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ABSTRACT

Reported were over 20 related studies that were intended as attempts to discover the psychological implications of deafness, with an emphasis on the perceptual-cognitive manifestations. The report was divided into three sections: the first reported the results of many studies investigating mainly the relationship between language and perception and language and cognition and which use memory as the vehicle of experimentation. The second chapter focused on results of psycholinguistic studies. The third section reported a series of interrelated studies investigating the causes behind the emotional or affective immaturity found to be frequently displayed by a large number of deal persons. Selected general findings were that the deaf may have problems with sequencing information where nonverbal forms are involved, that auditory input is not necessary for the learning of perception of rhythms, that the deal show superior performance for signable words but do not differ from the hearing on words that do not have sign equivalents, and that the deaf show better reading performance level when written materials are presented in sign order rather than in English order. (CB)

Final Report

SYMBOLIC AND LINGUISTIC PROCESSES IN THE DEAF

by

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Rehabilitation Implications

The studies reported in this volume and conclusions from previously reported studies demonstrated rather unanimously that there is little, if any, qualitative difference between deaf and hearing subjects in the processing of visual input, verbal or non-verbal. The differences we found were primarily in the ability to read, understand, remember, and output complex English sentences. Hence, the deficiencies in language performance skills, such as reading, writing, etc., found in the deaf may be attributed, in part, to their lack of a language system like that of the hearing. Whether this system is dependent on the auditory modality is not known. However, the deaf lack the constraints provided by such a system which results in the anomalous sentences they may produce and the seeming lack of understanding. Reasons for this type of deficiency may be sought in one or both of the following:

a. Inadequate training materials, e.g. materials based on written, formal English rather than spoken English; materials based on inadequately documented or inappropriate sentence-frame grammars.

b. Absence of an existing symbolic framework onto which English language skills may be based. There should be (1) a language-communication system first, followed by (2) written language which begins (in training) by corresponding in grammar and other structural features to the existing communication system.

The second most important rehabilitation implication suggested by the reported research is concerned with affect or emotional development. Apparently, parents and the community-at-large play a significant role in the development of some aspects of normal affect. We found that deaf children can recognize emotional expressions on other faces as well as their hearing counterparts. Their difficulty, however, lies in being able to interpret emotion-arousing situations and, therefore, reacting inappropriately. We felt this was due to the deficit incurred by receiving fewer communications from parents or teachers about the salient aspects of the situation. Workers and counselors with the deaf should make a concentrated effort to point out aspects of situations which are emotion-arousing to people. For example, children with normal hearing hear phrases like "I get so mad at you when you don't mind me," or "Spilled garbage is awful to clean up," etc. Notice that the speaker explicitly states what it is about the whole scene that is causing him emotion. It appears that such training might help alleviate some of the emotional flatness often attributed to the deaf.

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PREFACE

This report marks the end on nine years of research in the general area of language and cognitive processes in the deaf. During this period we have witnessed in ourselves a change in viewpoint as to the important consequences of a pre-lingual hearing loss. Part of the change can be traced to the recent emergence of the area of psycholinguistics and information processing. The rest can be attributed to knowledge gained as a result of the experiments and studies carried out under the auspices of the grants.

We have been extremely fortunate to have the continued interest, cooperation, and support of Lloyd Graunke, Warren Flower, and Delmas Young of the Tennessee School for the Deaf. The research would have been almost impossible without them. In addition, the superintendent, Lloyd Funchess and the principal, Jerome Freeman of the Louisiana School for the Deaf have been most hospitable to our visits and the Pennsylvania School for the Deaf has also been quite helpful and cooperative. It's not always easy to accommodate a research team in the well-planned, tightly-packed schedule of a residential school. These administrators and teachers are to be commended for recognizing the importance of basic research and allowing us access to their students. I would also like to mention in passing that we were extremely impressed with the level of understanding and concern these men showed with respect to the problems and needs of the deaf on one hand and the issues involved in research with the deaf on the other. For control subjects, we always sought the aid of nearby Williamson County Schools. Here, Superintendent Milton Lillard, Pearl English, and the principals of the schools were always kind enough to accommodate us.

Part of the success of the project can be attributed to two faithful, indispensable, intelligent assistants, Cynthia McIntyre and Linda Maggart, who have been with the project since 1966 and 1965 respectively. They have been primarily responsible for preparation of materials, administration of experiments, data tabulation, and typing in addition to the hundreds of errands, phone calls, etc. that go along with the activities of a vigorous research program. Mrs. McIntyre's contribution was so extensive that she earned co-authorship on two articles. Mrs. Jan Robinson joined our staff recently and has been quite helpful in the final activities of the granting period.

Curtis McIntyre joined the project as research associate in September of its last year. At least half the studies performed since then have been contributed by him. His approach and views have been quite stimulating and have in part, determined the direction of the research this last year.

The project has fostered several graduate students whose future work will be directly related to the deaf:

Dr. Kathryn Rileigh whose dissertation on rhythm perception in the deaf is discussed on page 22 has contributed many valuable ideas and techniques. A study on the effect on learning of the abstractness of a word (page 21) was also her contribution.

Dr. Judith Burroughs, now of Callier Speech and Hearing Center in Dallas, was responsible for the project discussed on pages 89-101 (it was also her dissertation).

Two honors students have been intimately involved in research:

Miss Claire Laukhuf and Mrs. Suellyn Boyd have done their honors theses on various aspects of some of the problem areas discussed in the text.

A large number of undergraduates have helped: Lucy Long, Betty Hagen, Larry Sims, Sandy Bailey, Mary Byassee, Paul Hagen, Sally Webber, and Pat Peterman.

Graduate students who have become involved in one or more of the studies include: Macalyne Freeman, Dick Guzman, Ray Wintker and Ken Disch.

Special thanks are due our expert and willing interpreter, Pepper Moore.

The experiments reported have resulted in the publication of four articles, with twelve more in various stages of preparation. A number of convention papers and informal talks have also been a direct result of the research presented here--the informal talks are unlisted but the convention papers are listed in the bibliography. Many of the studies indicated that the deaf were very similar to the hearing on the independent variable being investigated. This has several consequences: (a) it frequently makes the study unpublishable, (b) it gives us a lot of information about the deaf, especially when previous investigation of the same problem has detected differences. Furth has said, "If an organism without a certain factor fails on a given task, one cannot conclude that the factor is directly related to the task since other uncontrolled influences may be at work. But if he succeeds on a given task, one can infer conclusively that the missing factor is not a prerequisite for the task. As a consequence, where deaf subjects are somewhat retarded produces a far less conclusive interpretation than where they are equivalent [sic]" (1971), (c) it speaks well for the techniques and methodology in that one is fairly confident the deaf understood the instructions as well as the hearing, (d) it usually has implications for the concepts used in generating the research, as in the case of acoustical confusion data (page 36).

The investigators consider the project successful, in part, because we've learned a great deal, and, in part, because we've had many opportunities to talk to other people about our ideas and research. Generally, we've found all audiences to be attentive and interested, indeed, fascinated as they come in contact for the first time with the problems of deafness. An additional reward has been the intellectual stimulation resulting from thinking through the area of psycholinguistics, and ways in which it can be applied to auditory-vocal deficit, and speculating on the cognitive and personality effects of deafness.

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Summary of Findings

Chapter I. Memory

1. There is some evidence from our data that the deaf have problems with sequencing information where nonverbal forms are involved, but there are apparently differences within the deaf population by educational program and by age level with regard to sequencing ability. The possible relevance of this for the difficulty of the deaf in learning to read needs further study.

2. The deaf do not appear to be qualitatively different or quantitatively deficient with regard to codability of perceptual information.

3. The rhythm experiment shows that auditory input is not necessary for the development of perception of rhythms; however, different aspects of rhythm are more salient at different times in development, e.g. number of beats, duration, and pattern of beats are perceived at different points in development. The deaf appear to be somewhat delayed in rhythm perception but go through all the stages at a level comparable to hearing controls.

4. The deaf and hearing both depend on visual aspects in verbal span of apprehension tasks to the same degree. Auditory and manual-motor interference factors do not differentially effect span of apprehension in either group. The hearing are effected by articulatory interference but not acoustic; the deaf are not confused by either factor.

5. There is good evidence for distinctive feature learning in deaf children. For visual distinctive features the deaf actually perform at a level superior to that of hearing controls.

6. It was found that where visual distinctiveness of the form is low, the deaf are able to recall low distinctiveness forms with high pronunciability better than matched hearing subjects, probably due to their superior utilization of spelling rules.

7. In a study of the effect of signability on learning and retention of word lists, it was shown that the deaf show superior performance for signable words but do not differ from the hearing on words that do not have Sign equivalents. This suggests that the use of Sign vocabulary is probably helpful to the deaf subjects who Sign in learning and retaining verbal materials. An expanded vocabulary of signs would be useful to the deaf because more words would be available with response codes.

8. Factors affecting secondary organization of verbal materials, such as homonymic relationships, semantic factors, visual form factors, and phonetic factors, tend to facilitate recall performance after learning in hearing subjects to a greater extent than in deaf subjects, suggesting that secondary organization variables are less available to the deaf and for this reason they may do less well in free recall tasks where secondary organization factors are involved.

9. The study of modality effects was done using hearing subjects to determine whether modality effects found by other investigators may be due to meaningfulness factors rather than differences in the storage systems related to each modality. It was found that meaningfulness does not account for reported differences but that different short-term memory systems may exist for each modality.

Chapter II. Syntax and Semantics

1. It was discovered that the deaf show a better reading performance level (as measured by retention of materials) when the written materials are presented in Sign order rather than in English order.

2. Deaf and hearing children matched for reading ability can perceive the underlying logical relationships in declarative and passive sentences to the same degree. We conclude that the deaf can learn to comprehend the base structure of simple English without difficulty and that it is the subtle grammatical relationships conveyed in more complex syntactic constructions which account for any comprehension difficulty.

3. In a study of word order recall for scrambled and unscrambled sentences, it was found that the deaf recalled whole sentences better than scrambled ones, as did the hearing, but that the redintegrative effects of English syntactic organization enables the hearing to retrieve phrasal components of the sentence, but do not similarly facilitate the retrieval of phrasal components in the deaf. Syntactic rules governing phrasal components of sentences are not well learned by the deaf although whole sentences are relatively easy for them to retrieve.

4. In a study investigating the recall of verbal segments conforming to the structure of Sign versus verbal segments conforming to the English standard versus scrambled segments, deaf subjects did not show differential performance. A follow-up study using a different presentation modality showed about the same results.

5. Programmed instructional materials were constructed over the last six years in several pilot studies to train deaf children in the meaning of relational terms, e.g. prepositions, conjunctions, etc. Sample data and teachers' questionnaire ratings indicated that the learning task is an important one, but that our methods need considerable expansion and the development of intrinsically motivating materials.

6. In a study investigating comprehension of sentences made systematically anomalous deaf and hearing subjects showed equivalent performance, indicating again the deaf subjects' adequate comprehension of semantic and syntactic relationships in simple sentences.

7. A study of learning and recall of abstract and concrete words was performed to determine whether the presumably greater imagery involved in concrete words would facilitate their recall by the deaf to a greater degree than by the hearing. Results indicated that on the contrary it is abstract words that are more effectively recalled by the deaf, whereas

recall of abstract words seem to be relatively impaired in the hearing. This may be explained by the theory that abstract words share a larger number of learning contexts for the hearing and the larger number of possible associations produces greater interference in recall. For the deaf abstract words may be, in fact, concrete, in the sense that their meanings may be more specifically associated to particular learning contexts or images.

Chapter III. Affective Development

Some important problems in social communication were revealed in studies of judgment of facial expressions and situations leading to the various kinds of emotional arousal. While they can discriminate and classify facial expressions with skill, the deaf are deficient in the ability to identify situations to which the various emotions are appropriate. This suggests that some characteristics of the deaf in interpersonal communication, e.g. la ck of appropriate emotional empathic response, may be due to a lack of training in identification of the conditions which lead to emotional arousal in others. Since this training is informal in the hearing child, it should probably be more extensively studied in both deaf and hearing.

INTRODUCTION

Background Information on the Project and Statement of the Problem

Grant number RD-2552, Symbolic and Linguistic Processes in the Deaf is the third three-year project designed to investigate cognitive, symbolic processes in the deaf. The first project, RD-846p (Language Habits, Cognitive Functions and Self-attitudes in the Deaf) began as an interest in personality characteristics and attitudes in the deaf and proceeded to study language behavior, especially the problem of meaning. The project revealed a number of important practical and theoretical issues in areas of concept formation and meaning, especially in social-emotional areas, and questions regarding training in the generative features of language.

The second project, Psycholinguistic Processes in the Deaf (RD-1479-s), turned, almost entirely, to problems of language learning by the deaf. The research was concerned with three areas: (a) the importance of phonological components in language learning and the extent to which they might be replaced by visual cues, (b) the acquisition of reference and semantic systems, and (c) the use of the syntactic aspects of language by the deaf. With respect to the first two items, the phonological and semantic factors in language, we found that the deaf have little problem in storing and retrieving single words even though they couldn't use the phonological cues. Also they seem to have little trouble learning the appropriate meanings for individual content words, with the possible exception of evaluational or emotional words. On the third topic, the use of syntax, we found that, although on a word-for-word basis, it's difficult to distinguish experimentally deaf and hearing subjects, the deaf seemingly benefit very little from the organizational aspects of English.

These investigations raised a number of questions. Namely:

What is the role of vocal (phonological) factors in acquiring a language? In what ways does sign language resemble an auditory-vocal language? How is it different? Are the differences critical?

Can English be taught to the deaf visually? Can it be taught as a second language? What is there about English that is so difficult for deaf students to learn?

How are cognitive processes affected by not being able to hear? If the deaf are inferior on tests of cognitive abilities, is it due to lack of hearing (as an information source) or lack of an auditory-vocal language? How would the hearing/language deficit work to produce such effects? Would such effects be general or in selective areas of cognitive functioning?

How do the deaf compensate, if they do, for the absence of verbal memory? Is their visual memory capacity enhanced?

The project included in this report does not pretend to answer all the questions listed above, but there were experiments or projects related to each one. The report is divided into three sections: the first relates the results of many studies which are primarily on the relationship between language and perception and language and cognition and which use memory as the vehicle of experimentation. The second chapter is devoted to the results of some psycholinguistic studies. The third section is a report of a series of interrelated studies investigating the causes behind the emotional or affective immaturity purportedly displayed by a significant segment of deaf persons.

In almost all cases, the studies are experimental in nature. They were intended as attempts to discover the psychological implications of deafness--with an emphasis on the perceptual-cognitive manifestations.

The majority stem from theoretical orientations which, when considered in terms of a handicap like deafness, characterize and probe into the problem in unique and productive ways. The theories underlying each set of investigations will be discussed at the beginning of the chapters.

The tone and approach inherent in the research reported here represent an attitude on the part of the investigators that a great deal of basic research is essential and prior to concentrated attempts to alleviate the undesirable intellectual and social consequences of being deaf. Much of the research, then, asks the general question "What's it like to be deaf?"

CHAPTER I

MEMORY AND COGNITIVE PROCESSES

A. Visual Memory

Our studies of verbal memory in the deaf suggested that they possess very good storage and retention ability for visual forms. At the same time, considerable evidence exists which suggests that deaf persons may have more difficulty with storage of information regarding sequential order. In 1966, we began to do studies of this problem with specially developed equipment. Some of our results with this pilot equipment were reported in the final report on RD-1479-S, Psycholinguistic Processes in the Deaf. New equipment was developed during the first two years of the current project, and a number of investigations have been completed, which had the primary purpose of standardizing method and acquiring normative data on hearing subjects. Since the equipment cannot, in its present form, be transported to the schools for the deaf, we have done one pilot study on deaf children at the university, and report that here along with an extensive parametric investigation which was reported at the 1969 convention of the American Psychological Association. A preliminary form of this equipment was used in a study of deaf adults which was reported in Psycholinguistic Processes in the Deaf. Since instruction and reporting methods were difficult to equate between deaf and hearing, we have developed the new equipment to deal with these problems. Two master's theses and one doctoral dissertation have been undertaken with the new equipment. The previous equipment produced one doctoral dissertation and one master's thesis. The first study reported here is the parametric one which yielded considerable data to support our contention that non-verbal stimuli, occurring in serial order, are stored and retrieved in much the same manner as verbal ones, at least with hearing subjects. Without such information, of course, the serial memory processes in the deaf would be uninterpretable.

1. Serial Recall of Visually Presented Nonverbal Stimuli as a Function of Presentation Method, Set Numerosity, and Sequence Length.*

Research in short term memory (STM) recently has moved toward a more intensive study of the perceptual and cognitive aspects of the stimulus materials employed. The present paper describes an approach to STM research which examines the variance associated with several such factors.

With verbal materials--letters, numbers, syllables, or words--we can study recall, since the subject can retrieve and report the material in storage. With nonverbal materials we are usually limited to studies of recognition, since the subject can report only labels or descriptive statements. The semantic processes are then confounded with the mnemic ones. Much of our knowledge of memory and most of our knowledge of recall is, therefore, knowledge of recall of linguistic materials and symbols. When we began our studies of psycholinguistic processes in the deaf, these questions of relationships between language and memory arose, and we attempted to develop a nonlanguage method for the study of recall.

Equipment designed for this purpose, called the Vanderbilt Iconic Memory Apparatus (VICON), consists of a display panel which presents the subject a diamond-shaped array of 100 1 in. translucent discs which can be illuminated by solid state switching equipment simultaneously or serially at programmable time intervals. The subject perceives a series of simple visual events, the location of an illuminated disc in a matrix of such discs. He can be asked to retrieve either location or both location and serial order, responding by touching the discs with a probe which operates a tape punch and records the location touched. Matrix numerosity can be varied between experiments by masking a portion of the face, thus fixing the set numerosity within which the events may occur.

In a recognition experiment, the subject may be shown a sequence of lights presented serially, and shown a repetition of the same sequence in the same or in different order with one or more locations changed. The task is then to identify either old or new material. In a recall task, the subject may be required to report from memory the locations previously displayed either in the order of their occurrence or in free order.

The study reported here was designed to examine some of the parameters of STM as measured by this method, in order to learn something of its reliability. Of particular interest were three stimulus presentation methods which varied rehearsal opportunities and the type of stimulus attributes employed in the retrieval task. Two sequence lengths and three stimulus-set sizes also were examined.

METHOD

Randomly selected sequences of lights were presented. Each light in a sequence lasted for 3/4 sec.; after a 1/4 sec. interval, the next stimulus appeared. At the end of each sequence the subject, responding with the wand, attempted to recall the lights in the order of their appearance.

The factors examined were Presentation Method (PM)-I, II, and III; Set Numerosity (SN)-25- , 49- , and 100-light matrices; Sequence Length (SL)-7 and 10 lights; Serial Position (SP); and Subjects.

In PM I the stimulus sequences consisted of consecutively presented individual lights; the subject recalled both the location and the order of presentation. PM II was identical to PM I except that all lights that had been used individually in the sequence presentation also appeared simultaneously during the recall period; the subject had to recall only their order of presentation. In PM III a cumulative or "build-up" presentation was used, with each presentation of a new light occurring concurrently with the re-presentation of all previously presented lights in the sequence; the subject had to recall both the position and order of the lights. This PM was designed to facilitate rehearsal of previously presented items during presentation of subsequent items.

Procedure

Subjects were seven adult females. The same materials were used for each subject and presented in the same order. The 7- and then the 10-light sequence lengths were used in the same manner. The same procedure was repeated with the 49- and 100-light sets. One series of 24 sequences was displayed for each of the 18 combinations of variables. Three trial sequences were given to familiarize the subject with the conditions for each change of task.

RESULTS AND DISCUSSION

The major results of the experiment are presented in Figures 1, 2, and 3. Two 3-factor analyses of variance were performed on the total number of correct responses per serial position, one for each of the two sequence lengths. The data for the 10-light sequences yielded insignificant results for SN, PM X SN, SN X SP, and the three-way interaction. For the 7-light sequence length, only SN X SP proved to be insignificant. All other factors and interactions were significant at the .01 level or beyond. Figure 1, 2, and 3 indicate the direction of the significant interactions.

Table 1 shows that for the 7-light sequences, as set numerosity increases, the mean number of correct responses for PM I decreases markedly. Such a decrease indicates that when the retrieval task requires the retention of both serial order and stimulus identity information, retaining the location of an individual light stimulus becomes more difficult. PM II results in an increase in the number of correct responses as set numerosity increases. This seems to indicate that: (a) when retrieval operations do not demand the retention of location information, storage demands can be reduced by retaining only the sequential aspects of the stimuli, and that (b) interitem interference is reduced because as set numerosity increases so does the average distance between locations illuminated, resulting in an increase in their specificity. PM III makes allowance for additional rehearsal by the accumulative manner in which the stimuli build up during sequence presentation. Scoring the response data as ordered and free recall indicates that PM III aids the retrieval of light location but results in considerable loss of order information.

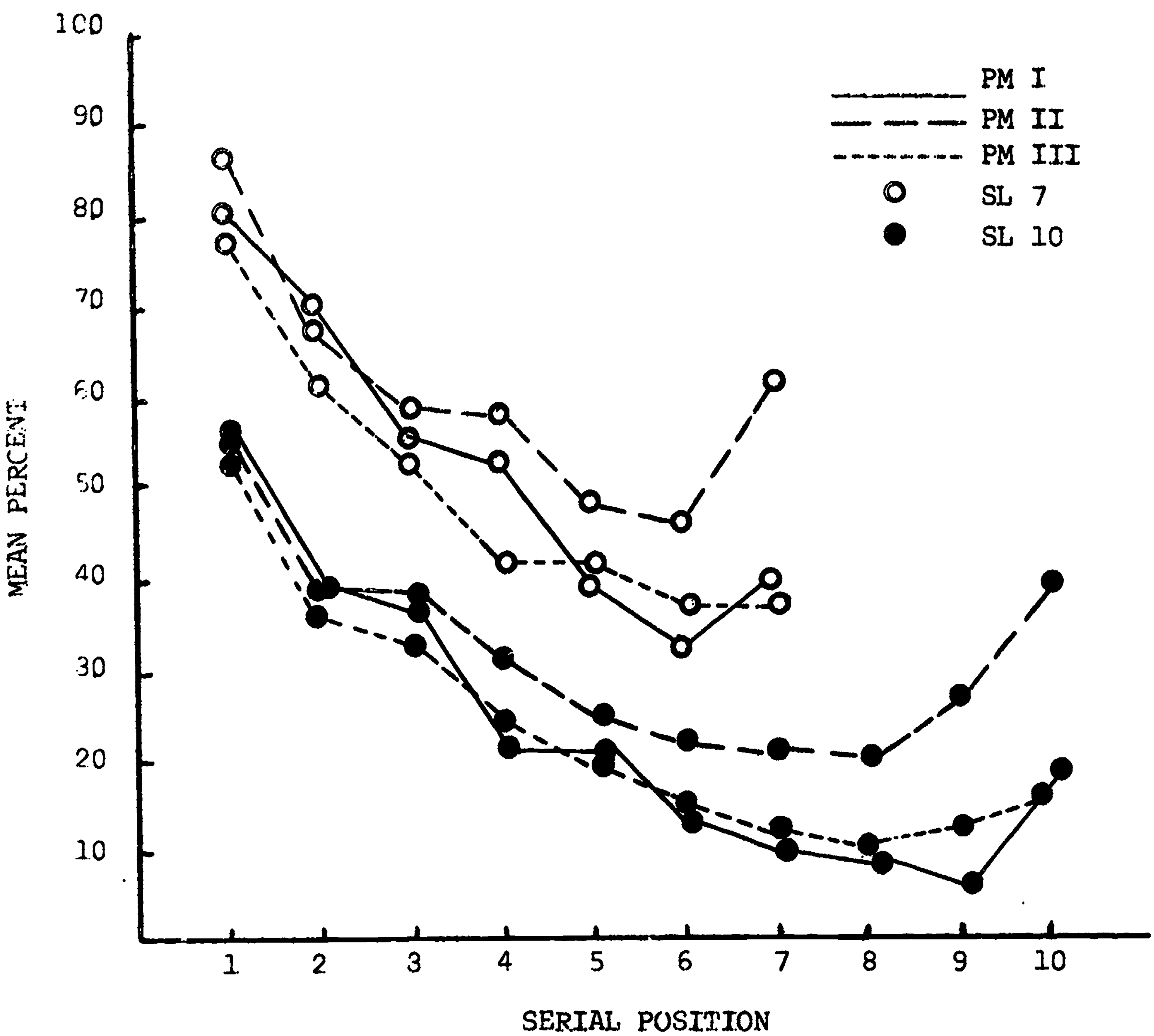


Figure 1. Mean percentage of correct responses as a function of presentation method (PM), and sequence length (SL), for 25 light sets.

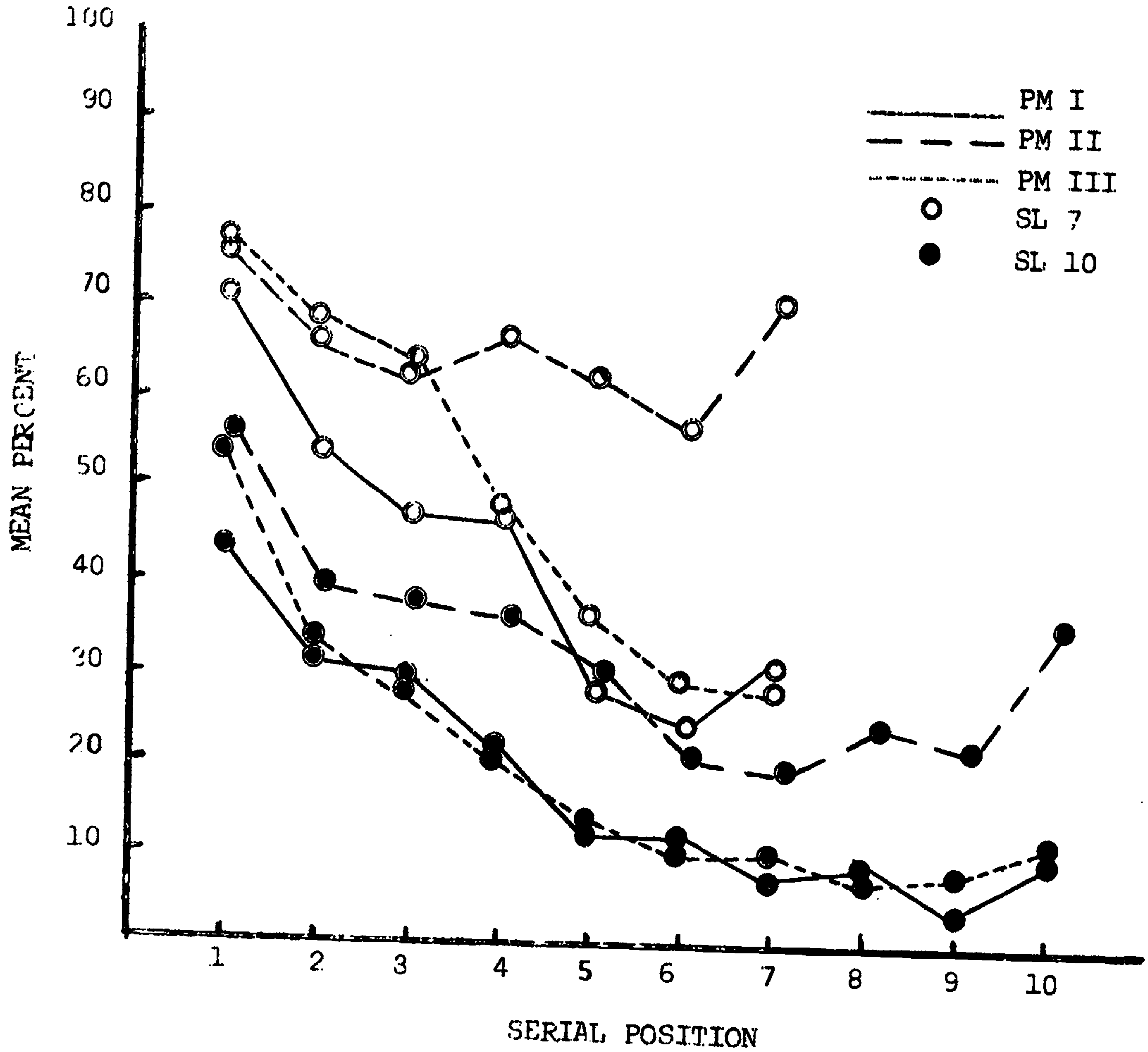


Figure 2. Mean percentage of correct responses as a function of presentation method (PM), and sequence length (SL), for 49 light sets.

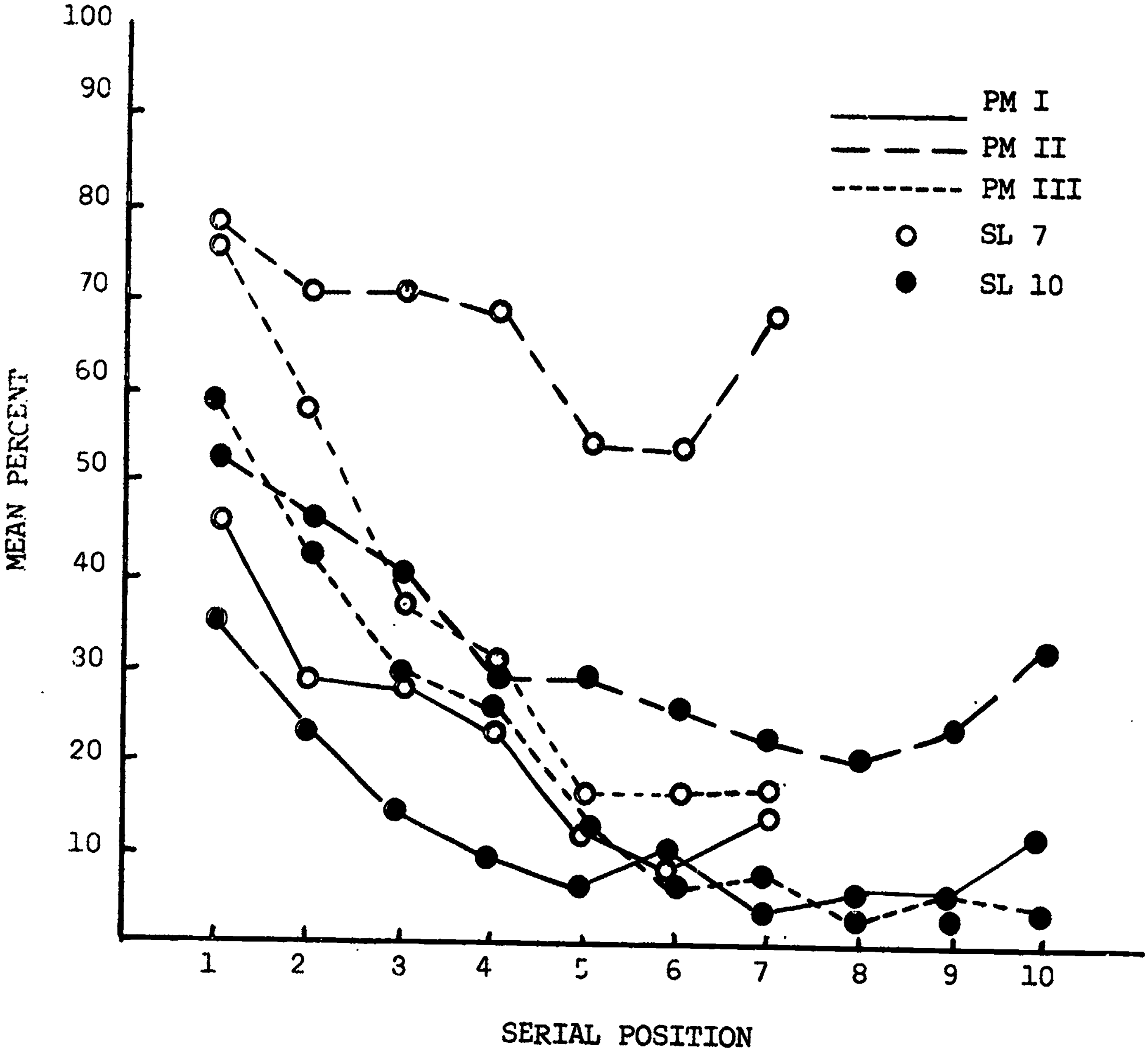


Figure 3. Mean percentage of correct responses as a function of presentation method (PM), and sequence length (SL), for 100 light sets.

TABLE 1

Mean Number of Correct Responses Summed Over Serial Positions for Three Presentation Methods(PM) and Two Sequence Lengths(SL)

SN	SL = 7			SL = 10		
	25	49	100	25	49	100
PM I	13.0	10.0	5.0	5.7	4.5	3.1
PM II	14.8	16.4	16.5	7.7	7.9	8.0
PM III	12.2	12.5	8.8	5.6	4.9	5.0

The generalizations made about PM I and II for the 7-light sequences also hold for the 10-light sequences. The principle difference produced by PM III is that for the 7-light sequences increasing set numerosity produces a greater decline in the mean number of correct responses when compared to the relatively stable performance level for the 10-light sequence data.

2. A Missing Scan Study of Perceptual Memory in Children and Adults.

An experiment was designed to measure immediate visual short-term memory without requiring complete retrieval following a method developed for measuring memory for digits by Buschke (1963). The independent variables involved here are the different conditions within the test, i.e., which light failed to appear in a specific row. The dependent variable was the subject's response as to which light he thought failed to appear.

METHOD

Subjects

A total of twenty subjects were used. The subjects were divided into two main categories. One group ranged from 8 to 13 years of age with an average age of 10 years. All were attending grade school. This group consisted chiefly of children belonging to members of the faculty and staff of the Psychology Department of Vanderbilt University. The other group consisted of both male and female students (average age 20 years) at Vanderbilt who were selected by the experimenters. In both cases, the subjects knew nothing about the nature of the experiment before hand.

Stimuli

The stimuli consisted of lights on the 10 X 10 light matrix display panel. A cardboard covering was positioned in front of the board in order to obtain a pattern of four rows of lights. The four rows consisted of 4, 6, 8, and 10 lights respectively. A buzzer indicated the end of each individual trial. A wand was provided for the subject to indicate his response.

Two different 8-channel control punch tapes were used. The two tapes were identical in length, i.e., 88 trials, including four sample trials but each had different sequences of light stimuli.

Procedure

The subject was positioned in a desk approximately two feet from the light board. He was told that the lights in a particular row would flash on and off alternately until all but one of the lights in the row had flashed. A buzzer would then sound, at which time he was to indicate which light had not flashed by pointing to that light with the wand. The subject was given four practice trials and again asked if he understood the instructions. He was then told to indicate his response for the remaining trials. The particular row (and thus the number of lights) in which the lights happened to appear for each trial was in random order. The experimenter recorded the subject's response for each trial.

RESULTS

Figure 4 shows the results for the two groups of subjects. For 10 year olds, the error rates are a constantly increasing function of sequence length, the curve deviating only slightly from a straight line function. For adults, the curve is positively accelerated, with an inflection point between the six and eight light sequences, which probably reflects the shift in human immediate memory span noted by Miller (1956).

The regularity of our data with young subjects is impressive, and indicates that the method may be very useful with young or nonverbal subjects.

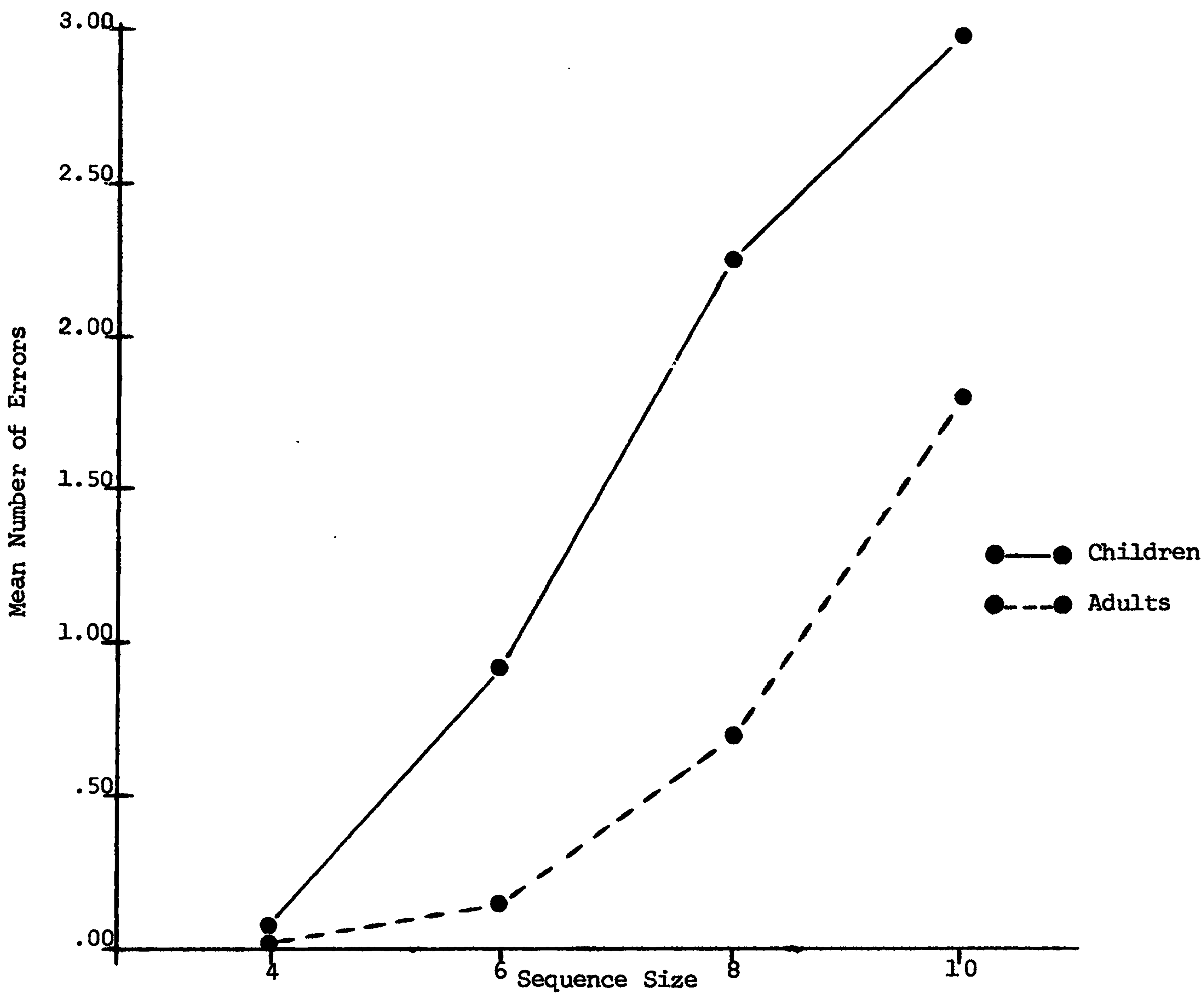


Fig. 4. Mean Number of Errors by Sequence Length for Children and Adults.

3. Performance of a Group of Deaf Children on Sequential Recall

Since our studies had shown a continuous increment of error by sequency length for children at the ten year level, it appeared likely that sequences of five lights on the Vicon would produce substantial error rates in younger children, making the comparison of deaf children between five and ten years of age an appropriate investigation. It was expected that this might give us some indication of any developmental retardation, of the sort commonly found in cognitive tasks with deaf children, and it was assumed that some of the children could be tested prior to their entrance into a residential school.

METHOD

Subjects

Twenty-one deaf children between the ages of five and nine were tested, these being the entire population of such children in Davidson County, with the exception of those with brain damage and/or other perceptual-motor disabilities or mental retardation. There were four 5-year olds, five 6-year olds, five 7-year olds, four 8-year olds, and three 9-year olds. Ten of the children were in the Davidson County Schools, and eight in the Tennessee School for the Deaf.

Procedure

The child was seated in front of the display board, and the use of the wand was demonstrated. Following practice trials, 24 sequences of five lights each were presented, the child responding in serial recall after each sequence. Following the memory testing procedure, the child was administered the Bender Gestalt Test, and the visual-motor perception age was estimated, using Koppitz norms.

