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A TACHISTOSCOPIC RECOGNITION TASK WITH DEAF AND HEARING ADULTS

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A TACHISTOSCOPIC RECOGNITION TASK WITH DEAF AND HEARING ADULTS

by

M. Diane Clark

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Eight deaf and eight hearing adults were tested on a tachistoscopic recognition task involving letters and novel symbols. All subjects received both sets of stimuli to evaluate prior findings of poor perceptual skills in deaf subjects. Overall, deaf subjects obtained lower scores on letter stimuli than did hearing subjects, but the two groups had comparable scores in the novel symbol condition. This result suggested that prior findings of poor perceptual abilities had resulted from a confound between perceptual abilites and linguistic abilities, in that when linguistic factors were controlled the two groups had similiar scores. A second manipulation in Experiment 1 allowed a comparison of the time parameters of iconic memory in deaf as compared to hearing subjects. Three inter-stimulus-intervals (ISIs), no delay, 250 msec delay, and 500 msec delay, were included. No differences were found between the two subject populations over the three ISIs, suggesting that the time parameters of deaf and hearing subjects iconic memories were comparable.

An additional finding was an overall effect of stimulus familiarity in both deaf and hearing subjects when novel symbols were presented prior to letters, but not with the reverse order of presentation. A second study was conducted in order to evaluate this order by stimuli interaction. Because the effect had been the same in both deaf and hearing subjects in the first experiment, only 16 hearing subjects were tested. Three sets of stimuli were presented: either

letters/symbols/letters or symbols/letters/symbols. Results showed that letters following symbols had significantly higher recognition scores, suggesting that this facilitation was related to the availability of a coding strategy.

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CHAPTER I

INTRODUCTION

The deaf population is composed of persons having a functional hearing loss of sufficient severity to affect aural comprehension of speech even with hearing aids (Furth, 1973). This population consists both of individuals who became deaf prelingually, prior to the acquisition of speech, and postlingually, after having acquired language. But it is prelingual deafness, in particular, that makes the acquisition of a society's verbal language difficult and oftentimes impossible. Because about 90 percent of deaf children are born to hearing parents with little or no knowledge of sign language, there is often no mother tongue available to children who are born deaf or lose their hearing prior to the age of two. For many of these prelingually deaf children, their first forms of communication are "home signs": gestures that come to represent concrete actions and objects within the family (e.g., Feldman, Goldin-Meadow, & Gleitman, 1978). Historically, these children were not exposed to language until they entered school, around the age of five, due to either late diagnosis or lack of community programs for the deaf at the preschool level. This form of environmental deprivation (Furth, 1973; Liben, 1978) has been related to the later poor school performance of deaf adults, which is characterized by an average, third grade reading level. In evaluating the finding of such low reading levels, however, one must be aware that the "grade levels" of deaf individuals are computed by testing their reading of written English. Unfortunately, this finding of poor reading skills has led many educators and researchers to conclude that deaf individuals are deficient in their cognitive abilities. Because English is not the preferred language of many prelingually deaf individuals, an evaluation of English reading skills may not be an appropriate estimation of their language abilities (e.g., Marschark & West, 1985).

After having little or no success with learning an oral language, many deaf people learn a manual form of communication. The acquisition of a manual form of communication such as American Sign Language (ASL) typically occurs through informal and oftentimes sporadic exposure to other deaf individuals using manual communication. It is interesting to note that prelingually deaf individuals learn manual forms of communication relatively quickly, whereas they have difficulty learning English (in both its signed and written forms). Morariu and Bruning (1984) suggested the rapid acquisition of ASL is related to its structure. ASL is visual-spatial in nature, making use of hand movements, facial expression, and position of the sign within a signing space directly in front of the person (Bellugi, Klima, & Siple 1975). The linguistic structure of this language thus is ideally suited for the visual sensory system which accepts input of information in a parallel fashion, in contrast to the auditory system which inputs information in a sequential fashion (see Morariu & Bruning, 1984).

Different sensory registers are involved in language input for deaf and hearing people, and a comparison of the information processing parameters of these two systems is necessary to understand how individuals in the two populations process language. Hearing individuals rely on their auditory sensory register for language input. In experiments using dichotic listening tasks, "echoic memory" (Neisser, 1967) has been found to have a duration of at least one second (see Zechmeister & Nyberg, 1982, for a full discussion). Echoic memory is necessarily sequential in nature, briefly storing sensory input so that information arriving later can be integrated with the earlier input. Tzeng and Wang (1984), in fact, suggested that the fine temporal resolving ability of the auditory system has evolved to facilitate the development of communication skills.

In contrast to hearing individuals, deaf individuals rely on their visual sensory register, or "iconic memory," for language input. Prior to 1960, the available data indicated that iconic memory held only a small amount of information, for approximately 250 msec. For example, when subjects were briefly presented with a 3 x 4 matrix of letters and then asked for recall, only three to four items typically were remembered. Sperling (1960), however, showed that the iconic memory is a "larger" system that holds information for about 250 msec before "fading." Within that time, considerably more information is present than can be reported, but only three or four items from the total array can be selected for further processing. Sperling demonstrated this large-but-brief characteristic of iconic memory using a partial report technique in which subjects were required to report only part of the information in the matrix. He showed subjects 3 x 3 matrices of letters for 50 msec. Immediately after termination of each matrix, a tone was presented to signal which row of the matrix was to be reported: top, middle, or bottom. Recall in this task was almost 100%, demonstrating that all of the information in the matrix was available immediately after presentation.

Apparently, no studies have been conducted to evaluate the characteristics of iconic memory in deaf individuals. As a result, several important but unresearched questions are relevant here: What are the characteristics of iconic memory in deaf individuals? Is their iconic memory the same or different from that of hearing individuals? Are encoding and rehearsal strategies similar or different in the two populations? Nickerson (1979) suggested the importance of evaluating the parameters of the visual system's information processing capabilities for language input, pointing out reasons for not assuming similar processing in the visual systems of deaf and hearing individuals. He suggested that investigations of this type might lead to the development of strategies to remediate the reading performance deficits often found in deaf subjects.

Two lines of research have evolved in evaluating the visual perceptual abilities of deaf individuals: one involving the physiological properties of the system (Kelly & Tomlinson-Keasey, 1981; Neville, Schmidt, & Kutas, 1983; Nickerson, 1978) and a second involving the types of strategies employed for encoding and processing information (Parasnis & Long, 1978; Siple, Hatfield, & Caccamise, 1978). Many similarities and differences between the visual perceptual skills of deaf and hearing individuals have been found in both research areas. One purpose of the present study was an attempt to integrate several of these findings.

Comparisons of cerebral organization in deaf and hearing populations

Differences have been found in the brain organization of deaf as compared to hearing individuals, using several different paradigms. Several studies, for example, have presented information singly to the right and left visual hemifields to investigate the effects of auditory input on cerebral laterality (Kelly & Tomlinson-Keasey, 1981; McKeever, Hoemann, Florian, & VanDeventer, 1976; Phippard, 1977). A second area of investigation has come out of visual evoked potential (VEP) research by Neville and her colleagues (Neville, Schmidt, & Kutas, 1983) These investigators compared the VEP patterns in deaf and hearing subjects.

