) produced decreased recall accuracy; that is, the normal ISI condition (considered to be the shortest ISI--about 100 msec) produced the greatest recall accuracy, while the longest ISI condition, 400 msec, produced the most number of recall errors. The intermediate ISI condition of 200 msec produced recall accuracy scores somewhere between those scores associated with the normal condition and the 400 msec condition.

These results provided information that may be important in discussing theories of speech and language perception in normal and pathologic (auditory perceptually impaired) children. Implications for audiology and the diagnosis of these impairments through central auditory system testing were discussed. As well, theories as to how faulty auditory perception can affect language development and implications for language therapy were presented. However, more information is needed, especially in terms of more controlled normative data, more and varied pathologic populations, expanded experimental conditions, and various types of analyses, before solid conclusions can be made.

APPENDICES

APPENDIX A

APPENDIX A

CRITERIA FOR NORMAL HEARING

1. Pure-tone air-conduction thresholds at 15 dB HL (re: ANSI, 1969) or better for octave frequencies 250 Hz - 4000 Hz.
2. Pure-tone bone-conduction thresholds within ±5 dB of air-conduction thresholds.*
3. Speech reception threshold (SRT) of 15 dB HL (re: ANSI, 1969) or better.
4. Speech discrimination scores of 94% or better at 40 dB SL or 50 dB HL, whichever intensity was lower.

*If air-conduction and bone-conduction thresholds varied by more than ±5 dB at two frequencies, impedance audiometry was done to determine middle ear functioning. Normal middle ear functioning was defined as:

1. Middle ear pressure within ±50 mm air pressure.
2. Static compliance within .27-1.5 cc equivalent volume.

APPENDIX B

APPENDIX B

REVISED WORD LIST

BASAL VOCABULARY ON WE GO

HOUGHTON MIFFLIN (1966)

a	box	eat	toy	come
girl	big	do	wish	six
cry	car	call	sat	ten
all	five	cat	good	ring
boy	day	him	it	said
but	red	up	ride	they
had	zoo	us	play	lock
her	with	you	wood	see
I	ten	next	yes	snow
dot	set	store	no	food
man	is	pan	name	dish
out	in	high	end	go
on	to	eye	door	egg
put	we	dog	run	know
tell	pop	feet	one	work
see	take	like	sand	word
sun	will	my	stop	tree
two	me	not	was	this
of	hot	milk	late	time
here	the	that	jar	would

APPENDIX C

APPENDIX C

STANDARIZED VERBAL INSTRUCTIONS

You are going to hear a man say some sentences. Some of the sentences will make sense (they will be real sentences), some of them will not. I want you to listen to what the man says and say it back to me. Do you have any questions? (Answer questions.) Okay, let's begin.

APPENDIX D

APPENDIX D

RESPONSE FORM

Subject _____

Condition _____

First Order

Three Word

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 jar will

Comments

APPENDIX D

RESPONSE FORM

Subject _____

Condition _____

First Order

Five Word

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

Comments

APPENDIX D

RESPONSE FORM

Subject _____

Condition _____

Second Order

Three Word

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 food one
8. up end to
9. man zoo food
10. do hot wish

Comments

APPENDIX D

RESPONSE FORM

Subject _____

Condition _____

Second Order

Five Word

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 sat 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

Comments

APPENDIX D

RESPONSE FORM

Subject _____

Condition _____

Normal Sentences

Three Word

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

Comments

APPENDIX D

RESPONSE FORM

Subject _____

Condition _____

Normal Sentences

Five Word

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

Comments

APPENDIX E

APPENDIX E

MEAN PERCENT CORRECT SCORES

Table 2. Mean percent correct scores for interstimulus interval by order of sentential approximation and sentence length.

Sentential Approximation	Sentence Length	Interstimulus Interval normal	200	400	Total
First order	Three-word	100.0	97.5	93.4	97
	Five-word	91.5	77.5	73.0	80.7
	Total	95.8	87.5	83.2	88.8
Second order	Three-word	97.5	98.4	95.9	97.3
	Five-word	95.0	87.5	82.5	88.3
	Total	96.3	93.0	89.2	92.8
Normal sentence	Three-word	100.0	99.2	100.0	99.7
	Five-word	100.0	98.5	100.0	99.5
	Total	100.0	98.9	100.0	99.6
Grand total		97.3	93.1	90.8	93.7

Table 3. Mean percent correct scores for order of sentential approximation by interstimulus interval and sentence length.

Interstimulus Interval	Sentence Length	Sentential Approximation 1st	2nd	normal	Total
Normal interval	Three-word	100.0	97.5	100.0	99.8
	Five-word	91.5	95.0	100.0	95.5
	Total	95.8	96.3	100.0	97.4
200 msec	Three-word	97.5	98.4	99.2	98.4
	Five-word	77.5	87.5	98.5	87.8
	Total	87.5	93.5	98.9	93.3
400 msec	Three-word	93.4	95.9	100.0	96.4
	Five-word	73.0	82.5	100.0	85.2
	Total	83.2	89.2	100.0	90.8
Grand total		88.8	93.0	99.6	93.7

APPENDIX F

APPENDIX F

RANGES OF SUBJECTS' PERCENT CORRECT SCORES

Table 4. Ranges of subjects' correct scores for sentential approximation by interstimulus interval and sentence length.

Interstimulus Interval	Sentence Length	Sentential Approximation 1st	2nd	Normal
Normal	Three-word	100	100-90	100
	Five-word	98-82	100-82	100
200	Three-word	100-93.3	100-96.7	100-96.7
	Five-word	92-68	92-78	100-96
400	Three-word	96.7-86.7	100-90	100
	Five-word	88-64	98-68	100

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