RESULTS

An examination of the data revealed that there were marked differences between the population of children from the residential school and those from the public schools. The data are thus shown in Figure 5 by school as well as by age. The mean number of correct responses is shown on the ordinate. Figure 6 shows mean number correct by serial positions. As can be seen, there is a marked difference by residential schools, and a continual improvement with age for the non-residential group. The drop at the nine-year level for non-residential represents an unreliable estimate, since only one child could be located meeting the criteria. The children from the residential school seem not to improve with age. In general, there is no serial position effect, as shown in Figure 7. The

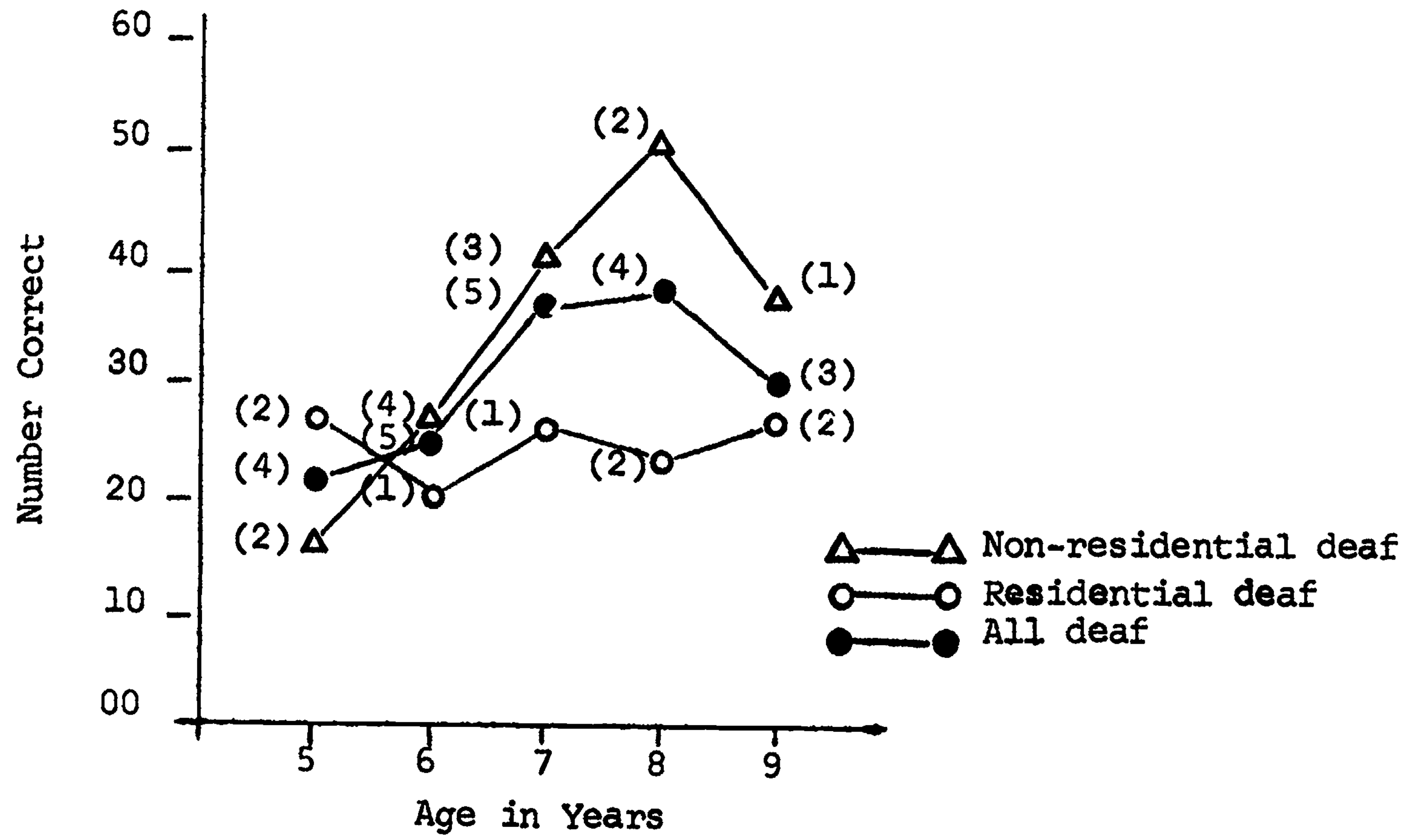


Fig. 5. Mean Score by Age (numbers in parentheses indicate number of children represented by that point).

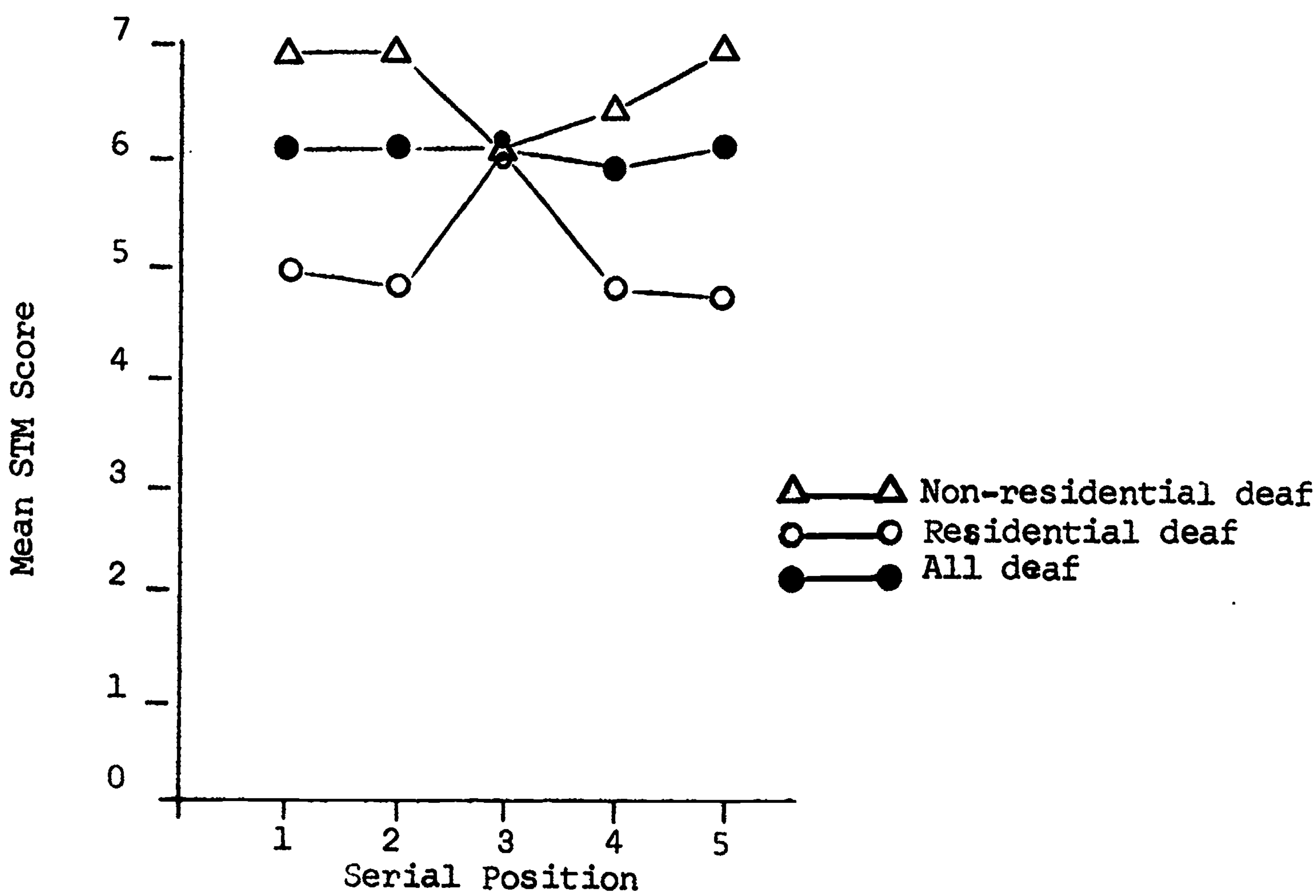


Fig. 6. Mean Score by Serial Position

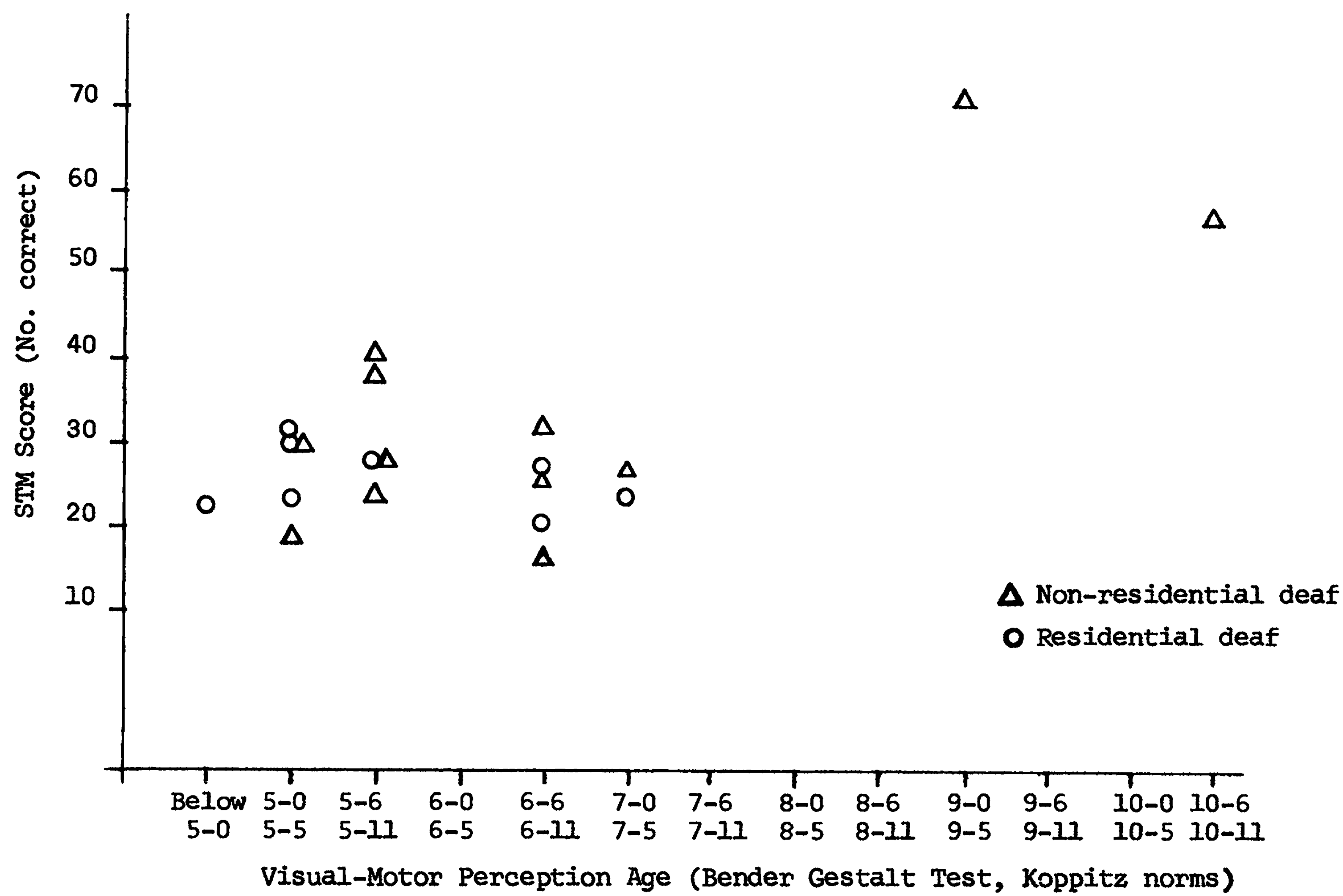


Fig. 7. Mean Score by Visual-Motor Perceptual Age

increase in performance for residential deaf children at serial position three is an anomalous effect, since it is inconsistent with the universal observation that middle serial positions are less accurately recalled, as can be observed in the curve for the non-residential subjects.

An examination of the scatter-plot for memory score by Visual-Motor Perceptual Age (Bender Gestalt) indicates no significant relationship. While the two oldest non-residential children had the highest Bender and memory scores, no such relationship obtains for the other 19 subjects.

The performance of the residential deaf children remains to be accounted for. It is possible that a specific response set occurred, or that, attentional factors interfere with the storage of the first two items, so that storage begins, in effect, with item three. The data are not reliable enough for exact statistical estimates of such factors as tendency to report in free order, and these remain for further study.

Although these data represent pilot study of the problem, we are very pleased with the potentialities implicit in our method. Further studies are designed which will use a range of sequences from three to five items in length using both serial and free recall. Normative studies of hearing children are planned for the coming year also.

4. The inability of deaf children to process sequentially presented visual information has been demonstrated in several studies (Withrow, 1968; Hiskey, 1956; Blair, 1957). The rationale behind these findings has been the hypothesized reduced ability of the visual system to organize perceptions in time (or the reduced ability of a central organizing system to organize time-dependent visual input). If, however, man recodes some visual information (as, for example, when he reads) into an auditory/articulatory code, perhaps recodability of material is the important variable rather than the presence of an auditory system. The deaf and hearing subjects used in the studies above could easily have differed in the availability of coded names for the stimuli used. A second point is that it's rather difficult to separate simultaneously and successively presented visual information since, if a simultaneously presented display is complex at all, the subject will scan its components--successively--in time. Then, the word "simultaneously" refers to the way the projector displays the stimulus, and not necessarily the way the subject perceives "it." It seemed appropriate to do a study similar to Withrow's as the initial step in investigating the variable of stimulus codability as it applies to the deaf and their ability to remember sequences of visual information. Withrow's study accomplished this to some degree; he used three kinds of stimuli, familiar silhouettes, familiar geometric forms, and random geometric forms. It's doubtful, however, that the familiar silhouettes were familiar at all. They were

developed in 1931 and represent some items that have changed silhouettes in the last 40 years. The familiar geometric forms were indeed familiar, but varied, themselves, in their codability and would tend to be more codable to students who had some advanced arithmetic than those who had not, e.g., pentago . hexagon.

METHOD

Materials

Ten sets of five items each were constructed so that each set contained different types of material. Table 2 gives the names of the sets and some description of their content.

TABLE 2

Sets of Stimuli and Their Composition

Stimuli	Codability[a]	Content
1. Real paisley	6.63	A piece of paisley fabric was cut into five pieces so that no one piece was identical in pattern to any other
2. Simple designs	7.21	Five similar but discriminable designs were drawn in black ink
3. Complex designs	6.19	Similar complicated designs were drawn in black ink
4. Plaid pictures	5.48	Actual photos of five different patterns of plaids
5. Paisley pictures	5.60	Actual photos of five different paisley-like patterns
6. Colors	2.18	Five squares--each a different color--brown, orange, yellow, blue, and green
7. Letters	2.07	Consonant letters--N, W, S, K, F
8. Numbers	2.26	9, 8, 7, 1, 0

TABLE 2--continued

Stimuli	Codability[a]	Content
9. Objects	2.24	Line drawings of five common objects--bird, key, car, flower, and cup
10. Forms	2.06	Five simple forms--heart, square, circle, arrow, and triangle

[a] indicates mean no. words per item

All items were scaled for codability by 20 hearing subjects who were not in the main experiment. They ranged in age from 11 to 40. The task involved showing an individual an item and having him describe it. The experimenter noted the number of words that the subject required to describe the item and that became the measure of codability. Such a measure had been used by Brown and Lenneberg (1954). The average (per subject and item) number of words used to describe the items in each set are shown beside each type of set in Table 2. The result of the codability assessment reflects the experimenter's intuition: the sets of materials could easily be divided into two degrees of codability with sets one through five low in codability and sets six through ten high in codability.

Design

The five items in a set were shown to the subject in a predetermined order either laid out in a row (simultaneous) or one-at-a-time flash-card style (successive). Each set was a simultaneous problem twice and a successive problem twice for each subject. The subject's task was to look at the set and try to reproduce the order of items.

Procedure

Subjects participated in the experiment individually. They were seated across the table from the experimenter. Between the experimenter and the subject was a rectangular wooden frame mounted so that it sat perpendicular on the table. Attached to the top was a window shade which could be pulled down to hide from the subject the section of the table closest to the experimenter. The experiment would, in the case of a simultaneous problem, lay out the five items side-by-side behind the closed window shade, open the shade so that the subject could view the cards for 8 sec.; close the shade and hand the subject an identical set of five items for him to arrange in a row like the experimenter's. In the case of a successive problem, the experimenter held up facing the subject the five items arranged in a stack (covered by a blank card which said "Ready") and put each one face down on the table at the rate of 1 1/2 sec. each. The subject's instructions when handed this set (shuffled) were to make a stack in which the pictures were in the same order as the experimenter's. The 20 successive and 20 simultaneous problems were presented in a random order that was different for each subject within a group. Some practice problems (a minimum of two of each kind) were given the subjects before the experimental problems. There was one practice set comprised of four actual playing cards--king, queen, jack, and ace of clubs. Subjects were given practice problems until they were successful in following the instructions. (The intent was to make sure the subjects understood the procedures, therefore, no record was kept of performance on the practice problems.)

Subjects

The deaf subjects were obtained from two residential schools. All 17 had IQ scores above 80 and were prelingually and severely deaf. The 17 hearing subjects were from a rural elementary school. The mean age of the deaf subjects was 13.4; the hearing subjects, 10.6. There were nine girls and eight boys in both groups.

RESULTS

The order of the sequences of pictures reproduced by the subject was recorded for each problem. The data reported here refers only to the number of correct whole sequences reproduced. A 2 (deaf, hearing) X 2 (codability) X 2 (sim., suc.) X 17 analysis of variance was performed on this measure. The means are shown in Table 3.

The analysis of variance revealed two significant main effects. Simultaneous patterns were remembered better by both deaf and hearing subjects than successive patterns [$F(1,32) = 10.71$, $p < .01$]. High codable sequences were remembered more frequently than low codable sequences by both deaf and hearing subjects [$F(1,32) = 139.82$, $p < .001$]. The performance of the deaf and hearing subjects did not differ [$F(1,32) = 2.65$, $p < .20$], nor was there a significant interaction between hearing status and codability or the simultaneous-successive variable.

The unexpected lack of interactions prompted a closer examination of the individual problem types. Although none of the problems duplicated Withrow's, some could be considered approximately the same

TABLE 3

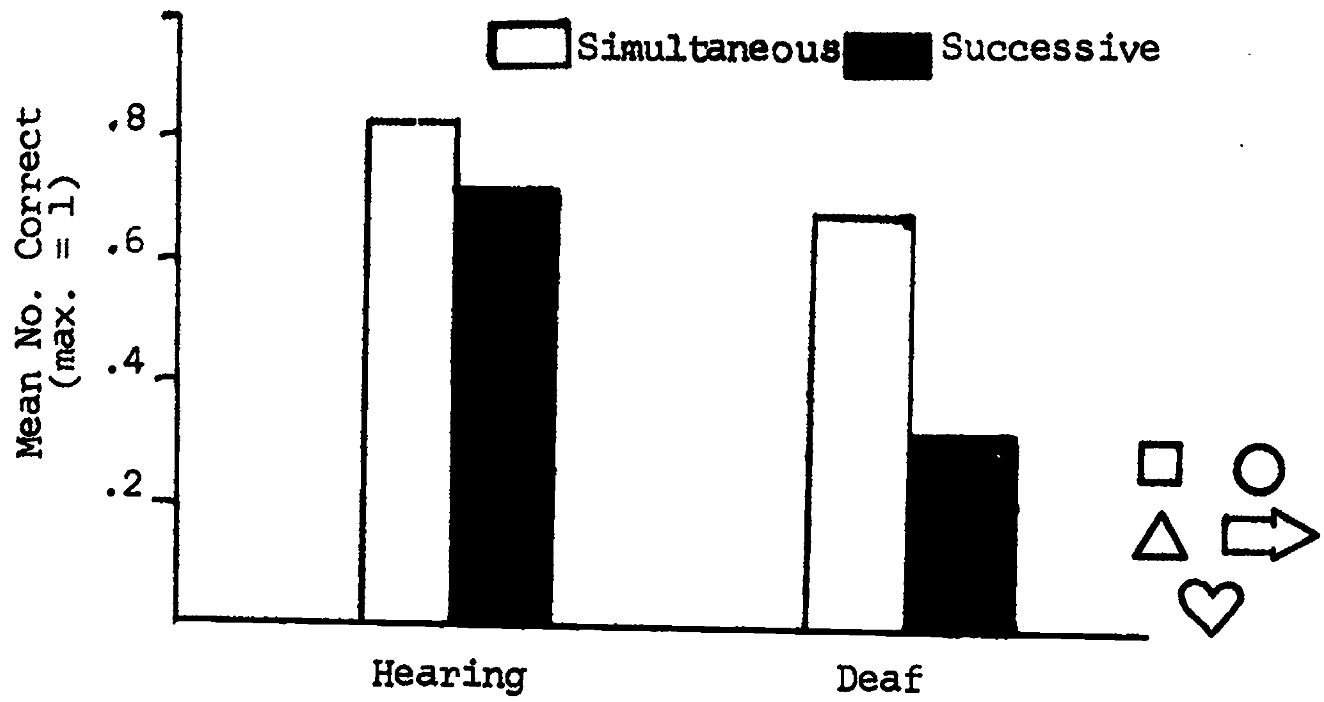
Mean Number of High Codable and Low Codable Simultaneous and Successive Problems Correctly Recalled by Deaf and Hearing Subjects

	High Codable		Low Codable	
	Simultaneous	Successive	Simultaneous	Successive
Deaf	3.8	2.8	1.8	1.3
Hearing	4.0	3.8	2.0	

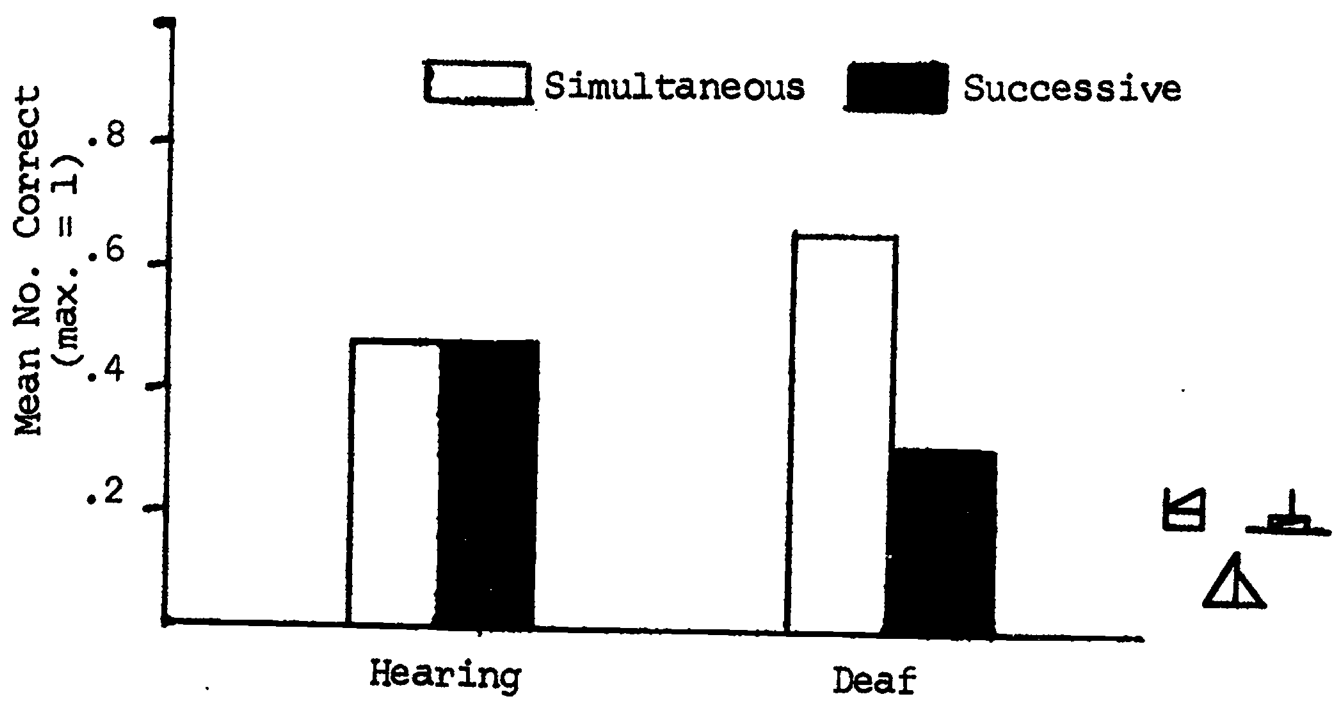
type of items. Our "form" set was similar to his familiar silhouette and familiar geometric forms and our black lined simple design set was similar to his random forms. The figure showing our deaf and hearing subjects on the form and simple design problem sets appears below.

It is obvious from the figure that, at least on these kinds of materials, there was an interaction between simultaneous/successive presentation order and hearing status. This finding suggests that Withrow's results may be specific to the kinds of materials used in the task. Such a conclusion would be difficult to explain unless the following assumptions are made: (a) verbalizing or labeling enhances memory for items sequentially presented but not necessarily items simultaneously presented. This is a reasonable assumption because an item in a simultaneous sequence has a larger number of contextual cues, (b) differential availability of names or labels exists in deaf and hearing subjects with the former having the disadvantage (vocabulary differences), (c) the materials used by Withrow and some we used were borderline codable in that they weren't so common that everyone could name every item instantaneously yet they did resemble something that had a name which the subject could derive. If the material was potentially codable, then a population like the deaf, who, perhaps are less verbally agile, would be less likely to label the items and be less able to remember them. If all the items are almost uncodable like the plaids, then everyone should perform the same because availability of labels would not be a factor.

Another source of difference in Withrow's study and ours was the choice of control subjects. His deaf and hearing subjects were matched on age by pairs. Ours were matched on reading achievement, which meant the deaf subjects were about three years older than the



Forms



Black and White Simple Designs

Fig. 8. Mean No. Correct Responses on the Two types of Simultaneous and Successive Problems.

hearing subjects. It is interesting to speculate on the finding that reading skill is correlated with ability to remember sequentially presented visual material. Perhaps the phenomenon is a habit rather than an ability and that extensive training and practice on the skill, i.e., reading, make one better at related problems. It's inevitable that hearing children should learn to read earlier than the deaf because they "know" the language before they start. With respect to this study, then, we may have matched for the very variable we expected the deaf and hearing to be different on.

5. Hirsh (1967) has stated that auditory perception, unlike visual, is very related to time-dependent phenomena in that the referents for auditory perception are events whose qualities depend upon what it is that changes (in time). Conversely, the accurate perception of time probably depends upon the use of a sense which can detect temporal changes rapidly, namely the sense of hearing. Hirsh suggested that learning about time through the use of the ears is important in being able to make estimations of duration. Guyua (1902), Hirsh (1952), and Hirsh, Bilger, and Deatherage (1956) maintained that audition is the primary mode through which we perceive time. In the latter study, noise was found to influence subjects' estimates of the duration of a tone or light while visual distractors had no effect on estimation. Hirsh and Sherrick (1961) found that in judging whether stimuli were presented simultaneously or successively (the first stage in temporal resolution), the auditory sense was the most rapid of the senses. The tactual sense was, in turn, more rapid than the visual. This finding offers further support for a connection between hearing and perception of time.

While time has been acknowledged widely as the important dimension in auditory perception, Hirsh (1967) maintained that it has still another somewhat different role in ordering events in language. The perception of acoustic events in long temporal patterns (such as speech) depends not only on discrimination of those events but also on the listener's knowledge of a complex structure that determines which sequences are orderly and which are not.

Several authors have implicated systems other than the auditory one in the perception of time. From the results of their study, Hirsh and Sherrick (1961), characterize the time-perceptive system as "...some kind of time-organizing system that is both independent of and central to the sensory mechanisms." Fraisse, in his review of the thinking concerning time (1963), has mentioned several possible mediating systems for time perception. One of these, having application to temporal order, involves a sort of visual imagery (Guyua, 1902): "...any change which is registered in our consciousness leaves there, as a residue, a series of images arranged in a sort of line in which all distant images tend to become obliterated to leave room for other more distinctive images." Another possible mediator of temporal order that has received some attention is the notion of a "temporal sign." Purportedly, alternating sensations of tension and relaxation may impose a sign on successive sensations and make it possible to give them an order. Regarding the perception of temporal duration, on the other hand, "vocal imagery" has been thought to act as a scale against which to measure stimulus duration as well as order. This notion suggests that we accompany any series of perceived stimuli by speech sounds (either subvocal or overt) which we produce. In this way it is possible to keep track of the order of stimuli and the duration of filled and empty intervals.

Rhythm Perception as a Special Case of Time Perception. Within the topic of time perception, rhythm has been treated as a special case of the more general phenomenon (Fraser, 1966). The perceptual and cognitive mechanisms underlying time and rhythm perception have been the focus of several studies (Gault & Goodfellow, 1938; Fairbanks, 1955; Karlovich & Graham, 1966, 1968). The evidence presented by these investigations indicates that the auditory sense has a critical function in time and rhythm perception.

Several authors have noted similarities between the task of rhythm perception and the mechanisms for encoding spoken and written language (Martin, 1969; Eisler, 1968; Birch & Belmont, 1964, 1965; and Rosenbusch & Gardner, 1968). The relationship among the antecedent faculties and these various processes might take the form suggested in Figure 9.

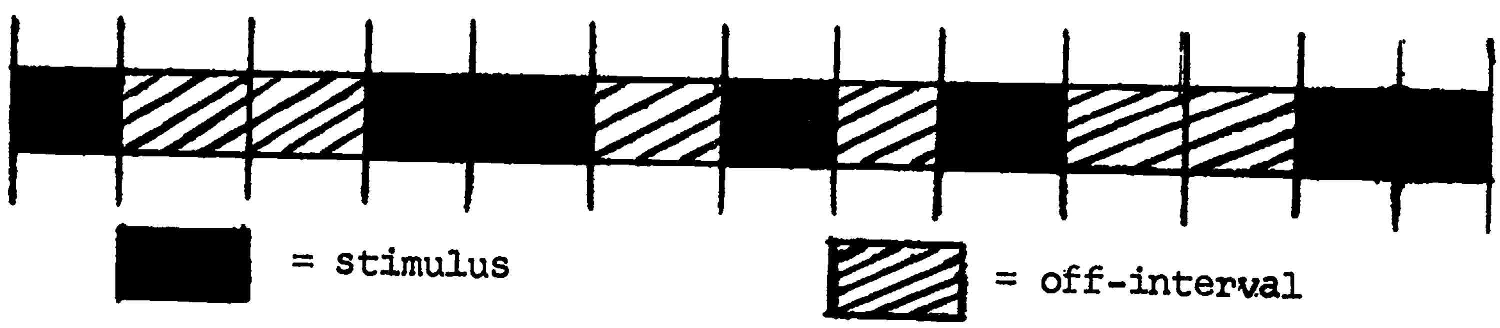


Fig. 9. Anatomy of a rhythm.

This model postulates a number of mechanisms which contribute to the "time sense." These factors are not to be considered the necessary and sufficient determiners of a time system but, rather, as contributors to some extent. The most notable of these factors in the pre-existing literature has been audition. The major issue of the research studies to be described below is to determine whether hearing enjoys an exclusive position as the antecedent to rhythm perception. The studies will address themselves to the question of whether, in the absence of hearing, a normal time-organizing system develops.

Rhythm Perception by Deaf Subjects. In order to assess the importance of the auditory sense in the perception of rhythms, a study involving deaf subjects would seem to be appropriate. The extent to which one's concept of time (or rhythm) affects his perceptions is not known. However, in the case of the deaf, it appears that any deficiencies in their conceptualizations are caused by a difficulty in applying the verbal labels for concepts, not in the actual abstraction process (Rileigh, 1969). For example, studies of conceptual ability by Rosenstein (1960, 1961) which have minimized linguistic requirements have demonstrated that deaf and hearing subjects performed equally well. If the implication of these studies is correct, then in a non-verbal perceptual task differences obtained between deaf and hearing subjects may be assumed to be attributable to perceptual, rather than conceptual, factors.

One such study designed to be a pure test of perceptual skills has been completed by Sterritt, Camp and Lipman (1966). They used the rhythm reproduction method with hard-of-hearing and normal-hearing subjects of various ages (three through seven years). The rhythms were presented in both visual and supra-threshold auditory modes. The results indicated that the hard-of-hearing subjects performed less well than the normal-hearing subjects in both modes, and that simple patterns were reproduced more accurately than complex ones. If this study involved only perceptual skills, it could be concluded that the hard-of-hearing subjects were less proficient in this regard. However, the technique used in this study seems to have placed more emphasis on the cognitive than on the perceptual aspects of the process. It is entirely possible that the task could be successfully solved by cognitive means. To say that this represents a legimitate comparison of the perceptual abilities of subjects with deficient and normal hearing seems inaccurate.

The following two research studies attempted to investigate the relationship between hearing status and rhythm perception and to ascertain if the deaf are able to compensate for their hearing loss in various types of tasks.

Experiment I

METHOD

Subjects

A total of 72 subjects participated in this study. Twenty-four subjects comprised each of three groups: Deaf, Hearing I, and Hearing II. An equal number of males and females were selected and they represented two age groups: (a) ten-year-olds, who typically have some notion of durations and succession of events and (b) fifteen-year-olds, who usually have acquired a mature concept of time (Bradley, 1947).

The subjects comprising the deaf group were students with a profound (80 dB or more in the best ear) prelingual (onset before age two) hearing loss from the Louisiana School for the Deaf in

Baton Rouge, Louisiana. The mean ages of the two groups were 10-10 and 15-11.

The subjects in the Hearing I group were students with normal hearing ability. Subjects in the Hearing II group also possessed normal hearing, but their listening ability was experimentally impaired by the presentation of white noise through earphones. The subjects in both Hearing I and Hearing II groups were students from Williamson County, Tennessee public schools; their mean age were 10-4 and 15-8 for the two age groups.

All students selected for participation showed IQ's of at least 80. The majority of the normal-hearing subjects had been evaluated by either the Lorge-Thorndike Intelligence Tests or the Otis-Lennon Mental Ability Test. The deaf subjects for whom IQ scores were available had been evaluated on the Chicago Non-Verbal Examination.

Design

The experiment had a factorial design of the form: 3 X 2 X 2 X 3 X 3 X 5. There were three between-subjects factors (hearing status, age and sex) and three within-subjects factors (total length of the rhythm pattern, number of beats, and trials). There were six subjects in each of the twelve cells of the study.

Stimulus patterns

Rhythm patterns were presented to the subjects visually by means of 16 mm. movie film. The film was shot using a Bolex movie camera (25 mm. lens, f stop = 4) and Kodak Tri-X Reversal film. Single frame pictures were filmed of a black dot centered on white poster board. The time corresponding to a rhythm pattern can be conceptually divided into 1/16 sec. units, each of which corresponds to one frame of the movie film. The duration of the black dot over all occurrences remained constant at four frames (1/4 sec.). A presentation of the dot for this length of time defines one beat of the rhythm. The minimum interval of plain white stimulus between any two beats was six frames (3/8 sec.). The white stimulus prior to the pattern served as a "ready" signal for the subject. The white display after the pattern acted as an aid to adaptation of the subject's eyes. The solid black display was the period during which the subject reproduced the rhythm pattern.

Nine types of rhythm patterns were represented on the film:

A = 5 sec., 3 beats

B = 10 sec., 7 beats

C = 10 sec., 3 beats

D = 5 sec., 7 beats

E = 5 sec., 5 beats

F = 10 sec., 5 beats

G = 10 sec., 5 beats (matched for rhythm pattern with E)

H = 10 sec., 7 beats (matched with D)

I = 10 sec., 3 beats (matched with A)

The 10 sec. matched group of patterns was included in order to avoid confounding pattern length with the actual rhythm pattern. Each subject received five different patterns of each type in a random arrangement.

Apparatus for stimulus presentation

The film was presented on a Traid Selecta-Frame movie projector at a speed of 16 frames per sec. The subject sat at a table with his head resting in a chin support and facing a plexiglass screen on which the projected image appeared. All subjects wore headphones throughout the study; subjects in the Hearing II group received white noise through the headset during both presentation and reproduction of the rhythm patterns.

Apparatus for stimulus reproduction

Subjects reproduced each rhythm pattern after having seen it projected. A telegraph key was connected by means of a battery to a Texas Instruments event recorder. As the key was pressed, a record appeared on the paper tape corresponding to the subject's responses.

Procedure

The subject was seated at a table with his chin in a chin rest looking at a rear projection screen. He was given written instructions (in addition, deaf subjects received instructions by fingerspelling). In order to partially prevent the subject from forming tactual representations of the rhythm patterns, his arms were made to rest on the table with his hands hanging off the edge of the table and he was asked not to move them during the film presentation. The subject was given 10 practice trials (on patterns not included in the regular set) to ascertain that he understood the instructions.

When the subject had adequately completed the practice trials he was shown the rhythm patterns one at a time and asked to reproduce them on the telegraph key. Each subject received 45 trials with several rest periods interspersed. The total time per subject in the experiment averaged approximately 40 min.

Following the data collection, the subject was requested to complete a questionnaire in which he was asked for a statement regarding his strategy in getting the rhythms correct.

RESULTS

The results are reported in three sections according to three dependent measures--number of beats reproduced, duration of reproduction, and rhythm reproduction accuracy. In many cases, complex interactions were significant but these are not reported here. For more detailed reports of results, the reader is referred to Rileigh (1970).

Number of Beats

The data consisted of an accounting for each subject of his success in producing the same number of beats as the standard rhythm patterns presented to him. The 45 patterns of interest were scored dichotically (correct = 1; incorrect = 0). These observations were submitted to a 3 (hearing status) X 2 (age) X 2 (sex) X 3 (pattern duration) X 3 (number of beats) X 5 (trial blocks) general balanced design analysis of variance (Winer, 1962).

The analysis of variance revealed a significant age main effect [$F = 5.88$, $p < .05$]. The fifteen-year-olds obtained a higher proportion of correct responses than the ten-year-olds.

In addition, a significant main effect was obtained with respect to the number of beats in the pattern [$F = 39.52$, $p < .001$]. Multiple t-tests (Hays, 1963) performed on the means for the three levels of that variable revealed that all three pattern types differed significantly from one another ($p < .001$ for each comparison). Specifically, subjects had the greatest ease in producing the correct number of beats on patterns which contained three beats. Further, their performance was better on the patterns with five beats than on those with seven beats.

Total Duration of Patterns

Each pattern was assigned a value representing the ratio of the subject's response duration to the actual duration of the standard pattern. These ratios were submitted to a 3 (hearing status) X 2 (age) X 2 (sex) X 3 (pattern duration) X 3 (number of beats) X 5 (trial blocks) general balanced design analysis of variance.

A significant sex main effect was obtained [$F = 9.21$, $p < .01$]. Male subjects tended to underestimate somewhat the total length of the rhythm patterns, but they were significantly more accurate than were the female subjects, whose underestimation was pronounced.

The analysis revealed an extremely significant main effect due to the duration of the patterns [$F = 185.05$, $p < .001$]. Multiple *t*-tests showed that subjects were more accurate in reproducing total duration for 5 sec. patterns than for either group of 10 sec. patterns ($p < .001$). The accuracy of duration reproduction for the 10 sec. patterns matched with the 5 sec. ones on rhythm did not differ from that for the 10 sec. unmatched patterns. The main effect of pattern duration can be seen in Figure 10.

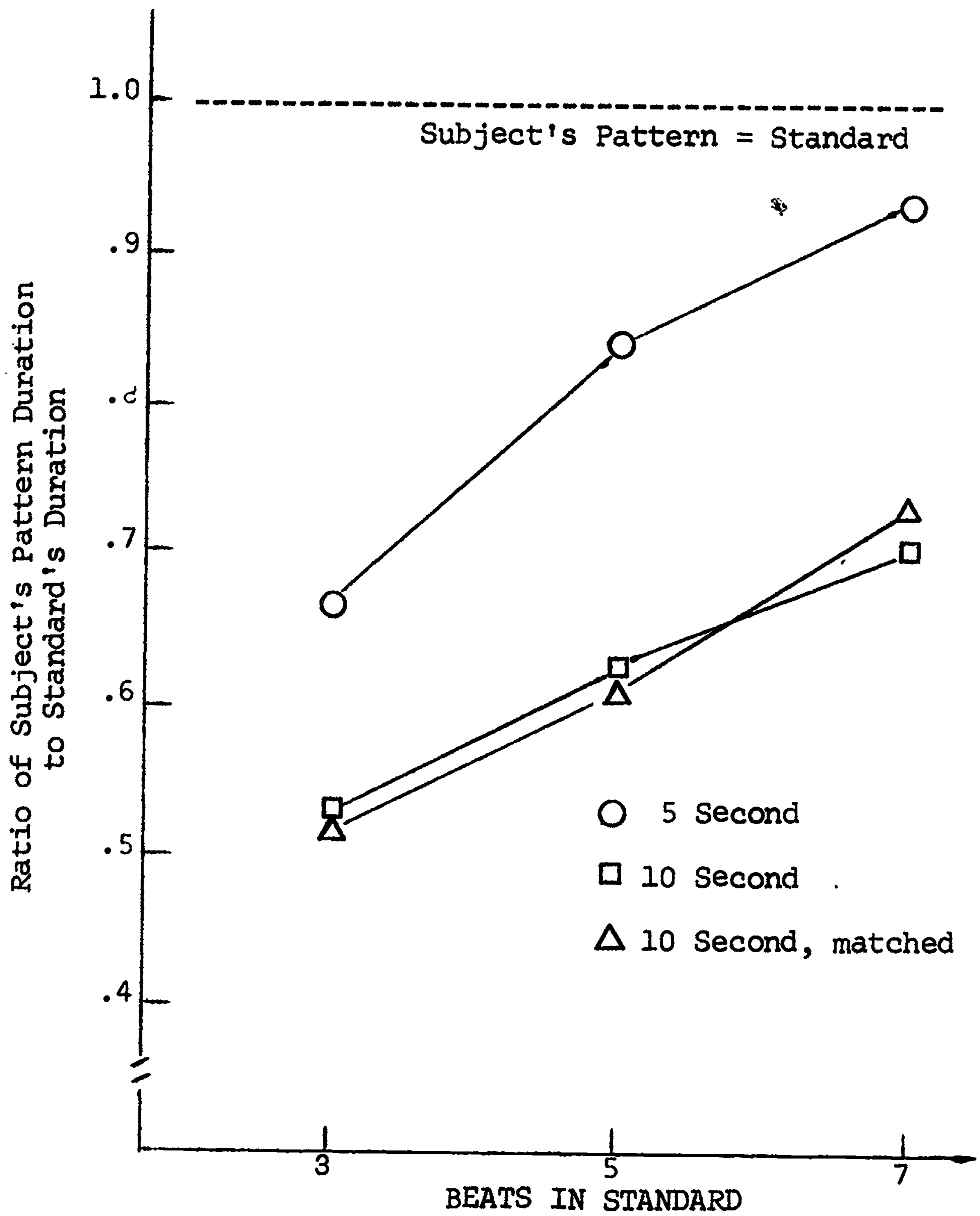


Fig. 10. Accuracy of pattern duration response as a function of number of beats and duration of the standard.

The main effect of number of beats was found to be significant [$F = 28.51$, $p < .001$]. Multiple t-tests performed on the means revealed that as the number of beats in the pattern was increased, subjects' reproductions of the total duration improved progressively. That is, performance was best when involving seven-beat patterns and poorest on three-beat patterns, each individual comparison being significant ($p < .001$). Figure 10 presents graphically the main effect of number of beats.

The Duration X Beat interaction was also significant [$F = 9.83$, $p < .001$]. As can be noted in Figure 10 this interaction is attributable to a proportionately higher improvement in performance of the 10 sec. matched group of patterns when they contained seven beats.