Cerebral Lateralization. The effect of auditory input on cerebral laterality has interested many researchers. In the 1970's, a conflict existed in the literature about whether or not auditory language input served as a stimulus for hemispheric specialization. Liberman (1974a, 1974b; as cited in Kelly & Tomlinson-Keasey, 1981) hypothesized that hemispheric lateralization for language information occurs as a result of processing the grammatical codings involved in speech perception. Others (Bakker, 1979; Hiscock & Kinsbourne, 1977; Kinsbourne & Hiscock, 1977; cited in Kelly & Tomlinson-Keasey, 1981) argued that lateralization of function is present at birth and does not go through developmental changes.

To help resolve this conflict, Kelly and Tomlinson-Keasey (1981) studied the hemispheric specialization in congenitally deaf individuals who had never experienced auditory stimulation. Young deaf and hearing children (third, fourth, and fifth graders) served as the subject population. Kelly and Tomlinson-Keasey's methodology involved tachistoscopic presentation of either word pairs or picture pairs, shown singly to the separate visual hemifields. Order of stimuli presentation was a fixation dot followed by a slide containing either a word or picture, then a brief blank period, and, finally, a second slide with either a picture or word on it. The response measure was a button push: Each subject was told to push one button if the slides were the same and a second button if they were different.

The results of Kelly and Tomlinson-Keasey's (1981) study indicated that, overall, deaf children were more efficient with right hemisphere (left hemifield) presentations, while hearing children showed a left hemisphere (right hemifield) advantage. The only significant hemispheric processing differences between word and picture pairs occurred in the hearing subject group with low imagery words. For these subjects, there was a left hemisphere reaction time advantage for low imagery words. Deaf subjects on the other hand, processed low imagery words at the same speeds in both hemispheres. For these subjects, low imagery words were the only set of stimuli that did not show a right hemisphere advantage. The most pronounced difference between the two subject groups was in their speed of responding, with deaf children having a tendency to respond faster and with fewer errors to all stimuli than did hearing children. These findings were interpreted as indicating that processing of linguistic and nonlinguistic information is lateralized for hearing children, but is not lateralized for deaf children. Therefore, these results are congruent with the hypothesis that the lack of auditory cues does impact on early hemispheric specialization.

Geschwind and Levitsky (1968; cited in McKeever et al. 1976) suggested that the left hemisphere may be morphologically specialized for sequential input of information, such as auditory language input. This conclusion resulted from postmortem measurements of normal hearing adults, where anatomical differentiation was found between the right and left cerebral hemispheres in the planum temporale, located in the auditory association cortex. They concluded that these anatomical differences might provide the biological basis for the prevalent lateralization of language functions within the left hemisphere.

Based on Geschwind and Levitsky's findings, McKeever et al. (1976) examined whether or not congenitally deaf subjects would show hemispheric lateralization. They used a visual recognition task to evaluate any similarities or differences between deaf and hearing subjects in their processing of visual information. Both English words and ASL signs were used as stimuli. For all tasks, a single-digit number was used as a fixation point. This "focus" number was followed by an English word or ASL sign, located on one or the other side of the "focus" number. Subjects were told to report the "focus" number and then any lateralized stimuli they thought they had seen.

Results of the McKeever et al. (1976) study showed no significant asymmetries for deaf subjects in unilateral word recognition tasks, whereas hearing subjects showed a significant right visual field (left hemisphere) superiority on these tasks. In the recognition of ASL stimuli, hearing subjects showed a significant left visual field (right hemisphere) superiority. No significant hemispheric differences were found for deaf subjects, although they showed the same pattern of results as the hearing subjects in the recognition of ASL stimuli. Because no significant hemispheric differences were found among deaf subjects in comparison to significant hemispheric differences among hearing subjects, McKeever et al. (1976) hypothesized that the right hemisphere of deaf subjects was less dominant for spatial functioning. This conclusion was based on the fact that ASL (which was suggested to be spatial in nature) was processed equally well in both hemispheres. They concluded that auditory input appeared to influence the development of cerebral laterality, creating different patterns of organization in prelingually deaf individuals than hearing individuals.

Because differences in hemispheric lateralization had been previously found in deaf populations, Phippard (1977) questioned whether language input impacted this lack of specialization. She investigated the cerebral organization of oral (i.e., English fluent) deaf subjects in comparison to manual (i.e., non-oral) deaf subjects. It was found that the oral subjects had a left visual field (right hemisphere) advantage for the perception of both verbal and nonverbal stimuli but that the manual subjects showed no differences between the visual fields. Because differences were found between oral and manual deaf subjects, Phippard's study indicates that not only auditory experience influences hemispheric specialization.

Phippard's (1977) oral subjects were fluent in a language with an underlying temporal-sequential input (i.e., English) whereas the manual subjects were fluent in a language with an underlying visual-spatial input. Therefore, her results suggest that the structure of the language input influenced the development of hemisperic lateralization. It appears that it was not auditory experience per se that facilitates lateratization, but the experience of processing temporal-sequential input. Although auditory linguistic input utilizes a temporal sequential format, some researchers appear to have confounded auditory experience and experience with temporal-sequential input. Phippard's (1977) finding of lateralization in oral deaf subjects, but not in manual deaf subjects, demonstrates this confound.

Visual Evoked Potentials. Perhaps indicating compensation in the sensory capabilities of deaf individuals are the results of a study by Neville, Schmidt, & Kutas (1983). Neville et al. measured scalp-recorded visual evoked potentials in deaf and normal subjects and found that deaf subjects had an enhanced response at N150 (i.e., negativity in the evoked potential waveform at 150 msec post stimulus presentation) to peripherally presented stimuli and not foveally presented stimuli. This pattern was opposite to that found in hearing subjects. These results were interpreted as indicating that deaf adults have more cortical area devoted to processing visual information than do hearing adults. Neville et al. (1983) suggested that this difference may result from a special compensation in the perception of peripherally presented visual information. This enhancement was suggested to be related to the deaf individual's primary reliance on peripheral information for language input. At the very least, this finding suggests that a reorganization of intermodal sensory cortical areas occurs in profoundly deaf subjects.

A Theoretical Note. Because the above studies suggest that deaf individuals may experience different types of hemispheric lateralization, deaf children who are labelled "developmentally delayed" may not be delayed but rather may be experiencing a different pattern of development (Kelly, 1978). A possible theoretical explanation for the observed differences in cerebral organization can be found in the developmental psychobiological view of Gottlieb (1976), based on an epigenetic view of development. "Epigenesis" refers to the idea that various features of an organism′s features come into existence in a serial progression over the course of development, in contrast to the preformationist view, according to which all of the features are present at birth. There are two views of epigenesis: predetermined epigenesis and probabilistic epigenesis. The traditional view of predetermined epigenesis is that the development of behavior in fetuses can be explained entirely in terms of neuromotor and neurosensory maturation. In this view structural maturation explains all embroyonic and neonatal behavior. Therefore, predetermined epigenesis, is based on a unidirectional relationship between structure and function (structure -> function).

Gottlieb′s (1976) view of probabilistic epigenesis, on the other hand, is based on a bidirectional relationship between structure and function (structure <-> function). This interactionist view of development takes into account the effects of early pre- and post-natal stimulation during maturation. These factors then contribute to the developing neural maturation in both an inductive and a facilitative manner, causing the bidirectional relationship between structure and function. In this view, structural maturation determines function but function also interacts with structural maturation, causing actual structural changes. This theory could account for differences in the cerebral organization of deaf individuals that are "induced and facilitated" by an early reliance on visual-spatial input accompanied by a lack of auditory input.