Figure 11 shows the significant Hearing status X Age interaction [$F = 4.32$, $p < .05$]. At the ten-year age level, deaf subjects were greatly inferior to either normal-hearing group in reproduction of durations. At the fifteen-year age level, however, there was little difference in performance among any of the groups. The deaf subjects enjoyed a large increase in their ability to do this task as age increased, while the hearing subjects' performance dropped markedly with age. At both age levels the Hearing I group performed slightly better than the Hearing II group.

Rhythm Patterns

An average squared difference (D) score was calculated for each pattern. The magnitude of the error was directly represented by the magnitude of the D score. The D scores were submitted to a 3 (hearing status) X 2 (age) X 2 (sex) X 3 (pattern duration) X 3 (number of beats) X 5 (trial blocks) general balanced design analysis of variance.

A significant age main effect was obtained [$F = 12.58$, $p < .001$]. The fifteen-year-old subjects made significantly fewer errors in rhythm reproduction than did the ten-year-old subjects.

The main effect of duration was found to be significant [$F = 24.36$, $p < .001$]. Multiple t-tests performed on the means revealed that the errors made on 5 sec. patterns were significantly fewer than those made on 10 sec. matched patterns ($p < .001$). In addition, error scores were lower for 10 sec. matched patterns than for 10 sec. unmatched ones ($p < .01$). Figure 12 presents graphically the main effect of duration.

Several interesting strategies were reported by the subjects in the post-experimental interview. Of 38 subjects responding, 25 said they counted the beats, eight attempted to estimate the time passage between two beats, two tapped the beats contrary to the experimenter's instructions, and one used vocalizations. One subject claimed to use visual imagery: "I looked at the screen while I was tapping and

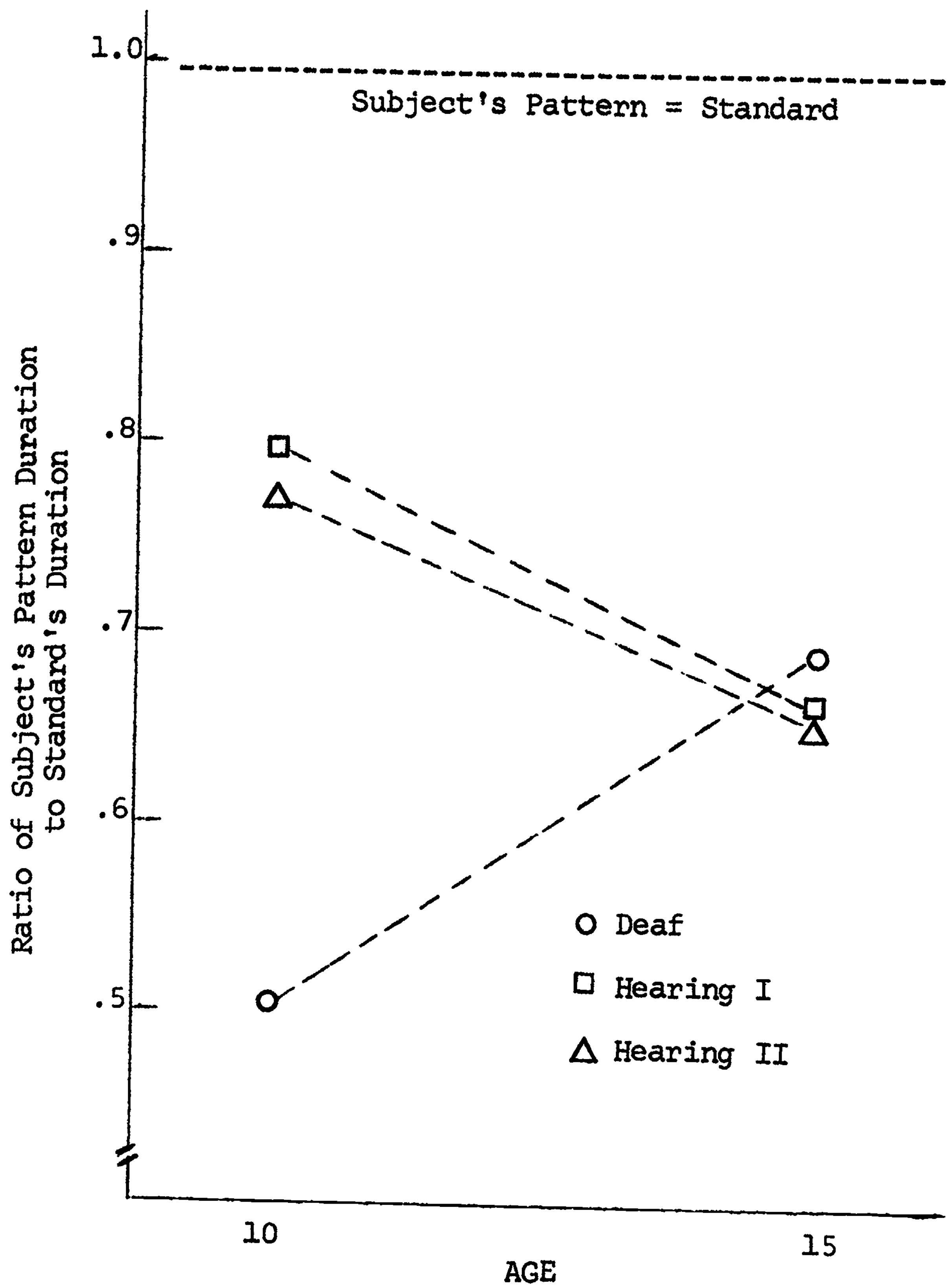


Fig. 11. Accuracy of pattern duration response by deaf and hearing subjects of various ages.

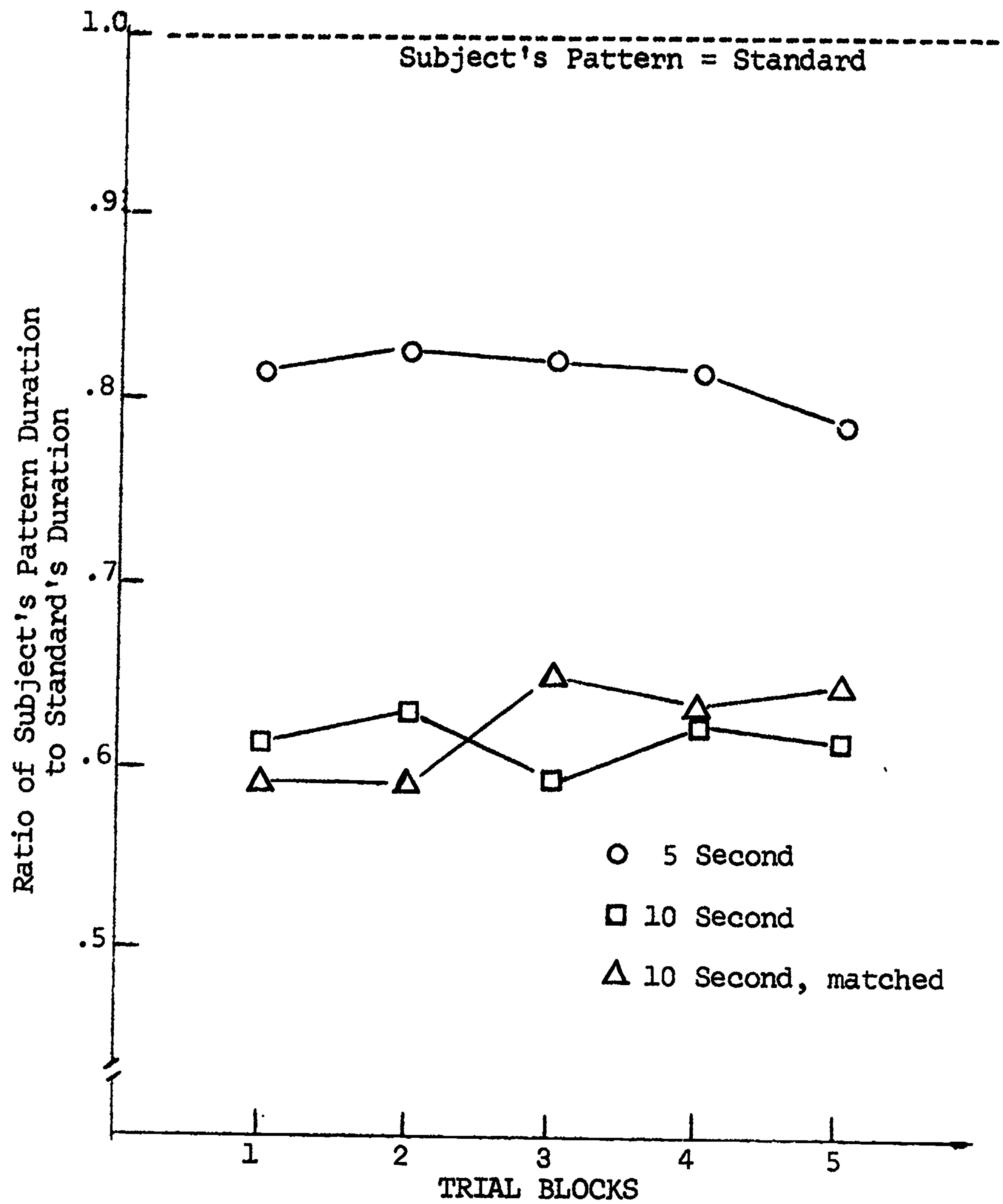


Fig. 12. Accuracy of pattern duration response as a function of length of the standard and trial blocks.

remembered when and to what rhythm it went." Another subject paced the rhythms with his breathing: "I tried to space the dots with my normal breathing rhythm." From these reports, it is apparent that there is some variety in the methods utilized.

DISCUSSION

The main thrust of this study was to determine the mediating process in the perception of rhythmic patterns. Specifically, it represents an examination of the importance of hearing to the perception of time-related things.

Much of the literature cited in the introduction supported a connection between the auditory sense and time perception. With respect to persons without hearing, it has been suggested that they may have an inadequate concept of time as a result of their hearing loss (Silverman, Lane, & Doehring, 1960). If this were the case, one would expect their perceptions of time to be less adequate also. However, it is not clear that hard-of-hearing subjects or deaf subjects perceive rhythms less well than hearing subjects.

It is interesting that, despite the frequent suggestion that hearing is crucial to time perception, this study obtained no overall main effect due to hearing status. Not only were the hearing-interfered subjects able to reproduce the rhythms as adequately as the normal-hearing ones from the beginning, but the deaf persons performed equally well also. This finding was consistent across all three dependent measures.

The question as to what mediating scheme does operate in rhythm perception still remains unanswered. The fact that the hearing mechanism has not been supported as a sole mediator lends credibility to a theory involving a more central time-organizing system (see Figure 13). Hearing may be but one aspect of such a mechanism with other senses involved in a similar subordinate role (as suggested by Hirsh and Sherrick, 1961). If such a cluster of mediators is available, individual subjects might be inclined either to rely on only one particular mediator at a time or on some combination of them.

The reports obtained from subjects on the post-experimental questionnaire prove somewhat revealing with respect to the mediators that may be used in rhythm perception. Most of the respondents reported using counting to aid in the storage of the patterns. Although these subjects did not directly mention using vocalization, it is highly probable that their counting did involve a vocal aspect. Subjects who reported using more intricate mediators mentioned some which have been discussed in the previous literature. For example, several subjects tapped the rhythms on the table while they watched the screen. It is likely that, had the instructions not discouraged

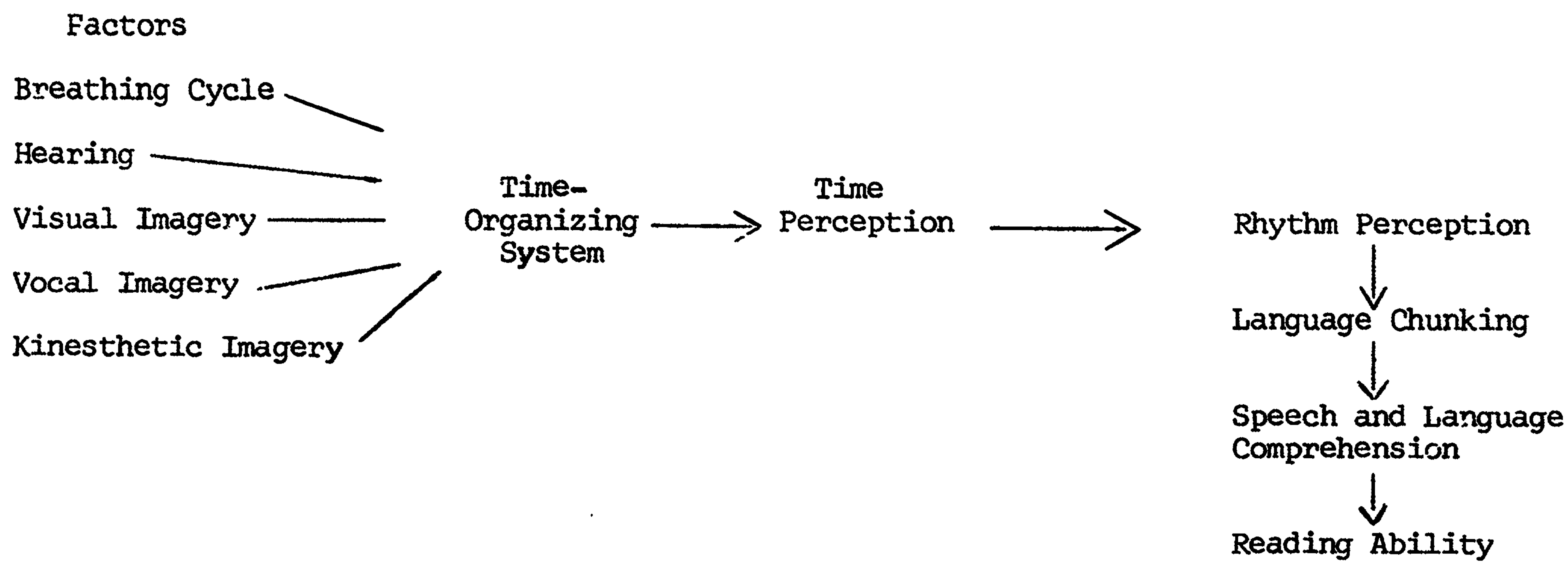


Fig. 13. Model of time-organization system.

it, more subjects would have taken advantage of kinesthetic cues. Overt vocalization was practiced by one subject, while visual imagery (such as described by Fraisse, 1963) was reported in another case. One subject claimed he used his breathing pattern as a template for the rhythms. This is a particularly noteworthy strategy with respect to Eisler's (1968) discussion of breathing rhythms and reading.

Further research is indicated in order to explore more fully the range of mediators generally available, the contingencies for selecting particular ones in specific situations, factors which affect their usage, and the possibility of individual preferences.

How these results involving the deaf relate to their difficulties with language in general and especially reading is not clear. As stated earlier, it is felt that rhythm is important in language chunking, particularly in speech perception and reading. If the deaf had been found lagging in the perception of rhythmic patterns, that may have had some connection with their language deficiency. However, they have been observed to perform equally with the hearing subjects, at least at the fifteen-year level. Future research in this area should prove fruitful in elaborating the mediation notion in rhythm perception and in exploring the relationship between rhythm and language ability.

A subsequent study investigating memory of the deaf for visual rhythm patterns has been initiated. The literature encompassing short-term memory investigation offers several points for investigation of memory for temporal patterns in the deaf. Sperling's model (1966) includes a primary auditory-rehearsal component in short-term memory. However, both Laughery and Harris (1970) and Posner (1967) have found some evidence that visual storage may also be present in STM.

One technique for investigating encoding and memory storage is the insertion of an interpolated task between stimulus presentation and recall. Brooks (1968) and Atwood (1968) employed this technique finding differences in the recall of verbal and visual material depending on the type of interference task employed.

The next study will investigate differences in the recall of temporal patterns between the deaf and hearing with the introduction of visual, motoric, and "no" interference tasks. Since the deaf have been found to recall temporal patterns as well as the hearing, some storage mechanism independent of audition or a STM auditory-verbal component may be operating.

Experiment II

METHOD

Subjects

Twenty young congenitally deaf adults from a residential school for the deaf and twenty students from a local high school will serve as subjects. All hearing subjects will wear headphones to block out extraneous noises from equipment and other sources.

Design

A 2 X 3 X 3 factorial design will be employed. Each deaf and hearing subject will receive all levels of the interference-task variable and the number-of-beats variable in a counterbalanced arrangement. Subjects will be given all conditions in one session with rest periods between conditions.

Stimuli and apparatus

Patterns will be presented on 16 mm. movie film at a speed of 16 frames per sec. by a Traid Selecta-Frame projector. A modification of Rileigh's method (1970) of pattern construction was employed. Patterns were structured as groups of Morse code-like signals of four, five, and six beats. A black dot centered on white poster paper appearing for six or 18 frames (.375 or 1.125 sec.) served as a short or long beat. Off-intervals filmed as white stimuli appeared for six frames (.375 sec.). Preparatory and terminal frames signalled the beginning and ending of a pattern. Each subject will be given 36 trials in each condition; a trial consisting of two like and one unlike patterns. The first two patterns will be presented rapidly separated by a 1.5 sec. interval. A six-sec. interval will separate the first two patterns from the third pattern. Patterns, on a whole, vary in time length. However, only identical-beat (same number of short and long beats), equivalent-length patterns are compared within a trial. The position of the odd pattern was counterbalanced, appearing an equal number of times for each beat category within a condition and across conditions. The same stimulus pattern combinations were employed in each condition with their order of appearance randomized for each condition.

Stimuli for the visual interference task consist of slides containing two pentagon-shaped geometric forms. These are to be matched by the subject from a group of six different forms. Eighteen random pairs of forms were selected to be presented two times within this condition in a random order.

Motor interference task stimulus consists of a form board with like indentions on each side (square, circle, rectangle, and triangle). Blocks will be given to the subject to fit into the various indentions.

Procedure

Each subject will be seated in front of a white screen covered with a plexiglass sheet. He will then be given a copy of written instructions. His task will be to determine if the third pattern in a series of three patterns is the same as the first pattern, the second pattern, or neither of the first two patterns. Before the visual and motoric interference conditions, the subject will first be given a written description of the task occurring between second- and third-pattern presentation. The experimenter will give the subject several practice trials before each condition.

At present, stimuli for the study are in the final stages of completion and pilot work will begin immediately. This study will be completed after the termination of the grant because it is the substance of an undergraduate Honors Thesis by Mrs. Suellyn Boyd.

B. Memory for Linguistic Material

There are other factors than organizational ones associated with encoding and memory of linguistic material. One of these which is especially relevant for the deaf is the form (and modality) in which the encoding and decoding of linguistic material takes place. Sperling (1966) has suggested that visual memory is comprised in part by a recognition buffer which transfers linguistic images, e.g., letters, into a motor component and then when that's executed, into auditory storage.

The linguistic nature of short-term memory is well-documented. At the present time, it appears that the basis of immediate memory is articulatory rather than acoustic in character (Hintzman, 1965; Wicklegren, 1969.) See Neisser, 1966 for a discussion of the topic). If short-term memory for linguistic material depends on being able to hear or being able to talk, the deaf should have a severe memory problem. That they don't has been demonstrated many times. Whether the conventional concept of short-term memory allows other kinds of coding in addition to articulatory/auditory or whether it allows for a substitution in the case of the deaf, or whether the findings to date are misnamed is an empirical question.

The studies discussed in this section investigate some aspect of these questions. This chapter is divided into two sections--the first set concerns smaller units, e.g., letters and numbers. The second set concerns larger units, e.g., words. The first studies, performed by Curt McIntyre, adapted a technique developed by Estes (1965), to investigate visual information processing as a function of different types of interference.

The fourth study approached the same question with a different technique and the fifth study, another done by Curt McIntyre, compared deaf and hearing subjects on the learning of letter-like forms.

The last studies involve the coding, memory and organization for words. The initial one looks at Sign as a possible coding medium and the second compares deaf and hearing subjects on their organization of words in memory.

1. Effects of Auditory Loss and Types of Noise Similarity on the Information Processed from Visual Sensory Memory.

The influence of prelingual deafness upon memory has long been of interest. Usually, either short term or long term memory has been studied while little interest has been directed toward sensory memory, i.e., the large capacity peripheral storage mechanism which briefly holds sensory information. An understanding of any influence of prelingual deafness on sensory memory is important since all information processed by an individual must be extracted initially from sensory memory.

One quantity of sensory memory which has been studied extensively is the amount of information a subject can extract from a briefly exposed visual display, i.e., the span of apprehension. Sperling (1960) found that the span was an increasing monotonic function of the amount of information in the display. The conceptual model developed from this result contains two fundamental assumptions: First, all of the information in the display is available to the subject for several hundred milliseconds after physical termination of exposure in the form of a rapidly decaying afterimage of the initial exposure. Second, a central processing device operates upon this image to retain information before it decays. Information elements in the display are retained permanently if they are processed by the device; elements not processed prior to their decay are lost.

How this central processing device operates upon the image in sensory memory to extract information before it decays is not known. Most likely, the elements of visual information contained within sensory memory as images are recoded and retained by means of an auditory information storage mechanism associated with short term memory (Sperling [1963] discusses this possibility extensively). However, this is not likely to be the case for the deaf since, presumably, they lack an auditory information storage mechanism.

Estes (1965) and Estes and Taylor (1966) have developed an explicit quantitative model of the span of apprehension which specifies an indirect method for estimating the span. Although the model is not complex, there is no need to review its formal assumptions here. It will be helpful, however, to state the general rationale of the measurement procedure. From the standpoint of the subject the basic task is simply a forced-choice letter recognition task where on any tachistoscopic exposure either one of two letters will appear. The subject knows what these letters are, say for example the letter T and the letter F, and he also knows the *a priori* probability of their occurrence. The letters can be thought of as analogous to the signals one would be required to detect in a standard signal-detection experiment. If the signal or target letters are placed in an array of other irrelevant letters, then it is intuitively clear that these irrelevant letters can be considered analogous to noise in the signal detection sense. That is, if a subject is going to make above-chance recognitions of the signal letters, his scanning process must discriminate the signal letter from the irrelevant noise letters. The number of letters that the scanner examines, of course, is an operational statement of the span of apprehension.

Estes has shown how the number of letters scanned can be estimated from the percentage of correct recognitions and from the number of letters physically present in a display. He has demonstrated that as the number of letters in a display increases the probability of correct recognition predictably declines, but the number of elements scanned or processed, i.e., the span of apprehension, increases with display size.

Experiment I

In the first experiment, the span of apprehension, as assessed by the forced-choice technique developed by Estes, of congenitally deaf subjects and hearing subjects was compared for three information conditions. In one condition no noise letters were presented. In the other two conditions, the signal letter was surrounded by either three or seven noise letters. Note that the subject's task remains the same independent of the number of noise letters in a display. He merely gives a forced-choice recognition response, e.g., it was a *T* or it was an *F*.

It is reasonable to expect that if an auditory information storage mechanism is involved in the processing of information from visual sensory memory then differences in performance should be obtained for congenitally deaf subjects, (who, presumably, lack this mechanism) and hearing subjects (who, presumably, have this mechanism).

METHOD

Subjects

Subjects matched on age and sex were selected from two populations: the junior and senior classes of the Tennessee School for the Deaf and the junior and senior classes of a local high school (Williamson County, Tennessee). Sixteen subjects (8 male and 8 female) were selected from each population. The mean age of both groups was approximately 17 years.

Materials

The stimulus displays, consisting of arrays of letters, were designed and constructed in the following way. Each array was made by typing letters on a white index card, which in turn was mounted on a cardboard insert which facilitated rapid insertion and removal from a tachistoscope. To allocate letters in each array, an imaginary matrix of 16 letter spaces was located at the center of each card. Each matrix (4 letters wide and 4 letters high) subtended $2^{\circ} \times 3^{\circ}$ of visual angle. Each array contained one of two signal letters (T or F); each signal letter appeared once on three separate cards in each of the 16 possible matrix positions, yielding a total of 48 T arrays and 48 F arrays. One set of 32 arrays, composed of 16 T arrays and 16 F arrays, contained only the signal letter (matrix size 1). The other two sets of 32 arrays, 16 T arrays and 16 F arrays in each set, contained the signal letter plus either three or seven noise letters (matrix sizes 4 and 8, respectively). In these latter sets of stimulus displays, a signal letter was first located at one of the 16 possible positions and then either three or seven different consonant letters were randomly selected without replacement and randomly allocated to either three or seven of the 15 remaining positions in the matrix. Each letter in the matrix subtended approximately 12' X 18' of visual angle, while letters occurring in adjacent cell were separated vertically by 30' of visual angle and laterally by 24' of visual angle.

The stimulus arrays were exposed in a two-channel tachistoscope (Scientific Prototype, model 800-E). One field, the constantly illuminated fixation field, contained four black lines 12' in width arranged to form a $2\ 1/2^{\circ} \times 3\ 1/2^{\circ}$ cornerless rectangle. The center of the rectangle defined the fixation area. The fixation field luminance was 9.6 ft-L. The stimulus displays were exposed for 90 msec. in the other field of the tachistoscope. The exposure field luminance was 78 ft-L.

Procedure

Each subject was given a standard set of written instructions and a response booklet. The subjects were instructed to indicate which signal letter (either T or F) appeared on each trial by circling the appropriate letter (either T or F) in the response booklet. Practice trials were given to habituate the subject to the task and to insure that the subject understood the instructions. During the practice trials each subject was presented with three randomly selected blocks of 10 trials, each block drawn from a separate matrix size with the restriction of an equal occurrence of the signal letters (5 T's, 5 F's). After the practice trials each subject was allowed to rest for two min. before the experimental trial blocks began. Each subject then viewed three sets (matrix sizes 1, 4, and 8) of two 10-trial blocks, each separated by a 2 min. rest period. Order of presentation of the matrix sizes was randomized within subjects. Each subject received a different randomization of stimulus materials. The intertrial interval varied with the individual subject's response rate, but an average of approximately one trial every 15 sec. was maintained. A 30 sec. rest was given after each block of 10 trials.

RESULTS AND DISCUSSION

The basic data was the mean probability of correct recognition (Pc) by each group for each of the three matrix sizes. These data are presented in Table 4. Analysis of variance revealed a significant effect for matrix size [$F(2,60) = 94.85$, $p < .01$] but no significant effect for group or for the groups X matrix size interaction. Newman-Keuls multiple comparison tests ($p < .01$) revealed significant differences between all comparisons with the following order: Pc matrix size 1 $>$ Pc matrix size 4 $>$ Pc matrix size 8.

This significant effect for matrix size was expected. As mentioned before, Estes has demonstrated that as the number of letters in the display increases the probability of correct recognition decreases. Estimates of the span of apprehension (SOA) were obtained from the probability of correct recognition (Pc) at a given matrix size (M). Specifically, these estimates were obtained by use of an equation, SOA = M (2 Pc-1), derived by Estes (1965). These estimates, which are presented in Table 5, agree with Estes' demonstration that as the number of letters in the display increases the estimated number of letters processed increases.

The lack of an effect for groups and the lack of an effect for the group X matrix size interactions indicates that the performance of the deaf and the hearing subjects was equivalent. This equivalence in performance may have occurred for several reasons. First, the forced-choice technique used in the present study may have eliminated important performance differences between the deaf and the hearing subjects which might have occurred with a method of report that confounded the information initially available to the subject with his subsequent ability to remember and report the elements in the display. Second, the difficulty level of the task, as reflected in the high performance levels of both groups, makes the occurrance of stable difference observations less likely. The difficulty level was established to reflect any consistent deficits within groups, but the errors which actually occurred were apparently produced by random attentional fluctuations.

Experiment II

In the second experiment, the possibility that performance differences between the deaf and the hearing subjects may have occurred with a method of report that confounded the information

TABLE 4

The Mean Probability of Correct Recognitions
As a Function of Group and Matrix Size

Group	1	4	8
Deaf	.994	.947	.816
Hearing	.988	.938	.822

TABLE 5

The Estimated Mean Number of Elements Processed
As a Function of Group and Matrix Size

Group	1	4	8
Deaf	.988	3.576	5.056
Hearing	.976	3.504	5.152

initially available to the subject with his subsequent ability to remember and report the elements in the display was tested. Here, a full-report technique which requires the subject to report all the elements seen in a briefly exposed display was used. This technique requires that each element be processed completely before it can be reported. This complete processing requirement and the additional retention requirements associated with this technique may make an auditory information processing mechanism necessary. Hence, the span of apprehension of congenitally deaf subjects and hearing subjects was compared again. Only one information condition, matrix size 8, was used. This matrix size was selected because it contains a number of elements greater than the maximum span of apprehension observed during Experiment I.

METHOD

Subjects and Materials

The same subjects, tachistoscope, fixation field, and exposure duration used in Experiment I were used in Experiment II. A new set of 32 stimulus displays was constructed. For each stimulus display, eight consonant letters were randomly selected without replacement and randomly allocated to eight of the 16 possible positions in the matrix.

Procedure

Each subject was given a standard set of written instructions and a response booklet. The subjects were instructed to write down all the letters which appeared in the display for each trial in the response booklet. Practice trials were given to habituate the subject to the task and to insure that the subject understood the instructions. During the practice trials the subject was presented with a randomly selected block of 10 trials. After the practice trials, each subject was allowed to rest for two minutes before the experimental trial blocks began. Each subject then viewed two 10-trial blocks, separated by a 2 min. rest period. Each subject received a different randomization of the stimulus displays. The intertrial interval varied with the individual subject's response rate, but an average of one trial every 30 sec. was maintained.

RESULTS AND DISCUSSION

The basic data was the mean estimate of the number of letters processed per trial, i.e., the estimated span of apprehension (SOA'), which was 2.79 for the hearing subjects and 2.67 for the deaf subjects. These estimates were obtained from the number of letters reported correctly on each trial, C, the number of letters reported on each trial, A, and the matrix size, M. Specifically, these estimates were obtained by use of an equation, $SOA' = \frac{20c-MA}{20-M-A+c}$ derived by Estes and Taylor (1964).

Application of a t-ratio to these data failed to reveal a significant difference. This result indicates that failure to obtain a performance difference between the deaf and the hearing subjects during Experiment I was not due to the method of report. However, the method of report did influence the size of the estimate of the span of apprehension. The estimate obtained with the full-report technique was approximately half that obtained with the forced-choice technique. This difference is due to the confounding of the information initially available to the subject with his ability to remember and report the elements in the display associated with the full-report technique.

Experiment III

In the third experiment, both the possibility that an auditory information storage mechanism is not important to and the possibility that some other storage mechanism is used by the deaf for the recoding and retention of information from visual sensory memory was tested. The use of the forced-choice technique developed by Estes to estimate the span of apprehension allowed indirect evidence, about the storage mechanism being used, to be obtained via manipulation of the selection of noise letters, i.e., different sets of noise letters were selected which maximized a certain type of confusion with the signal letters. Noise letters were selected on the basis of their auditory similarity, graphic similarity, and fingerspelling similarity to the signal letters used in the auditory confusion condition, the visual confusion condition, and the manual-motor confusion condition, respectively. Comparison of the performance of deaf and hearing subjects on these confusion conditions with their performance on a random noise (random confusion) condition allowed assessment of whether any or all of three possible storage mechanisms (auditory, visual, and manual-motor) were being used. Only one information condition, matrix size 6, was used.

METHOD

Subjects and Materials

The same subjects, tachistoscope, fixation field, and exposure duration used in Experiments I and II were used in Experiment III. Four new sets of 32 stimulus displays each were constructed. For the auditory confusion condition (Condition A), each array contained one of two signal letters (B or P); each letter appeared once in each of the 16 possible matrix positions, yielding a total of 16 B arrays and 16 P arrays. A signal letter was first located at one of the 16 possible positions and then five consonant letters were selected randomly without replacement from a six element pool (C, D, E, T, V, and Z) and randomly allocated to five of the fifteen remaining positions in each matrix. The same construction procedure was used for the other three sets of 32 stimulus displays except that different letters were used for each set. For the visual confusion condition (Condition V), the signal letters were C and R and the noise letters were B, D, G, Q, P, U. For the manual-motor confusion condition (Condition M), the signal letters were N and X, and the noise letters were A, C, E, O, S, and T. For the random confusion condition (Condition R), the signal letters were D and H, and the noise letters were A, T, N, S, Y, and Z.

Procedure

Each subject was given a standard set of written instructions and a response booklet. The subjects were instructed to indicate which of the signal letters appeared on each trial by circling the appropriate letter in the response booklet. Practice trials were given to habituate the subject to the task and to assure that the subject understood the instructions. During the practice trials, the subject was presented with four randomly selected blocks of 10 trials, each block drawn from a separate confusion condition with the restriction of an equal occurrence of the critical elements (five each). After the practice trials each subject was allowed to rest for two min. before the experimental trial blocks began. Each subject then viewed four sets of two 10-trial blocks, each separated by a two min. rest period. Order of presentation of the confusion condition was randomized within subjects. Each subject received a different randomization of stimulus displays. The intertrial interval varied with the individual subject's response rate, but an average of approximately one trial every 15 sec. was maintained. A 30 sec. rest was given after each block of 10 trials.

RESULTS AND DISCUSSION

The basic data was the mean probability of correct recognition (Pc) by each group for each of the four confusion conditions. These data are presented in Table 6. Analysis of variance revealed a significant effect for confusion condition /$F(2,60) = 26.90$, $p < .01$/ but no significant effect for groups or the groups X confusion condition interaction. Newman-Keuls multiple comparison tests ($p < .01$) revealed significant differences as follows: Pc Condition M = Pc Condition R > Pc Condition A > Pc Condition V.

This pattern of results indicates that the performance, and, thus, the size of the span of apprehension of the deaf and the hearing subjects decreased under both the auditory confusion condition and the visual confusion condition. These interference effects indicate that both an auditory information storage mechanism and a visual information storage mechanism are involved in the recoding and retention of information from visual sensory memory.

Experiment IV

The most likely candidate for a coding process in the deaf still seemed to be through motor channels since they are the best functional analogue of the vocal mechanisms. The previous study, and ones by Locke (1969) and Putnam, Iscoe and Young (1962) gave some indication that if deaf subjects did code letters manually, such a process would

TABLE 6

The Mean Probability of Correct Recognitions As a Function of Group and Confusion Condition

Group	Confusion Condition: Visual	Auditory	Manual-motor	Random
Deaf	.763	.847	.966	.944
Hearing	.747	.819	.900	.916

be difficult to discover experimentally. As in studies of articulatory and auditory coding in hearing subjects, the present study attempted to cause confusion by having subjects try to recognize which of a set of "similar" items were the items they were supposed to remember. We attempted to get deaf subjects to generalize from, say, a letter to a number, both of which have identical manual signs.

METHOD

Materials

A master list of letters and numbers was constructed with the requirement that in themanual alphabet and number system for every letter, there was a number that was made in a similar fashion. The pairs were as follows:

A	10
B	4
D	8, 1
F	9
V	2
W	6

A set of unrelated control pairs was also constructed:

J	12
P	1
T	5
G	3
M	11
R	7

Procedure

Subjects were required to learn a list of letters, say A, B, D, G, M, R mixed with numbers, 9, 2, 6, 12, 1, 5. At a later time, they were given all the letters and numbers in the list above and told to circle the ones they had just learned. (Actually, the subject's were also given some letters and numbers which made the list longer and had no related items. These control items appeared in both learning and recognition lists, but their recognition frequencies are not shown because they were the same as those for "original items.")

The lists were designed so that half the subjects learned half the letters and numbers, and the rest of the subjects learned the other half. All subjects were given the same test list with all the letters and numbers from which to choose the ones they had learned.

The 12 letters and numbers of the initial list were presented on 2 X 2 slides, with the individual items displayed one-at-a-time for 1 sec. each. The order of presentation was randomly determined and was different for each group of subjects. Subjects viewed the list only once. Then they were given a sheet of paper with all the letters and numbers listed in two columns (each subject in a group had a different random order of items on the page) and were instructed to circle the letters and numbers they saw on the screen.

Instructions for the task were printed on the top page of the response booklet. Subjects were given time to read the instructions and the opportunity to ask questions.

Subjects

Deaf subjects were 24 high school students and 16 ten to twelve-yr. olds at the Louisiana State School for the Deaf. All participants had an IQ in the normal range, prelingual and severe hearing loss. A control group of 24 high school students with normal hearing also participated in the experiment.

RESULTS

The critical measure was the number and kinds of errors the deaf subjects made on the recognition task compared to the control subjects. Table 7 shows the mean number of correct and erroneous responses made by all subjects.

It is obvious from the table that no statistics were necessary. The deaf and hearing subjects made almost the same kinds of errors. Once again there is no evidence whatsoever that the deaf rely on manual coding to remember written or printed material. It may be that manual signs are so discrete and discontinuous that it would be impossible to induce confusion among the items. Whatever the explanation, there seems to be good reason to try a new method of attack or to try to find other processes which might be involved in the deaf's coding.

TABLE 7

Mean Frequency of Correct Responses and Errors Made by Deaf and Hearing Subjects on Recognition Task

	Original Items		Related Items		Control Items	
	Letters	Numbers	Letters	Numbers	Letters	Numbers
LSSD H.S. (N = 24)	2.0	2.0	.3	.2	.2	.3
LSSD Elem. (N = 16)	2.3	1.8	.3	.3	.3	.4
Hearing H.S. (N = 24)	2.0	2.3	.4	.3	.2	.3

5. In general, congenitally deaf children have great difficulty in learning to read. As yet, the specific causes of their difficulty have not been isolated. This failure has been due, in part, to our lack of knowledge about the skills involved in reading. Recently, Gibson (1969, pp. 433-434) has described four separate skills that are mastered by normal children in learning to read: (1) learning to discriminate the auditory-vocal symbols used in spoken communication; (2) learning to discriminate the visual symbols used in written communication; (3) learning the correspondence between specific visual symbols and specific auditory-vocal symbols; (4) learning the higher order relationships between certain visual symbols.

Obviously, the deaf child never masters the first of these skills. This failure is of primary importance in understanding the difficulty the congenitally deaf child has in learning to read. Not only does he fail to learn to discriminate the auditory-vocal symbols used in spoken communication, he also fails to acquire a basic language competence as shown by Furth (1966) and Odom and Blanton (1970).

Nevertheless, deaf children do learn to read, even if at a much lower level of achievement than that attained by normal children. How they learn to read in the face of this inability to master the first skill described in Gibson's analysis is not known, but it is likely that they are able to substitute some equivalent skill, e.g., learning to discriminate visual symbols instead of auditory-vocal symbols. These visual symbols may be derived from several sources: spoken communication (lipreading), manual communication (Sign and fingerspelling), and written communication (reading). But whatever their source, some perceptual learning process must underlie the discrimination of visual symbols.

This visual perceptual learning process is the central focus of this study. Specifically, the type of learning used by deaf children in learning to discriminate the graphic visual symbols used in written communication is studied. A match-to-sample perceptual learning and transfer procedure is used to test the relative reliance of deaf children on two alternative processes of perceptual learning: prototypic learning (Solley & Murphy, 1960) which assumes that sensory input is matched to stored memory models, and distinctive feature learning (Gibson, 1969) which assumes that distinctive features that distinguish one stimulus array from another are detected. Evidence for both prototypic and distinctive feature learning has been reported by Pick (1965) for normal children. Distinctive feature learning has been found to be superior to prototypic learning except in conditions that were highly conducive to memory prototypes.

In the present study, deaf first grade children were assigned to three transfer conditions following a training task that was comparable for all subjects. One of the transfer conditions was designed to facilitate performance if the training experience had resulted in prototypic learning. A second transfer condition was designed to facilitate performance if the training experience had resulted in distinctive feature learning. The control condition was designed so that it would not facilitate performance if the training resulted in either prototypic learning or distinctive feature learning.

METHOD

Subjects

Eighteen subjects were selected from the population of deaf first grade children at the Tennessee School for the Deaf. Six subjects were assigned to each of three transfer conditions. Each transfer condition group contained an approximately equal number of boys and girls. The mean chronological ages of the group of subjects assigned to the separate transfer conditions did not differ significantly. The range of mean chronological ages of the transfer condition groups was ten years four months, to ten years eleven months.

Materials

The stimuli were the letter-like forms used by Pick (1965). Each stimulus was a black outline, approximately 1 X 1 in., drawn on a white background. Each form was centered inside a 2 X 2 in. glass slide mount.

There were six sets of nine stimuli each, with each set containing three copies of a standard form and six different transformations of that standard. The standard forms used in the six sets differed from one another, while the stimulus representatives of the transformations were the same. Each of the transformation stimuli differed from the standard stimulus in one of the following ways: (1) one straight line changed to a curve, (2) two straight lines changed to curves, (3) a 25 per cent size increase, (4) left-right reversal, (5) a 45° rotation, and (6) a perspective shift equivalent to a 45° backward tilt. The stimuli were presented on a wooden stand, slanting at approximately a 45° angle.

Procedure

Each subject came to the testing room individually and was seated at a small table. In order to familiarize the subject with the general procedure to be used in the experimental task, a brief task using real letters as stimuli was presented. The subject was required to identify the copies of two standard letters from an array of 10 comparison letters, which included two copies of each standard and six different letters. No errors were made in this task.

Following the warm-up procedure, the experimenter began the training phase. Each training trial began by the experimenter turning the stimulus array stand to face the subject. On each trial the stand held 18 stimuli. Three different standard forms were adjacent to one another and centered on the top row of the stand. Below the standard stimuli were three rows, each of which contained five comparison stimuli. The comparison stimuli for both training and transfer consisted of two copies and three transformations of each of the standard forms. The assignment of the comparison stimuli to the fifteen possible positions adhered to the following restrictions: (a) two copies of each standard did not appear within the same row, (b) only one comparison (either copy or transformation) stimulus for each standard appeared in each column, (c) comparisons for a specific standard did not occupy adjacent positions (either horizontal or vertical).

Sign was used to instruct the subject to point to only those comparison stimuli that were exactly like the standards and to inform the experimenter when selections were completed. Each trial began with the presentation of the stimulus array and terminated when the subject informed the experimenter that he had completed his selections. After termination of a trial the experimenter turned the stand and replaced the stimuli according to a predetermined schedule that was designed to prevent position learning. During all trials except the first, the experimenter provided feedback following the subject's choices. For correct choices the experimenter signed, "Good"; for incorrect choices the experimenter signed, "No, not same top. Find same top." After each choice, the experimenter took the selected comparison stimulus off of the stand, held it next to its standard, and then provided feedback. This procedure was continued until the subject reached a criterion of one perfect trial, i.e., selected only the copies of each standard.

Immediately after the criterion trial of training was completed, two transfer trials were given. The general procedure during transfer was the same as that followed in training, except that no feedback was given. Throughout the training and transfer phases both errors and latencies were recorded. Errors consisted of both the selection of a transformation stimulus and the failure to select a copy of the standard. On each trial the latency from the beginning of each trial to the subject's first selection response was measured by means of a stop watch.

The stimuli employed in the transfer phase differed in certain ways from those employed in the training phase and determined the three experimental conditions. In the prototype condition the standards were the same as those presented during training but the transformations were different. The distinctive feature condition provided new standards but the same transformations used during training were applied to the new standards. Unlike the prototype condition in which the subjects saw some stimuli (the standards) that they had seen previously in training, the distinctive feature condition employed all new stimuli. The control group also received all new stimuli, however, the transformations applied to the new standards were different from those employed in training.

To control for possible differences in the discriminability of particular stimulus combinations, at least one subject and no more than two subjects in each transfer group was assigned to each of the four stimulus combinations described by Pick (1965, p. 334). This assignment occurred prior to the training phase.

RESULTS

Training

To assess differences in the training performance of subjects assigned to the transfer conditions, separate analyses of variance were performed on each of three dependent measures: errors to criterion, trials to criterion, and latencies of first choice response on each presentation trial. No significant differences between transfer conditions were found for performance on any dependent measure.

Transfer

The mean number of errors made by the deaf subjects in each transfer condition are presented in Table 8 along with the mean number of errors made by the normal subjects in each transfer condition as derived from data reported by Pick (1965). Subjects in the distinctive feature condition made the fewest number of errors, while subjects in the control condition made the greatest number of errors. Analysis of variance and subsequent multiple comparisons tests (Winer, 1962, p. 62) applied to the transfer errors revealed a significant difference between the distinctive feature condition and the control condition [$F(1,15) = 4.73$, $p < .05$] but not between the prototype condition and the control condition.

Analysis of variance applied to the first choice response latencies obtained during transfer presentations revealed no significant differences between transfer conditions.

TABLE 8

The Mean Number of Errors Made by Subjects in Each Transfer Condition

	Control	Prototype	Distinctive Feature
Deaf	3.33	1.66	.83
Normal*	5.05	3.45	1.95

* based upon data reported by Pick (1965, Experiment 1).

DISCUSSION

As expected, no significant effects for any of the dependent measures obtained during training were obtained. This indicates that no differences existed in original learning among the three subgroups that were assigned to the various transfer conditions. Since Pick (1965) does not report the number of errors made during training by her normal subjects it is not possible to compare their performance with that of the congenitally deaf subjects used in the present study.

However, comparison of the mean number of errors made during transfer by the deaf subjects used in the present experiment with the mean number of errors made by normal subjects during transfer in Pick's first experiment reveals that the deaf subjects made fewer errors (see Table 8). Most likely, this is due to the difference in level of general visual experience between the two subject populations: the present study used subjects who were approximately 10 years old, while Pick used subjects who were approximately five years old. Results reported by Gibson, Gibson, Pick, and Osser (1962) support this explanation. They found that eight year old children are superior to four year old children in making visual discriminations among these stimuli.

The smaller number of errors made during transfer by the distinctive feature group is consistent with Pick's conclusion (1965, p. 339) that distinctive feature learning is basic to visual perceptual learning. Evidently, both congenitally deaf children and normal children rely primarily upon distinctive feature learning.

This finding has implications for the type of training technique that should be used in teaching the deaf child. Training techniques which are based upon the simultaneous comparison of visual arrays should yield the best results, i.e., be most conducive to distinctive feature detection, and thus to perceptual learning. Whether this is true only for stable visual arrays, e.g., letters, and is not true for changing visual arrays, e.g., lipreading, Sign, fingerspelling, is not known. Further research is needed on this question.

Furthermore, it may be that the specific set of visual symbols learned by the deaf child influences the latter three reading skills described by Gibson (1969), and, thus, reading performance. Evidence for such an influence has been reported by Odom and Blanton (1970). They found that the reading performance of deaf children improved if the reading material conformed to Sign grammar rather than to English grammar. However, little is known about whether learning certain sets of visual symbols rather than others facilitates later reading performance. Research is needed on this question also.

SUMMARY

The deaf child learns visual symbols instead of the auditory-vocal symbols learned by normal children. To test whether these visual symbols are learned by a prototypic or distinctive feature perceptual learning process, a match-to-sample perceptual learning and transfer procedure was used with deaf first-grade children. Evidence for distinctive feature learning was found. The implications of this result for reading are discussed.

6. A study published under the auspices of a previous grant (RD-1479, Odom and Blanton, 1967b) found that, while the deaf and hearing subjects could remember and extract rules similarly from serially presented letters, the hearing subjects' performance was superior when the task involved recognition of uncodable nonsense forms. One of the hypothesis we thought could account for this interesting result supposed an inability on the part of the deaf to transfer a time-dependent rule (like remembering which form came first and which came second) to a left-right, spatial response. The reason why this explanation was a candidate involved a superficial analysis of reading behavior which relies on a correspondence between time-dependent events (language) and spatial events (printed language). The deaf have had little experience with this correspondence since their language and written English are quite unlike each other.

We chose to check this explanation by replicating part of the original study using nonsense forms and adding a condition in which memory for the material was tested in the same form as it was presented, either simultaneously (SIM) or successively (SUC). The resulting design contained four conditions: training with stimuli presented in either simultaneous or successive manner and testing with items presented in either simultaneous or successive order.

The test items were presented by a Carousel projector for two sec. each for the simultaneous recognition items and for one sec. each for the members of the successive recognition items.

Eight deaf subjects participated in each of the four conditions. They were all between the ages of 15 and 19 years. They participated in groups of four. The instructions for the four recognition test conditions were as follows:

Simultaneous Training-Simultaneous Testing

Now you will see more pairs of shapes on the screen. Some you have seen before; some you have not seen before. Look at each pair. If you have seen it before circle YES. Circle YES for only those pairs EXACTLY LIKE THE ONES YOU SAW BEFORE.

If it is a new pair or you have not seen it before, circle NO.

Simultaneous Training-Successive Testing

Now you will see more pairs of shapes on the screen. Some you have seen before. Some you have not seen before. This time, the two shapes (in a pair) will not be side-by-side. Instead the left shape will come first; the right shape will come second.

Look at each pair. If you have seen it before, circle YES on the paper. Circle YES for only those pairs EXACTLY LIKE THE PAIRS YOU SAW BEFORE. If it is a new pair, a pair you have not seen before, circle NO.

Successive Training-Simultaneous Testing

Now you will see more pairs of shapes on the screen. Some you have seen before. Some you have not seen before. This time, the two shapes (in a pair) will be side-by-side. Look at each pair. If you have seen it before, circle YES on the paper. Circle YES for only those pairs EXACTLY LIKE THE PAIRS YOU SAW BEFORE.

If it is a new pair, a pair you have not seen before, circle NO.

Successive Training-Successive Testing

Now you will see more pairs of shapes on the screen. Some you have seen before; some you have not seen before. Look at each pair. If you have seen it before circle YES. Circle YES for only those pairs EXACTLY LIKE THE ONES YOU SAW BEFORE.

If it is a new pair or you have not seen it before, circle NO.

The mean number of correctly recognized items is shown in Table 9. Means from the previous experiment (Odom and Blanton, 1967b) are shown in parenthesis. (The number possible was greater in the previous experiment, so the means are larger; the relationship is the same).

TABLE 9

Mean Number of Correctly Recognized Items (out of 10 Possible)

Training Condition	Test Condition	
	Simultaneous	Successive
Simultaneous	8.1 (15.4)	7.6 (14.6)
Successive	8.1	7.4

Most of the interesting results in the previous experiment involved the types of errors. The means for the four kinds of errors tested by the recognition task are shown in Table 10. Again, the approximate numbers from the previous study are given in parenthesis.

TABLE 10

Mean Numbers of Incorrectly Recognized Letter Pairs

Training-Test	Systematic	Error Reversed Systematic	Reversed Training
Simultaneous-Simultaneous	8.0 (3.5)	3.1	4.0 (1.0)
Simultaneous-Successive	6.9	3.8	4.9
Successive-Simultaneous	7.9 (3.4)	3.6	2.9 (2.7)
Successive-Successive	6.0	4.9	4.8

It is obvious from Table 10 that the errors that occurred in the previous study did not follow the same pattern in the present study namely, the low number of reversals on the training pairs (1.0) in the SIM-SIM condition and the higher number in the SUC-SIM condition (2.7). Whatever conclusions were made in the previous study were made on the basis of inconsistent, nonreliable data, and should not be given much consideration. While it may be the case that subjects are aided in some of their general cognitive abilities by having a temporal-spatial correspondence between verbal and written language, we have no data that would indicate it.

7. Our initial thinking about reading and coding in the deaf included some informal hypothesis about what process might compensate for an inability to verbalize words. That is, if pronunciability has a facilitative effect in word recall for hearing subjects, could there be an analogous variable operating to the advantage of deaf subjects? This question was, in part, prompted by the many occasions in which deaf and hearing subjects performed equivalently in verbal learning tasks. /It was also conceived prior to the serious doubts questioning the facilitative effects of pronunciability (see Blanton & Odom , 1968)./ One candidate for this role was word discriminability or "orthographic distinctiveness." This construct has been extensively investigated by Zechmeister (1969) who found a negative correlation between pronunciability ratings and rated orthographic distinctiveness of low-frequency words. He also found that orthographic distinctiveness was directly related to number of lower case letters which protruded above or below the "body" of the word.

If the deaf could use "orthographic distinctiveness" more effectively as a cue in recognition of printed words than hearing subjects, the effect should appear in a memory task. The experiment reported below compared deaf and hearing subjects on recall of paired-associate items varying in distinctiveness and pronunciability.

With such a design, an interaction was predicted with the hearing subjects performing better on the high pronounceable items than the low but the deaf differing on the distinctiveness variable. The first section reports the assemblance of materials. Intuitively, investigating the effects of orthographic distinctiveness by using real words seemed to complicate the issue unduly, since real words have unique properties that are not yet clearly understood. Consequently, four-letter nonsense words were used, e.g., abba. These, of course, had to be scaled for distinctiveness and pronunciability. The second section is concerned with the actual learning task.

METHOD

Materials

Eighty-eight 4-letter nonsense words (tetragrams) were generated by the authors. These were typed onto 3 X 5 cards which fitted into a two-channel tachistoscope (Scientific Prototype, Model 800-E). The distinctiveness task consisted of obtaining recognition times for the tetragrams from 12 graduate students each of whom viewed half the items, one-at-a-time. An item was exposed for increasing amounts of time until the subject correctly identified all letters. The mean recognition times for each of the 88 items is given in Appendix A .

The tetragrams were also given to 28 undergraduates to rate on ease of pronunciation. The rating task was administered in two classrooms. It was untimed but subjects were urged to "work straight through the list" until finished. The scale had five points on it and is reproduced below:

	ALMOST IMPOSSIBLE TO PRONOUNCE	FAIRLY HARD TO PRONOUNCE	NEITHER HARD NOR EASY TO PRONOUNCE	FAIRLY EASY TO PRONOUNCE	VERY EASY TO PRONOUNCE
Hard:	____ 1	____ 2	____ 3	____ 4	____ 5 : Easy

The scale descriptions only appeared at the top of each of the three pages. The tetragram was printed above each item. Subjects were instructed to "look at each word and try to say it to yourself. Make a decision as to how easy it is to pronounce. Then put a check in the blank beside each word which best describes how easy the word was to pronounce for you. Check the far left-hand blank if the words would be almost impossible to pronounce; the far right-hand blank if you feel the word would be very easy to pronounce. Check one of the middle blanks if you think one of them best applies to the word. The labels for the five blanks are at the top of the page. Be sure to look at them before you rate each word so that you won't get confused."

The mean ratings on pronunciability for the 88 items is also included in Appendix B . The most difficult tetragram to pronounce was zqqz with a mean rating of 1.18; the easiest to pronounce were keek and ommo each with a mean rating of 4.96.

Learning Task

From this list of items with pronunciability and distinctiveness measures it was possible to designate six words in each of the four categories: high distinctive-high pronunciability (HD-HP), high distinctive-low pronunciability (HD-LP), low distinctive-high pronunciability (LD-HP), and low distinctive-low pronunciability (LD-LP). These items are shown below in Table 11. Three of each sixsome were arbitrarily assigned to list I, the rest to list II. A number between 1 and 12 was randomly assigned to each tetragram in both lists and was designated the stimulus. The number-tetragram pairs were typed on individual cards using only lower case letters on an IBM directory typewriter. These cards were subsequently photographed and the transparencies were made into 2 X 2 slides.

The subjects, participating in small groups of four, were given 10 study-test trials on one list or the other (half of the subjects saw each list). Pairs were presented at a 1 1/2 sec. rate in a different random order on each trial. At the end of a trial subjects wrote the response items (tetragrams) in booklets which had one trial represented on each page. The numbers 1-12 were listed in a random order down the left hand side of the pages. There was a line beside each number for subjects to write their responses on. Two minutes were allowed after each presentation of the list for subjects to respond.

Subjects

Subjects were 40 deaf students at the Tennessee School for the Deaf and 40 hearing subjects from a local elementary school. The mean age for the deaf subjects was 16.0; for the hearing subjects, 10.4. Younger hearing subjects were used as a control for reading achievement which was approximately at fifth grade level for both groups. Only prelingually and severely deaf students participated.

RESULTS

A 2 (hearing status) X 2 (distinctiveness) X 2 (pronunciability) X 10 (trials) analysis of variance was performed on the number correctly recalled responses. The following main effects were significant with a probability of less than .05: trials [F(9,702 = 150.6], pronunciability [F(1,78 = 68.04], and distinctivess [F(1,78) = 112.4]. The mean number correct associated with each of these is shown in Table 12.

TABLE 11

Lists of Items Used in Pronunciability-
Distinctiveness Experiment

	List I	List II
Hi-Distinguishable & Lo-Pronounceable	tddt	fkkf
	rppr	dlld
	fccf	txxt
Lo-Distinguishable & Hi-Pronounceable	agga	ommo
	moom	azza
	zeez	gaag
Lo-Distinguishable & Lo-Pronounceable	gqqg	vnnv
	rggr	zggz
	pjjp	pggp
Hi-Distinguishable & Hi-Pronounceable	oyyo	foof
	atta	ullu
	leel	arra

TABLE 12

Means Associated with Significant Main
Effects (summed over trials)

Trials	Means	Pronunciability	Distinctiveness
1	1.68	High--29.3	High--28.8
2	2.71		
3	3.58	Lo--20.2	Lo--20.7
4	4.44		
5	5.05		
6	5.32		
7	5.84		
8	6.50		
9	7.05		
10	7.26		

The general effects of pronunciability, distinctiveness, and better performance as a function of trials were all significant. In addition, a large number of interactions were significant. These included:

(a) groups X trials: The deaf subjects performance improved at a slightly faster rate than the hearing subjects.

(b) trials X pronunciability: At the end of the 10 trials, the low pronounceable items were being recalled slightly better relative to the high pronounceable items than on the first few trials.

(c) group X pronunciability: Pronunciability had a slightly greater effect on performance for the deaf than the hearing. See below G X P X D interaction.

(d) trials X distinctiveness: Both types of items were recalled equally on the first two trials. From then on the performance on the high distinctive items improved at a faster rate than the low distinctive items.

(e) distinctiveness X pronunciability: Pronunciability was a more effective variable when distinctiveness was low than when it was high.

(f) groups X distinctiveness X pronunciability: This interaction is shown in Figure 14 below. For the hearing subjects, pronunciability had the same effect whether the items were high or low in distinctiveness. For the deaf subjects, pronunciability influenced performance more when the items were highly distinctive than when they were low distinctive.

(g) groups X trials X pronunciability: The rate of improvement on the high pronounceable for the hearing subjects was unlike the other three components in that the mean number correct on trials 4 through 7 was approximately the same. The other three components displayed a relatively linear increase with trials.

(h) trials X distinctiveness X pronunciability: The disparity between performance on high and low pronounceable items increased at a greater rate when distinctiveness was low than when it was high.

DISCUSSION

The reader may recall that an effect in performance due to pronunciability was predicted for the hearing but not the deaf. On the other hand, the deaf should have been more sensitive to physical distinctiveness than the hearing subjects. These predictions were only partly fulfilled. The deaf's performance was affected by pronunciability. Interestingly enough, this effect was exhibited primarily when the items were composed of letters that were difficult to

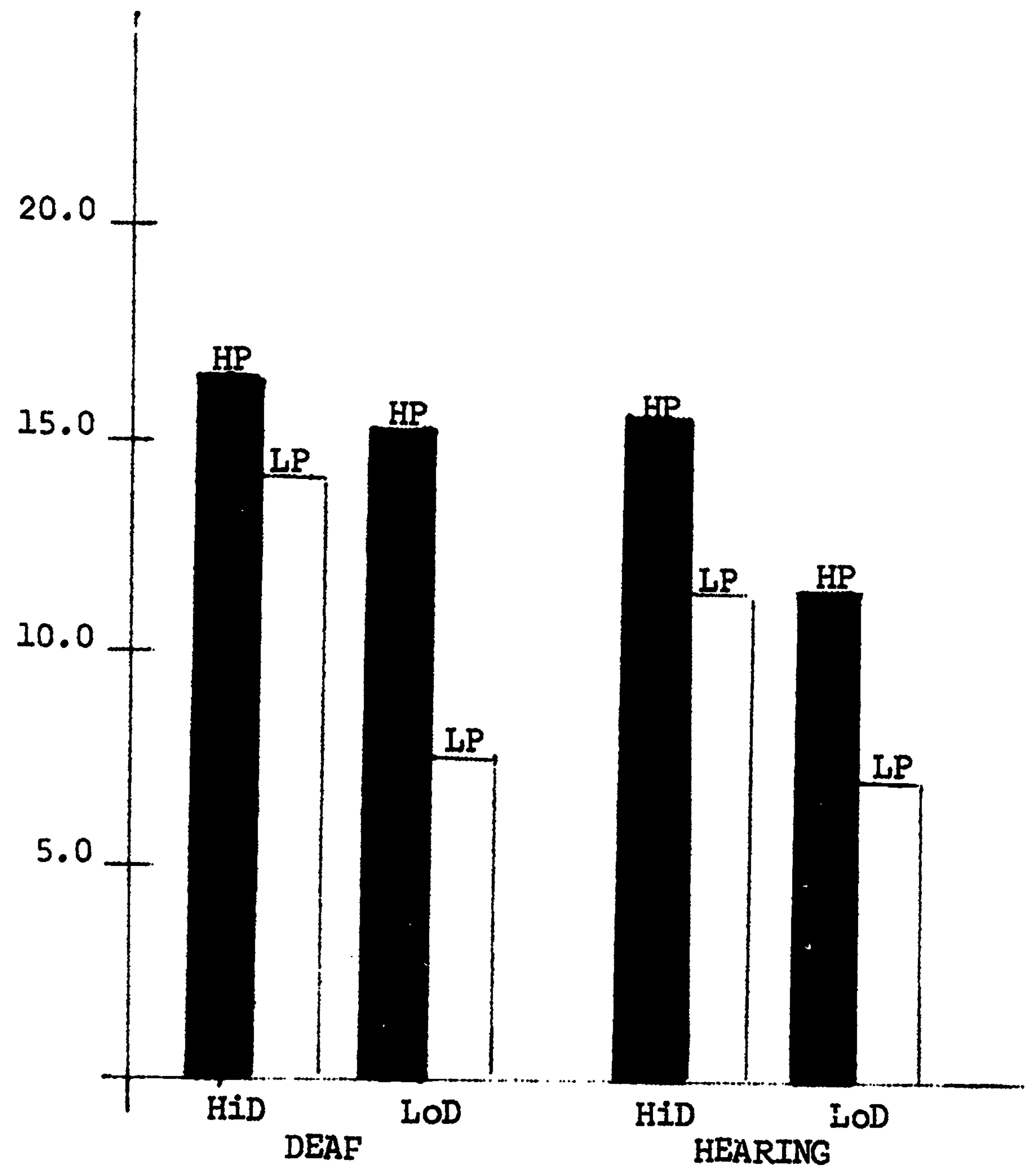


Fig. 14. Relationship between hearing status, pronunciability and distinctiveness.

distinguish. Perhaps when physical dimensions interfered with coding, some (or all) of the deaf relied on articulatory cues and attempted to pronounce the items.

There are a couple of other possible factors involved in this result, however. In the first place, some of the deaf subjects may have attempted to code the items by fingerspelling. Since relationships between fingerspelling variables and pronunciability are completely unexplored, it's impossible to predict how such dimensions would operate in the present experiment.

A second factor that could help explain these rather unexpected results on the part of the deaf is a finding by Gibson, 1968. She found evidence that the deaf utilize spelling patterns to facilitate recognition of English-like words. Since English spelling patterns are highly correlated with pronunciability, perhaps the deaf's elevated performance on the high pronounceable, low distinguishable items occurred because the items conformed to some rather frequent spelling patterns.

The performance of the hearing subjects, on the other hand, was significantly affected by the distinctiveness of the items, but equally so under conditions of high and low pronunciability. Pronunciability was also a significant factor in their performance, as expected. It appears that hearing subjects find it easier to perceive and encode high distinctiveness items, and to remember those which are easier to pronounce than those which are not.

8. Coding Medium and Word Recall by Deaf and Hearing Subjects.*

In determining a language medium to use in the education of the deaf, initial attempts should be guided by two factors; the degree to which a system approximates normal language acquisition and the efficiency of the proposed system. Recently, there has been increased interest in fingerspelling as the fundamental means of communication. This technique has some of the properties of an auditory vocal language in that the number of units in both (letters in fingerspelling and sounds in language) are limited, and larger units are composed of different combinations of the repeating letters or sounds. Fingerspelling is at a disadvantage when compared with natural signs, however, in terms of efficiency. A single sign for a word is faster and simpler to perform than several movements, as used in fingerspelling. A hearing person can understand this by having someone audibly spell an entire sentence. The sentence would be incomprehensible were it not for complete words into which the listener groups the letters as the speaker spells. The present experiment attempted to test the supposition that words are easier to remember when they can be coded into single distinctive units, rather than spelled out. Related effects have been noted by Brown and Lenneberg (1954) and Lantz (1963) for colors and by Glanzer and Clark (1963) for arrays of familiar forms.

We compared deaf and hearing subjects' recall of words which did or did not have sign equivalents, i.e., some words had to be coded by fingerspelling and others could be expressed by a single sign. It seemed reasonable that the deaf would recall the signable words more readily than the unsignable words. There should be no differential recall for comparable hearing subjects.

METHOD

Subjects

The subjects were 40 deaf students--20 male and 20 female from the Tennessee School for the Deaf--and 40 hearing subjects from a local elementary school. The average reading achievement grade equivalent for the deaf subjects was 5.0 (range: 4.0-6.3) and their mean age was 16 years. For these subjects, a combination of fingerspelling and sign language had been the prime method of communication. All were deafened before age two and had a hearing loss of 80 dB or more in their better ears. The hearing subjects had a mean age of 10.4 years (younger hearing subjects were selected as a control for reading achievement grade equivalent). No subject with an IQ below 80 was included.

Materials and Procedure

Sixteen five- to nine-letter words served as stimuli in the experiment. Eight words had sign equivalents (S words); eight did not, as determined by a dictionary of signs (Stokoe, Casterline, Croneberg, 1965) and the opinion of two interpreters. The latter words were designated UNS words. Both sets of words (shown in Table 13) were matched on (a) word length and (b) word frequency by means of the Thorndike-Lorge "G-count."

Subjects were divided into groups of four (two males and two females). Each subject was given a response booklet with the instructions (including examples) printed on the front page. The instructions said that words would appear on the screen, and beside each word would be a number. Subjects were to remember which word went with which number. The experiment consisted of eight study-test trials administered at one session. The response booklet contained eight pages (plus instructions) with the digits from one to sixteen in two columns down each page. Beside each digit was a line on which the subjects were required to write the word corresponding to the digit. The order of digits was randomly determined with the restriction that it was not the same for any two subjects in a group on a given trial, nor was it the same order as the presentation order on a given trial.

The words were presented individually for 1 1/2 sec. each by a Carousel slide projector, automatically paced by a Flexipulse timer. There were eight randomizations of the sixteen words, one for each of the eight trials. After each presentation trial, 1 1/2 min. were allowed for recall.

TABLE 13

Recall Accuracy of S and UNS Words

Words	Mean Number of Times Correctly Recalled per S	
	Hearing	Deaf
Signable		
earth	5.52	6.50
travel	3.05	4.20
people	4.28	4.85
future	2.30	3.32
control	2.65	4.25
success	1.38	3.20
mountain	2.68	5.30
important	2.80	4.48
Unsignable		
steam	5.48	6.20
harvest	4.40	3.60
modern	2.42	3.12
energy	1.85	2.48
material	1.52	3.10
special	0.98	2.98
engineer	2.18	2.08
condition	2.88	3.75

RESULTS AND DISCUSSION

The response sheets were scored in terms of words correctly recalled. Two scorings were made of the response sheets--one in which only correct spellings of a word were counted and one in which a more lenient criterion was used. Both counts yielded similar results. The statistics discussed in this section are from the analysis of correctly-spelled responses, but the inferences are appropriate to both scoring procedures. The mean number of correct responses by groups, conditions and trials are shown in Figure 15.

An analysis of variance on these data yielded significantly better overall recall by the deaf subjects [$F(1,78) = 12.81$, $p < 0.01$], a significant advantage associated with the S words [$F(1,78) = 587.0$, $p < 0.01$] and a significant increase in recall with trials [$F(7,546) = 241.6$, $p < 0.01$]. The most interesting interaction, that between hearing status and codability, was also significant [$F(1,78) = 162.5$, $p < 0.01$], indicating that there was a larger difference between S and UNS recall for the deaf than for the hearing.

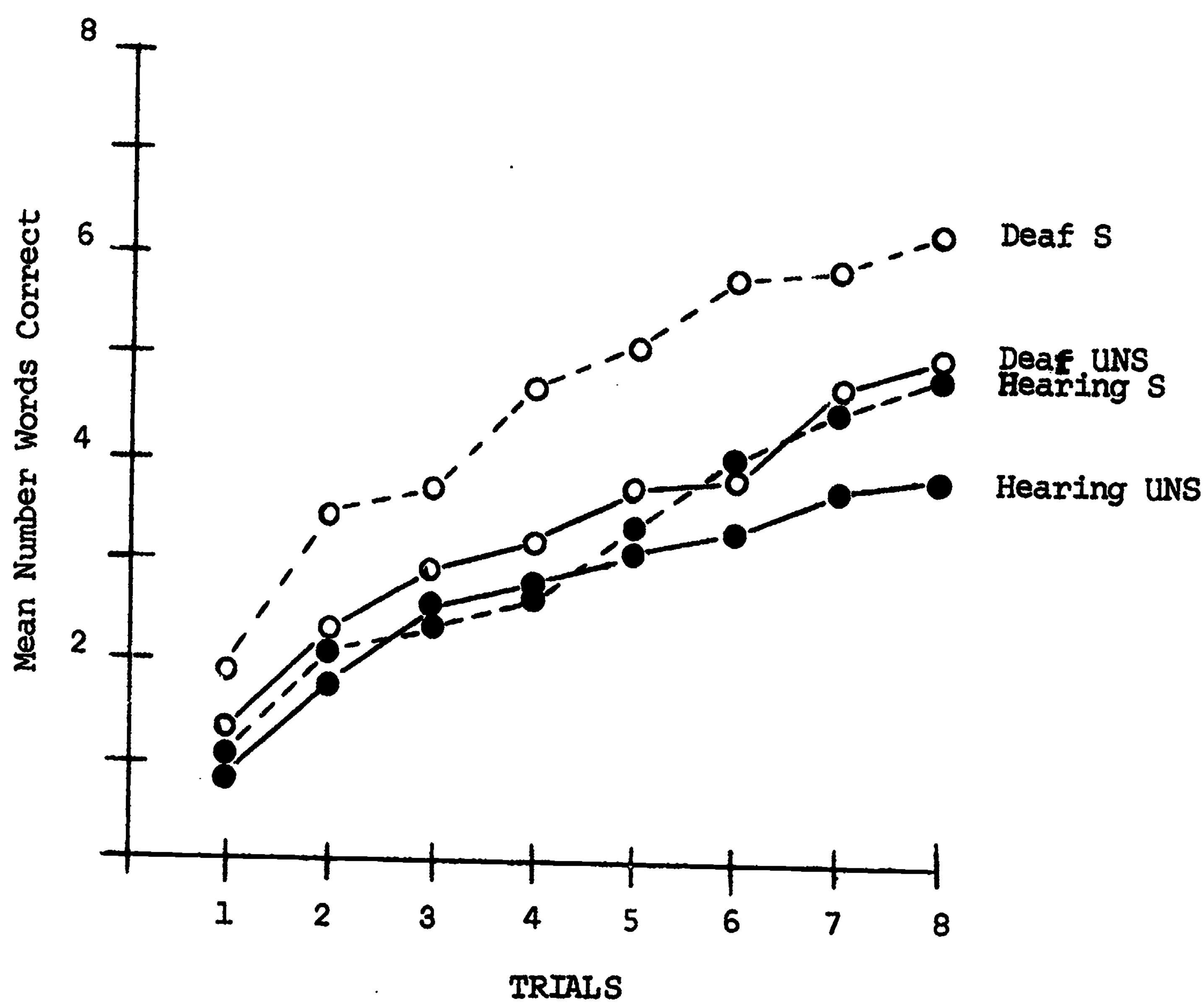


Figure 15. Mean numbers of signable and unsignable words recalled by deaf and hearing subjects.

This study, although limited in scope, demonstrated the importance of a coding system which reduces the number of units necessary to store and retrieve from memory a certain piece of information. Deaf subjects presumably access the visual image of the word in memory more readily with one motor-encoding (a sign) response than with a series of fingerspelling responses or with an association to the appropriate digit on the response list. A sign response would be expected to serve the deaf subjects in much the same way as pronunciation responses serve hearing subjects as additional means to access verbal memory. The relatively more comparable performance of the hearing on both lists could be explained by such a dual response theory. It is difficult in this case, as in previous studies (Putnam, Iscoe, Young, 1962), to account for the superior recall performance of the deaf. Four hypotheses may be offered: (1) Hearing subjects with large vocabularies have more interresponse interference. (2) Pronunciation responses involve phonetic similarity variables which produce more interference due to response competition with the hearing. (3) Motor signs are especially powerful memory access codes. (4) Matching the deaf and hearing subjects on reading (especially on vocabulary) does not match them on mnemonic skills for words; the age differential may play a role in such skills. While strong arguments can be marshalled against (2), the others remain only as interesting possibilities for further research.

The superior recall performance of the deaf on words with sign equivalents suggests that the expansion of the vocabulary of signs in common use would be helpful to deaf persons who communicate primarily by manual language. The extent to which such an expanded vocabulary would be of value in reading is a question which also requires further study.

9. The Influence of Auditory Loss on Secondary Organization during Free Recall: An Initial Investigation.

How deafness influences organization in memory is not known but such knowledge is of importance since organization is closely related to both storage and retrieval. One of the most successful procedures used to study the influence of organization on memory, free recall, involves the presentation of a list of items to a subject and then subsequently asking him to recall the items contained within the list in any order he chooses. Differences between the orders in which the items were given to the subject and the order in which the subject reports the items during recall are used to determine whether organization influences recall, and if so, what type of organization is involved.

Tulving (1968) distinguishes two types of organization which influence free recall, primary and secondary. Primary organization refers to differences which are not the result of the subject's prior experience with the items in the list. The primacy effect and the recency effect are examples of primary organization. Secondary organization, on the other hand, refers to differences which result from the subject's prior experience with the items in the list. Semantic effects and phonetic effects are examples of secondary organization. Koh, Vernon, and Bailey (1969) have suggested that the lack of an auditory-motor speech system in the deaf may reduce their secondary organization. Thus, it is most likely that any differences observed between the free recall behavior of deaf and hearing individuals would be attributable to differential influences upon secondary organization.

The purpose of the present study was to explore the relative influence of four possible types of secondary organization effects in the free recall performance of both deaf and hearing subjects. In order to do this, subjects were asked to recall words contained within a 30-word list after each of five presentations. Within the list, certain pairs of words were related on the basis of either their semantic, form, homonymic, or rhyming properties. Nonrelated (neutral) pairs of words were included within the list as controls.

METHOD

Subjects

The subjects were 28 pre-lingual deaf students, 13 males and 15 females, selected from the sophomore and junior classes at the Louisana State School for the Deaf (mean age = 16.53 yrs.) and 24 hearing students, 12 males and 12 females, selected from the sophomore and junior classes at the Williamson County High School (mean age = 15.83 yrs.).

Materials

The stimulus materials were 30 words selected on the basis of their Thorndike-Lorge (1944) G-frequency count. Words having a G-frequency count below 37 were selected to form a two-level list in which each of six main categories is divided into three pair subgroupings, e.g., homonyms, foul-fowl. Table 14 contains these words and their respective G-frequency counts.

Procedure

The subjects participated in the experiment in groups of four. Each subject was given a response booklet containing instructions and five response sheets. The instructions informed the subject that 30 words would be projected individually for three sec. each onto a screen before them. Subjects were told to remember as many words as possible and after all 30 words were presented to write (in any order) down as many words as they could remember. Each subject was given three min. in which to make his responses after each of the five separate presentations of the words. The order of the words was counterbalanced within each presentation.

TABLE 14

The Words Used to Form the Recall List and
Their Respective G-Frequencies

Neutral		Form		Semantic		Homonym		Rhyme	
Word	G-frequency	Word	G-frequency	Word	G-frequency	Word	G-frequency	Word	G-frequency
glue	15	comb	19	spin	24	foul	27	cope	10
joke	32	tomb	22	twirl	3	fowl	20	soap	37
ounce	26	bough	27	balm	7	loan	30	hale	7
reed	22	dough	11	salve	3	lone	22	pail	16
vault	17	dense	19	frog	25	slay	21	boot	37
ward	18	lense	7	toad	15	sleigh	7	flute	9

RESULTS AND DISCUSSION

A significant effect for hearing-deaf was observed for both the mean number of words recalled and the mean number of word pairs recalled [$F(1,46) = 4.03$, $p < .05$] and [$F(1,46) = 4.57$, $p < .05$] respectively. These significant effects for hearing-deaf revealed that the free recall performance of the hearing subjects was superior to that of the deaf subjects. A significant effect for trials was observed for both the mean number of words recalled and the mean number of word pairs recalled [$F(4,184) = 392.03$, $p < .001$] and [$F(4,184) = 56.36$, $p < .001$] respectively. This significant effect for trials was expected since it reflects the improvement in performance usually observed for repeated recall trials with the same words. Both the mean number of words recalled and the mean number of word pairs recalled on the five successive trials by the deaf and by the hearing subjects are given in Table 15. A significant hearing-deaf X trials interaction was observed for the mean number of words recalled only [$F(4,184) = 3.28$, $p < .05$]. This significant interaction occurred because although the performance of the deaf and hearing subjects was equivalent on the first trial, the performance of the hearing subjects was superior to that of the deaf subjects on each of the successive trials. This superior performance of the hearing subjects is most likely due to their superior use of secondary organization.

TABLE 15

The Mean Number of Words Recalled and the Mean Number of Word Pairs Recalled on Each Trial by the Deaf and the Hearing Subjects

	Trials					
	1	2	3	4	5	All
Deaf						
Words	1.833	2.808	3.517	3.875	4.417	3.290
Word Pairs	.108	.367	.558	.642	.775	.490
Hearing						
Words	1.875	3.250	3.900	4.367	4.967	3.672
Word Pairs	.267	.500	.742	.792	.925	.645
Both						
Words	1.854	3.029	3.708	4.121	4.692	3.481
Word Pairs	.188	.433	.650	.717	.850	.568

The basic data used to evaluate the relative use of different types of secondary organization was the mean number of words recalled and the mean number of word pairs recalled under each of the five types of pairings (form, semantic, homonym, rhyme, and neutral) by the hearing and by the deaf subjects. Table 16 contains these data. Analysis of variance applied to the mean number of words recalled revealed significant effects for types of pairing [$F(4,184) = 5.33$, $p < .001$] and, for the hearing-deaf X type of pairing interaction [$F(4,184) = 2.43$, $p < .05$]. Analysis of variance applied to the mean number of word pairs recalled revealed significant effects for type of pairing [$F(4,184) = 44.37$, $p < .001$]; and, for the hearing-deaf X type interaction [$F(4,184) = 2.39$, $p < .05$]. The significant effect for type of pairing obtained with both dependent measures revealed differences in the performance of the hearing and of the deaf with the words used within each type of pairing group. The hearing subjects recalled words used in the form type of pairing group most frequently and they recalled word pairs used in the homonymic form, and semantic type of pairing groups most frequently. The deaf subjects recalled words used in the semantic type of pairing groups most frequently and they recalled word pairs used in the homonymics, form, and semantic type of pairing groups most frequently.

Because of the differences in the mean number of words recalled from the various type of pairing groups, the ratio of the mean number of word pairs recalled over the mean number of words recalled was computed. Inspection of these ratios (see Table 17) revealed that both the hearing and the deaf subjects were able to make use of the homonymic, form, and semantic properties of the words. However, the hearing subjects were able to use the homonymic properties to greatest advantage. This pattern of results fits the expectation that the deaf do less well in free recall because of their basic lack of an auditory-motor speech system which is important to secondary organization.

TABLE 16

The Mean Number of Words Recalled and the Mean Number of Word Pairs Recalled for Each Type of Pairing by the Deaf and the Hearing Subjects

	Neutral	Form	Type of Pairing Group Semantic	Homonym	Rhyme	All
Deaf						
Words	3.342	3.425	3.508	3.125	3.050	3.290
Word Pairs	.108	1.083	.500	.658	.100	.490
Hearing						
Words	3.767	4.192	3.542	3.192	3.667	3.672
Word Pairs	.100	1.017	.842	1.033	.233	.645
Both						
Words	3.550	3.810	3.530	3.160	3.350	3.481
Word Pairs	.104	1.050	.671	.846	.167	.568

TABLE 17

The Ratios Obtained for Each Type of Pairing Group by Dividing the Mean Number of Word Pairs Recalled by the Mean Number of Words Recalled

	Neutral	Form	Type of Pairing Group Semantic	Homonym	Rhyme
Deaf	.032	.316	.143	.211	.033
Hearing	.026	.243	.238	.327	.064

10. Like- and Cross-Modality Recognition at Two Levels of Meaningfulness in a Short-Term Memory Task.*

In short-term memory research involving visual and auditory modes of presentation the auditory mode has often been found superior. Loss of efficiency due to modality crossing (auditory encoding of visual input) has been suggested to explain this phenomenon. Since language and audition are both temporal while vision is primarily spatial, an alternative hypothesis is that auditory superiority may result from the use of highly meaningful material in modality experiments. An experiment was performed in which modality combination and meaningfulness were varied independently and found to be highly significant, while interaction between the two was conspicuously absent, thus favoring the first hypothesis. This suggests that modality differences in memory are due to differences in storage, that is, that each sensory mode has its own short-term memory system. The finding has considerable important for language research with the deaf, since the nature of a visual short-term memory system remains a matter for study, and will have an important bearing on the nature of the reading task for the deaf.

One aspect of the recent interest in short-term memory (STM) research has been the evaluation of different modality effects. Prior to the 1930's research in modality effects was mainly concerned with long-term memory and with the pedagogical question as to which modality, visual or auditory, was superior for comprehending, learning and retaining verbal materials. Results of these early studies were equivocal and interest dwindled. Renewed interest in modality effects occurred in conjunction with STM research, with the first report on this subject being published by Broadbent and Gregory in 1961. Since that time there has been an increasing number of reports of research into modality effects in STM, reports which indicate important differences in the processing of information for STM.

In studies by Buschke (1962), Margrain (1967), and Murdock (1966, 1967, 1968) a general superiority of auditory over visual presentation results has been shown. In addition Margrain (1967) and Murdock (1968) have presented evidence suggesting that modality effects are due to differences in storage. Loss of efficiency due to modality crossing (the auditory encoding of visual input, such as that described by Sperling in 1963 and Conrad in 1964) is one possible explanation for this phenomenon. However, since language and audition are both thought to be temporal in nature while vision is primarily spatial, an alternative hypothesis is that the reported auditory superiority may result from the use of only highly meaningful material in modality experiments, verbal material which is better suited to temporal than spatial processing. According to Blanton (1968, p. 3), "Learning language...involves the perception of sequences and the storage of information according to sequential order in the short-term memory of the listener...the hearer must decode the meaningful elements as they occur." When language must be handled through the visual channel it is forced into a mold that is essentially foreign. The visual system best handles information about spatial order or arrangement, allowing simultaneous processing of many stimuli. Because reading is based on language it necessarily is time dependent, but the material is received through the visual modality. There is some evidence that such meaningful visual material must be processed through the auditory system so that its sequential information can be decoded (Sperling, 1963; Conrad, 1964).

In order to test the meaningfulness hypothesis, modality combination and meaningfulness must be varied independently so that obtaining a significant interaction between the two would lend support to the meaningfulness hypothesis. Also the memory task should be one of recognition rather than recall, which has been used in all but two of the studies mentioned above. Recall necessarily involves temporal sequence and would tend to favor the auditory modality. We have been unable to discover any recognition studies of STM in which level of meaningfulness has been reported as a variable.

METHOD

Materials and Procedure

A signal detection (TSD) confidence rating procedure was used, based on recognition memory studies by Murdock (1966, 1968). Materials consisted of serial lists of items representing two different levels of meaningfulness--words and trigrams. The words, the high meaningfulness level (high M) stimuli, were selected from the Thorndike-Lorge lists (1944) to meet the following criteria: (1) they must be among the 20,000 most frequently used words in American English; (2) they must be two syllables and four to eight letters in length; (3) they must be spondees or else have nearly equal syllable stress, with no syllables of tertiary stress; (4) no proper names, homophones, contractions, or archaic words could be included. The trigrams, the low meaningfulness (low M) stimuli, were selected from among all possible CVC trigrams to meet the following criteria: (1) they must be easily pronounced; (2) they must not represent dictionary words in spelling or in their most common pronunciations; (3) they must have meaningfulness ratings of 60 or less on the Archer (1960) lists; (4) they must have the lowest frequency of appearance rating on the Mayzner and Tresselt (1965) trigram tables.