Different Strategies Used by Deaf Individuals in Information Processing Tasks

Understanding deaf individuals' ability to process visual information is important in investigating their language abilities, since language input is received through this system. In some early studies of visual information processing, (Heider, 1940; Larr, 1956; Myklebust & Brutten, 1953; Olson, 1967), deaf subjects were found to have an apparent inability to perform as well as hearing subjects, a deficit attributed to problems in their visual perception. Many of these studies were attempts to understand why deaf people typically were severely limited in their reading abilities, and the alleged visual information processing deficits among profoundly deaf people provided one explanation. The goal of this early research, however, was to understand the deaf individual's poor reading skills, and English stimuli were used in these studies. The deficits thus observed often may have been the result of a confound between perceptual and linguistic abilities.

Several studies have attempted to untangle the confound between deaf people's perceptual abilities and their linguistic skills (e.g., Blair, 1957; Siple, Hatfield, & Caccamise, 1978). Investigations of this type typically have shown some differences between deaf and hearing populations, but they have not confirmed the earlier studies that always found deaf subjects deficient in visual information processing. Similar problems arise in the related area of investigation concerning rehearsal and retrieval strategies used by deaf individuals. When linguistic abilities are equated between deaf and hearing subjects, some researchers have found similar memory performance (Hartung, 1971; Morariu & Bruning, 1983). Other researchers, however, have found a correlation between reading ability and utilization of speech-based recoding strategies (Conrad, 1979; Lichtenstein, 1983). These studies suggest that deaf people may not be deficient in comparison to hearing people but rather may develop different skills and strategies.

Information Processing Abilities. The information processing strategies used by deaf children were investigated by Blair (1957). Several types of visual-spatial tasks were evaluated. Some of these studies required only perceptual information, for example, the Knox Cube Test, which involves watching a series of taps, remembering the sequence of movements, and then duplicating the sequence. Others required integration of information, for example, a Digits Backwards task, in which a sequence of digits is read at the rate of one per second and has to be recalled in the reverse order of presentation. Blair found that deaf subjects performed better than hearing subjects on tasks requiring only perceptual information, such as the Knox Cube Test and the Memory-for-Designs test. This advantage was reversed in tasks requiring integration of information into related sequences, as in the Digits Forward and Digits Backwards tasks (see also Ottem, 1980).

From his findings, Blair (1957) concluded that the information processing differences between deaf and hearing individuals were not at the perceptual level but were at the "infra-conceptual" level where prior knowledge interacts with information processing strategies. Blair (1957) thus argued that deaf people are unable to think in an abstract manner (see also Furth, 1973). It is important to remember, however, that his findings were interpreted in the Zeitgeist of the time, according to which deaf individuals were extremely rigid in their cognitive skills. But recalling sequences of digits, the task where deaf subjects were inferior, also appears to be a concrete task. The problem thus seems to be more a deficit in the ability to organize and recall sequences of information, rather than in the ability to think abstractly (Ottem, 1980).

Research comparing the information processing strategies used by deaf individuals in comparison to hearing individuals has often focused on how these strategies affect other abilities. Siple, Hatfield, and Caccamise (1978), for example, investigated whether sign language fluency altered the strategies that subjects used on tasks of spatial thinking, perceptual speed, closure speed, and finding embedded figures.

They found that deaf students at the National Technical Institute for the Deaf (NTID) who were fluent in sign language used different response strategies on the perceptual tasks in comparison to new hearing staff at NTID, who had only recently learned sign language. The deaf students tended to use more featural strategies (i.e., looking for individual components of the stimuli) rather than global strategies (i.e., looking for overall patterns within the stimuli) when performing on the above tasks. These featural strategies were effective for some cognitive/perceptual tasks, such as a test of Gestalt completion, but hindered performance on others, such as a test of embedded figures (see Parasnis, 1983, for a review). These results suggested the importance of featural strategies in the perception and comprehension of sign language. Therefore, featural strategies also may be important for efficient acquisition of signs.

Rehearsal and Retrieval Strategies. One robust finding in tests of deaf individuals' memory retrieval has been that when presented sequences of information to recall, their recall is lower than hearing subjects (see for example Blair's, 1957, digit span tasks). Several studies (Hanson, 1982; Conrad, 1979; Lichtenstein, 1983) have related deaf subjects' relative deficiency on these tasks to their inability to effectively recode information into an acoustic or speech code.

Conrad and Rush (1965) found acoustic confusions in some deaf individuals when recalling consonant sequences, suggesting that they were using articulatory codes in rehearsing sequences for later recall. This articulatory code apparently is used to maintain information in working memory and to store the information for later retrieval. Conrad and Rush (1965) suggested that deaf people have deficits not at the input stage but rather in the recoding stage, the point where they integrate information (Blair, 1957; Ottem, 1980).

Conrad (1979) continued research in the area of articulatory or speech-based recoding strategies and devised a measure to evaluate whether or not deaf students were using an acoustic recoding strategy. Evidence for an acoustic code was obtained by computing a ratio of homophonic errors divided by the total number of errors, where homophonic errors are assumed to be caused by acoustic similarities between the correct item and the outputted item. Conrad (1979) found a high correlation between good readers and students who utilized a speech-based recoding system: Students who were proficient at utilizing an acoustic code consistently had better reading skills. This correlation led Conrad (1979) to conclude that it was not the quality of the acoustic recoding or internal speech that was important in utilizing a speech-based recoding strategy but rather the consistency of the speech sounds. Once an individual had associated a specific acoustic pattern with a particular word, then this pattern could be the basis for their speech-based recodes.

Lichtenstein (1983) also was interested in the correlation between speech-based recoding strategies and good readers within deaf student populations. Like Conrad (1979), he similarly found evidence of an acoustic recoding system when applying Conrad's error ratio to deaf college students' reading skills. Lichtenstein (1983) conducted a memory experiment to investigate exactly what types of recoding strategies were utilized by these students. His stimuli were four sets of eight words each. Three of the sets were similar along the dimensions of either speech (phonetically similar), sign (cheremically similar), or vision (graphemically similar), with the fourth list being the (dissimilar) control list. Lists were presented at a rate of one word every 1.5 seconds and recall was measured both immediately and one week later. Subjects were found to have high error ratios for both the phonetically similar and the graphemically similar lists, suggesting that both speech-based recoding and visual types of recoding strategies were employed by these students. Moreover, the error ratio for the cheremically similar list showed no evidence of cheremic confusions, providing no evidence of a sign-based recoding strategy in the short term memory experiment.

Perhaps Lichtenstein's (1983) most interesting finding was obtained from a Recoding Strategies questionnaire where subjects were asked how much they used sign, speech, and fingerspelling recoding strategies in the previous short term memory experiment. Students reported using multiple types of codes to access and rehearse information that had been received visually, and even reported using a sign-based code although no evidence had been found suggesting this type of recoding strategy in the short term memory experiment. Lichtenstein (1983) interpreted these results as indicating that deaf students do use a sign-based recoding strategy along with a speech-based recoding strategy when rehearsing visually presented English information.

Lichtenstein's (1983) memory results were related to subjects' reading abilities insofar as the best readers in his deaf sample reported using both a speech-based code and a sign-based code when attempting to recall information. He suggested that the ability to use a speech-based recoding strategy increased deaf subjects' ability to process sequential information, either at encoding or retrieval, and therefore interpreted his findings as demonstrating that the ability to use a speech-based recoding strategy increased the working memory capacity of deaf students.