The words that were selected were arranged in random order in the word lists and divided into groups of nine; the same was done for the trigrams. The nine different words or trigrams plus a test item at the end made up a list. In the terminology of Murdock (1967) the test items or probes were of two types: target, an item which had been present in the list and to which the correct answer was yes, and lure, an item which had not been present in the list and to which the correct response was no. The subject's task was to tell whether or not the probe had appeared in the list of nine that he had just seen or heard and to give an indication of his confidence in the accuracy of his judgment, using a five-point scale. An item from each serial position (1-9) was tested once within each block. Two types of lures were used--items from the previous list (occurring there in positions 2, 5, and 8) and novel items, items which had not appeared in the experiment previously. Following Murdock's 1968 plan, the present study used targets and lures in a 3:2 ratio, requiring 9 targets and 6 lures for each block of 15 lists. Each block represented one replication for each serial position and three replications for novel items.

After the first five lists, which were for practice, the lists were presented in six blocks of 15 lists each with a pause between blocks. Each subject was given the same 100 lists, 50 containing high M materials and 50 with low M materials. The lists were presented in a balanced manner so that 50 per cent of the subjects in each modality combination were given the trigrams as the first portion of the test and the other 50 per cent were given the trigrams last. The order of presentation of materials within each half of the test remained constant across all subjects.

Four different modality combinations were used, with a different group of subjects being tested for each combination (Figure 16). AA refers to auditory presentation of the list with auditory presentation of the probe, VV to visual list and visual probe presentation, AV is the auditory list visual probe combination, and VA is visual list with auditory probe.

All test materials were designed to be presented at a fast rate to minimize rehearsal. Materials for the auditory presentation were recorded on one track of professional quality magnetic tape with a Sony stereo-phonic tape recorder which was run at a speed of 7.5 ips. The lists were read by a trained male speaker at the rate of one per sec. with a duration of approximately 1/2 sec. After the ninth word a pure tone was used to indicate that the next word was to be the probe word. After the probe there was a pause of approximately 12 sec. to allow the subject to record his response. Then three brief tones indicated that another list was to begin.

Materials for visual presentation were written in primary type and photographed on 16 mm black and white film with a Bolex movie camera set on single frame exposure, with one item per frame. Between each two item frames was a filler, a frame completely covered with a random dot design. Following the ninth item in each list was a row of asterisks and then the probe item. It was followed by a filler that remained on the screen until the beginning of the next list, which was arranged in the same manner. The visual materials were displayed on a large screen in front of the subjects by means of a single frame projector (Traid Selecta-Frame). The frames were shown at the rate of one each half second, with items and fillers alternating, resulting in an item exposure rate of one per sec. and duration of one-half sec. The AV and VA conditions were combinations of these two types of presentation.

The presentation of the photographed and recorded materials was synchronized by means of the control track of the magnetic recording tape, with advancement of the film in the projector controlled by metronome signals on the control track. The projector and tape recorder continued to run throughout each section of the test. In all four conditions the filler appeared on the screen unless a word or trigram was being presented visually.

Testing took place in a room that was slightly darkened to give adequate visibility for both the materials on the screen and the response sheets. Each subject was instructed to mark his response sheets with his yes-no decision as to whether or not he recognized each probe to be from the list that preceded it and his confidence in the accuracy of his answer. The five-interval confidence rating scale appeared at the top of each response sheet, followed by 90 numbered items of this form:

yes   no   1   2   3   4   5

The auditory materials were presented through earphones which the subject wore throughout the test. They were individually adjusted to a comfortable loudness level. The subject did not hear the signals from the projector control track.

Subjects and Design

Subjects, who were tested in groups, were 80 female students who were being paid for their participation or were volunteers fulfilling class requirements.

The experimental design was a six-way factorial (Figure 17). The first two variables (4 X 2) are between subjects: Mode (combinations of AA, AV, VA, and VV), Order (a, low M lists first, or b, high M lists first), with 20 subjects, 10 subjects per set, under each modality. The 2 X 3 X 15 within-subjects variables represent the 90 test lists received by all subjects. The first variable is Meaningfulness (high M or low M), the second is Replication (1-3), and the third is Probe (1-15), representing nine target words and six lures.

With this design there was a total of 14,400 observations (80 subjects X 90 lists, requiring two responses each) to enter into the analyses. The dependent variables are accuracy (right or wrong) of the recognition judgment and confidence rating of the judgment.

	LIST MODALITY	PROBE MODALITY
AA	Auditory	Auditory
VV	Visual	Visual
AV	Auditory	Visual
VA	Visual	Auditory

Figure 16. Modality combinations used in presenting lists and probes.

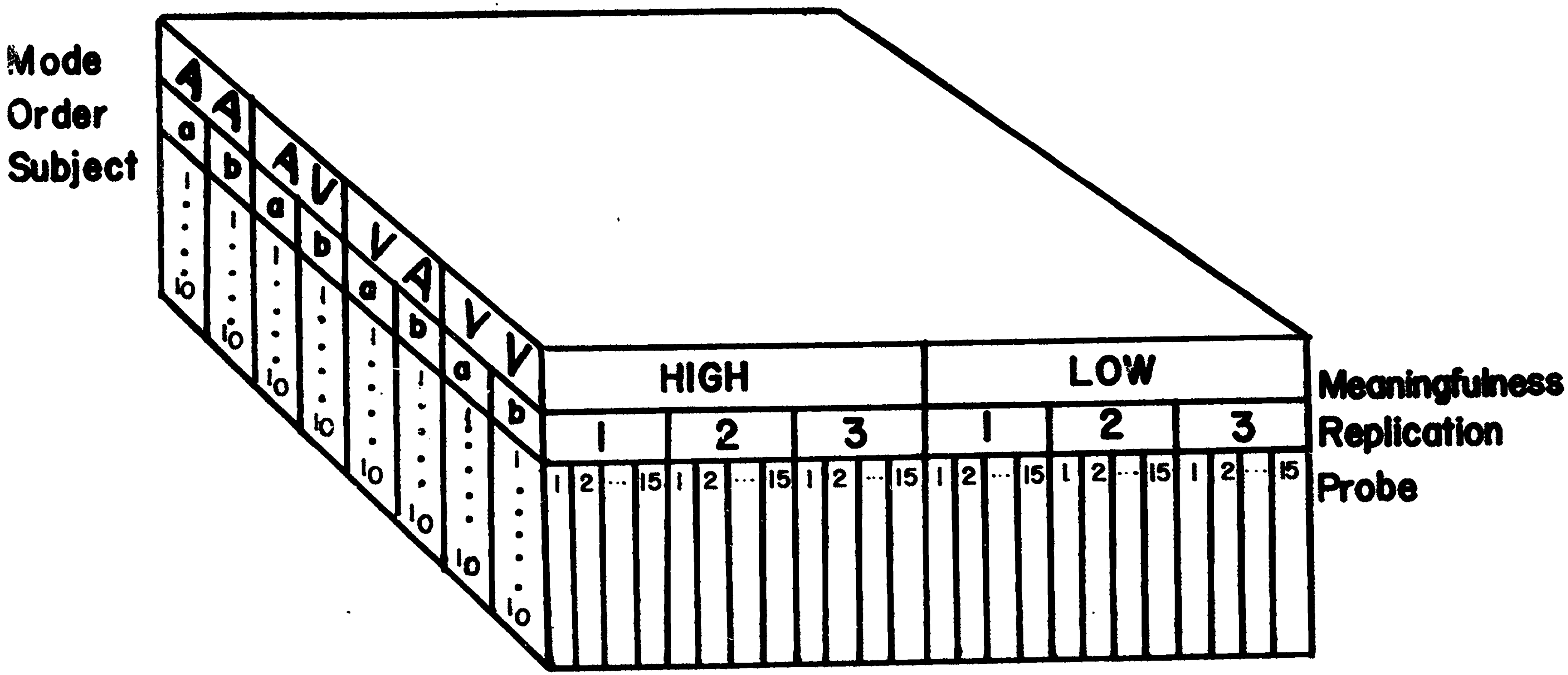


Figure 17. **EXPERIMENTAL DESIGN**

RESULTS AND DISCUSSION

The yes-no decision scores were treated by a 5-way analysis of variance (Figure 18). The main effects of Mode, Meaningfulness, Replication, and Probe were all significant beyond the .001 level. Order was not a significant factor. With regard to Mode, testing by the Newman-Keuls method revealed that the significant differences lie between the VA modality and each of the other three modalities ($p < .01$). The high M material was retained significantly better than the low. For Replications, performance on the first block was better than that on the second and third blocks ($p < .01$) and the second block was better than the third block ($p < .05$).

Visual examination appears to offer the most meaningful way to study the Probe or serial order factor (Figure 19). This can be divided into examination of performance on targets (the correct answer for these being yes) and examination of performance on lures (for which the correct answer is no.) When targets are viewed according to serial position an appreciable recency effect is apparent. Performance on lures from the previous list (positions 2, 5, and 8) was poorer than the average for the three novel lures, suggesting the influence of pro-active inhibition (with memory for items from the previous list still being present to a slight degree.)

No significant interaction between Mode and Meaningfulness was found, indicating no support for the hypothesis that modality results are differentially affected by the meaningfulness level of the material used. All significant interactions include Replication and/or Probe effects, suggesting that modality and meaningfulness had differential serial position effects.

In order to remove the influence on the results of differences in response criteria, the confidence rating data were used to plot memory operating characteristic (MOC) lines on double-normal coordinates for each level of meaningfulness in each modality. The point of intersection of the MOC line with the negative diagonal, which may be said to represent the strength of memory trace exclusive of the influence of the confidence factor is represented by the value d'. A comparison of the resulting d' values for each modality combination at each level of meaningfulness can be seen on Figure 20. Except for the AV-VV Mode comparisons, the differences within Mode and within Meaningfulness were all found to be statistically significant at the .01 level when subjected to t-tests. No interaction between Mode and Meaningfulness was found, however. Thus auditory presentation was again found to yield better results than visual, but there was no evidence that meaningfulness of material used accounts for auditory superiority.

The results agree with those of Murdock (1968) in finding recognition of list membership to be better when words are presented auditorially than when they are presented visually. The results also

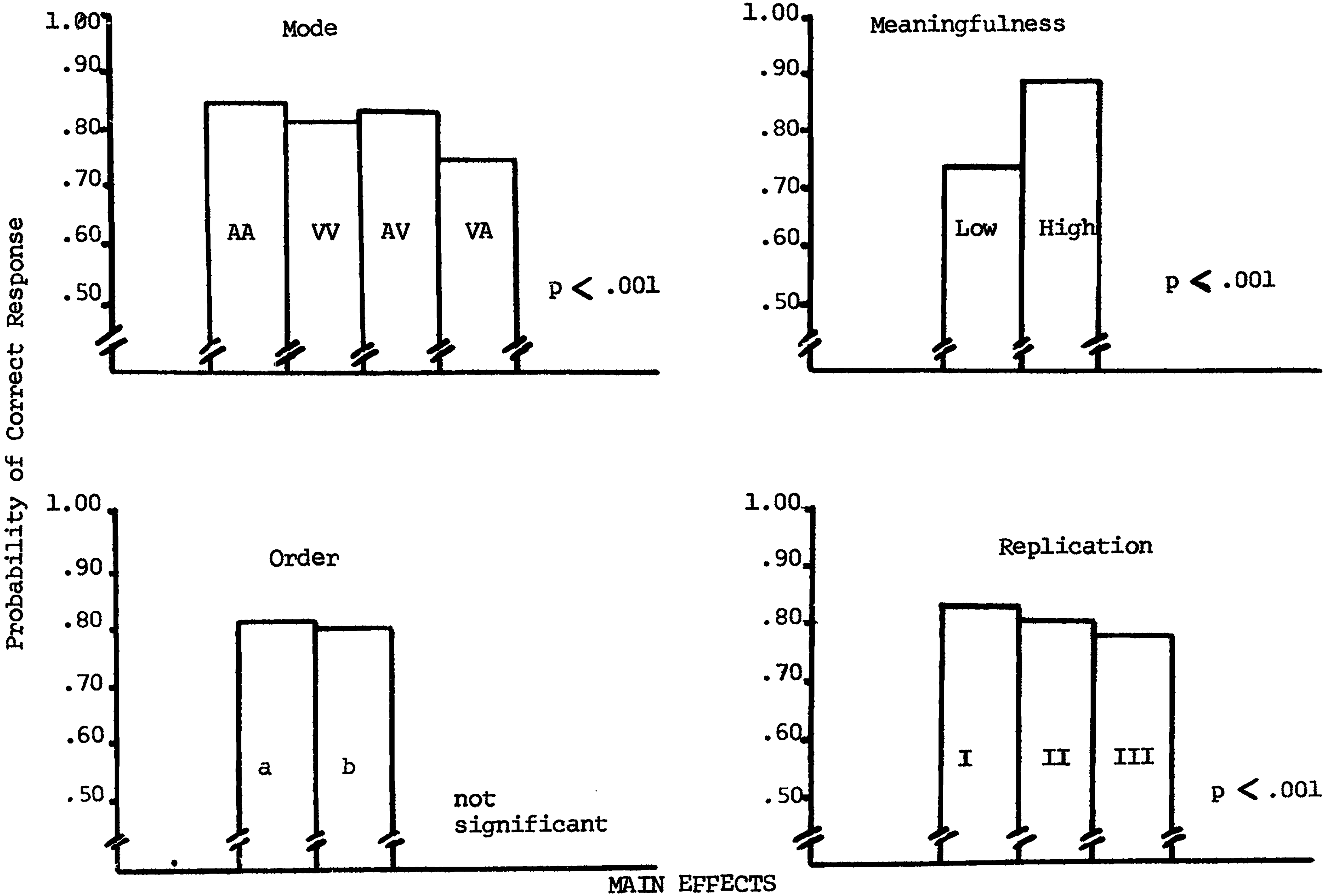


Figure 18. Results of analysis of variance on yes-no decision scores showing the main effects of mode, meaningfulness and replication.

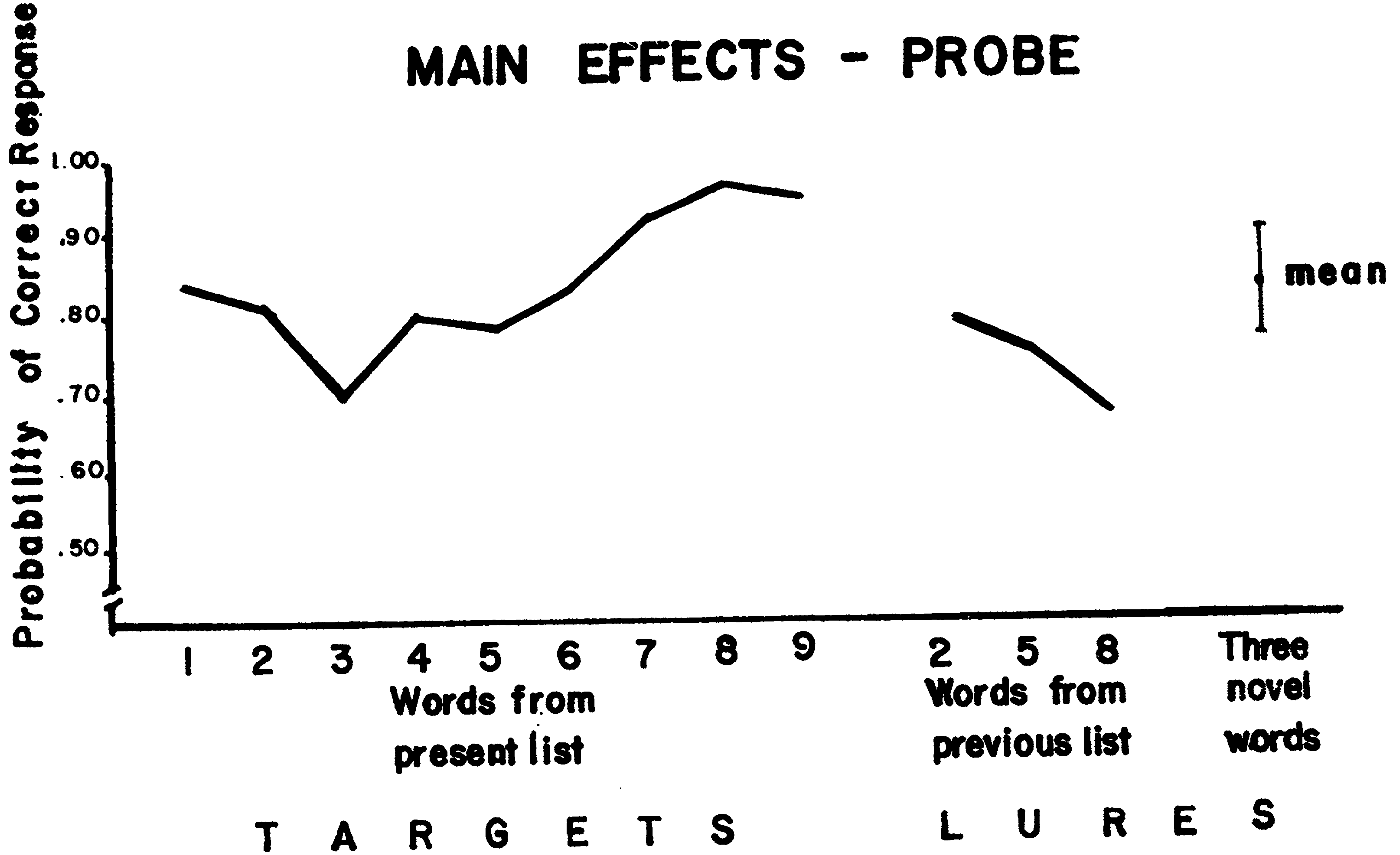


Figure 19. Results of analysis of variance on yes-no decision scores showing the main effect of Probe.

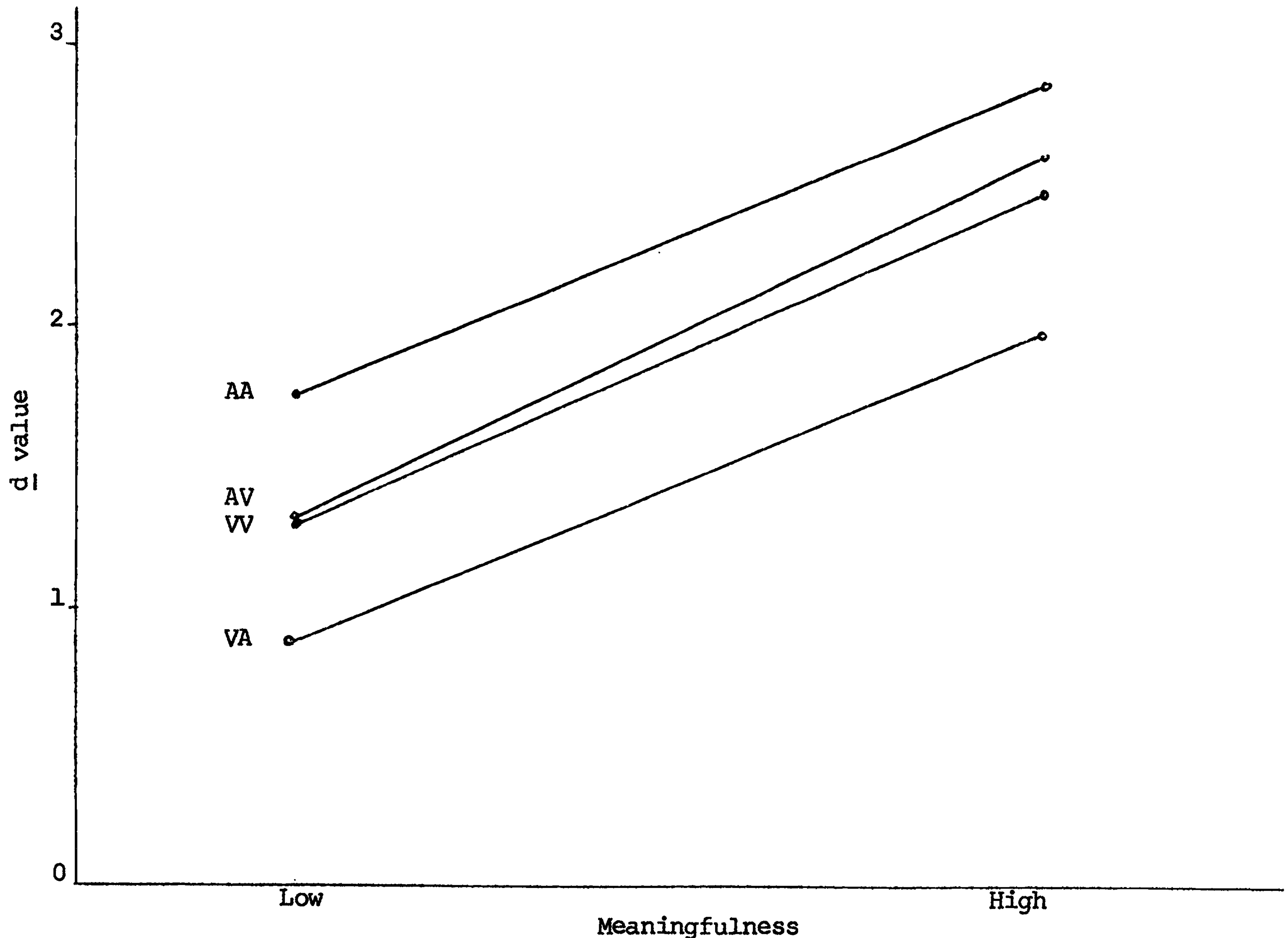


Figure 20. Strength of memory trace as a function of meaningfulness level and modality combination.

confirm the findings of Murdock (1968) and others that auditory presentation is superior to visual presentation in STM tasks. The effect was present both with the TSD analysis, which removed response criteria effects, and with the ANOVA, which was based on overall accuracy. The greater the auditory component the greater the level of performance (AA > AV > VV > VA), except in the case of the VA combination. The VA results were consistently poorer than those of the other modality combinations, regardless of the other factors involved. It is possible that the subjects in the VV and VA modes did not rehearse the visually presented lists subvocally but stored them as visual images, making comparison with an auditory probe especially difficult. If visual items of this type of task were stored visually rather than being transferred immediately into auditory storage then such results would be anticipated. The use of an auditory probe to retrieve visually stored material would seem to be especially inefficient in this type of task.

In summary, no evidence was found to suggest that the use of highly meaningful material is responsible for the superiority of auditory over visual presentation frequently reported for STM tasks. Results were found which tend to support the findings of Murdock (1968) and Margrain (1966), suggesting that the modality differences are due to differences in storage--to the presence of two different and somewhat independent STM systems for these two sensory modalities.

CHAPTER II

ASSESSING THE ROLE OF SYNTAX AND SEMANTICS IN LANGUAGE PROCESSING BY THE DEAF

A. Syntax

One of the beliefs the principal investigators have acquired in our research endeavors is that many of the "language" problems exhibited by the deaf can be traced to the presence of organizational characteristics and non-substantive markers in the language, i.e., syntax. The relationship between semantics and syntax is certainly not clear; yet there are certain components in the language structure which can best be characterized as syntax.

Whatever function these serve for people with ordinary hearing, the deaf seem to have difficulty making use of syntactic markers and in turn, in using them appropriately in the generation of language, i.e., writing. There are interesting possible reasons behind this notion. One takes into consideration that the deaf (at least most of the ones in our studies) have been fluent in Sign. Although it has an inadequate vocabulary, Sign is quite versatile and has served as a noteworthy substitute for an auditory-vocal language in communication. It is not English, however, and does not parallel English in the sense that a literal (word-for-word) translation of Sign into English would be nonsense to an English speaker. The difficulties encountered by the deaf in reading and writing English may be due to the lack of correspondence between Sign and English. The organizational aspects of English, whatever their basic medium, may be almost impossible to learn without being able to hear. If this is true, reading in English for the deaf becomes a search for the words and constructions one knows. Information gained from reading a paragraph in English would be equal to information gained from reading a list of the substantive words in the paragraph.

This section of the report contains accounts of several studies designed to discover how the deaf process English and if it is treated differently from Sign. Our initial hypothesis was that they would be different in a number of ways; the data are not entirely clear. There are two studies of reading characteristics in the deaf, one on understanding of basic sentential relationships, one on recall of sentences as a function of organization and type of cue, one on the recall of alleged units of Sign, and a progress report on some programmed instruction material written for remedial instruction in some limited aspects of English.

1. Implicit and Explicit Grammatical Factors and Reading Achievement in the Deaf.*

As a language, Sign is learned very quickly by the deaf, and it would be reasonable to postulate that it has cognitively the same properties as any verbal language, although the systems involved in its manifestation are vastly different. To a hearing observer, Sign appears to be a stripped down version of English, devoid of function words, tense, number and other syntactic and inflectional features of English. A literal translation, however, suggests that, in fact, it is qualitatively different from English in many respects other than its apparent telegraphic nature. For example, English is generally characterized as having a subject-verb-object word order, yet, Leont'yev (1965) reported that a subject-object-verb word order was common to Sign, regardless of the predominant pattern of the surrounding speech community. If a deaf person already knows Sign, English that is learned orally assumes some of the properties of a second language, that is, it is learned laboriously and explicitly with a great deal of effort. It also suffers the frequent fate of languages learned in this manner--incomplete mastery. When a deaf student is competent in Sign, it doesn't follow that he also should be an expert at reading English. Expecting a deaf student to do well on a reading achievement test would be comparable in some respects to testing American high school students in French and attributing their failure to a lack of reading skills. Therefore, for many deaf students, an apparent difficulty on reading achievement tests may be an artifact of a propensity for testing them in the wrong language.

In the study reported below, the performance of deaf students on a reading test was compared when the reading test was administered in English, Sign and nonsense word order. A control group of hearing subjects was also given the same tests. It was predicted that the deaf subjects would perform better when the test was in the word order of Sign than English word order. The reverse should be true of the hearing subjects. Both the hearing and the deaf subjects should perform poorest on the nonsense (scrambled) material.

METHOD

Subjects

The subjects were 36 deaf students (18 male and 18 female) from the Pennsylvania School for the Deaf, and 36 fifth graders (20 male and 16 female) from a Tennessee elementary school. The deaf students had a mean age of 17.11 years with a mean IQ of 102.57 and a mean reading achievement grade equivalent of 4.0. The hearing students had a mean age of 10.5 years (younger hearing subjects were selected as an approximate control for reading achievement) with a mean IQ of 108 and a mean reading achievement of 6.15. Their overall mean reading scores were computed after the experiment and were unusually high for the ages used; ideally the hearing subjects should have been selected so that the two groups were equated. No subject with an IQ below 80 was included.

Materials

Ten stories from the "Gates Basic Reading Test for Grades 5 through 8, Reading to Note Details" supplied the basic materials. These stories and the related questions were given to four interpreters to translate into the word order and constructions of sign language. The stories were rewritten in the form used by at least two of the interpreters. A typical paragraph appears below.

> Since early young, Christopher Columbus want go sea. Study navigation, maps, charts. Every time can traveled to Mediterranean ports. Then, in 1492, prepare sail to find new way to India by crossing Atlantic Ocean. After hard trip, see land. But land not India. Columbus find America.

These Sign versions of the stories were used as bases for rewritten English versions--simpler and shorter than the original stories.

> From his early youth Christopher Columbus wanted to go to sea. He studied navigation, maps, and charts. Every time he could he traveled to Mediterranean ports. Then in 1492 he set sail to find a new way to India by crossing the Atlantic Ocean. After a hard trip he saw land. But the land was not India. Columbus had found America.

The third treatment was formed by scrambling the words of the Sign version. Within each sentence, the component words were randomly ordered, resulting in nonsense paragraphs like the one below.

> Young sea Columbus early Christopher since want go. Charts navigation maps study. Can ports every Mediterranean traveled to time. Ocean new sail then crossing 1492 to prepare in find way India to Atlantic by. Trip after see land hard. Not India land but. Find Columbus America.

The manipulations of the material resulted in the English paragraphs being an average of eleven words longer than the Sign and scrambled paragraphs. The inequality was necessary if content was to be kept constant.

The questions following each paragraph were also rewritten by the investigators as true-false questions. Students who read English versions of the paragraphs answered questions in English, e.g., "Christopher Columbus wanted to go to sea"; students who read Sign paragraphs answered the same questions written in the word order of Sign, e.g., "Christopher Columbus want go sea," but students who received scrambled paragraphs were also asked questions in the word order of Sign. Both the Sign and scrambled groups were asked identical questions so that, should a difference in their performance be found, it could not be attributed to differential understanding of the questions. The order of the stories and questions in the test booklet was randomly determined and different for each subject.

The stories and questions were printed on separate pages of a test booklet which consisted of the 10 individual stories and 10 pages of questions plus a page of instructions. Twelve hearing subjects and twelve deaf subjects were randomly assigned to each condition with the restriction that the mean reading achievement score for the three conditions be approximately the same.

Since true-false questions are rather difficult and are particularly subject to misunderstanding, two forms of the questions were written. For six subjects in each group, half of the questions were correct when answered "true," for the remaining six subjects in each group the other half of the questions were correct when answered "true."

Procedure

The test was administered to the subjects in groups of four (2 males and 2 females) in the case of the deaf students. The hearing subjects received the test in larger groups in their two classrooms. The instructions were read by each subject individually and then were read aloud to the group. The subjects were allowed to ask questions about the procedures. They were instructed to read each story carefully for two minutes; then they were to turn the page and answer true and false questions about the story they had just read. This procedure would continue until all stories and questions were completed. They were not allowed to refer back to the story while answering the questions and if they were unsure of an answer they were to guess. They were also told that some of the students would have stories that "made sense." Others would have stories that did not "make such sense" but they should try hard and do the best they could.

RESULTS AND DISCUSSION

The number of questions correctly answered by each group in each condition were counted and the results are shown in Figure 21. The hearing subjects apparently understood more of the English paragraphs and the Sign paragraphs than the scrambled paragraphs. The deaf subjects, on the other hand, understood the material better when it was in Sign than in English, and better in English than scrambled.

An analysis of variance and subsequent orthogonal comparisons on the mean number of correctly answered questions confirmed the difference between Sign and English versions for the deaf [$F(1,66) = 50.32$, $p < .001$] but not the hearing [$F(1,66) = 1.19$]. There was no overall significant difference between stories [$F(9,594) = 1.81$] of differential performance by deaf and hearing subjects on the various stories. The use of orthogonal comparisons precluded a statistical comparison of the Sign and English paragraphs with the scrambled.

Direct comparisons between deaf and hearing subjects were not made either since the superiority of the hearing was evident and predictable on the basis of reading achievement. The overall patterns or relationships of the different kinds of constructions are the critical data. In this respect, it is clear that the deaf as compared with the hearing, understood the material better when it conformed to the grammar and word order of sign language.

That Sign is more than a collection of gestures, which only communicates in list form the more concrete elements of English, is clear from the superior performance by the deaf on the Sign compared with the scrambled Sign paragraphs. Sign, as a language, evidently has implicit order rules to the extent that not any order of elements produces optimum understanding. Apparently these order rules are fairly similar to those of English but not identical since there was differential understanding in favor of the Sign paragraphs by the deaf. Since the hearing subjects appeared to understand the Sign paragraphs almost as well as the English paragraphs, it's possible that the transfer between the two languages is not symmetrical. Another possibility is that since the Sign paragraphs are shorter, the hearing subjects could read them more often and more thoroughly. The same argument could apply to the deaf subject performance. If the deaf scan material more slowly, perhaps they cannot read the English paragraphs as thoroughly as the Sign paragraphs. If time-allowed-per-word was the effective variable, however, the deaf should have performed as well on the scrambled paragraphs as the Sign paragraphs.

While the nature of the relationship between English and Sign remains unclarified, the results of this study certainly suggest that the two languages are different, at least to the deaf who would have obtained a higher reading achievement level on the original material had it been given in their implicit "native" language. It would follow that when standardized versions of English reading achievement tests are administered to "manual" deaf, what is really

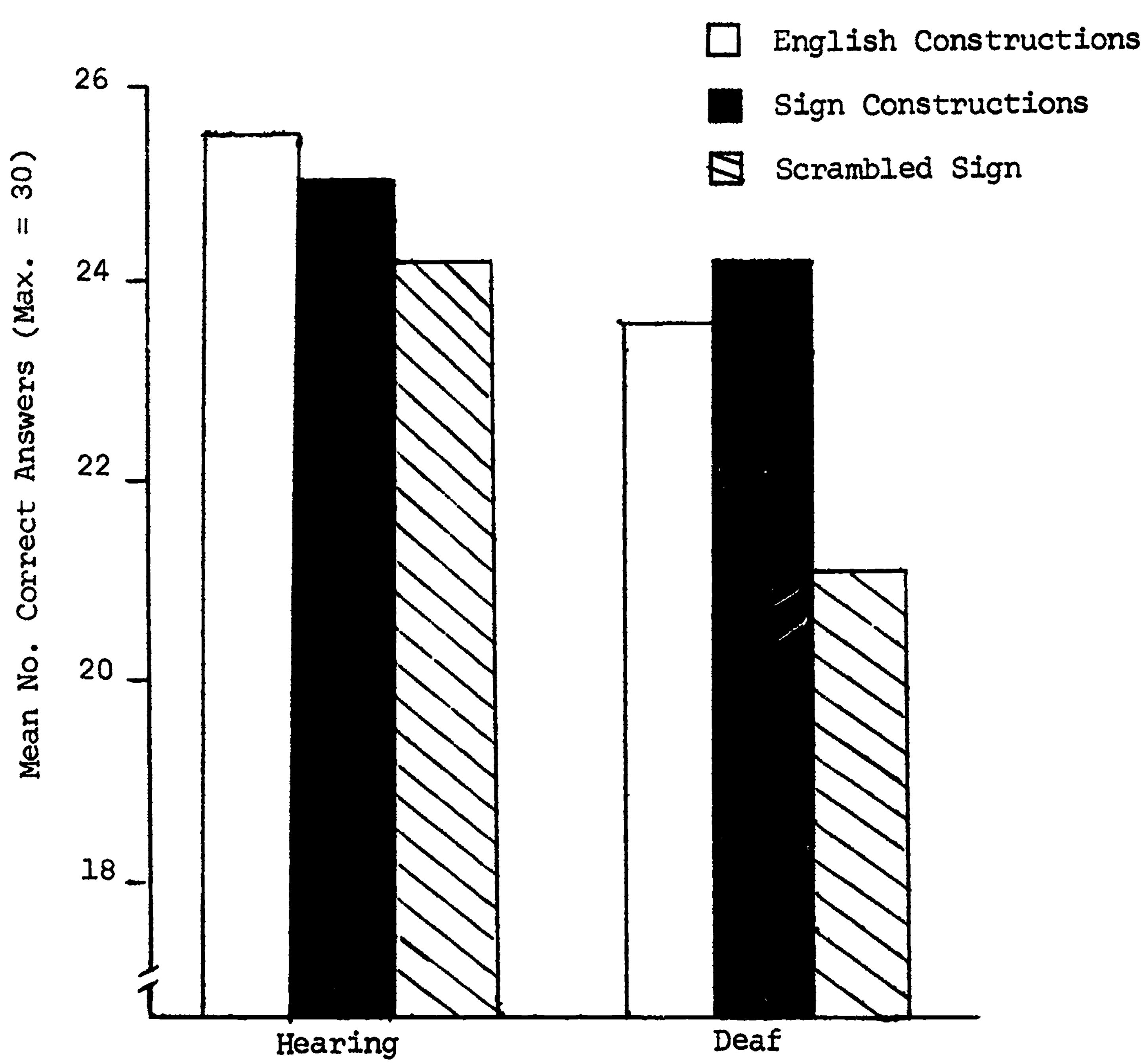


Figure 21. Mean number of questions correctly answered by deaf and hearing subjects.

measured is not reading ability but mastery of an explicitly learned second language, English. The same reasoning should be applicable in situations where the subjects have a non-standard dialect as a native language.

2. As a follow-up of the previous experiments discussed, we wondered if we could find ways of making English more or less comprehensible for the deaf by increasing or decreasing its syntactic complexity while keeping vocabulary constant. Several stories were written in each of two forms--one very stilted, direct, with short, declarative sentences and the other with longer sentences containing lots of function words. Some examples of these matched paragraphs are given below:

Syntactically Complex Paragraph

Mary is one of the many children who ride the schoolbus that takes them home everyday. When the schoolbus stops at the corner, the door opens and Mary gets off and, waving to her friends, goes into her house. She hangs her coat on the rack after she has put her books on the desk, and then says hello to her mother. Mary is hungry and, since dinner is not ready, decides to have a snack. She has some milk and some cookies which are chocolate, and both taste good. She decides to do her homework which is arithmetic and spelling so that she can play dolls for the rest of the evening with her sister.

Syntactically Simple Paragraph

Many children ride the schoolbus. Mary rides, too. Everyday after school it takes her home. The schoolbus stops at the corner. Mary gets off the bus. She goes into the house. First, she puts her books on the desk. Next, she hangs her coat on the rack. She says hello to her mother. Mary is very hungry. It will be a while before dinner. She wants a snack. Mary decides to have some milk and cookies. The cookies are chocolate. They taste good. Now she feels better. Mary decides to do her homework. She will do arithmetic and learn spelling words. She will have the rest of the evening to play. She and her sister will play with dolls.

Questions on Paragraphs

1. The first thing Mary did after coming home from school was?

   a. get her homework

   b. put away her books

   c. change her clothes

2. What was Mary's homework?

   a. read a story

   b. arithmetic problems

   c. geography

3. After dinner Mary will

   a. get her homework

   b. wash dishes

   c. play dolls

Syntactically Complex Paragraph

Fred, whose hobby is building model cars and airplanes, has decided that he wants a new airplan to put together. Taking his spending money from his drawer, he then walks to the corner drugstore where he buys a model kit, a knife to shape the plane and also some glue which is very strong. Putting the wooden pieces together takes a long time but painting the model will be lots of fun. He paints it bright red and glues on a number that is painted yellow. He puts the finished plane on a shelf until a pretty day when he can fly it and all his playmates will want to look at it.

Syntactically Simple Paragraph

Fred's hobby is building model airplanes and cars. Fred wants a new model airplane. He takes his spending money from his drawer. The drugstore is on the corner. There he looks to find the plane he will build. He must buy the kit, paint, knife and strong glue. Fred hurries home to start building his model. He puts all the wooden pieces together. This takes a long time. It will be fun to paint. Bright red will be pretty for his plane. The number is painted yellow. Now it is all finished. Fred puts his plane on his bookshelf. One pretty day Fred can fly his plane. Fred's playmates will want to see his plane.

Questions on Paragraphs

1. What does Fred want to do?

   a. buy a new model car

   b. build a new plane

   c. buy a coke at the drugstore

2. What color of paint does Fred use?

   a. blue

   b. green

   c. red

3. Putting the pieces together

   a. is easy

   b. takes a long time

   c. is not easy

Questions on each topic were also composed (see examples above). Our hypothesis was that if the deaf are confused by syntactic elements in English, then the presence of long strings of function words (whatever syntactic aspects they reflect) perhaps would interfere with their understanding of the paragraphs, but the performance of the hearing would be unaffected.

The study was never completed but the preliminary results indicated a mean of 16.4 questions answered correctly on the simple stories and 17.2 correct on the complex stories.

3. According to Furth "The hearing individual enjoys a comfortable mastery of the language even though he may be retarded in reading. For the deaf on the other hand, the reading level is the ceiling of linguistic competence. It is quite inappropriate to designate this latter condition as retardation in reading. It is properly termed incompetence or deficiency in verbal language..." (1966, p. 13-15). In hearing children as well as deaf, the best way to assess this competency (or lack of) is in a language comprehension task. (To date, there is no pure way to observe language competence that is free from non-linguistic concerns, however, comprehension tasks come the closest. If their is a failure to understand, one cannot necessarily attribute it to a lack of competency. The present study sidestepped this issue by comparing comprehension in two groups. Had one been different from the other, the author probably would have attributed it to a lack of competence in the lowest performing group. If they were the same, one can only speculate that the two groups possess the same processes with respect to the language being tested.)

There is convincing evidence that supports the hypothesis that speakers of the language perform transformations on sentences as they comprehend and that the time required for such processes is measurable, e.g., Gough, 1965, 1966; Huttenlocher, Eisenberg, and

Strauss, 1968; Huttenlocher and Strauss, 1968. If a deaf child's comprehension processes parallel those of a hearing child's, then the function describing the time it takes both children to "understand" different kinds of sentences ought to be the same.

In her dissertation Burroughs (1969) replicated and extended a study originally done by Huttenlocher, Eisenberg, and Strauss (1968). They had carried out an experiment designed to detect differential comprehension times involved in active and passive sentences (which differ in underlying structural differences, defined, supposedly, by transformational complexity). In their experiments, the subject (fourth grader) was asked to place his truck (designated mobile truck or MT) in a position relative to a second truck (fixed truck, FT) on a track in response to relative position described in one of four types of sentences read to him:

(1) active statements with MT as grammatical and logical subject, e.g., "The (color of S's truck, MT) truck is pushing the (color of fixed truck, FT) truck."

(2) active statements with MT as grammatical object and logical subject, e.g., "The (color of FT) truck is pushing the (color of MT truck."

(3) passive statements with MT as logical subject and grammatical subject, e.g., "The (color of FT) truck is pushed by the (color of MT) truck."

(4) passive statements with MT as logical subject and grammatical object, e.g., "The (color of MT) is pushed by the (color of FT) truck."

Errors and reaction time in placing the mobile truck were the measures employed. Results showed an increase in reaction times for the types of problems progressing from type (1) through type (4). Comprehension was easier when there was a correspondence between the perceived actor in a situation and the logical subject of a statement. Clearly temporal priority of the grammatical position of the subject was not the critical factor as demonstrated with passive sentences. Huttenlocher et al., suggest that the subject first transforms the passive sentence into its corresponding active form, i.e., identifies the logical subject. When in its active form the sentence describes the mobile truck as logical object rather than subject, the subject imagines that the fixed truck is actually mobile and places his truck accordingly. The subject attempts to make the extralinguistic situation and the statement correspond.

Whether one attempts to characterize the logical concepts or the grammatical syntactic representations, this comprehension task presents a novel means from which to make inferences about the nature of a child's competence. These same measures should be applicable to the performance of deaf children. Can the deaf child's competence be characterized by a transformational grammar? Does his performance show ividence of the use of transformation rules? The following report is a summary of the method, results, and discussion of Burrough's dissertation research.

METHOD

Subjects

Forty-eight hearing subjects (mean age 10-3) were selected from fourth grade classes in the McKenzie, Tennessee, public schools. Reading level, as estimated from previous testing (Stanford Achievement Tests), ranged from 2.7 to 6.7 with a mean of 4.5.

Deaf subjects were drawn from three different educational populations. Twelve subjects were from Louisiana School for the Deaf where the fingerspelling method, or visible English, has been used exclusively in the classroom for several years. Pilot School for the Deaf, Callier Center in Dallas, Texas, provided twelve subjects who have been trained in a purely oral setting. The third group of twelve subjects came from the Texas State School for the Deaf which uses a combined approach of oral language, fingerspelling, and sign. Deaf subjects were selected whose estimated reading level was between 3.5-5.5, mean age 13-2. Average reading level based on previous testing for the three groups was as follows: LSD, 4.4; Pilot, 3.8; TSD, 3.8. All deaf subjects have a measured hearing loss of 75 dB or greater in the better ear and were known to be prelingually deaf, i.e., prior to age two years.

Apparatus

The arrangement for the apparatus is diagrammed in Figure 22.

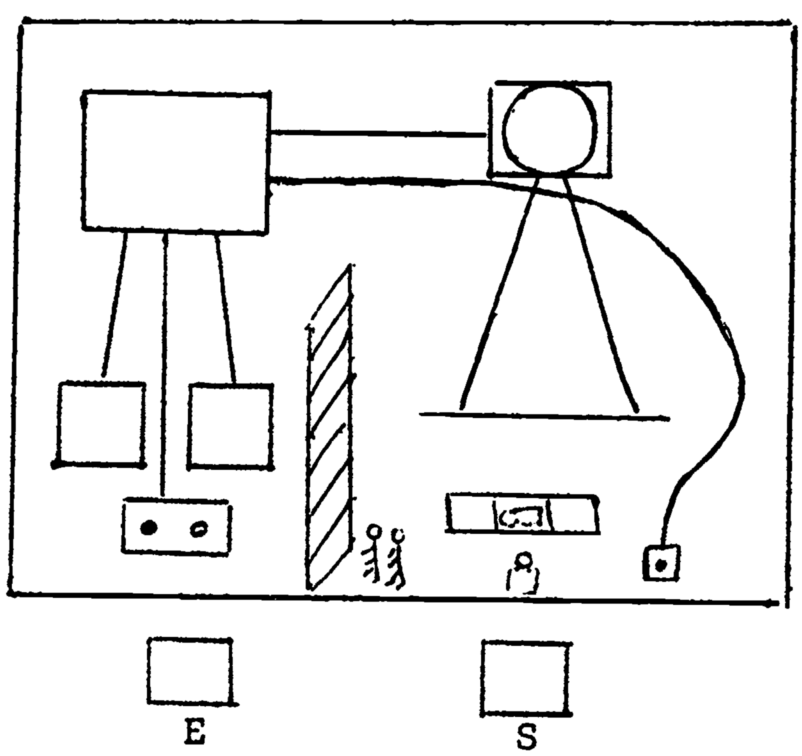


Figure 22. Arrangement of apparatus.

The equipment placed in front of the subject included a piece of board 3/4 in. thick and approximately 3 x 16 in. painted grey. Strips of white tape divided the board into three equal rectangular sections, and strips of molding framed the outer perimeter. Two identical Tonka (No. 515) trucks, one red and one green, and two identical molded rubber dogs of similar size to the trucks, one black and one white, were used.

Slides were projected from a Carousel slide projector onto a translucent plastic screen, 15 1/2 in. x 21 1/2 in. The screen was centered behind and several inches above the track so that the sentences would be approximately at eye level for the subject. The projector was about six feet behind the screen and was connected to a central power and circuit supply box.

The button which the subject pushed after he read a sentence on the screen was mounted in a small metal, rubber tipped box. The box was placed to the side of the subject's dominant hand and was wired directly to the central power supply box.

Two electric timers were used by the experimenter to measure latencies. Three buttons were wired to the central power source so that the experimenter controlled the first and third buttons and the subject pushed the second button. By pushing the first button, the experimenter simultaneously exposed a slide on the screen and started the first timer. The second button, which the subject pushed, changed the slide, stopped the first clock, and started the second clock. The third button was pushed by the experimenter at the appropriate time to stop the second clock. The clock and the experimenter's panel of control buttons were placed to the left behind a screen so as to be out of the subject's range of vision.

Materials

The stimulus materials presented to each child consisted of 26 sentences, each printed on a 2 x 2 slide. Interspersed between each of the sentences was a slide with a black dot in the center to serve as a focal point for the child's eyes prior to seeing a sentence. The first two slides were practice slides that allowed the experimenter to assess whether the child understood the instructions and also gave the child some experience with the procedure. One of these sentences had the form of "The green (or red) truck pushes the red (or green) truck." The second was "The black (or white) dog chases the white (or black) dog." The remainder of the task description will be given in terms of the trucks for clarity. When the schedule called for the objects to be dogs, "black dog" and "white dog" were substituted in the noun positions and the appropriate form of the verb "to chase" was used. The subject's task was to place his truck (MT for mobile truck) either in front of or behind the truck already placed in the center section by the experimenter (FT for fixed truck) to match the description given in the sentence. The 24 test sentences included presentations of the four types of problems listed on page .

Sentences were constructed according to the four types for two sets of objects: a green and a red truck; a white and a black dog. Thus the eight sentences shown in Table 18 were derived for use in the test presentation.

From the eight sentence types (Type 1, trucks; Type 1, dogs; Type 2, trucks; Type 2, dogs; Type 3, trucks; Type 3, dogs; Type 4, trucks; Type 4, dogs) to schedules of presentation were arranged. Each consisted of three random series of the eight sentence types. Color of fixed and mobile trucks or dogs for each sentence type was counterbalanced across the blocks of eight sentences. The two schedules were assigned alternately to subjects as they came for testing.

TABLE 18

Sentences Used in Test Presentation

The red truck is pushing the green truck.
The green truck is pushing the red truck.
The red truck is pushed by the green truck.
The green truck is pushed by the red truck.
The black dog is chasing the white dog.
The white dog is chasing the black dog.
The black dog is chased by the white dog.
The white dog is chased by the black dog.

Huttenlocher, Eisenberg and Strauss (1968) employed for each problem type two statements, using the two verbs "push" and "pull." A comparison of results showed "pull" statements to be consistently more difficult than "push" statements. However, the effects of problem type were the same for both "push" and "pull" statements. Thus the proposed study will not use "pull" statements to eliminate interference effects between "push" "pull." This simplification is especially important in reducing confounding factors when working with deaf children. However, it was considered advisable to include parallel sets of sentences employing two different sets of objects, trucks and dogs, in order to test the generalizability of this phenomenon. The additional set of sentences also provided a larger number of sentences in the test series and thus increased the chances for reliability.

Procedure

Each subject was tested individually in one session. The subject and experimenter sat next to each other facing the apparatus with the subject to the experimenter's right. After the subject was allowed exploration of the experimental setting and had established some rapport with the experimenter, he was given the following instructions:

> This road is divided into three sections. I am going to put one of the trucks in the center. I am going to give you the other truck. You are to make it so one truck is pushing the other truck. A truck has to be behind the one it is pushing. (Activity - the experimenter shows a card stating 'The red truck is pushing the green truck.' The subject responds and any errors are corrected. The experimenter then shows card with 'The red truck is pushed by the green truck.' Again any error in the subject's response is corrected.)
>
> Now I am going to put a dog in the center. I am going to give you the other dog. You are to make it so one dog is chasing the other dog. A dog has to be behind the dog it is chasing. (Activity - same as with trucks.)
>
> Each time a sentence on the screen will tell you how the trucks or dogs should be. Look at the spot on the screen. I will show you a sentence. Read it once, and as soon as you finish, push this button. (The subject pushes button to see what it does.) Then put the truck or dog where it belongs. Remember, read the sentence, push the button, and put the truck or dog in the track. Any questions? Let's try one for practice.

These instructions were given orally to hearing subjects. To the deaf subjects they were conveyed by speech-reading, fingerspelling interpretation, gestures, and printed cards in whatever way was necessary for the individual subject's understanding. An interpreter was available to communicate fingerspelling instructions to the deaf subjects in settings where this was required.

After he was satisfied that the subject understood the instructions, the experimenter proceeded with the two practice sentences. Before exposing a statement, the experimenter placed one truck in the center section of the board and put the other truck on a spot equidistant from the other two sections. He asked the subject to place the index finger of his preferred hand over the button and to look at the spot on the screen. The experimenter then pushed the button that simultaneously exposed the first practice sentence and started the first clock. The subject read the sentence, and as soon as he finished, he pushed his button, which removed the sentence slide (a dot replaced it), stopped the first clock, and started the second clock. When the subject then placed his truck on the board, the experimenter pushed the third button as the object touched the track to stop the second clock. After the experimenter cleared the clocks, the other practice trial was given. On the practice trials corrections were made for the subject's errors and any questions were answered. If the subject performed satisfactorily, the experimenter proceeded with the 24 test trials in the same manner. No questions were answered or corrections made during the test trials. If the subject did not understand the task, as demonstrated by his responses on the practice trials, the experimenter repeated the practice trials until the subject followed the procedure correctly. If the subject did not respond correctly after two repetitions, he was dismissed from the experiment.

The experimenter recorded the location of each of the subject's responses. At the end of each trial he also recorded the two latency measures. The first was the time between the experimenter's pushing of the button to start the projector and clock and the subject's pushing of the second button when he finished reading the sentence. The first period of time was designated as reading latency, L_1. The second latency extended from the time the subject pushed his button to the time his object was placed on the track. This second latency was referred to as placement latency, L_2. The sum of the two time periods was total latency, L_3.

In the Huttenlocher, Eisenberg and Strauss (1968) experiment, the sentences were presented verbally to the subjects. Thus a single latency was recorded for the time to place the truck after the last word of the sentence was spoken by the experimenter. The experimenter used a stopwatch for this measure. Since the present study involved deaf subjects, the sentences had to be presented in a written form to be read by the subject. This procedure necessitated the measuring of latencies for reading time as well as object placement. Thus a more detailed measuring device and procedure as described above was required. Since the pattern of relative latencies among the four problem types is the important variable rather than absolute latency, this change in procedure should not affect the pattern of results if the basic finding is a stable one.

At the end of the experiment, after the subject had completed all trials, post experimental information was gathered by several questions. These questions included: "Which was easier, trucks or dogs?"; "How did you know where to put the truck or dog?"; "Write (or tell me) some of the sentences you saw on the screen."; "Were any of the sentences harder than any others?"

RESULTS

Detailed analysis may be obtained from Burroughs' dissertation; a much abbreviated summary is reported here.

There were four dependent measures used in this experiment: reading latency, L_1; placement latency, L_2; combined or total latency, L_3; and errors. Summary data for each subject included eight scores on each dependent measure. These eight scores were the mean scores over three presentations for two object types (trucks and dogs) at each level of sentence ty (type 1--active with logical and grammatical agreement; type 2--active with logical and grammatical disagreement; type 3--passive with logical and grammatical agreement; type 4--passive with logical and grammatical disagreement). Descriptive data, means and standard deviations, for all groups of subjects on L_3 and errors are shown in Tables 19 and 20. (Combined or total latency was found to be the most meaningful dependent measure in this study. Thus only graphs, ANOVA summary tables, and multiple comparisons for L_3 scores will appear within the text of this section.)

An analysis of variance on L_3 measures indicated that the deaf took significantly longer [$F = 10.99$, $p < .001$] to place the truck or dog than the hearing. There was also a significant effect for sentence type [$F = 20.43$, $p < .001$] and a significant interaction between latency and sentence type [$F = 5.76$, $p < .001$]. For both hearing and deaf subjects, sentences employing trucks were in the predicted order of increasing latencies across sentence types 1 through 4 while those for dogs were not. Note in Table 19 that the pattern of latencies across sentence types was quite similar for the two groups. The analysis of variance on errors showed no significant difference between deaf and hearing subjects. There was not significant difference on L_3 among the subjects from the three deaf schools included in the sample.

At the conclusion of the experiment, subjects were asked to reproduce the sentences which they had seen on the screen. Hearing subjects stated the sentences orally while the experimenter recorded them. Deaf subjects wrote their sentences. All of the sentences were

TABLE 19

Means and Standard Deviations for L_3 Total Latency

		Problem Type							
		Trucks				Dogs			
		1	2	3	4	1	2	3	4
Hearing Ss	$\overline{M}$	5.43	5.81	6.09	6.18	5.37	5.26	5.81	5.71
N = 48	SD	1.35	1.49	1.60	1.26	1.35	1.26	1.47	1.42
Deaf Ss	$\overline{M}$	7.04	7.13	7.37	7.67	7.08	6.35	7.12	7.27
N = 36	SD	1.95	2.18	2.56	2.60	2.07	1.84	2.09	2.42
LSSD	$\overline{M}$	7.27	7.47	7.69	8.04	7.10	6.54	7.24	7.29
N = 12	SD	2.10	2.10	2.04	2.35	1.89	2.06	1.98	2.08
Pilot	$\overline{M}$	7.40	7.40	7.78	8.02	7.63	6.46	7.10	7.86
N = 12	SD	2.13	2.63	3.48	3.17	2.31	1.86	1.92	3.28
TSSD	$\overline{M}$	6.44	6.51	6.63	6.95	6.52	6.06	7.01	6.67
N = 12	SD	1.60	1.78	1.94	2.57	2.01	1.71	2.51	1.63

TABLE 20

Means and Standard Deviations for Errors

		Problem Type							
		Trucks				Dogs			
		1	2	3	4	1	2	3	4
Hearing Ss	$\overline{M}$	0.21	0.38	0.88	0.98	0.48	0.19	0.79	0.85
N = 48	SD	0.58	0.64	1.18	1.08	0.69	0.57	1.07	1.13
Deaf Ss	$\overline{M}$	0.25	0.39	0.83	0.61	0.56	0.33	0.78	0.56
N = 36	SD	0.60	0.80	1.11	0.99	0.91	0.63	0.96	0.88
LSSD	$\overline{M}$	0.08	0.25	0.75	0.75	0.50	0.07	1.00	0.58
N = 12	SD	0.29	0.87	1.13	1.06	0.96	0.39	0.95	0.90
Pilot	$\overline{M}$	0.17	0.42	0.67	0.33	0.17	0.25	0.33	0.42
N = 12	SD	0.58	0.90	1.07	0.89	0.58	0.62	0.78	1.00
TSSD	$\overline{M}$	0.50	0.50	1.08	0.75	1.00	0.58	1.00	0.67
N = 12	SD	0.80	0.67	1.16	1.06	0.95	0.79	1.04	0.78

scored for errors. Table 21 shows the percentages of correct and incorrect sentences for hearing and deaf subjects. Since this was not a formal part of the design, these data were not suitable for statistical analysis.

TABLE 21

Percentages of Correct and Incorrect Sentences Reproduced by Subjects

	Correct	Incorrect
Hearing Ss	77%	23%
Deaf Ss	31%	69%
LSSD	36%	64%
Pilot	36%	64%
TSSD	22%	78%

DISCUSSION

Very little is known about how children (or adults) understand language. In her experiment, Huttenlocher speaks of the child's performing a preliminary grammatical analysis of the statement before considering its relation to the extra-linguistic situation it describes. Since Huttenlocher has little interest in the nature of grammatical operations, she makes no attempt to explain this preliminary grammatical analysis other than to suggest that in it the subject identifies the grammatical subject (which of the trucks is described as doing the pushing). It is possible that this stage involves the type of syntactic rule-governed transformations described by Chomsky (1967). A sentence, active or passive, may be transformed to its abstract representation, and in such a process the child does indeed identify the grammatical subject. More time may be required for passive sentences because of their greater syntactic complexity.

However, this process must include interaction with a semantic component. It is this interaction which Huttenlocher deals with as logical-grammatical agreement or disagreement. After the subject identifies the grammatcial subject of the sentence (the truck described as doing the pushing), he then compares this description with the logical situation. In the logical situation, i.e., the actual arrangement of the trucks which he sees, the truck which the subject has in his hand to place (MT) is always the perceived actor or logical subject. The object which he places is acting or moving, as opposed to the object already in the middle of the track, which is stationary (FT). Therefore he views the truck he places as logical subject. When the grammatical subject and the logical subject are the same (type 1) the child merely places the truck. However when the grammatical subject is not the same as the logical subject (type 2) there is a conflict which the child must resolve. Adult subjects questioned by Huttenlocher reported that when this disagreement occurred, they imagined that the truck in the middle of the track (FT) was actually moving and then placed their truck in front of it. This extra cognitive step was hypothesized as accounting for the increased latency for sentence type 2 over type 1 and type 4 over type 3. Children in the present study, when asked, could not describe any processes by which they placed their objects. Results from the[1] present study parallel this pattern for trucks but not for dogs.

Since the direction of means for the deaf was similar to that of the hearing, it is possible that the deaf have the same kind of transformational processes as part of language competence as the hearing at least with respect to the sentences tested in this experiment. There are two qualifications: (a) the deaf subjects were three years older than the hearing subjects and could have other skills like better memory or analyzing processes which compensate for lack of language skills. It would be difficult, however, to devise such a model which would analyze the sentences with the same order of latencies; (b) the deaf subjects were matched with the hearing on reading ability so that they may have been matched on the very competence measure that was being tested.

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[1]In sentences where dogs were the object category employed, the latency for type 2 sentences was less than for type 1. The same reverse was found for types 3 and 4. A possible explanation for this unexpected result lies in the nature of the semantic difference between trucks pushing trucks and dogs chasing dogs. When one truck pushes another truck, the one pushing is clearly the actor while the other is the inactive recipient or object. But when one dog chases another dog, the dog being chased is actually just as active as the one doing the chasing. Thus in the case of dogs, the subject may not find it necessary to make the final step in the process described above as he does for trucks. That is, when the dog he must place (logical object) is the grammatical subject, he does not have to adjust his image of the fixed dog as being active and the mobile dog as being the inert object because the dog he places, in this case, is still an actor even as the grammatical object.

The pattern and number of errors for the deaf subjects was quite similar to that of the hearing. This finding and the increased latencies on the part of the deaf may reflect a decreasing impulsivity as a function of age, an interesting notion that should be investigated further.

In contrast to their similar performance in number of errors on the comprehension task, the deaf children made many more errors in the sentences which they were asked to reproduce post-experimentally. Almost all the errors made by the deaf involved an incorrect form of the verb--wrong tense ending or omitted or inappropriate auxiliary element (is, by).

The present study showed no significant meaningful difference among the three educational orientations sampled. The post-experimental data did indicate that the LSSD and Pilot students made a smaller percentage of errors than did the TSD students. The students from TSD, where a combined approach of fingerspelling, oral, and Sign is used, appeared to the experimenter to rely more heavily on Sign than either of the other two means of communication. The Pilot population can accurately be described, by the experimenter, as relying exclusively on oral language. The sample from LSSD, although they knew Sign, appeared to the experimenter to use fingerspelling more readily. Thus one may infer that the fingerspelling and oral approach convey more of the syntactic nuances used in production of English language than does Sign. A further observation of the experimenter concerned the important contribution of the fingerspelling approach to language development. Although the children at Pilot appear to be from a higher socio-economic level and generally receive initial deaf education at a much earlier age, than the children at LSSD, there were no differences between these two populations in sentence production. Thus there seems to be some evidence for the merit of fingerspelling in conveying syntactic details such as verb inflection to the deaf. However, these are post-experimental observations somewhat confounded with socioeconomic class, reading levels, and IQ's and cannot be given too much weight.

4. English syntactic variables line word order and phrasal boundaries are irrelevant to the deaf since they presumably lack English syntactic organization (Odom & Blanton, 1967). This leads to several expectations about differences in performance between deaf and hearing subjects in task involving memory for sentences. But before discussing these expectations it is necessary to review briefly some of the recent research on memory for sentences.

Horowitz and Prytulak (1969) report results which suggest that the probability of recall of an entire sentence given that a part (either subject, verb, or object) was recalled was very high. Further, they found that the order of the frequency of recall of these parts of speech (subject > object > verb) under conditions of free recall reflected their relative power (subject > object > verb) at producing the entire sentence when these same parts of speech were used as recall cues. Horowitz and Prytulak suggested English syntactic organization as one possible cause of the difference in the redintegrative power of these parts of speech for memory for sentences. The natural syntactic ordering of these parts of speech is subject, verb, their object which may account for the superior recall cueing power of the subject.

Horowitz and Prytulak discuss these results in terms of redintegrative memory where the stimulus which gives rise to recall is part of the memory itself. Since not all memory tasks are redintegrative, they suggest the following criterion: a memory task is redintegrative if during free recall the probability of recalling a whole unit given that an element of that unit is recalled is high, e.g., above .60. Memory tasks meeting this criterion conform to a principle of redintegrative power. This principle asserts that the element of a unit which is most frequently recalled during free recall possesses the greatest power for cueing recall of the whole unit. The validity of this principle was demonstrated with several types of memory, including memory for sentences.

Other research has demonstrated the influence of English syntactic organization on the grouping of English words into functional units for recall (Johnson, 1965, 1966a, b). These functional units tend to be recalled in an all-or-none fashion. Furthermore, dependencies existing between adjacent words within the same functional unit are greater than dependencies existing between adjacent words at the boundaries of these functional units.

Now, as mentioned previously, it has been suggested that the deaf lack English syntactic organization. How this lack may influence the redintegrative power of the parts of speech or the organization of the functional units which are recalled is not known, but several expectations about differences between the performances of deaf and hearing subjects on a memory for sentences task can be generated: (1) if English syntactic organization influences the redintegrative power of parts of speech, then differences should be observed between the redintegrative power of these parts of speech for deaf and hearing subjects. However, since the form of any syntactic organization that the deaf may possess is unknown, specific predictions about the relative redintegrative power of these parts of speech cannot be made, (2) if English syntactic organization defines the functional units which are recalled, then deaf subjects should not recall these functional units in an all-or-none fashion more often than they recall word segments of equal size lacking English syntactic organization. On the other hand, hearing subjects should recall these functional units in an all-or-none fashion more often than they recall word segments of equal size lacking English syntactic organization, and (3) if English syntactic organization defines the boundaries of these functional units, then deaf subjects should not show greater dependencies between adjacent words within the same functional unit than between adjacent words at the boundaries of functional units.

To test these expectations, the performance of deaf subjects was compared with that of hearing subjects on the cued recall of groups of words in both English and scrambled word orders. Four separate conditions were defined by the part of speech used as the cue: (1) Condition S--the subject of the sentence formed by the English word order group served as the recall cue, (2) Condition V--the verb of the sentence formed by the English word order group served as the recall cue, (3) Condition O--the object of the sentence formed by the English word order group served as the recall cue, and (4) Condition C--no recall cue was given yielding a free recall control condition. For purposes of control, the same recall cues were used with the corresponding scrambled word order groups.

METHOD

Subjects

Two populations were used. Twenty-four students (twelve male and twelve female) were selected from classes at a local high school; twenty-four subjects (twelve male and twelve female) were selected from classes at the Louisiana School for the Deaf. The hearing and deaf subjects were matched on the basis of age (the mean equaled approximately 16 years with a range from 14 years to 18 years). Twelve subjects (six male and six female) from each population were assigned to each of the word order conditions (English and scrambled).

Materials

Thirty-two different groups of seven words each were used as the basic learning materials. For the English word order, the order was article + adjective + subject + verb + article + object, e.g., "the busy cashier paid the tall lady." See Table 22 for a complete listing. The thirty-two groups of words used in each word order condition were divided up into sets of four, with each set of four containing one group of words assigned to each of the four recall cueing conditions (S, V, O, and C). Within each set of four, the order of occurrence of each recall cue condition was randomized.

Subjects participated in the experiment in groups of four (two males and two females). Each subject was given a response booklet containing instructions, examples, recall cues, and response spaces. The instructions informed the subjects that groups of seven words would be projected for five seconds onto a screen before them. Subjects were told to remember the words in the same order in which they appeared, and that after four individual groups of words were seen they would be asked to write down each group exactly as seen. Furthermore, subjects were instructed that sometimes the experimenter would give them a hint by enclosing in parentheses a word taken from the sentence and placing it in front of the response space for that sentence. All subjects were given two minutes in which to write their responses.

TABLE 22

Recall Cues and Word Groups Used in Experiment 4

Recall Cue	English Word Order	Scrambled Word Order
	The busy cashier paid the tall lady	The busy cashier the tall paid lady
suit	The beautiful model wore the blue suit	The model wore beautiful the suit blue
lost	The forgetful teacher lost the class notes	Forgetful the teacher the lost notes class
wave	The huge wave sank the little boat	Huge the sank little wave the boat
nut	The fat squirrel hid the green nut	Squirrel green hid the nut the fat
cop	The confused cop arrested the wrong man	Man wrong arrested the cop the confused
flew	The navy pilot flew the silver plane	Pilot silver the plane navy the flew
	The grocery store sold the last orange	The sold store grocery last the orange
caught	The fast halfback caught the first pass	Caught fast pass first halfback the the
ring	The nervous bride dropped the wedding ring	Ring nervous the dropped bride wedding the
shark	The brown shark ate the small fish	Ate brown the shark small the fish
	The playful kitten chased the yarn ball	Ball playful the the chased kitten yarn
gun	The brave soldier fired the rusty gun	The gun the brave soldier fired rusty
	The deep snow covered the fence post	Fence the covered deep post the snow

TABLE 22--continued

Recall Cue	English Word Order	Scrambled Word Order
cornered	The growling dog cornered the paper boy	Boy the paper growling dog the cornered
man	The strong man bent the iron bar	Strong man bent the iron the bar
	The thirsty camel drank the muddy water	Camel water muddy the the drank thirsty
saved	The handsome doctor saved the dying man	Man the dying handsome doctor the saved
car	The flashing light stopped the speeding car	Flashing stopped the car light speeding the
mouse	The gray mouse sniffed the dry corn	Corn dry mouse the sniffed the gray
postman	The friendly postman delivered the big package	The postman package delivered large the friendly
change	The coin purse held the exact change	Held the exact change coin purse the
dried	The warm sun dried the wet clothes	The the wet clothes dried warm sun
	The young calf licked the old farmer	The young the calf licked old farmer
crossed	The crowded bus crossed the wooden bridge	But the crowded bridge wodden the crossed
	The strict librarian heard the noisy children	Librarian the the children noisy heard strict
sail	The heavy wind filled the white sail	Filled sail heavy the white the wind
train	The roaring train passed the water tower	Passed tower the train the water roaring

TABLE 22--*continued*

Recall Cue	English Word Order	Scrambled Word Order
student	The new student took the wrong order	The desk new the wrong took student
brook	The old tree shaded the fresh brook	The tree shaded brook the old fresh
	The skinny girl tasted the delicious stew	Girl the stew skinny tasted delicious the
roped	The dusty cowboy roped the spotted pony	Spotted dusty cowboy roped the pony the

RESULTS AND DISCUSSION

Table 23 contains the probability of recall of the subject, the verb, and the object by the deaf and the hearing subjects for both word orders during free recall (Condition C). With one exception, the hearing subjects with English word order, the probabilities of recall were ordered: Subject > object > verb. For the hearing subjects with English word order, the ordering was: subject > object= verb.

TABLE 23

The Probability of Recall of the Subject, the Verb, and the Object During Free Recall by the Deaf and the Hearing Subjects for Both Word Orders

Word Order	Subject	Part of Speech Verb	Object
Deaf			
English	.594	.531	.542
Scrambled	.417	.250	.333
Combined	.506	.391	.438
Hearing			
English	.708	.656	.656
Scrambled	.458	.365	.417
Combined	.588	.511	.537

Application of the criterion for redintegrative memory, i.e., that during free recall the conditional probability of recalling a whole unit given that an element of that unit is recalled must be high, to the data obtained during free recall (Condition C) reveals that only the memory of the hearing subjects with English word order approaches this criterion (see Table 24).

To test whether differences in the redintegrative power of the subject, verb and object existed, separate analysis of variance were applied to the mean number of words (only adjectives, nouns, and verbs were included in these analyses) recalled in the proper order for each

TABLE 24

The Probability of Recalling the Whole Segment Given That a Specific Element of That Segment is Recalled During Free Recall

Word Order	Subject	Part of Speech Verb	Object
Deaf			
English	.368	.412	.404
Scrambled	.125	.208	.156
Hearing			
English	.588	.635	.635
Scrambled	.364	.437	.400

of the word order by recall cue conditions. For the hearing subjects, this analysis of variance revealed a significant effect for word order [$F(1,22) = 36.20$, $p < .01$] and a significant effect for recall cue condition [$F(3,66) = 9.22$, $p < .01$]. Newman-Keuls multiple comparison tests ($p < .01$) applied to the recall cue condition means revealed that Condition S differed significantly from the other three conditions which did not differ significantly from each other, i.e., (Condition S > Condition C = Condition V = Condition O). No significant interaction between word order and recall cue condition was revealed. For the deaf subjects, also, this analysis of variance revealed a significant effect for word order [$F(1,22) = 30.63$, $p < .01$]; and a significant effect for recall cue condition [$F(3,66) = 14.14$, $p < .01$]. Newman-Keuls multiple comparison tests ($p < .01$) applied to the recall cue condition means revealed that Condition S differed significantly from the other three conditions, and that Condition V differed significantly from Condition O and Condition C, i.e., Condition S > Condition V > Condition C = Condition O. No significant interaction between word order and recall cue condition was revealed (see Table 25).

The pattern of results obtained for the hearing subjects is compatible with the principles of redintegrative power, i.e., the relative frequency of recall of the subject, verb, and object during free recall (subject > verb = object) predicted their relative power during cued recall (subject > verb = object). Since only the hearing subjects with English word order evidenced redintegrative memory, it appears that English syntactic organization is important for redintegrative memory.

TABLE 25

The Mean Number of Words (Only Adjectives, Nouns, and Verbs) Recalled Correctly in the Proper Order Per Trial by Both the Deaf and the Hearing Subjects for Each of the Word Order by Recall Cue Condition

Word Order	Condition				
	C	S	V	O	Combined
Deaf					
English	2.48	3.29	2.78	2.36	2.73
Scrambled	.62	1.58	1.27	1.10	1.14
Combined	1.55	2.44	2.03	1.73	1.94
Hearing					
English	2.84	3.71	3.07	2.74	3.09
Scrambled	1.25	2.04	1.53	1.58	1.60
Combined	2.05	2.88	2.30	2.16	2.35

To test whether, during free recall, English syntactic organization defined functional units which were recalled in an all-or-none fashion more often than word segments of equal size lacking English syntactic structure, several additional conditional probabilities were needed. The conditional probability of recalling five separate segments given that a subject recalled one word correctly within that segment were calculated separately from data obtained from both deaf and hearing subjects with both English and scrambled word order. For the English word order, the five separate segments were: (1) the whole sentence, (2) the subject phrase, (3) the subject phrase plus the verb, (4) the verb plus the object phrase, and (5) the object phrase. For the scrambled word order, the two separate segments corresponded in both length and position to the five English word order segments. The conditional probabilities computed for the English word order segments and their corresponding scrambled word order segments were compared by means of *t*-tests (see Table 26).

TABLE 26
The Conditional Probability (Averaged over 12 Subjects) That a Segment was Recalled Correctly Given That a Single Word of the Segment was Recalled Correctly

	SEGMENT				
Word Order	the whole phrase	the subject phrase	the subject plus the the verb	the verb plus the object phrase	the object phrase
Deaf					
English	.316	.670	.527	.444	.569
Scrambled	.118	.503	.288	.275	.382
$t(22) =$	2.19*	1.50	1.81	1.52	1.40
Hearing					
English	.565	.843	.642	.762	.843
Scrambled	.311	.591	.463	.376	.444
$t(22) =$	2.28*	2.63*	2.08*	3.40**	3.20**

* $p < .05$

** $p < .01$

The results of these t-tests revealed that deaf subjects recalled only one English word order segment, the whole sentence, more frequently in an all-or-none fashion than the corresponding scrambled word order segment. Hearing subjects recalled all the English word order segments more frequently in an all-or-none fashion than the corresponding scrambled word order segments. Evidently, English syntactic organization defines the functional units which are recalled for hearing subjects, especially.

To test for greater dependencies between adjacent words within the same functional unit than between adjacent words at the boundaries of functional units, the conditional probability that a word was correct given that the preceding word was computed for each adjacent pairs of words. These conditional probabilities are given in Table 27. If English syntactic organization determines the boundaries of the functional units then these boundaries should correspond to phrasal boundaries. Thus, less dependency should be obtained between the subject and the verb, and between the articles and the adjectives than is

TABLE 27

The Conditional Probability That a Word is Correct
Given That the Previous Word was Correct
with English Word Order

	Article to Objective	Adjective to Subject	Subject to Verb	Verb to Article	Article to Adjective	Adjective to Object
Deaf	.793	.940	.842	.824	.766	.933
Hearing	.732	1.000	.897	.984	.882	.950

obtained between the adjectives and nouns. This pattern of results was obtained for both the deaf and the hearing subjects, but the deaf subjects showed lower dependencies than the hearing subjects.

5. The 1967 report (RD-1479) contained an account of two studies investigating the organizational factors involved in recall of language. In the first one (Odom & Blanton, 1967a), we found that phrasal unity facilitated recall in hearing but not deaf subjects. This meant that a whole phrase like "paid the tall lady" was recalled better by the hearing subjects than "lady paid the tall" or "lady tall the paid." Since the deaf showed no differential performance as a function of linguistic structure, it was tentatively concluded that they did not have the same mechanisms or processes as hearing subjects with regard to English structure. The second study examined this question with respect to Sign. In this experiment the phrasal segments were defined according to a grammar of Sign (McCall, 1965). The data was not conclusive concerning facilitation due to the phrasal properties of the segments. The phrasal units like "frowned at young man" were recalled better than "man young at frowned" and "man frowned at young" by the deaf, but not significantly so and the pattern of recall was quite similar to that of the hearing control subjects. It was suggested, in concluding, that had the segments been presented in Sign rather than printed on the page, the results might have been more clear-cut.

During the just-completed grant period we finished two studies which were intended to uncover the role of structural units (defined according to auditory-vocal languages) in recall of segments of Sign.

(a.) For the first experiment we collected a set of constructions peculiar to Sign like those in the first column of Table 28. Our prediction was that in a recall task, deaf subjects would recall those segments better than their English equivalents or the same set of signs in a scrambled order (second and third column). We filmed

Pepper Moore, an interpreter, signing each segment. Each segment was preceded by a number from one to seven. Subjects in the experiment were given ten trials of viewing the seven segments and numbers being signed and subsequently trying to recall the segment when given the number as stimulus. Eight different deaf subjects were tested individually on each list. They were given the following instructions:

> You will see some groups of words being signed on the screen. The groups will be signed one-at-a-time. The lady will sign a number, then a group of words.
>
> Example: 9. Father and I go to town
>
> 10. Teachers learn need for
>
> These are just examples and are not part of the test. The groups of words may or may not mean anything to you. Try to remember all groups of words exactly as they have been signed and be sure to remember the right number with the right group of words. After you have seen all the groups of words, we will turn off the projector. Then we will ask you to sign back to us the numbers and words that you can remember.
>
> You will see the numbers and groups of words 10 times and sign back what you can remember each time. This task will seem very difficult at first, but it will become easier. You are not expected to remember all the groups of words at first. Try hard and do the best you can.
>
> These are the numbers that you will see each time. You may look at them at any time while you are signing them back.
>
> 1
> 2
> 3
> 4
> 5
> 6
> 7

The subjects' responses were interpreted into a tape recorder on-the-spot by the interpreter. At a later time the responses were transcribed and scored for accuracy.

Measures such as number of correct segment number pairings and number of words and number of whole phrases recalled were tallied but not analyzed since they reflected the availability in memory of the phrases. The measure most appropriate was a probabilistic one: the

TABLE 28

Segments Recalled Using Sign

Sign	English	Scrambled
1. Boy want Friday finish	1. Boy wants to finish Friday	1. Finish Friday want boy
2. I like stand than sit	2. I like to stand better than sit	2. Sit than stand like I
3. Must pay for eat	3. You must pay to eat	3. Eat for pay must
4. Girl more old me	4. The girl is older than I	4. Me old more girl
5. Little red shoes your	5. The little red shoes are yours	5. Your shoes red little
6. Charge children old 12 money 25	6. Charge 12 year old children 25¢	6. 25 money 12 old children charge
7. Baby same face Daddy	7. Baby's face is like Daddy's	7. Daddy face same baby

probability of getting the whole segment correct if one word in it was recalled. This measure detects wholistic recall or unit facilitation (if there is such) in any of the conditions. As it turned out, the mean probability values for the three conditions were: .36 for the Sign segments; .36 for the English segments; and .42 for the scrambled segments. These results mean that there was no facilitating effect on recall of having segments conforming to sign usage.

Somewhat discouraged over these results we considered two methodologically based explanations for the puzzling findings: the bad quality of the focus, exposure, and filming angle of the film and the extreme nervousness on the part of the subjects. We decided to approach the problem slightly differently in the second experiment.

(b.) The second study was, in a way, a replication of the study on recall of phrasal segments in Sign. In the present study, however, subjects were given a mixed list of all three types of phrases to recall (see Table 29) so as to eliminate group differences due to the necessarily small number of subjects.

The deaf subjects were between 15 and 19 years old and were students at the Tennessee School for the Deaf. All were prelingually deaf and had a severe hearing loss. Their reading achievement scores ranged from 4.0 to 7.0. Thirty subjects participated in the experiment; ten subjects learned one of three lists of phrases. Each list contained three intact verb phrases, three segments of the form N+V+Prep+Adj and three scrambled segments (N+Adj+Prep+V). The letter following each segment in Table 30 designates which list it appeared in.

Subjects viewed each phrase (preceded by a number from one to nine) individually. After all nine phrases were presented, subjects were given all the numbers on a sheet of paper and were required to write out the phrase that went with each number. They were given eight such study-test trials. The phrases were typed on cards, then photographed to be on 2 X 2 slides, and presented by a Carousel slide projector. One and one-half min. were allowed for recall. Instructions were given in Sign.

The number correct whole phrases and the probability of getting a whole segment correct if one word was recalled were tabulated. The table is divided by list in addition to segment type so that the reader can see that while the total recall valuex for list A and list C follow the predicted order, there is list B which overwhelmingly doesn't. No attempt at further examination of the data could account for the uniqueness of list B, but the effect was great enough that the performance averaged over lists paralleled that of list B. The probability values (in parenthesis) are also not in accordance with predictions. It appears that segments of the type N+V+Prep+Adj facilitate organization more than any other kind. No further

TABLE 29

Mixed List of Three Types of Phrases For Recall

	Segment Type		
	I Verb Phrases	II N+V+Prep+Adj	III N+Adj+Prep+V
List A	yelled at pretty teacher	table was under low	clowns funny at looked
	laughed at tall girl	clerk listened to angry	book green on lay
	stood on old chair	soldier told about large	man young at frowned
List B	was under low table	teacher yelled at pretty	girl tall at laughed
	listeded to angry clerk	clowns looked at funny	chair old on stood
	frowned at young man	book lay on green	soldier large about told
List C	looked at funny clowns	girl laughed at tall	teacher pretty at yelled
	lay on green book	chair stood on old	table low under was
	told about large soldier	man frowned at young	clerk angry to listened

analysis was completed on the data since any outcome other than the predicted one would be difficult to interpret at this time.

TABLE 30

Mean Number Whole Phrases and (in Parenthesis) Probabilities of Correctly Recalling Whole Segment when One Word Correct (Averaged over Trials and Subjects)

	Segment Type		
	I Verb Phrases	II N+V+Prep+Adj	III N+Adj+Prep+V
List A	1.54 (.68)	1.28 (.65)	1.24 (.64)
List B	.70 (.59)	1.46 (.70)	1.04 (.54)
List C	1.13 (.58)	1.04 (.66)	.84 (.49)

We had two possible explanations for the failure to obtain predicted results: (a) the theoretical notions underlying the expectation of facilitation due to organizational factors contributed by phrasal integrity were ill-conceived or (b) the grammar used to generate the phrase segments was basically in error as a description of psychological units. We couldn't think of any sound reasons for rejecting either of the explanations. The issue was not resolved in any further research.

6. For several years, we have been constructing experimental programmed instruction materials. The subject matter, appropriate use of prepositions and conjunctions, was chosen on the basis of the results of an earlier study utilizing "cloze" techniques with the deaf. In this study it was found that the deaf had particular problems with both the semantic and syntactic aspects of function words. The plan of the programmed instruction, then, was to try to cover the meaning (if there was one) and the correct placement, in the linguistic sequence, of the words to be learned. Examples of the initial effort, booklets covering one preposition--"after" were sent to a group of teachers of the deaf along with a questionnaire to evaluate the booklets. (Copies of the booklet are available upon request.) The tally of the 13 questionnaires is shown below along with selected comments.