On the basis of his results, Lichtenstein (1983) concluded that the actual working memory of deaf individuals is comparable to that of hearing individuals. Findings of relatively short memory spans for English materials by deaf individuals were suggested to be a result of less efficient strategies in encoding or retrieving sequential information, rather than a deficit in their working memory per se. Importantly, however, recall in both Lichtenstein's (1983) and Conrad's (1979) studies involved English stimuli. Because English is not the preferred language for prelingually deaf subjects, they may need more than one strategy when rehearsing such stimuli in order to retain the information as efficiently as hearing subjects. Further, because a speech-based recoding strategy is optimally suited in rehearsal and retrieval of sequential information, it is not surprising that deaf students have developed this type of strategy for encoding and retrieving sequentially presented English material.

Linguistic Abilities. Morariu and Bruning (1983) studied the problem of poor recall and comprehension often reported among deaf subjects when they are tested with English-structured language input. Their methodology evaluated the effects of syntax on stimulus presentation. Recall and comprehension scores were obtained for two modes of presentation (e.g., print or signed form) and two types of syntax (e.g., English and American Sign Language). Morariu and Bruning found that prelingually deaf students recalled more propositions when they were embedded within ASL-structured contexts (both signed and printed) than when they were embedded within English-structured contexts.

Morariu and Bruning (1983) concluded from these findings that the syntactic component of language input affects access to meaning. They suggested that the "roots" of signed ASL are likely to be established early for children who derive meaning primarily through movement and other visual stimulation rather than through auditory input. This early tendency to rely on visual input for meaning appears to lead to an advantage in processing visual-spatial information input. Morariu and Bruning (1983) suggested that this visual-spatial advantage is encouraged by ASL-structure, which is visual-spatial in form. They further suggested that ASL was better suited to deaf individuals' information processing capabilities than was English, because recall was better when propositions were embedded within an ASL syntax. Morariu and Bruning (1983) thus argued that ASL should be encouraged as the primary language of prelingually deaf individuals.

A study by Hartung (1971) suggested that the differences found in visual information processing between deaf and hearing individuals was related to the stimuli that had been used in prior studies. He suggested that visual perceptual skills of deaf children should be evaluated by using two types of materials: unfamiliar material that would assess the visual sensory abilities and familiar materials which would assess their information processing skills with regard to memory. This would allow an evaluation of differences between perceptual abilities and information processing strategies. Hartung (1971) suggested that these two skills had been confounded in past research due to the forms of stimuli that had been presented (i.e., written English). Therefore, previous findings of poor visual perceptual abilities within the deaf population may have been due to differences not in perceptual skills but in linguistic skills.

Hartung (1971) pointed out that English letters, frequently used in studies of visual information processing, were not as overlearned for deaf subjects as they are for hearing subjects. He controlled for the confound between perceptual skills and linguistic skills by including a manipulation of stimulus familiarity in a tachistoscopic recognition task. He found that with unfamiliar input (Greek letters) deaf subjects could identify the items as well as hearing subjects, but with familiar language input (English letters) the hearing subjects showed a significant advantage. These results are consistent with the findings of Robinson, Brown, and Hayes (1964) who showed that familiarity is a major factor influencing the recognition thresholds of hearing subjects. In a task that required a response of whether the stimuli were the same or different, Robinson et al. (1964) found that familiarity did not facilitate decisions; only when the task required identification of the stimulus did facilitation occur. The difference between the same-different judgments and identification was that prior linguistic experience with the stimuli was not needed for the same-different judgment but was necessary in an identification task.

In contrast to the Robinson et al. (1964) findings, Morrison and his colleagues (Morrison, Giodani, & Nagy, 1976; Morrison, Holmes, & Haith, 1974) found no overall effects of familiarity among three types of stimuli with a tachistoscopic presentation paradigm involving hearing children. They studied the effect of familiarity on short term visual memory using a circular display of either letters, codable geometric forms, or Glucksberg and Krauss's (1967) ambiguous figures that were difficult to label verbally. Several different display-probe delay intervals (0 - 2000 msec) were used to evaluate both the perceptual phase (0 - 300 msec) and the encoding memory phase (500 - 2000 msec) of visual memory. Morrison et al. found no significant differences in recognition in the perceptual phase between the three stimuli types when comparing older versus younger children (Morrison et al., 1974) or good versus poor readers (Morrison et al., 1976). The only significant differences between the older and younger children or the good and poor readers were found in the encoding memory phase, where older children and good readers were superior overall in recognition as compared to younger children and poor readers, respectively. From those findings, Morrison and his colleagues concluded that the higher recognition scores, shown by both older children and good readers, was the result of an ability underlying processing of both labelable and unlabelable forms, not an effect of familiarity with the stimulus materials.

The findings of Robinson et al. (1964) and Morrison et al. (1974) thus show conflicting results. In the Robinson et al. study, familiarity had an effect on recognition thresholds when identification was required, whereas in the Morrison et al. (1974) study no overall effects of stimulus familiarity were found. Examination of the Morrison et al. (1974; 1976) methodology, however, indicates one possible reason for these conflicting results. In that study, the presentation order of the three stimulus types was either letters, geometric forms and then abstract forms or abstract forms, followed by geometric forms, and finally by letters. No effects of stimulus materials (i.e., no familiarity effects) were obtained in that no significant differences were found in the recognition scores among the stimulus types. This may have resulted from a confound due to the fact that geometric forms, which are at a medium level of labelability, were always presented as the middle block. These stimuli thus may have influenced the labelability of the letters and the abstract forms by reducing the contrast between the high and low levels of labelability, (F. J. Morrison, personal communication, October 1984). Studies comparing the order of stimulus presentation may resolve these conflicting results.

Purpose of the Study

Researchers investigating the information processing strategies of deaf subjects have found similar performance between deaf and hearing subjects when deaf subjects receive familiar stimuli such as ASL signs (e.g., Morariu & Bruning, 1983). Other reseachers have shown that when stimuli unfamiliar to both deaf and hearing subjects are used, similar performance occurrs between deaf and hearing groups (Blair, 1957; Hartung, 1971). These later findings suggest that the information processing strategies employed by deaf individuals may be qualitatively different from those employed by hearing individuals. Several studies, however, have found differences in deaf individual's VEPs and hemispheric lateralization (e.g., Kelly & Tomlinson-Keasey, 1983; Neville et al., 1983). These findings suggest the possibility of a structure-function interaction within the visual perceptual system of prelingually deaf individuals'.

As stated earlier, there apparently has been no previous research evaluating the iconic memory of deaf individuals. The present study was an attempt to integrate these previous findings. Two independent manipulations were included to evaluate both the physical parameters of deaf individuals' iconic memory and the information processing strategies engaged in by deaf individuals in comparison to hearing individuals.

To evaluate the physical parameters of deaf subjects' iconic memory, the duration of that memory was investigated. The 250 msec "fade" of iconic memory in comparison to the one second "fade" of echoic memory places constraints on how long information is available for processing. If deaf individuals' visual systems have been altered by a structure-function type of interaction, one possible parameter for this change would be in the duration of iconic memory. To investigate this interaction hypothesis, three inter-stimulus intervals (ISIs) were included in the study: 0 delay, 250 msec, and 500 msec post stimulus presentation. Findings of an increase in the number of correct trials at the 250 and 500 msec delays for deaf subjects in comparison to hearing subjects would lend support to this interaction hypothesis.

The second manipulation was one of stimulus familiarity. Both English letters and novel symbols were presented in an attempt to untangle the prior confound between the perceptual abilities and linguistic abilities of deaf individuals.

CHAPTER II

EXPERIMENT 1

A tachistoscopic identification task was used for stimulus presentation. For each stimulus type, letters and novel symbols, identification at three ISIs was evaluated. Predictions for this study were based on pilot data obtained with hearing subjects, supporting the findings of Robinson et al. (1964). In the pilot study, the hearing subjects showed an effect of stimulus familiarity; viz., the subjects had significantly higher recognition scores with letters than with novel symbols. Therefore, in Experiment 1, the predictions were: (1) that hearing subjects would show a significant effect of stimulus familiarity, with letters being recognized easier than symbols; (2) deaf subjects would not show a familiarity effect, attaining non-significant differences in thier recognition scores for both letters and symbols; (3) the recognition of novel symbols would not be different between the two different populations; and (4) deaf subjects would have a significantly higher number of correct trials at the 500 msec ISI, than the hearing subjects due to a structure-function interaction.

The methodology used in Experiment 1 was based on that of Morrison et al. (1974). They used a brief visual display, with stimuli presented in a circular array. This method of stimulus display eliminates problems arising from a matrix display, as used by Sperling (1960). In Sperling's task, the subject was to report a row of three or four letters, after being cued by a tone as to which row to report. It was later shown that cueing a row of a matrix lead to response competition, and failure to recall an item could result either from forgetting the item or competition among the responses for output (Averbach & Coriell, 1961). In the circle display paradigm, only one item is cued at a time, so that no competition among responses occurs.

In summary, the purpose of Experiment 1 was to evaluate both the time parameter of deaf subject's iconic memory and their information processing strategies. Three ISIs were included to investigate whether or not the iconic memory of prelingually deaf subjects has different time parameters than that of hearing subjects, due to a structure-function interaction. The different stimulus types, English letters and novel symbols, were included to control for previous confounds between perceptual and linguistic abilities.

Method

Subjects. Sixteen subjects participated in this experiment, eight deaf adults (ages 17 to 28 years, mean=20.5) and eight hearing adults (ages 18 to 26 years, mean=20.6). All eight hearing adults participated for credit in a general psychology course. Deaf adults were recruited from the community by a local interpreter who worked at the Guilford County Communications Center for the Deaf in Greensboro; six subjects attended a local community college and the remaining two lived in the area. All eight deaf subjects were prelingually deaf with severe to profound hearing losses (> 80db in the better ear).

Apparatus and Materials. An IBM Portable Personal Computer with an amber screen was used to display all materials and record the data. The amber screen was choosen over the standard green CRT screen because of its rapid fade time.

Eight uppercase English letters and eight meaningless symbols were used as stimuli (see Figures 1 and 2). The letter set was drawn from consonants of the alphabet so as to be maximally discriminable. The symbol set was drawn from other characters available in the graphics package of the IBM Personal Computer.

Procedure. Stimuli were 2.4 log units above the background stimulation of .44 ml. The subject sat approximately 40.8 cm from the screen, so that the stimulus display subtented 3.7 degrees of visual angle. Each individual stimulus subtented .6 degrees of visual angle.

Subjects were tested individually. The criterion for subject inclusion was above chance performance on the letter stimuli in the no delay block. Only one deaf subject failed to reach an inclusion criterion, and was replaced.

Placement of the eight letter or symbol stimuli within each circular array was randomly generated by the computer. An asterisk was used as the indicator to cue subjects as to which position to recall on each trial, with the restriction that each position was cued no more than four times within each block of 20 trials. Placement of the asterisk (i.e., determination of a target) was randomly generated by the computer on each trial and occurred behind the cued stimulus position.

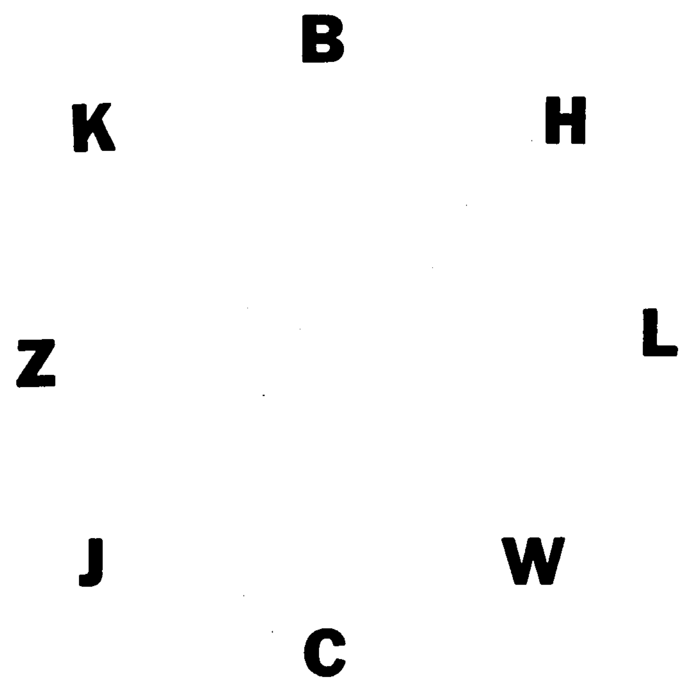

Figure 1. Sample stimulus array with letters as stimuli.

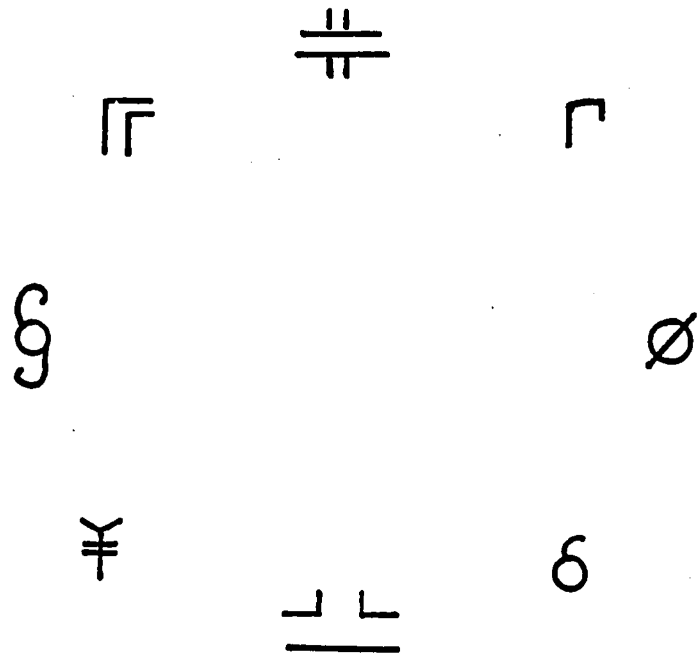

Figure 2. Sample stimulus array with symbols as stimuli.

Each test series had a total of 60 trials, consisting of three blocks of 20 trials each. The order of the blocks, one at an ISI of 0 msec, one at an ISI of 250 msec, and the third at an ISI of 500 msec, was randomly determined for each subject. Two sets were presented--one of letters and one of symbols--and two series were included in each set--the first series to acquaint subjects with the task and the second to test recognition after exposure.