Teacher's Questionnaire

1. Do you think that you will use the programmed instruction booklets:

   (a) with the entire class--4
   (b) with selected individual students only--7
   (c) both of the above--1
   (d) neither of the above--1

2. If you answered (a) above, will you use the booklets:

   (a) as a lesson in prepositions--4
   (b) as a fun exercise--0
   (c) to fill up some free class time--0
   (d) other, please explain--1

3. Do you think the booklets will hold their attention?

   (a) all the time they work on them--1
   (b) most of the time--7
   (c) about half of the time--1
   (d) just for a little while--2

4. Do you feel that instruction of this kind is needed:

   (a) for all students in the class--8
   (b) for a selected few students--5
   (c) for none of the students--0

5. Would you be interested in booklets of this kind for other prepositions?

   (✓) yes--12   ( ) no

6. Briefly summarise your overall impression of the booklets including utility, form, appearance, clarity, teaching potential, etc.

   utility: good, useful, attention-getting--3

   form: (1) could be improved--1
   (2) greatly impressed--lift-outs are good

   appearance: should be larger with bolder illustrations at beginning levels

   good--4

   clarity: (1) good but varies--3
   (2) sentence pattern would be clearer if used instead of a word fill in

teaching potential: good--4

(1) some sentences are too much for class of six year olds--need grade levels

(2) illustrations appear to be for kindergarten and concepts are for older children

7. Could you suggest any other ways to use this form of instruction to benefit language acquisition in deaf students?

   (1) with machines and/or skinner boxes--1

   (2) to clear up mathematical terms especially in modern concepts--1

   (3) vocabulary in different areas

8. In working with the booklets, will the class, in your opinion:

   (a) undertake the project as a learning experience--8
   (b) feel it is just a game--4
   (c) find it a boring task and race to get through it--1
   (d) enjoy it but learn little from it--1

9. Please add any comments, especially criticisms, you may have.

   (a) more transitional items when moving from one shade of meaning to another--does not assure learning and recall--9
   (b) consistency in illustrations--sentences used to determine sentence position of the word would be confusing--5
       elephant appears flying
       cat should be to right of mouse
       big brothers (show two or more)
       use only complete sentences
   (c) pages should be numbered as in other books--1
   (d) do not capitalize after in the sentences; use of upper and lower case letters confusing--1
   (e) "watching his dog after"--3 phrases are out of context--easier to teach after in dramatic play--1

The booklet entitled AFTER gives samples of activities that can be used for programmed teaching of prepositions to the deaf. It covers several meanings of the word and a wide range of ability to comprehend the written word.

Unit I--IN, OVER, UNDER, BESIDE (BY)--shown in Appendix C -- is designed to show how some material of this type can be expanded for use with the beginning reader. It incorporates many of the principles of programmed instruction, using gradual progression, prompting and guided discovery, fading, generalization and discrimination, and development of understanding. The activities illustrated in this unit are designed to insure maximum likelihood of eliciting a correct response from the student. For example, the preposition in is taught by presenting several illustrated sentences using objects and containers with names that are familiar to most young deaf children who have had some training in speech-reading and reading. The illustrations contain two objects, only one of which is referred to in the accompanying sentences. The subject must supply the correct preposition. In the following stage he must show his comprehension of the preposition and thus the entire sentence by making the choice of which object is in the container--Example: The (ball, airplane) is in the box. In the next stage of the unit he goes through the same procedure in learning the meaning and proper use of the preposition over. Then he must choose between in and over to complete sentences describing simple illustrated relationships between objects and containers. Finally he must complete similar sentences in which there is no prompting--he simply supplies the correct word for the blank in the sentences. The same form would be used to add under and beside so that he is able to use the correct preposition to complete sentences by the end of the unit. The student can go at his own pace, checking the accuracy of his answers against those supplied on the back of the page. A similar format was used to teach the use of up and down. In this case the prepositions connote direction of movement rather than the static positional relationship shown in Unit I.

The material used to teach the use of "before" and "after" (shown in Appendix C) illustrates what can be done for children who are at a higher level of reading skill. The student is led through steps of gradual progression in learning the use of these two prepositions as they connote temporal relationships. Illustrations are then given to show how different meanings, including colloquial meanings, can be taught to even more advanced students.

The materials included here are not intended to be exhaustive but to illustrate how such an approach can be used to aid deaf children in learning the meaning and use of structural elements of language. These materials are presently being developed but need to be tried on representative groups of children to make certain that they accomplish the desired goals of teaching the comprehension and use of such sentence structures by using small increments to insure maximum likelihood of eliciting the desired response. Some adjustment undoubtedly will need to be made before these materials reach their final form. Illustrations by a professional artist could then be used

B. Seman 'cs

Any attempts to undertake an investigation of the semantic aspects of language in the deaf must also necessarily be formative in nature. The first question is whether the deaf acquire the meanings of words in the same manner as hearing subjects, i.e., does the eye work like the ear works in acquiring and designating meaning? A superficial examination of the processes by which the subject learns reveals many possibilities. One of the most widely accepted ways to learn words is to learn the names of things or concepts. Different theories of conceptualization processes will not be discussed here, however, it seems that a child would have to have some internal, cognitive representation of a table before he could accurately "name" it or interpret the word when spoken to him). Most psychologists would also agree that one extrinsic part of the naming process occurs when parents and other people point out the referents of a name, e.g., "that's a dog," "see the dog," etc. Deaf children have a visual analog of this process in that, instead of sounds, they see signs, lip movements, etc. associated with a particular object. Therefore, disregarding processing specific to a modality, a deaf person should have some sign that has, as a referent, his representation of the object. Whether the representations are the same for the deaf and for the hearing is the interesting question which will be tangentially considered in the discussion of two studies.

The first study investigated a subtle semantic property of words--their potentiality for relationships in a sentence. This latter problem was approached in two ways by having deaf and hearing subjects rate simple sentences, varying in degree of subject-action-object anomaly, according to their non-sensicalness and by having the subjects replace one word of these same sentences to make them "make more sense." The second study by Dr. Kathryn Rileigh compared the learning of abstract versus concrete words in a paired-associate learning task. It is based on the assumption that abstract words refer to a peculiar type of representation--one that may have various degrees of objectivity but less objectivity than the type manifested by "concrete" words. Abstract words, then, are not abstract as words but as representations of things less able to be perceived directly. They are more difficult to learn (or differentiate) perhaps because their learning depends on already existing language and on acquaintance with a wider range of usage contexts than words about things which can be pointed to. If this assumption is valid, deaf children should have greater difficulty in acquiring abstract words since they don't have access to as much information of this sort as hearing children.

7. In a study alledgedly investigating the processes whereby people process sentences, Clark and Begun (1968) found evidence for two distinct stages or processes: (a) a hierarchical processing for "elementary functional relations" and left-to-right processing for semantic content. The evidence for hierarchical processing comes from subjects' differential ratings of sensibleness depending on the amount of agreement between subject, verb, and object in a set of constructed sentences. Subjects rated as quite sensible sentences in which the subject, verb, and object agreed as in"the cowboy lassoed the calf." In order of rated sensibility after complete agreement came verb-object agreement as in "the speech lassoed the calf," then, subject-verb agreement as in "the cowboy lassoed the speech," subject-object agreement as in the "president lassoed the speech," and lastly, no agreement as in "the speech smoked the calf." This ranking, in general, indicates that both subject and predicate must make sense by themselves before the judgment of the sensibleness of the subject and predicate together is taken into account.

A second finding in the two experiments in which subjects substituted words was that words later in the sequence tended to be replaced more frequently than words early in the sentence. This was taken as an indication that subjects also analyze sentences sequentially from left-to-right.

The study completed by Clark and Begun seemed an ideal vehicle to test some of the assertions concerning the deaf's inability to utilize the underlying syntactic aspects of English. It was predicted that the deaf would perform like the hearing subjects in substituting words but unlike the hearing in rating sensibleness. The methodology was quite similar to that used in the Clark and Begun study. Subjects rated on a seven-point scale of sensibleness five different kinds of sentences. The sentences were constructed by systematically repairing the subjects, verbs, and objects of the five base sentences in Table 31 below. The resulting 450 sentences were the ones rated by the subjects.

For a more complete description of the kinds of sentences derived from the original sentences the reader should consult the Clark and Begun article. The five main types and the number of sentences of each were:

(a) No agreement: The rabbit plowed the arrow. (40)
(b) Subject-verb agreement: The Indian shot the song. (80)
(c) Subject-object agreement: The Indian plowed the arrow. (40)

TABLE 31

Sentences Used to Derive 450 Sentences
Rated in the Experiment

Base Sentences
The artist painted the picture.
The rabbit ate the carrot.
The farmer plowed the field.
The Indian shot the arrow.
The bird sang the song.

(d) Verb-object agreement: The rabbit plowed the field. (80)
(e) Complete agreement: The artist painted the picture. (10)

METHOD

Subjects

Subjects were 10 high school age deaf students and 10 hearing students matched on age and IQ. Half of each group rated sentences on sensibility and half replaced a word in each sentence. The mean age of the deaf subjects was 17.1 and all of them were prelingually and severely deafened. The mean age of the hearing subjects was 16.8.

Procedure

In the sensibility rating task a single subject rated only one-fifth of the total number of sentences of each type. Three subjects of the fifteen in a group rated the same sentences. The same division of sentences was true for the replacement task, also. Each subject only saw 90 sentences of the 450.

In the sensibility rating task, subjects were instructed to rate on a scale from 1 to 7 the degree to which the sentence made sense, with a "1" being very nonsensical and a "7" meaning very sensible. Subjects in the replacement task were instructed to replace one of the underlined words with another word which would make the sentence make more sense.

RESULTS AND DISCUSSION

The mean ratings for each sentence type are shown in Figure 23. What is striking is not the differences between sentence types but the similarity between the ratings made by the 15 deaf subjects and the 15 hearing subjects. An analysis of variance (groups X sentence types) revealed no significant difference between the two groups and no interaction between groups and sentence types. A rank order correlation between ratings of the 16 sentence subtypes by the deaf and the hearing subjects was rather high, $\rho = .93$.

The per cent of subjects, verbs, and objects changed in each sentence type for each group is shown in Table 32. Evidence for left-to-right determinants of replacements is best demonstrated in sentence type 15 (complete agreement) where subjects tended to let the subject stay, the deaf less so than the hearing (deaf had higher per cent change). The deaf, unlike the hearing, chose more often to change the object rather than the verb, indicating a greater tendency to rely on left-to-right dependencies within a sentence than the hearing.

Except for sentences portraying complete agreement (nos. 15 and 16) and one type portraying verb-object agreement (no. 12, e.g., The Indian plowed the farmer), deaf and hearing subjects generally agreed fairly well on what words in a sentence determined its sensibleness. In the three cases where the deaf and hearing differed, it appears that it's due to a reluctance on the part of the deaf to change the verb, or conversely, a propensity on the part of the hearing to change the verb. Since the complete agreement sentences were only represented by one example for each subject, it would be unwise to give such a finding more than tentative consideration.

In all, on both rated sensibility and word replacement tasks, the deaf and hearing subjects performed similarly. This finding suggests that the deaf are capable of understanding and utilizing the basic subject-verb-object relationships which are present in a simple declarative sentence. In a more theoretical sense, it seems that the deaf possess the hierarchically ordered relationships necessary as a basis for further complex sentence construction. This is not to say that they would perform like the hearing if the sentences were constructed in any other form, say passive negative. The relationship between such abilities as sampled in this task and the ability to construct the more complex, well-constructed sentence is not yet worked out and speculation at this point would be hopelessly naive. However, it is heartening to note that, in some very basic respects, the deaf possess competency similar to that found in hearing subjects.

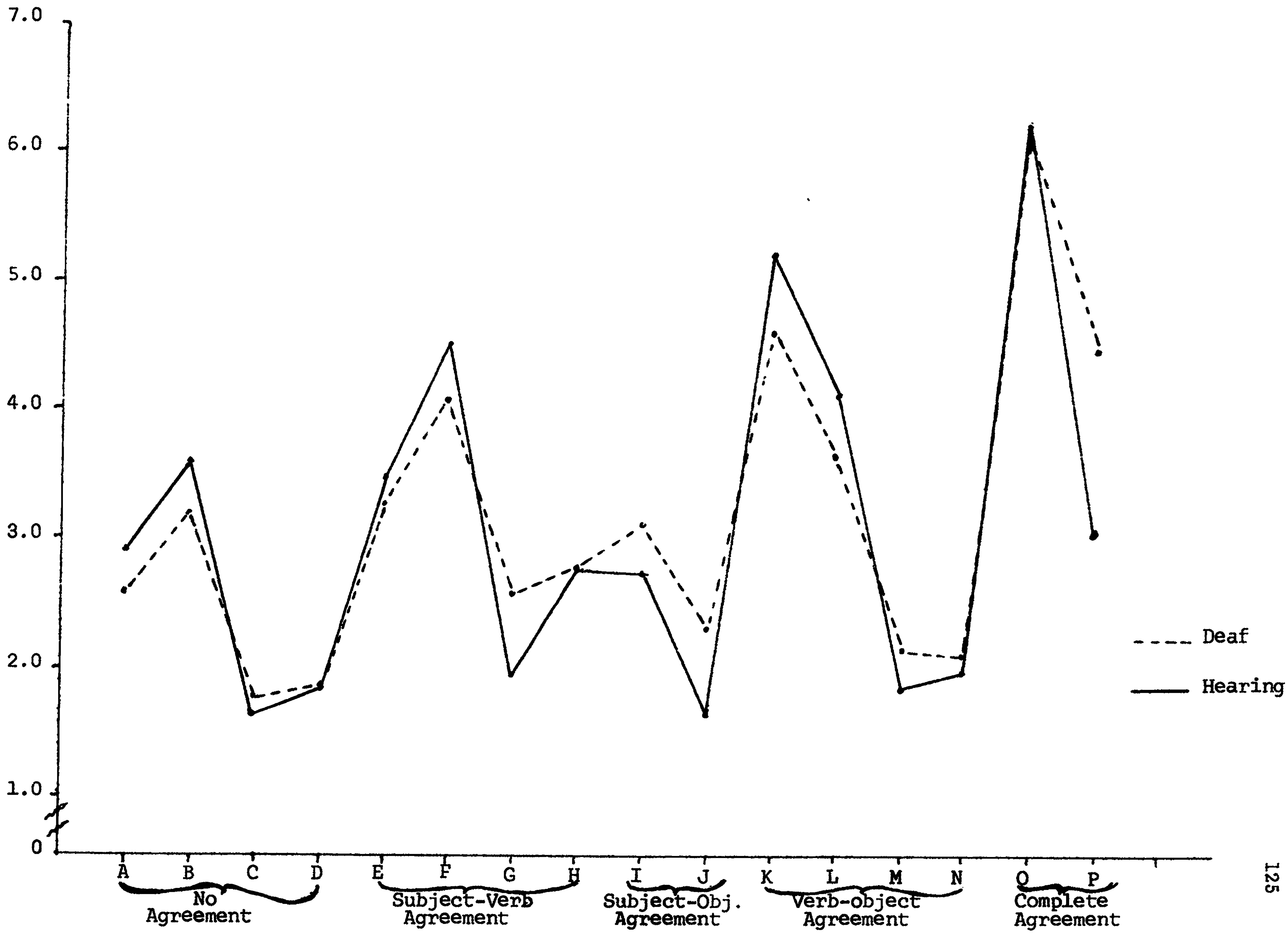

Figure 23. Mean sensibility ratings of the sentences.

TABLE 32

Proportion of Time the Subject, Verb, or Object
was Changed by the Subjects

Sentence Type	Agreement	Subject		Verb		Object	
		Deaf	Hearing	Deaf	Hearing	Deaf	Hearing
1	None	.27	.18	.29	.30	.44	.52
2		.40	.32	.21	.31	.39	.37
3		.54	.52	.26	.32	.20	.16
4		.69	.65	.16	.24	.16	.11
5	Subject-Verb	.02	.00	.10	.12	.86	.88
6		.10	.17	.06	.16	.84	.67
7		.47	.48	.12	.16	.41	.34
8		.54	.54	.05	.14	.41	.32
9	Subject-Object	.23	.08	.41	.45	.36	.46
10		.56	.67	.33	.23	.11	.10
11	Verb-Object	.66	.69	.13	.17	.21	.13
12		.44	.28	.16	.39	.40	.32
13		.94	.92	.02	.07	.05	.02
14		.86	.73	.06	.15	.08	.12
15	Complete Agreement	.33	.25	.09	.50	.58	.25
16		.67	.62	.00	.23	.33	.15

8. The suggestion that nonverbal as well as verbal symbolic systems may act as mediators in verbal learning is a particularly interesting subject with respect to persons of limited verbal ability, such as the deaf. Since they must rely solely on visual and tactual cues to language (e.g., sign and fingerspelling), their facility with verbal mediators would be expected to be less than their facility with imaginal ones. Furthermore, because of their intensive experience with visual cues, the deaf may be more skilled in the use of imagery than persons with normal hearing.

Paivio (1969) has written extensively on the topic of imagery, formulating a theory to explain the facility with which words evoke images and the effects of imagery on learning and recall. Imagery has been thought to be related to a concrete abstract dimension of stimulus meaning. Specifically, words of a concrete nature elicit images more readily than those which are abstract in nature. This expectation was confirmed in a study of verbal and imaginal associative reaction time of words varying in abstractness-concreteness and generality (Paivio, 1966). Associative latencies were in fact shorter for concrete as opposed to abstract, and specific as opposed to general words.

In verbal learning and memory, Paivio has suggested there may be two alternative coding systems which can act as mediators: (a) verbal representational or labeling responses which link the stimulus to the appropriate response and (b) nonverbal imagery. Which of these processes is applied in a particular learning situation depends upon the characteristics of the verbal stimuli and responses involved. Imagery is assumed to intervene as a function of the concreteness of the stimuli, while verbal representation is dependent upon the meaningfulness of the items.

If imagery does act as a mediator, the facility with which S-R associations are learned would be expected to vary with the image-evoking properties of the items. Since concrete words are assumed to elicit images more readily than abstract ones, they would be expected to facilitate learning more than abstract words. Numerous studies with adults have obtained supporting evidence for this claim (Paivio, 1963; Paivio, 1965; Paivio, Yuille & Smythe, 1966). Similar effects have been noted with children (Paivio & Yuille, 1966), but they have not been as striking as the adult data. Further, Paivio and his colleagues have noted that the facilitating effect of imagery on learning is more apparent when the stimulus item, rather than the response item, is concrete. That is, the following paired-associates are recalled in order of decreasing ease: concrete-concrete, concrete-abstract, abstract-concrete, and abstract-abstract.

It is important to note that the findings discussed to this point have been relevant only to a prompted recall paradigm. The concrete stimulus word has been thought to act as a cue which evokes a compound image involving both stimulus and response components. From this image, the response component is retrieved.

The data obtained from the free recall measure have been consistent with those from prompted recall designs, but the explanatory logic does not obtain entirely. For example, free recall of concrete words has been demonstrated to be better than that of abstract words (Olver, 1965) and words high in imagery (Paivio, 1967) and vividness (Tulving, McNulty & Ozier, 1965) have enjoyed higher recall than words with low image-evoking properties. These results cannot be attributed to the arousal of a visual image by the stimulus member of the pair during recall since no stimulus is presented. It is clear that the findings occurring in the free recall situation require another explanation.

Paivio has suggested two possibilities: (a) concrete words may be more available as responses or (b) concrete words may be better linked to one another by pre-experimental associations. Kammann and Streeter (1970) have leveled cogent arguments against both of Paivio's explanations. First of all, they argued that response availability is not logical since there is no correlation between ratings of concreteness and measures of frequency of occurrence in the language. Furthermore, they noted that concreteness does not facilitate learning on the response side of the pair. With respect to pre-experimental associative connections, Kammann and Streeter claim that there is no evidence that the free recall task makes use of inter-item associations, and words with many associations should, in fact, be less discriminable. Kammann and Streeter offered evidence to support the following alternative hypothesis: abstract words have more associative connections with each other, formed through overlap in contexts, and these connections lead to more abstract interference in free recall.

There has been a wealth of studies in the literature involving abstract conceptual tasks with deaf subjects (see Furth, 1964), some of which indicate that the deaf have particular difficulty with abstractions. One exemplary study (Templin, 1950) involved a nonverbal analogies task in which the subject was required to select a figure that had a relationship to another figure that was the same as that displayed by a standard pair. Deaf subjects performed much poorer on this task than did normal hearing subjects. In addition, Oleron (1957) found deaf subjects' performance inferior to that of normal-hearing subjects on a series of abstract tasks over a wide age range. Some researchers have claimed that the deaf have a "concrete attitude" (perceiving objects as having individual differences and not as representatives of categories) which accounts for their inferior conceptual performance.

The deaf have been observed to have a pattern of concreteness in their language as well as in their concepts. In a forced choice verbal association task (Blanton & Nunnally, 1964) where subjects chose between evaluational, detail, or conceptual associates, deaf subjects showed a greater preference for descriptive detail than either categorical or evaluational associations.

The present study compared deaf and normal-hearing subjects on the learning of word-letter paired associates varying in abstractness. Both prompted and free recall measures were administered. On the prompted recall sessions following each list presentation, it was expected that: (a) concrete words would be recalled better than abstract ones, (b) pairs in which the stimulus was a word would be recalled better than pairs in which the stimulus was a letter, (c) concreteness would have more effect on the stimulus side than on the response side, (d) deaf subjects would perform better than normal-hearing subjects on concrete words but worse on abstract ones, and (e) recall would improve across trials. On the free recall task at the completion of the last trial, it was expected that concrete words would be recalled better than abstract ones.

METHOD

Stimulus Materials

Each subject was presented a paired-associate list of 20 items, each item consisting of a word and an alphabet letter. Ten words were chosen as having abstract meaning and 10 as having concrete meaning according to the ratings obtained by Paivio, Yuille and Madigan (1968). On a 7-point scale, words chosen as concrete obtained ratings greater than five while those selected as abstract had ratings less than three.

The words chosen were restricted to those having four, five, or six letters, equal numbers of each kind being concrete and abstract. All words were above average in meaningfulness on the Paivio et al. (1968) scale and were high in frequency of occurrence (A or AA) according to the Thorndike-Lorge (1944) norms. Each word had a single sign equivalent as used by the deaf and catalogued in the American Dictionary of Sign. Since ratings of abstractness tend to correlate somewhat negatively with ratings of imagery, the abstract words were further restricted to those having as high imagery ratings (Paivio et al., 1968) as possible.

The abstract words employed were as follows: time, honor, theory, hour, heaven, duty, soul, life, glory, and mind. The concrete words were: animal, book, ship, fire, baby, chair, bowl, door, church, and party.

The letters paired with the words were selected such that the letter did not appear in the word with which it was paired and no letter was used more than once.

Two groups of the items were prepared, differing only in the position of the word as stimulus or response element. Group I contained the words as stimulus items and the letters as responses, while Group II contained the letters as stimulus items with the words as responses. For each of these groups, six random orders of the items were generated for presentation during the six trials of the learning phase. In addition, six different random orders of the stimulus elements alone were prepared for use in the prompted recall trials following each presentation of the list.

Subjects and Design

Sixty-four students served as subjects in this experiment. The deaf group consisted of 32 male and female students at the Tennessee School for the Deaf in Knoxville, Tennessee. All of these subjects had suffered a sensori-neural hearing loss of a severe to profound degree prior to the onset of language acquisition. The mean age of this group was 17.6 years, and their mean estimated IQ level (as measured by various non-verbal tests) was 104. The reading grade-level of these subjects, as determined by the Stanford Achievement Test, was 5.9.

The 32 subjects with normal hearing were selected from a Williamson County, Tennessee public school and served as age controls for the deaf subjects.[2] Average age for these subjects was 17.2 years. Their mean IQ level was 106 according to the Lorge-Thorndike Test. These students had been evaluated on the Metropolitan Achievement Test and were observed to read at the 8.6 grade level.

Half of the subjects in the deaf and normal-hearing groups received the verbal materials with the words as the stimulus elements and the letters as the responses (Group I), while the rest of the subjects received the letters as the stimulus elements and the words as the responses (Group II). Within each of these groups, half of the subjects were male and half were female.

The two between-subjects factors in the design that were under investigation were hearing status (deaf vs. normal-hearing)

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[2] In addition, a group of normal-hearing subjects with reading levels comparable to those of the deaf subjects participated in the study. The normal-hearing subjects in this group performed significantly less well than the deaf subjects due to the wide age difference. It was felt, therefore, that age controls would be more appropriate, and only those results are mentioned here.

and presentation order (word-letter pairs vs. letter-word pairs). The primary within-subjects factor was the abstractness of the verbal materials (abstract vs. concrete) in both the learning phase and free recall phase of the experiment. Of secondary concern was the trials factor in the learning phase.

Procedure

Subjects were seen in groups of four. They were given written instructions to read. Deaf subjects were given signed instructions in addition to the written ones. The instructions for subjects receiving Group I follow (appropriate changes were made for Group II instructions):

> You will see some words on the screen. Each word has a letter beside it that goes with it. For example: Train-A and Leg-K. Try to remember which letter goes with each word. After you have seen a lot of these, we will stop and ask you to write down on a paper the letters that go with each word. For example: Train-___ and Leg-___, and you should write in the letters like this: Train- A and Leg- K . After you have finished the paper, I will show you the list of words again and you will write the answers again. We will do this several times. At first you cannot remember all the pairs, but it gets easier. Try hard and do well.

All subjects were exposed to all the concrete and abstract items on each of 6 learning trials. A learning trial consisted of a practice session in which the subjects watched the item pairs projected one at a time onto a screen for 1 sec. each. Following each presentation of the entire list, subjects were administered a prompted recall task. A response sheet was distributed to each subject. The sheet had either the words along (Group I) or the letters alone (Group II) printed on it and a space provided for the subjects written response. Subjects were allowed 1 min. to complete the pairs. This procedure was repeated for each of the 6 learning trials.

After the learning trials were completed, a free recall task was administered. Subjects were given a blank sheet of paper and were asked to write the words from the list that they could remember in 2 min.

RESULTS

A 2 X 2 X 2 X 6 analysis of variance (general balanced design) was performed on the number of correct responses made on the prompted recall tasks. The independent factors were hearing status (deaf, normal-hearing), presentation order (Group I, Group II), word abstractness (concrete, abstract), and trials (one through six). The main effect of presentation order was significant, [$F(1,60) = 7.014$,

$p < .01$]. Pairs in which words were stimulus elements were recalled better than pairs in which letters were the stimuli.

A highly significant main effect of trials was also obtained, [$F(5,300) = 287.729$, $p < .001$]. Multiple comparisons were made according to the Scheffé method to determine on which trials significant differences actually occurred. The number of correct responses was found to increase significantly ($p < .01$) from each trial to the subsequent one until the fifth trial. There was a leveling off effect apparent, such that the correct responses on the fourth trial did not differ significantly from those on the fifth. The main effects of presentation order and trials during the learning phase are presented graphically in Figure 24.

The interaction of Hearing status X Presentation order X Trials X Word abstractness was also significant, [$F(5,300) = 2.442$, $p < .05$]. The conditions yielding the lowest performance scores during the learning trials were deaf subjects responding with the words to abstract pairs on the first trial. Obtaining the highest scores were deaf subjects responding with the letters to concrete pairs on the sixth trial.

The number of correct responses to the free recall task was submitted to a 2 (hearing status) X 2 (presentation order) X 2 (word abstractness) general balanced design analysis of variance. One main effect, word abstractness, was highly significant, [$F(1,60) = 14.815$, $p < .001$]. Free recall was significantly better for pairs incorporating a concrete word than for pairs with an abstract word. A significant interaction of Hearing status X Word abstractness was obtained, [$F(1,60) = 5.708$, $p < .05$]. Figure 25 presents graphically the abstractness main effect and the two-way interaction. As can be seen from the graph, deaf and normal-hearing subjects performed equally well on concrete pairs. On abstract pairs, the performance of both groups deteriorated somewhat, but the most marked drop was incurred by the normal-hearing subjects.

DISCUSSION

Previous investigations of the facilitating effect of imagery on paired-associate learning have obtained strong effects using a prompted recall measure. In this study, however, the expected effect of the abstractness variable was obtained only on the free recall measure. Even though in a free recall task there is no cue presented of which the subject can form an image, there seem to be several credible explanations for the finding that concrete words were more readily remembered. Kammann and Streeter's (1970) reasoning that abstract words become more confusible because of their shared contexts could account for this result. Another possible interpretation is that the images aroused by the concrete

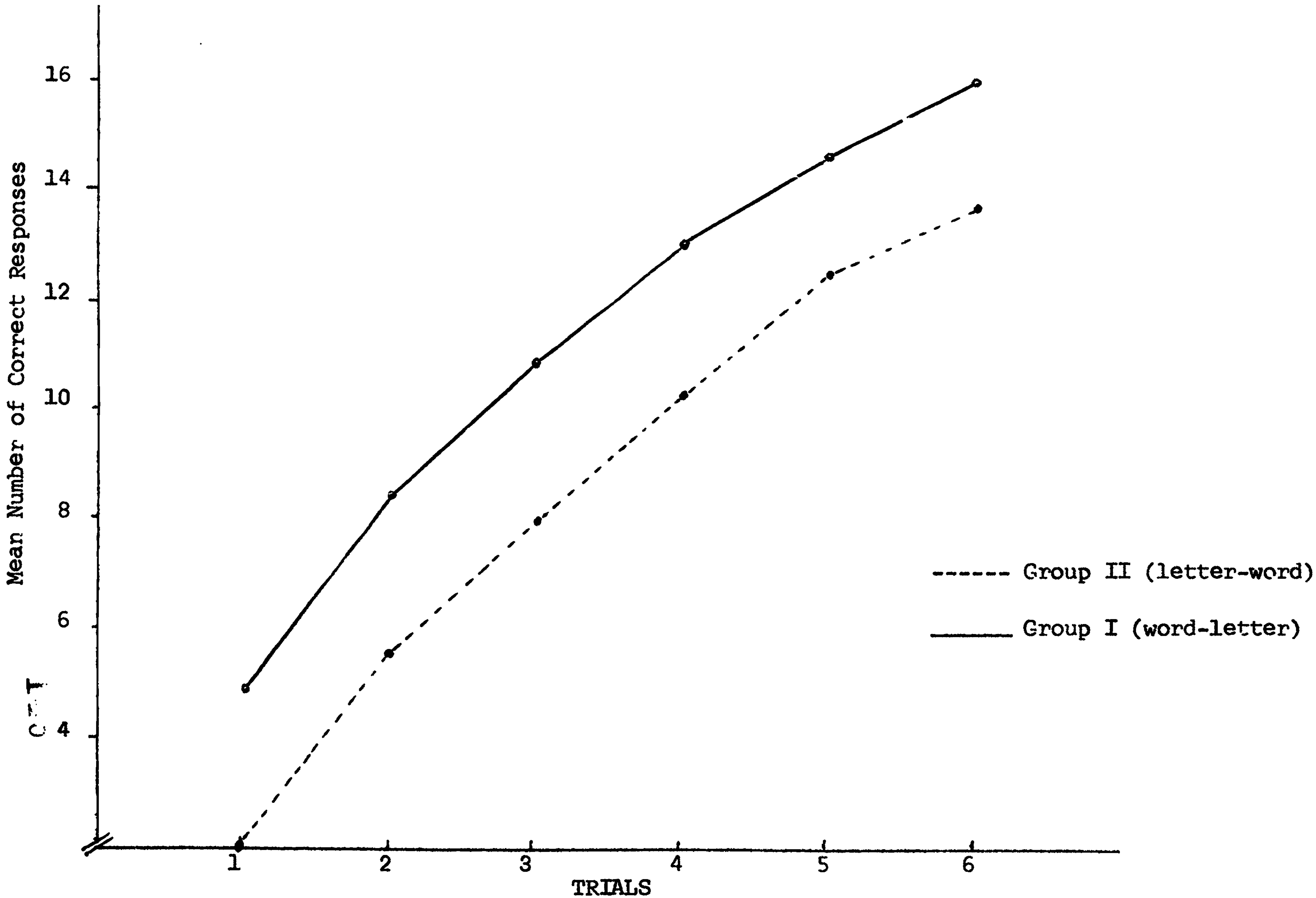

Figure 24. Correct responses to word-letter and letter-word pairs during learning phase as a function of trials

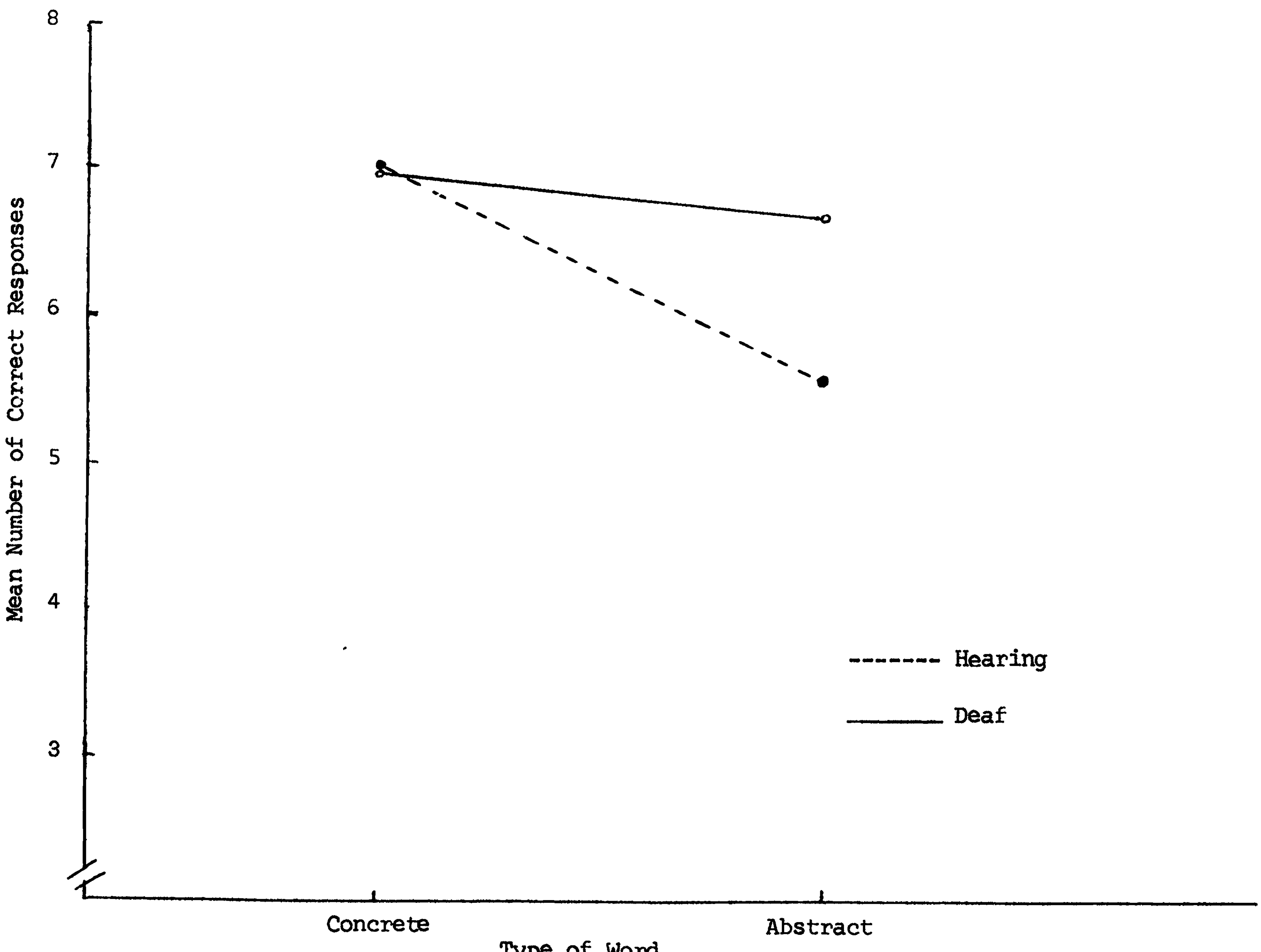

Figure 25. Correct responses to concrete and abstract pairs during free recall as a function of hearing group.

items during learning become functionally autonomous and can serve to aid subsequent recall even in the absence of a cue.

In order to be in line with the results of previous research, an Abstractness X Presentation order interaction would have been expected, illustrating that concrete words have more of a facilitating effect when acting as stimulus items rather than as response items. The fact that this interaction did not obtain in the present study is a little surprising.

The expectation that pairs with a word as the stimulus element would be remembered better in the prompted recall measure than pairs with a letter as the stimulus was supported. This is consistent with traditional verbal learning findings that a word is a more effective cue to recall than is an alphabet letter.

In view of the common idea that deaf persons approach thought and language in a concrete, specific manner, it is interesting to note that the deaf subjects in this study performed equally with the normal-hearing subjects overall and better than the normal-hearing subjects on free recall of the abstract items. Although their free recall performance for abstract words was slightly inferior to that for concrete words, the difference was not appreciable. From this result, it appears that the normal-hearing subjects in this study were affected by the subtle attributes of the verbal material to a much greater extent than were the deaf subjects. This conclusion is supported further by the observation that the English language competence of deaf persons rarely exceeds a very basic level. Additional research of this nature involving subjects with deficient hearing may prove fruitful in pointing out the features of semantics and syntax to which they are inattentive.

CHAPTER III

AFFECTIVE DEVELOPMENT

An emotional immaturity, namely lack of empathy and deficient impulse control, is one of the most consistent findings resulting from clinical investigations of deaf subjects. (See Levine, 1956, 1960; Altshuler, 1963, 1964, 1967; and Baroff, 1963). In general, these results are thought to be due to an insensitivity to the feelings of others on the part of the deaf; "cheerful indifference to the feelings of others" was the expression used by Levine (1956, p. 152).

A related set of findings stems from previous work by Blanton and Nunnally (1964a) in which they found, in a forced choice word association test, that the deaf chose significantly fewer evaluative associations than their hearing counterparts. In a subsequent study they (Blanton & Nunnally, 1964b) administered Miller's Locus of Evaluation Scale to 137 deaf children and 302 hearing children. The results indicated that deaf children have an external locus of evaluation relative to the hearing children. This tendency of deaf children to externalize responsibility for the evaluation of environmental conditions was interpreted by the authors to indicate "the relatively weak associative strength of evaluational terms in the deaf.... Our results support the idea that the deaf not only have a weaker pool of evaluative terms and associations, but feel inadequate to make meaningful evaluative judgments and tend to rely on others for such discriminations" (p. 893).

While it may come as no surprise that the deaf have noticeable emotional problems, the underlying causes of such and their specific connections with hearing loss have not been disentangled and are not immediately obvious. The observed "lack of empathy" in the deaf is a description, not an explanation, and, as such, is experimentally unwieldly. One of the purposes of the research reported here was to examine the notion of "empathy" as it was used to describe the deaf and to report three studies investigating some possible implications of the analysis.

In order to display "empathy" there are several skills that are required of the human organism: (a) he must have had past experience with a particular feeling directly or indirectly, (b) he must be able to recognize the cues in the environment which signal emotion, both in the situation causing the emotional reaction and in the reaction, physical and verbal, of the person experiencing on emotion, (c) he must be able to interpret or evaluate the cues as to their implications, i.e., he must do more than merely acknowledge "another instance of X," (d) he must have knowledge that the demonstration of empathy is important for interpersonal relations.

The research by Blanton and Nunnally described previously (Blanton & Nunnally, 1964a, b) would seem to imply that the deaf are deficient in the ability to interpret and evaluate emotion-arousing situations (c above). There is little reason to believe that (a) lack of direct or indirect experience with an emotion is an explanation for their "apathy" since it could be argued that they even experience more emotional situations than their hearing counterparts due to an institutional background plus an intense reaction on the part of hearing people to the deficit and the resultant behaviors.

The studies reported below were designed to investigate the probable source of the lack of empathy attributed to the deaf. The first study compared deaf and hearing children in their ability to match appropriate facial expressions with emotion-arousing situations. In the second study deaf and hearing subjects sorted facial expressions to determine whether the subjects could categorize the displayed emotions.

Experiment I

The task was one which seemed to measure the degree to which a subject could infer from emotionally-loaded situations what affect the person in that situation was experiencing and could match it with a facial expression appropriate to that emotion. For several years, Izard (1968) has been compiling a series of photographs of individuals depicting various emotions. To date, using these standardized materials, he has found evidence for nine affects that are detectable by their facial expressions. These are listed in Table 33 below. His photographs along with a set of drawings of situations were the materials used in the study reported below. Deaf and hearing children were compared in their ability to select a facial expression that was appropriate for a situation. The experiment was completely non-verbal so that the hearing subjects would have no advantage with respect to understanding instructions or establishing rapport with the experimenter.

METHOD

Materials

Drawings: The situation-drawings were made by giving a list of the affect categories to an artist with suggestions for appropriate situations. She made 67 sketches, approximately seven situations for each affect.

TABLE 33

Per Cent Agreement for Situations Used to Match with Facial Expressions

Emotion	Situation	Per cent of Response Agreement
Fear	lion chasing child	95
	man pointing gun at figure	93
	ghosts scaring a child	89
	coiled snake near child	79
Surprise	genie appearing from bottle	90
	surprise birthday party	88
	jack-in-the-box	84
	child's bubble gum popping	83
Joy	child eating ice-cream cone	95
	Christmas day scene	94
	child playing with puppies	92
	figure receiving lollipop	81
Distress	child who has fallen from bicycle	88
	truck running over dog	78
	child looking at de-headed snowman	76
	person in hospital with cast on leg	75
Anger	child hitting the other	90
	child hitting another with a bat	87
	child being put to bed and struggling	85
	children struggling over toy	77

TABLE 33--continued

Emotion	Situation	Per cent of Response Agreement
Interest	child watching his mother put on makeup	100
	construction being watched by child	100
	child watching mother cook	92
	child looking at monkey	77
Shame	child spilling milk	95
	child caught tracking dirt in house	92
	mother shaking hand at child who has broken piggy bank	85
	person being spanked	84
Disgust	child holding dirty diaper	88
	person holding an apple with a worm in it	74
	chewing gum stuck on foot	72
	child looking at pastry covered with flies	71
Contempt	group of children ignoring a lone child	80
	children looking at figure who missed the ball	65
	children watching child tangled in jump rope	37
	children watching child topple a pile of blocks	35

The 67 drawings were shown by opaque projector to a group of 70 college students who were instructed to pick (from a list provided) the word that best described the way the designated figure fit in the situation. The four situation drawings eliciting the most agreement in each affect category became the test stimuli. It was originally planned to have a criterion of 70 per cent agreement with no more than one-sixth of the responses in any other affect category. This criterion was met for at least four drawings in every affect category except contempt. The percentages are shown in Table 33. Additional drawings were made following suggestions for appropriate contempt situations solicited from the same subjects. Again upon testing, all of the drawings had to be rejected because of failure to reach criterion. After several such attempts, it was decided to use the four situation-drawings which received the most agreement. They are the ones shown in Table 33.