Blocks began when the space bar was pressed after a prompt. Trials began after another press of the space bar following a second prompt. Prior to each trial, a fixation point ("X") appeared in the middle of the screen and remained for one second. This point was followed immediately by an eight item array which remained for a duration of 100 msec. An asterisk then appeared adjacent to and outside one of the eight positions of the display; this event occurred either at no delay, a 250 msec delay, or a 500 msec delay. The asterisk remained on the screen for one second before the response prompt appeared.

Responses were prompted by the statement "Respond using keys at left" appearing at the lower left corner of the CRT screen. The IBM's function keys, to the left of the space bar, served as the response keys. Eight function keys were programmed to correspond to the eight items in the array. Each key was labelled to indicate which item it represented. After a response had been entered, the prompt "Hit space bar for next trial" reappeared, and the next trial was started by pressing the space bar.

Order of presentation of symbols and letters was counterbalanced across subjects. After completing the first set of trials, subjects were given a three minute break, during which time the experimenter and/or interpreter engaged the subject in conversation.

Results and Discussion

The present experiment had two between-subject factors (hearing status and order of stimulus presentation) and three within-subject factors (series, stimulus type, and delay of cue presentation). A split plot analysis of variance as well as planned comparisons were performed on the recognition scores (i.e., the number of correct responses within each block of 20 trials). For clarity, analysis will be presented in terms of the within subject factors. Unless otherwise noted, all effects described were significant at or beyond the .05 level. Planned comparisons (F-ratios) were used to analyze all deaf and hearing interactions, based on the a priori predictions. All other post hoc anaylses were Newman Keuls tests.

Series. Overall, hearing subjects had significantly higher recognition scores than deaf subjects, $F(1,12)=5.00$, $MSe=9.79$. This effect was qualified, however, by the finding of a significant difference between deaf and hearing subjects' scores on the first series of trials (deaf mean=3.81, hearing mean=5.29), $F(1,12)=2.68$, but not on the second series (deaf mean=5.21, hearing mean=5.91), $F(1,12) < 1$, (see Figure 3). This effect indicated the lack of a practice effect for hearing subjects. There was an overall significant practice effect, $F(1,12)=17.33$, $MSe=3.31$, but planned comparisons showed that the only

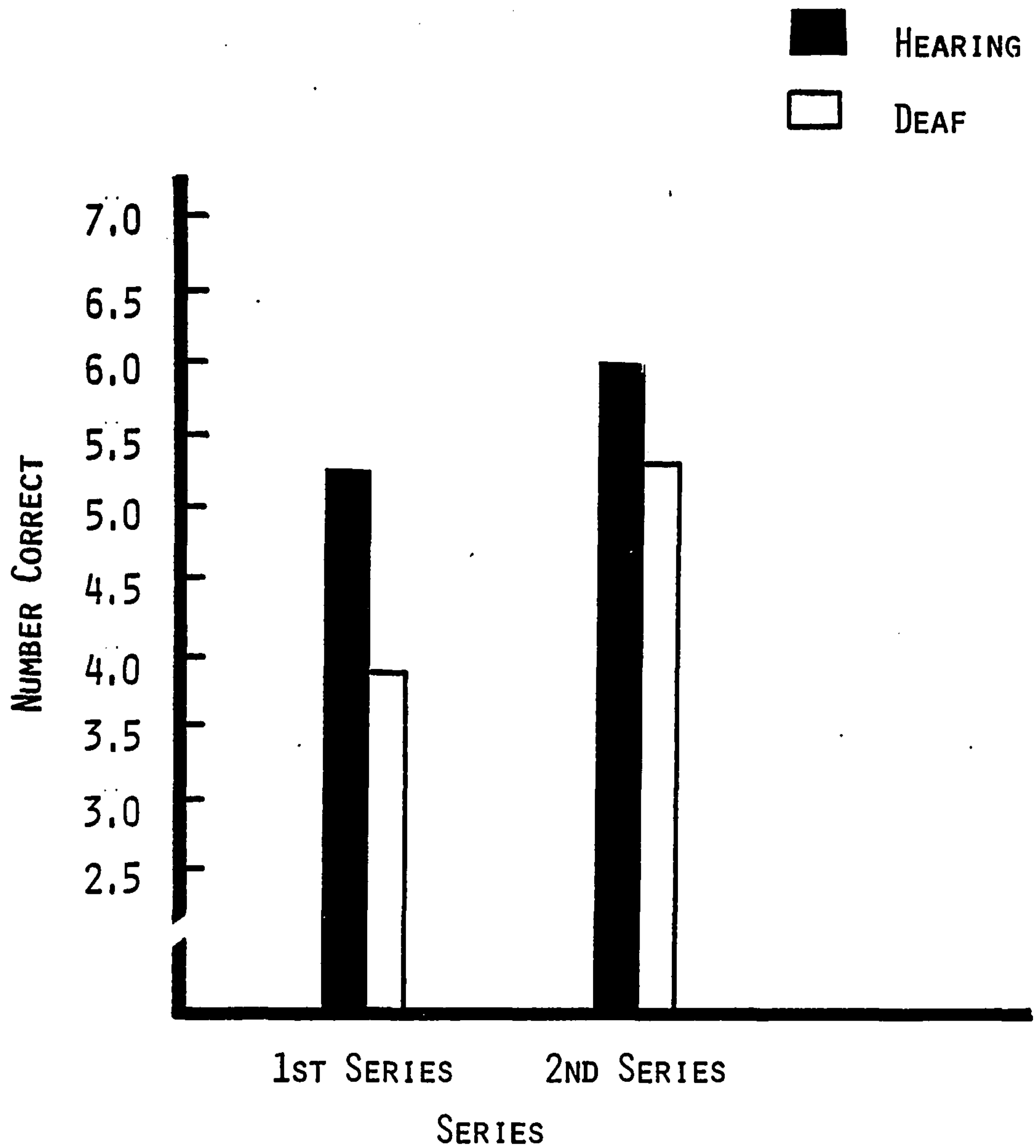

Figure 3. Mean number of correct responses on the first and second series for deaf and hearing subjects as averaged across stimulus delay (0, 250, and 500 msec) and stimulus type (letters and symbols).

significant increase in performance was between the deaf subjects' two series in the letter condition, $F(1,12)=2.50$ (see Figure 4). Hearing subjects showed no difference in their recognition scores for letter stimuli between the two series, $F(1,12)<1$.

The practice effect found with letter stimuli between the first and second series for deaf subjects suggests that both deaf and hearing subjects were capable of comparable performance with English stimuli when deaf subjects were allowed sufficient practice. Hearing subjects did not show a practice effect, suggesting that English letters were overlearned for this subject group. Deaf subjects, on the other hand, attained significantly higher scores on the second series, suggesting that English letters were either not as familiar to this group as they were to the hearing group or required practice to be rapidly recoded into an acoustic code.

Other researchers (Liben, Nowell, & Posnansky, 1978; Liben, 1979) have shown that with training deaf subjects do very well on tasks that employ English stimuli. Evidence such as this suggests that deaf subjects are more competent than their performance suggests (see Furth, 1966). Results showing a competence--perfomance discrepancy require an evaluation of the stimulus characteristics as well as the characteristics of stimulus presentation, stimulus response, and task instructions. Therefore, when comparing deaf and hearing subjects on language tasks, the researcher should be sensitive to how familiar the stimuli are to different subject groups. Liben and Drury (1977) suggested that it is important to consider the degree of stimulus

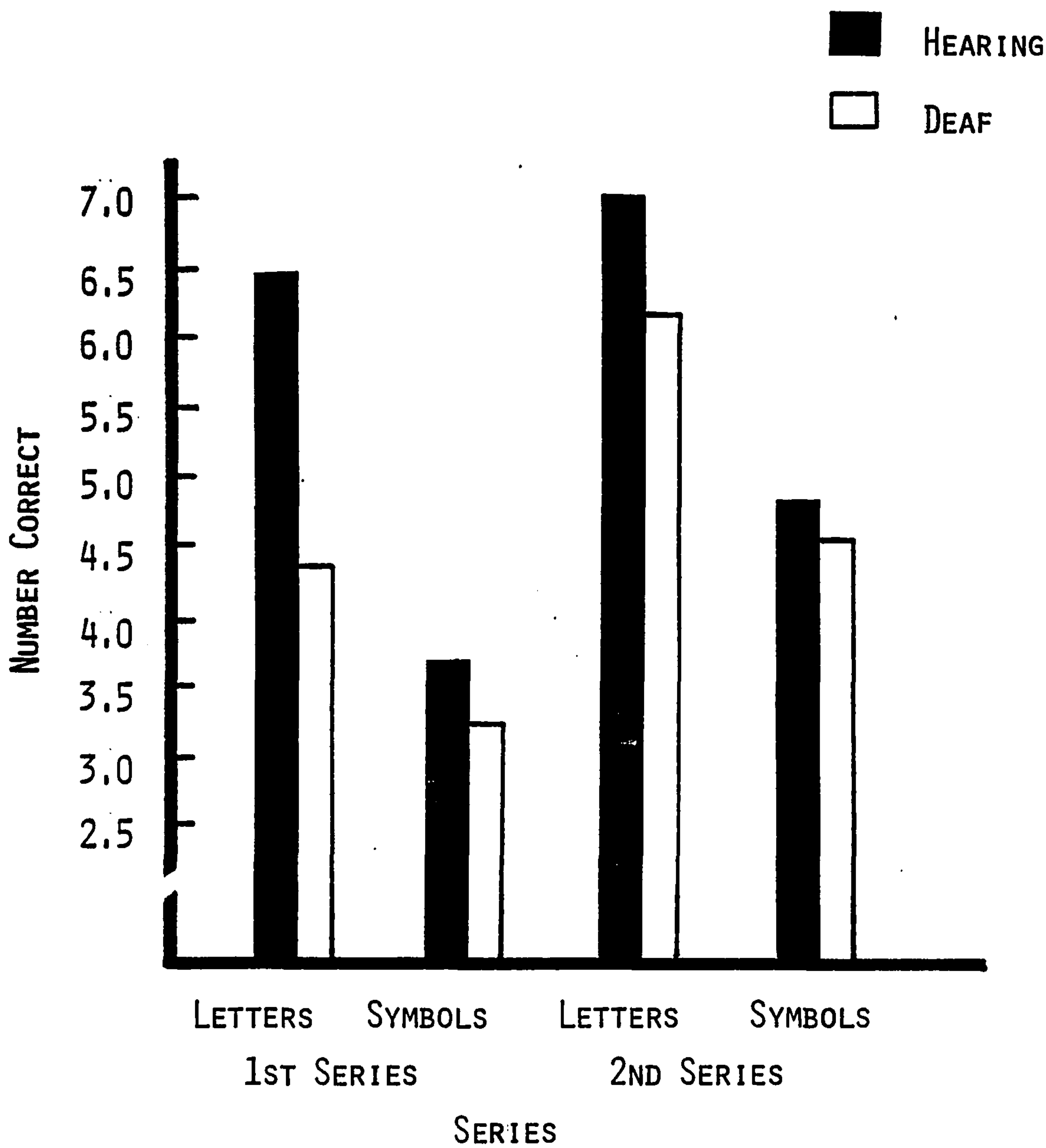

Figure 4. Mean number of correct responses to both letters and symbols on the first and second series for both deaf and hearing subjects as averaged across stimulus delay (0, 250, and 500 msec).

familiarity when comparing the results of deaf subjects to those of hearing subjects because overlearned stimuli for one group may not be overlearned for the other group. Differences in item familiarity between individuals can be influenced by many factors, such as educational experiences and linguistic background. Therefore, when evaluating populations as different as hearing and deaf subjects, background factors play an important role.

Stimulus Types. A main effect of stimuli was found, $F(1,12)=27.43$, $MSe=6.09$, with letters being recognized significantly more than symbols. In addition, there was a significant interaction of order with stimulus type, $F(1,12)=19.00$, $MSe=6.09$. Newman Keuls analyses revealed that when letters were followed by symbols, recognition scores were not significantly different (symbol mean=4.81, letter mean=5.13). With the reverse order of presentation, symbols followed by letters, a significant difference in recognition scores occurred (letter mean=6.85, symbol mean=3.44) (see Figure 5). Both deaf and hearing subjects showed this same pattern of responding, providing evidence for an effect of familiarity in briefly presented, visual tasks across both deaf and hearing subjects. This effect appears to be related to a contrast in labelability in which unfamiliar stimuli affect later performance on familiar stimuli. When familiar stimuli were presented first, it appears that subjects were able to adopt a coding (labelling) strategy that was not readily available when unfamiliar stimuli were presented first. Subjects spontaneously reported coding the novel symbols and having had letters first appeared to suggest a readily available strategy.