Training

Before each subject was tested on the actual matching task, twelve training items were administered. Each consisted of a picture of an object or situation drawn on a 9 1/2" X 7" poster card that the subject was to look at before selecting from a choice of three colors or objects (all presented on a 14" X 6 1/2" poster card), the one most appropriate for the picture. The early training items paired a banana with three colors, a pumpkin with three colors, etc. The later items paired a snowman with three different activities (the correct picture was a child in a snowsuit throwing a snowball) and a beach picture with three varied scenes. The last item concerned an appropriate face for a Santa Claus.

Test

The test materials consisted of the 36 situation drawings--four representing each of the nine affect categories--and the 36 triads of photographs of facial expressions used by Izard (1971). The triads were arranged so that every correct facial expression was seen once with a facial expression from every other affect category. The position (left-middle-right) of the correct face was randomly determined with the restriction that it occurred equally often in each position and that the same position was not the correct response for all four presentations of an affect category. Furthermore, no triad contained all three faces that belonged to the same sexed person. The four correct choices for each affect category were represented by four different faces, two male and two female.

Procedure

Each subject was tested individually in one session which lasted about 30-45 min. He was seated at the table with the experimenter and asked if he would like to play a game. The hearing subjects were also told that the game had one rule--"we can't talk while we play. You'll have to figure out from the way we point (on the first training trials) how you're supposed to play the game."

The twelve training items were shown to subjects. The first two items were demonstrated by the experimenter; the rest were demonstrated by the subject. There was a criterion of correct performance on five out of the last six items before he was allowed to participate in the test.

On the 36 test trials, subjects were shown the situation drawing which illustrated a particular affect and a triad of three faces, each portraying a different emotion. Subjects pointed to the face in the triad that illustrated the emotion in the situation. No feedback was given during the test.

Each subject had a different order of test stimuli, and the triad accompanying a given situation drawing was systematically switched within an affect category such that four subjects in each group were shown a particular triad of faces with, for example, the drawing of a hold-up. Another four subjects saw another triad with that drawing, and the first triad with another fear situation. There was no time limit imposed on the subjects.

Subjects

The fifteen deaf subjects were selected from a population of about thirty 7-8 year olds at the Tennessee School for the Deaf, a residential school. All subjects had a hearing loss of 75 dB in their best ear were prelingually deafened, and had an IQ of 80 or above.

The 30 hearing subjects came from two grade levels, (15 subjects from each): a private kindergarten, and the second grade of a rural public elementary school. All subjects were considered by their teacher to be of average but not superior ability. Eight boys and seven girls comprised each group of elementary school children; nine boys and six girls made up the kindergarten group.

Since the deaf are also in an institutional setting, it seemed appropriate to have a control group of institutionalized hearing children. Administrators at two homes allowed their children to participate. After screening for low IQ scores and eliminating two children for not meeting criterion on the practice items, only 13 children qualified--three girls and ten boys.

RESULTS

The mean number correct choices (agreements with college-age raters) is shown by groups and emotions in Figure 26.

Considering only the seven- and eight-year olds, the non-institutionalized hearing subjects performed best, the institutionalized children were in the middle and the deaf scored lowest on every emotion. An analysis of variance for unequal frequency per cell on number correct by all groups (kindergarten, deaf, second-graders, institutionalized second-graders) and emotions (9) provided a significant groups effect [$F(3,55) = 7.79$, $p < .01$]; a significant emotions effect [$F(8,440) = 33.33$, $p < .01$]; and a small but significant interaction [$F(24,400) = 1.37$, $p < .01$]. Apriori multiple comparisons (Winer, 1962) indicated the following order of goodness of performance: hearing eight-year-olds > hearing five-year-olds [$F(1,55) = 13.20$, $p < .01$]; hearing five-year-olds > institutionalized eight-year-olds [$F(1,55) = 4.85$, $p < .05$] and institutionalized eight-year-olds > deaf eight-year-olds [$F(1,55) = 8.51$, $p < .01$].

Experiment II

METHOD

This experiment required subjects to sort facial expressions into pre-determined categories. The younger deaf subjects and the younger institutionalized children were almost all the same subjects as were used in the previous experiment. There was a time lag of two mos. between the matching task and the sorting task for the deaf subjects. The institutionalized subjects did both tasks in the same experimental session, half completed the matching before the sorting. The remainder did the tasks in reverse order.

Subjects

There were six groups of subjects in the sorting task. Since the number in each group varied some, the number in each group is presented in Table 34 below.

Materials

The photographs to be sorted were the same ones used in Experiment I. One standard or prototype from each emotion category was laid face up on a large poster board which had black lines dividing it into nine equivalent sections, each 3 X 3 in. Subjects were given the rest of the photographs (the order of which was determined by shuffling) and were told to put all the people who felt the same way in the same pile. They were instructed to put each photograph under the photograph already displayed. No time limit

TABLE 34

Mean Number Correct, Mean Number of Errors, and Mean Number of Errors as a Proportion of Total Responses to a Photograph by Groups

Group	Mean No. Correct	Mean No. Errors	No. Errors/Total No. Cards Put in Category
Eight-year-old Institutionalized (N=14)	12.9	14.4	.521
Eight-year-old Hearing (N=16)	16.2	10.9	.400
Eight-year-old Deaf (N=12)	16.5	10.5	.388
High School Institutionalized (N=16)	20.7	6.3	.233
High School Hearing (N=16)	19.5	7.5	.342
High School Deaf (N=12)	17.8	4.1	.277

was imposed; most subjects took about 15 min. A different set of standard photographs was displayed for each subject and the position of the emotion on the board was changed for each subject. This means that a subject viewing the board with the nine exemplars exhibited was seeing different faces in different positions from the previous subject.

RESULTS

There are two ways to measure accuracy in sorting the faces--the number of correctly classified faces and the number of incorrectly classified faces. It is conceivable that a subject could have placed all members of his stack under the same photograph. This would have resulted in a perfect score of three correct on the first measure and an error score of 24 on the second. The means for each measure over all emotions are presented in Table 34. A derived measure, the number of erroneous placements in a pile divided by total number of items placed in that pile is also presented.

It can be seen that all measures seem to exhibit the same fluctuations. An unequal frequency per cell analysis of variance (6 groups X 9 emotions) was computed on only the number of photographs correctly sorted, since all the measures appeared to be highly correlated. There was a significant groups effect [$F(5,76) = 7.88$, $p < .01$], a significant emotions effect [$F(8,592) = 30.60$, $p < .01$], and another small but significant interaction [$F(40,592) = 1.45$, $p < .05$].

The following apriori comparisons were made:

Eight-year-old deaf vs. high school deaf, $F = < 1$

Eight-year-old deaf vs. eight-year-old hearing, $F = < 1$

Eight-year-old deaf vs. eight-year-old institutionalized, $F(5,76) = 2.35$, $p < .05$
Eight-year-old hearing vs. eight-year-old institutionalized, $F < 1$

High school institutionalized vs. High school deaf, $F = < 1$

DISCUSSION

Note that the differences found in the matching of situations to faces collapsed in the face-sorting experiment. Whatever effects were prevalent in the matching task could not be attributed to an inability on the part of the subjects to read or categorize facial expressions (except for the younger institutionalized subjects). In the matching task, the deaf exhibited a deficient performance above what could be expected as a result of institutionalization. Since they performed comparably in the expression sorting task, it can be concluded that their deficiency may be related to the analysis and interpretation of emotion-laden situations. There is an interesting asymmetry in facial expressions and situations although they both provide cues which signal emotion to the subject. Situations which elicit a particular emotion are disjunctive in nature in that one may be quite challenged in trying to find similarities between two instances which produce, say, surprise or interest. Indeed, the only thing these situations may have in common is that they elicit a common emotion. Whereas, a facial expression, on the surface, appears to have much more in common with other instances of the same expression. (Why we choose some features that we do as "similars" and ignore others is a related and very important question but will not be discussed here).

It is interesting to speculate as to why the deaf have difficulty in analyzing and interpreting situations with emotional consequences. Assuming that they experience the same situations as hearing children and see the subsequent expressions that people display, the question is: "Why can't they match the two as well as the hearing children?" In other words, what role, if any, does verbalization and its reception play in developing the ability to evaluate appropriately the nature of a situation? Although there may be several explanations, the one that has a great deal of intuitive appeal relies on some form of attentional construct. Verbalization of feelings and attributes of a situation may serve to focus (orient) a child's attention on its salient and relevant aspects. Consider the number of times a mother says:

(a) "Don't you ever ____ ____ ____ ____."

("hit your sister again," interrupt your father," etc.)

(b) "You ought to be ashamed of yourself for ____ ____ ____."

("hitting your sister," "spilling your milk," etc.)

(c) "Of course it hurt. Next time you ____ ____ ____, it'll hurt even more."

("hit anybody," grab the toy," etc.)

This list could be quite lengthy and still not capture the frequency with which a hearing child is told exactly what aspects of a situation are causing emotion in another person. The deaf child, especially one with hearing parents, is especially handicapped because most of this information is not available to him. Although rewards and punishments probably serve to isolate some factors that are important, they may not provide enough feedback to allow him the finer discriminations that hearing children are capable of making.

It seems that such information could be communicated to the deaf child by the parent or teacher with some effort added to the knowledge that it's important to do so. The data reported here, while certainly not conclusive, suggest that it is an important factor in the development of mature affective judgment.

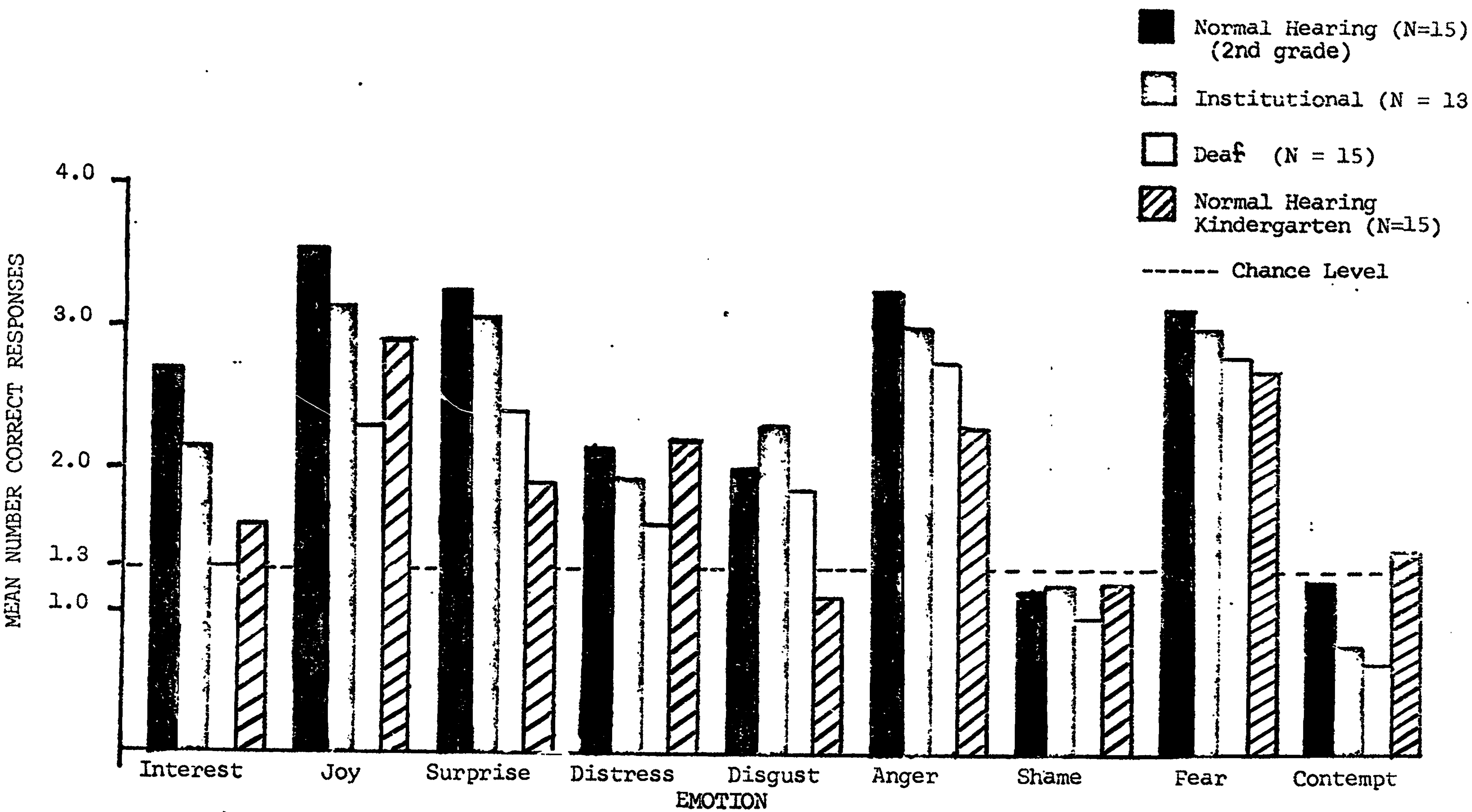

Figure 26. Mean number correct responses by group and emotions.

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APPENDIX A

SUMMARY OF RATING SCALES ON DISCRIMINABILITY

Word	Discriminability Rating
vaav	9.50
yppy	9.40
faaf	8.30
pjjp	10.30*
moom	10.58*
agga	10.30*
weew	9.25
arra	7.66*
chhc	8.83
oppo	9.30
rvvr	9.66
dlld	7.90*
jaaj	8.75
mkkm	9.83
lssl	9.33
raar	8.25
nuun	9.25
gqqg	11.75*
ette	8.40
xwwx	9.50
guug	8.30
bddb	9.58
bnnb	9.58
zeez	10.00
reer	8.75
yuuy	8.00
ummu	9.16
txxt	8.83
rggr	10.66*
cxxc	9.40
dvvd	9.16
baab	9.75
kbbk	9.40
vnnv	11.00*
pyyp	7.90
zddz	9.25
tcct	9.75
yrry	7.75*
oggo	9.25
nyyn	8.50
syys	8.40
gaag	10.30*
rbbr	8.40
zqqz	10.58*
kuuk	9.08

* Subject never correctly recognized letter grouping

APPENDIX A (Continued)

Word	Discriminability Rating
jooj	7.83*
liil	8.40
tfft	8.83
nmmn	12.25
atta	8.00
cssc	8.90
foof	7.66*
jmmj	9.50
pccp	9.58
zrrz	11.08*
vggv	9.00
rssr	8.86
xccx	9.16
tddt	7.58*
kllk	7.90*
leel	8.40
azza	10.83*
ullu	8.00
fccf	8.66
ollo	9.58
fkkf	8.50
yssy	8.08
lttl	8.33
ommo	10.75*
ibbi	9.50
ukku	9.00
ihhi	10.00
tiit	8.50
drrd	8.16
erre	9.16
oyyo	8.25
pggp	10.00
lbbl	9.66
xffx	9.40
itti	8.66
vrrv	9.08
obbo	9.75
mssm	10.58*
eppe	8.40
ujju	9.00
yvvy	8.16
rppr	8.33
fllf	8.40

* Subject never correctly recognized letter grouping

APPENDIX B

SUMMARY OF RATING SCALES ON PRONUNCIABILITY

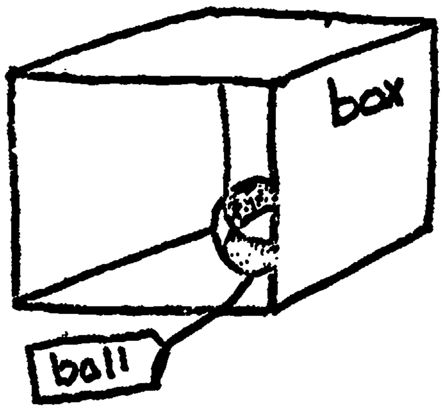
Word	Pronunciability Rating
vaav	4.36
yppy	3.68
faaf	4.32
pjjp	1.50
moom	4.86
esse	4.11
agga	4.82
weew	3.04
arra	4.68
chhc	1.50
oppo	4.75
rvvr	1.39
dlld	1.96
jaaj	3.43
mkkm	1.55
lssl	1.82
raar	4.46
nuun	4.25
gqqg	1.18
ette	4.43
xwwx	1.04
guug	3.96
bddb	1.61
bnnb	1.71
zeez	4.64
reer	4.96
yuuy	2.71
ummu	4.00
txxt	1.82
rggr	1.68
cxxc	1.11
dvvd	2.04
baab	4.75
kbbk	1.75
vnnv	1.86
pyyp	3.11
zddz	1.89
tcct	1.78
yrry	3.18
oggo	4.93
nyyn	3.25
syys	3.28
gaag	4.64
rbbr	2.25
zqqz	1.18
kuuk	4.25

APPENDIX B (Continued)

Word	Pronunciability Rating
jooj	3.96
liil	4.14
tfft	2.86
nmmn	1.82
atta	4.89
cssc	1.78
foof	4.86
jmmj	2.04
pccp	1.89
wnnw	1.54
zrrz	2.46
vggv	1.85
rssr	2.07
xccx	1.18
tddt	1.92
kllk	2.36
leel	4.89
azza	4.82
ullu	4.64
fccf	1.68
ollo	4.89
fkkf	1.81
yssy	3.46
lttl	2.46
ommo	4.96
ibbi	4.89
ukku	4.75
ihhi	4.46
tiit	4.00
drrd	2.71
erre	4.32
oyyo	4.75
pggp	1.64
lbbl	2.04
xffx	1.11
itti	4.82
vrrv	2.30
obbo	4.82
mssm	2.25
eppe	4.54
ujju	3.96
yvvy	2.71
rppr	1.93
fllf	2.11

APPENDIX C

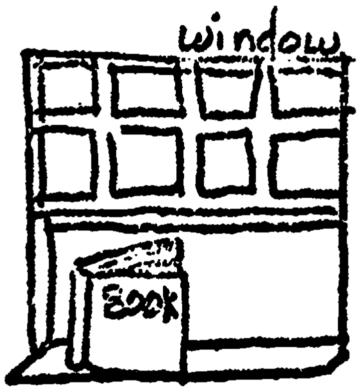
PROGRAMMED INSTRUCTION - BEGINNING LEVEL



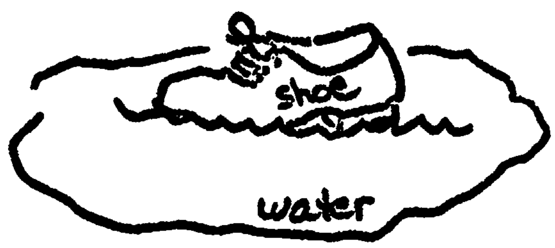
The ball is in the box.

The boy is in the house.

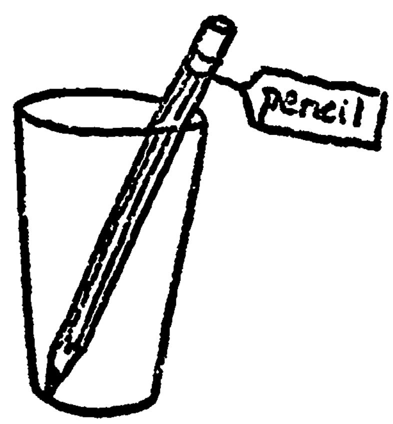
The bird is in the tree.



The book is in the window.



The shoe is in the water.



The pencil is ___ the glass.

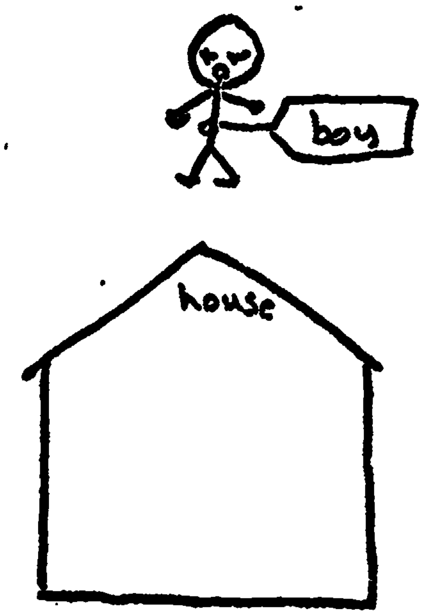
The airplane is in the box.

The dog is in the house

The spoon is ___ the cup.

The bird is over the tree.

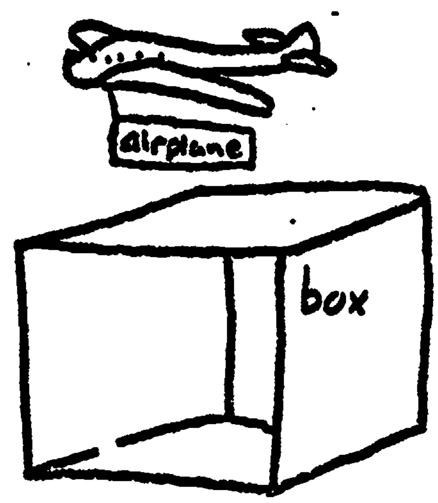
The fork is over the cup.



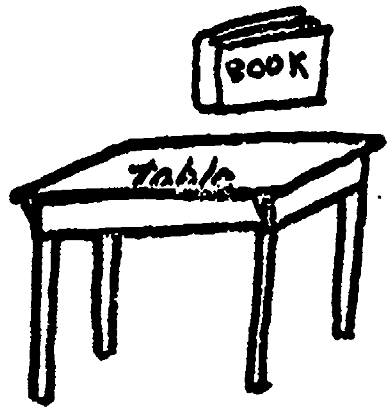
The boy is ____ the house.

The shoe is over the book.

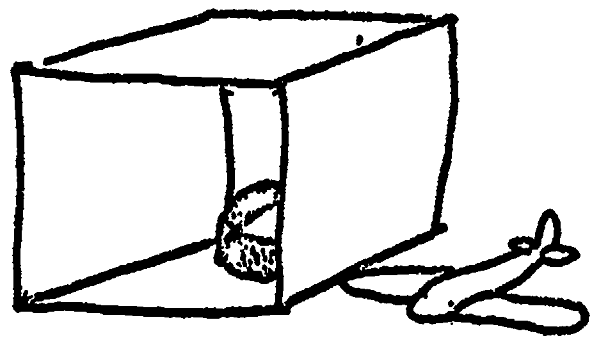
The dog is over the tree.



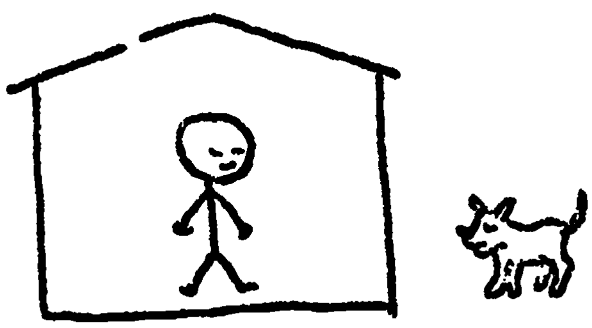
The airplane is over the box



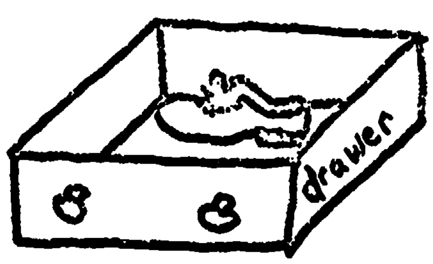
The book is ____ the table.



The ______________ is **in** the box.
ball, airplane

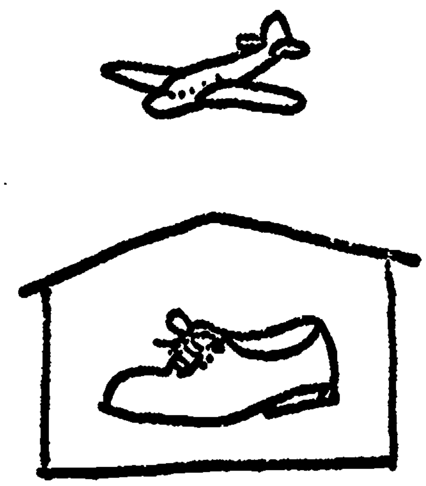


The ____________ is **in** the house.
dog, boy

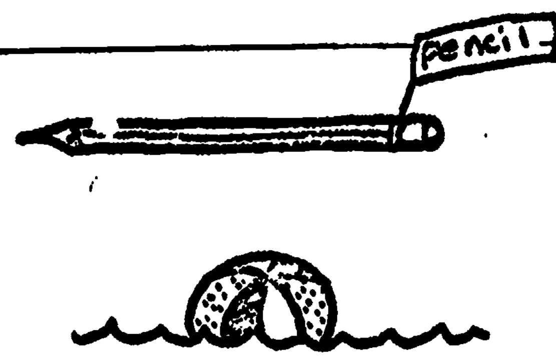


The ____________ is **in** the drawer.
shoe, book

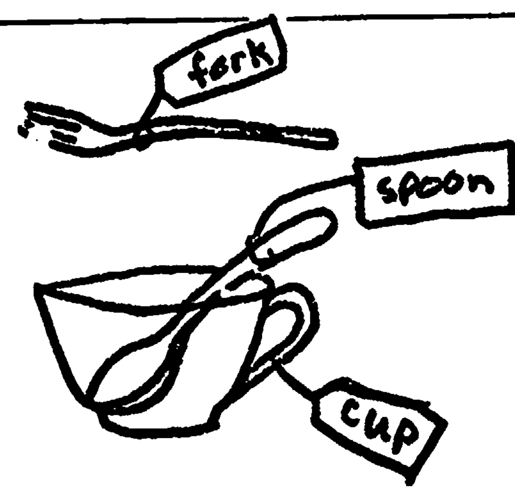
____



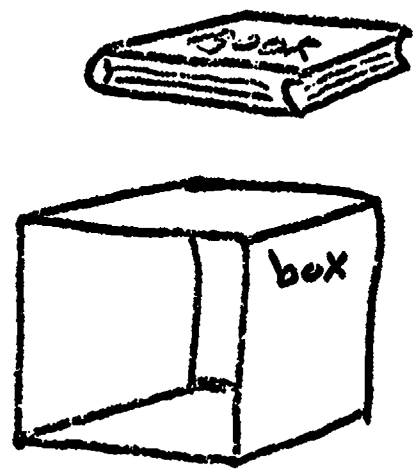
The ______________ is **over** the house.
shoe, airplane



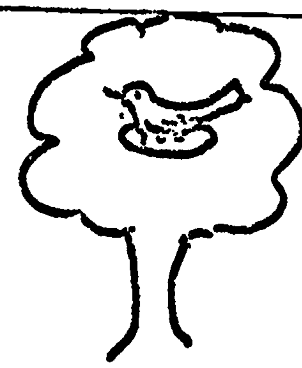
The ______________ is **over** the water.
pencil, ball



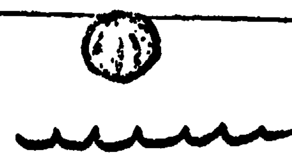
The ______________ is **over** the cup.
spoon, fork



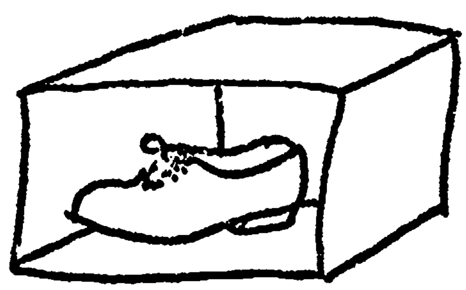
The book is _________ the box.
over, in



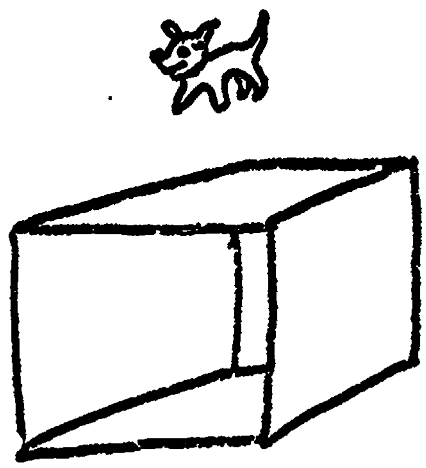
The bird is _________ the tree.
over, in



The ball is _________ the water.
over, in



The shoe is _________ the box.
over, in



The dog is ____________ the box.

The fork is ____________ the cup.

The airplane is ____________ the house.

The boy is ______________ the water.

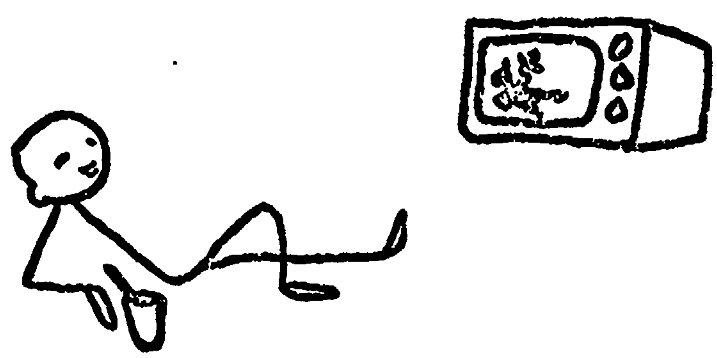
<u>before</u>

First Betty washed her hands.

Then she ate lunch.

Betty washed her hands **before** she ate lunch.

First Bobby cut the grass.



Then he watched TV.

Bobby cut the grass **before** he watched TV.

First Baby learned to crawl.

Then he learned to walk.

Baby learned to crawl _________ he learned to walk.

one two three four five six seven eight nine ten

1 2 3 4 5 6 7 8 9 10

Two comes **before** three.

Seven comes **before** eight.

Five comes _________ six.

First Tommy must eat his spinach.

Then he may have his ice cream.

Tommy must eat his ______________ **before** he eats his ______________.
(ice cream, spinach) (ice cream, spinach)

SUNDAY MONDAY TUESDAY WEDNESDAY THURSDAY FRIDAY SATURDAY

Monday comes **before** Tuesday.

Friday comes **before** Saturday.

Wednesday comes **before** ______________.
(Tuesday, Thursday)

after

Jack does his homework.

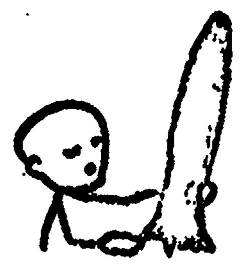
Then he rides his bike.

Jack rides his bike **after** he does his homework.

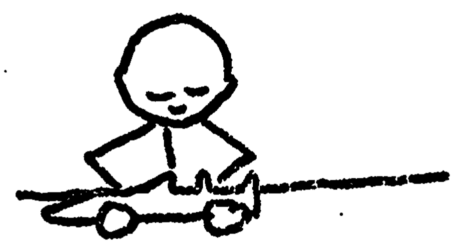
Donna bought a dress pattern.

then she bought some material.

Donna bought the material **after** she bought the pattern.



David built a rocket.



Then he built a racer.

David built the racer __________ he built the rocket.

January February March April May June July August September October November December

March comes after February.

May comes after April.

July comes __________ June.

Libby found a dime.

Then she found a penny.

Libby found the ____________ **after** she found the ____________.
dime, penny   dime, penny

1 2 3 4 5 6 7 8 9 10

3 comes **after** 2.

7 comes **after** 6.

4 comes **after** ______.
2, 5

before, after

Debby washes her hair. 

Then she rolls it up. 

Debby rolls up her hair **after** she washes it.

Debby washes her hair ____________ she rolls it up.
before, after

1 2 3 4 5 6 7 8 9 10

1 comes ____________ 2.
before, after

9 comes ____________ 8.
before, after

7 comes ____________ 6.
before, after

3 comes ____________ 4.
before, after

1	2	3	4	5	6	7	8	9	10

4 comes ______ ______ 2.
before, after

5 comes ____________ 8.
before, after

2 comes ____________ 6.
before, after

9 comes ____________ 4.
before, after

Jamie put on his socks. 

Then he put on his shoes. 

Jamie put on his shoes ____________ he put on his socks.
before, after

Jamie put on his socks ____________ he put on his shoes.
before, after

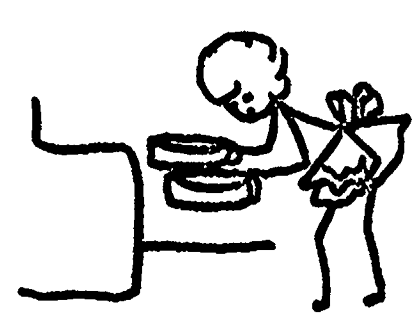
SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY

First comes Sunday.

Then comes Monday.

Monday comes ______ Sunday.
before, after

Sunday comes ______ Monday.
before, after



Tammy bakes a cake.

Then she ices it.

Tammy ______ the cake **after** she ______ it.
bakes, ices / bakes, ices

Tammy ______ the cake **before** she ______ it.
bakes, ices / bakes, ices

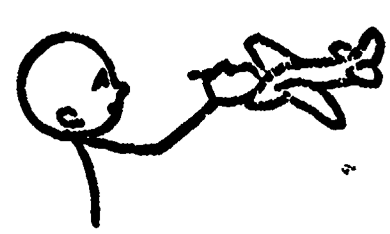
January February March April May June July August September October November Decembe

____________ comes **before** March.
February, April

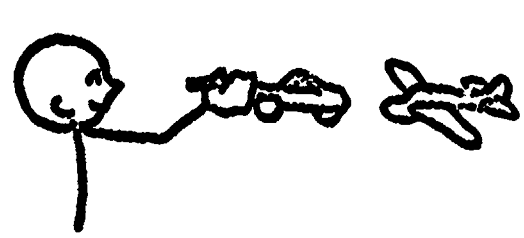
____________ comes **after** July.
June, August

____________ comes **before** November.
October, December

George drew an airplane.



Then he drew a car.



George drew the ____________ before he drew the ____________.
car, airplane car, airplane

George drew the car ____________ he drew the airplane.
before, after

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY

Sunday comes ______________ Monday.
before, after

Wednesday comes ______________ Tuesday.
before, after

Saturday comes ______________ Friday,

Thursday comes ______________ Friday.

APPENDIX C

PROGRAMMED INSTRUCTION - INTERMEDIATE LEVEL

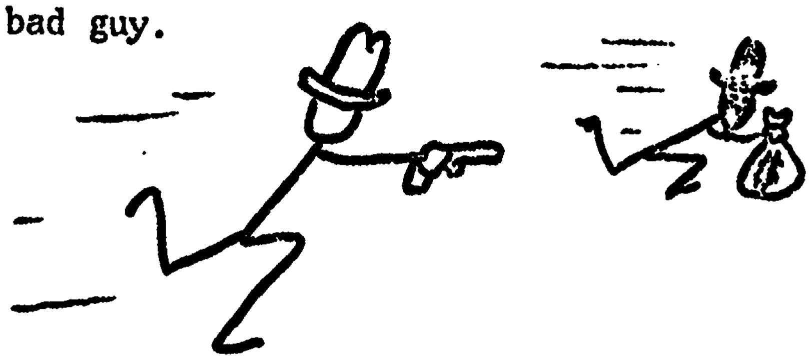
to go after / to be after = to try to get / to try to catch

The good guy is trying to catch the bad guy.

He is trying to get the bad guy.

He is **going after** the bad guy.

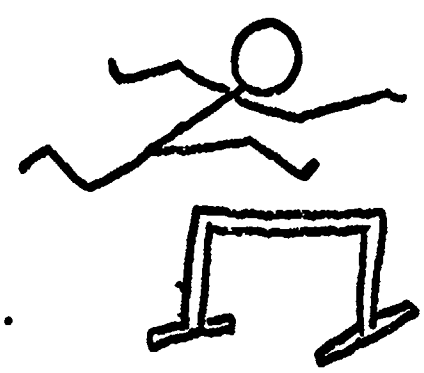
He is **after** the bad guy.



Jock wants to win the prize.

He is **going** ________ the prize.

He is ________ the prize.



Janet is **going after** Bill.

She wants him to be her boy friend.

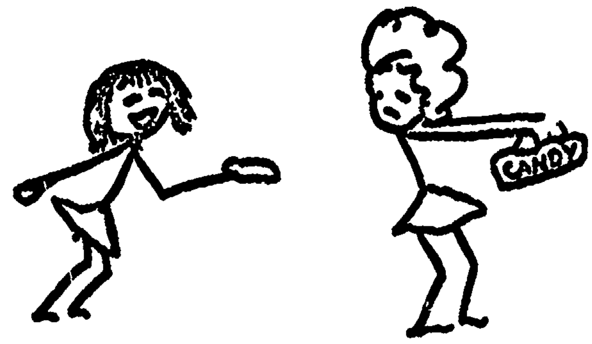
She is trying to __________ him to be her boy friend.
after, get

Janet is __________ Bill.

to be after = 1. to try to get
2. to keep bothering someone to get what you want.

Brad keeps begging his father to get him a car.

Brad is **after** his father to get him a car.



Barbara has some candy.

Linda wants some of it.

Linda asks Barbara for a piece of candy.

Barbara says, "No."

Linda keeps begging her for some candy.

Linda is a__________ Barbara for a piece of candy.

Andy wants 15¢ to buy a cold drink.

He asks his mother for the money.

She says, "No."

He asks her again and again.

Andy is ________ his mother to buy him a cold drink.

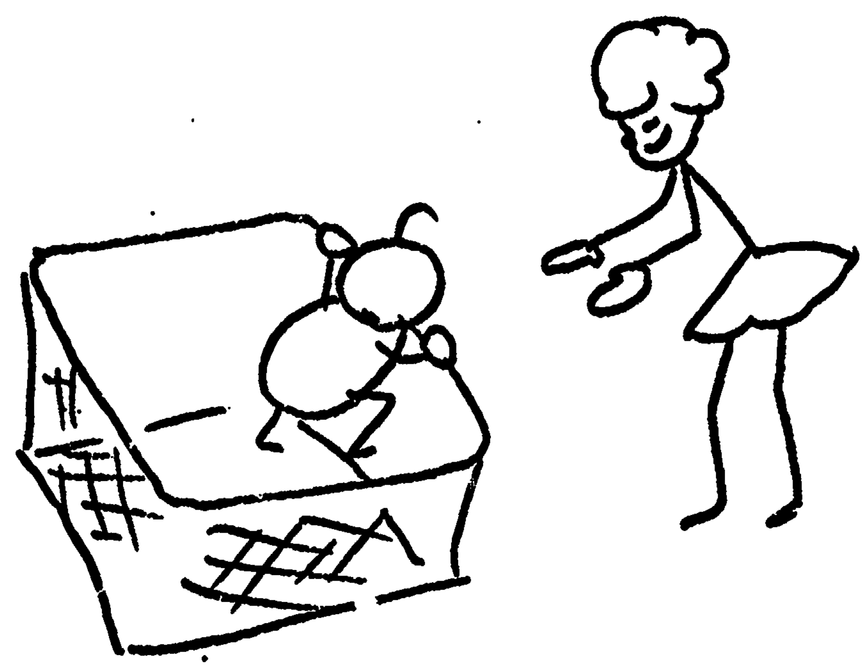
APPENDIX C

PROGRAMMED INSTRUCTION - ADVANCED LEVEL

<u>After</u> - Advanced level
<u>after</u> as a verb part

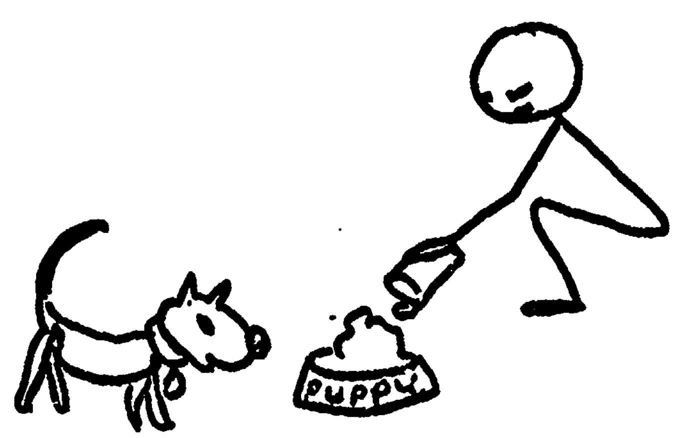
to watch after ⎤
to look after ⎦ = to take care of

Janet takes care of her baby sister.



She **watches after** her baby sister.

Bobby has a new puppy.



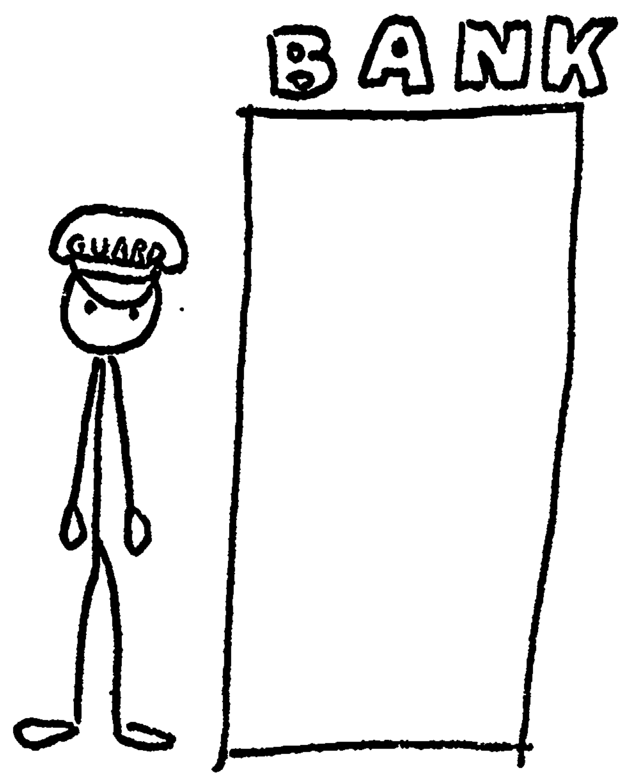
He takes care of his puppy.

He watches __________ the puppy.
to, after

The policeman stands at the corner.

He takes care of children when they cross the street.

He W__________ s__________ the children.



The guard is at the bank.

He takes care of the bank.

He w__________ __________ the bank.