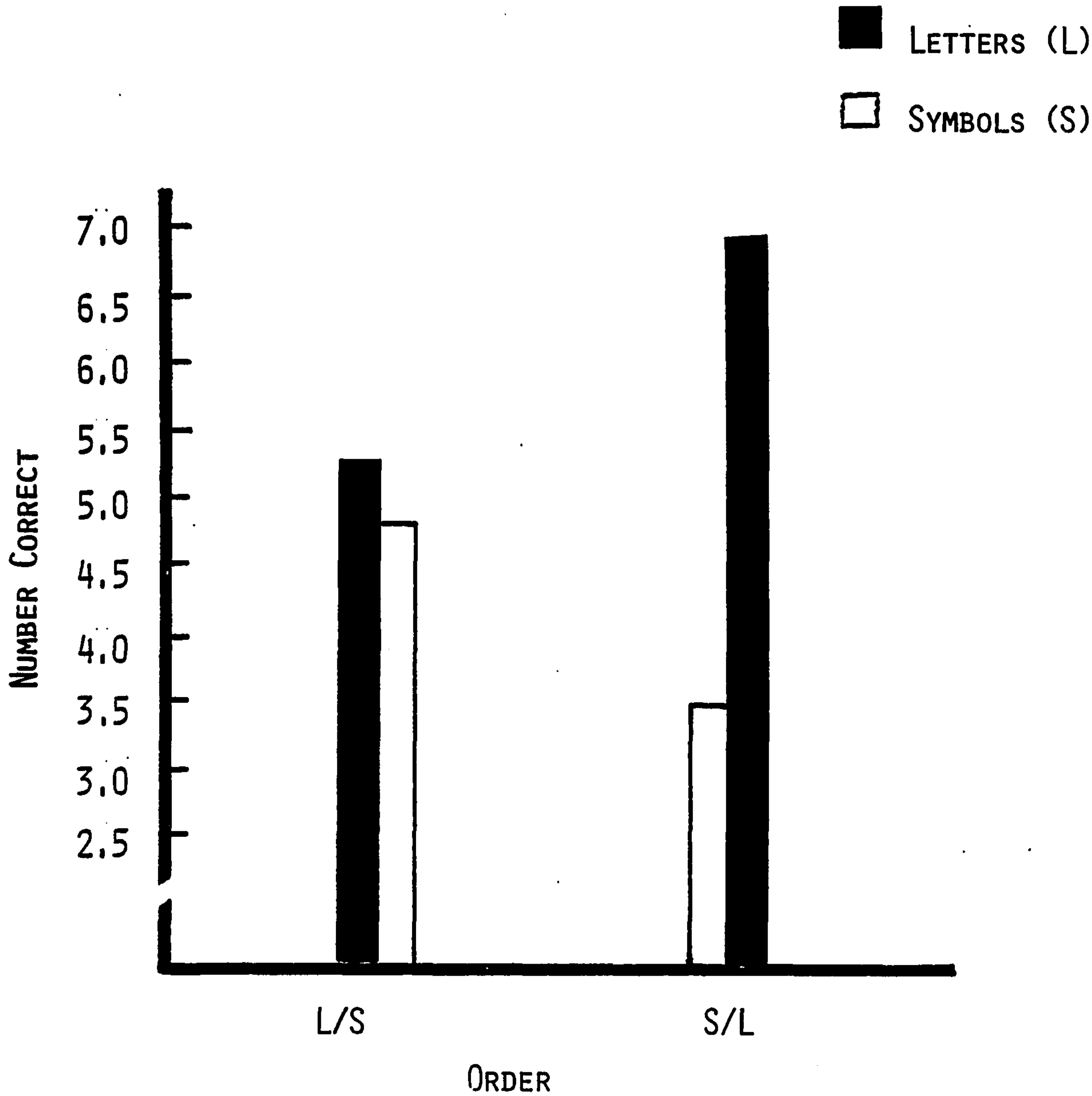

Figure 5. Mean number of correct responses for the stimulus type (letters and symbols) by order of presentation (letters/symbols and symbols/letters) interaction. Means are derived by averaging across subjects (deaf and hearing) and stimulus delay (0, 250, and 500 msec).

Planned comparisons revealed that, overall, hearing subjects had significantly higher recognition scores on the letter presentation than on the symbol presentation (letter mean=6.71, symbol mean=4.42) (see Figure 6). In comparison, deaf subjects did not show an overall significant letter-symbol difference (letter mean=5.27, symbol mean=3.83). These results confirm the first and second predictions made above, in that hearing subjects showed an effect of familiarity while deaf subjects did not. But referring to Figure 3, one can see that deaf subjects showed a familiarity effect on the second series (letters=6.17, symbols=4.42) even though they did not show this effect on the first series (letters=4.38, symbols=3.26).

Planned comparisons revealed no significant differences between deaf and hearing subjects' recognition scores in the symbol condition, $F(1,12) < 1$, thus confirming the third prediction. Neither subject group had significant differences between the two series, therfore no significant practice effects occurred for the symbol stimuli. This lack of a practice effect for deaf subjects in the symbol condition, contrasts with their practice effect in the letter condition. It appeared that letters were not as familiar to deaf subjects as they were to hearing subjects. Even for the deaf subjects, however, some advantage had accrued to the letters in comparison to the symbols, because the letters did show effects of practice.

Delays of Cue Presentation. In evaluating the effect of the three ISIs, a significant main effect was found, $F(2,23)=6.77$, $MSe=2.82$. Higher levels of correct responses were obtained at the 250 msec delay

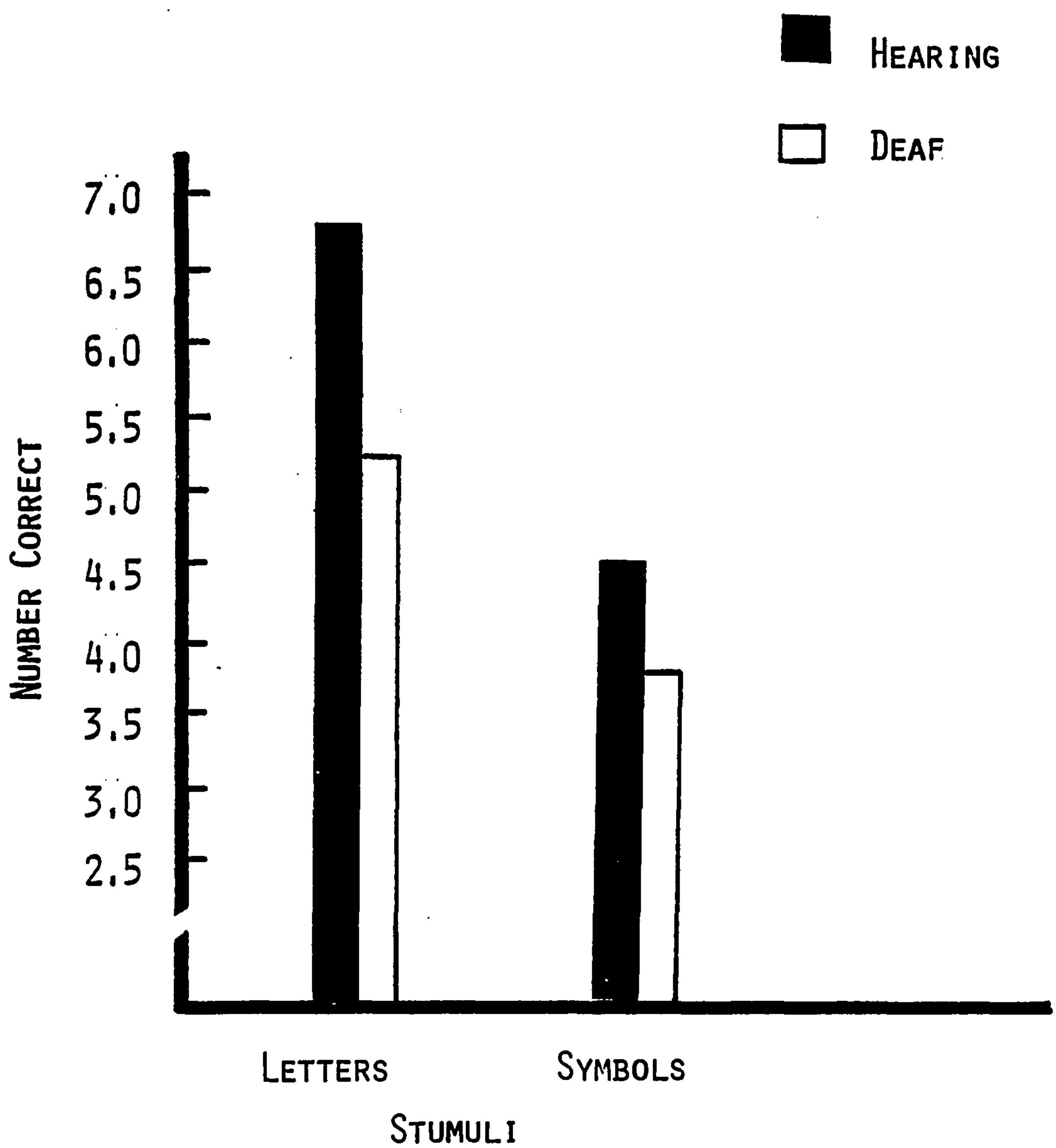

Figure 6. Mean number of correct responses to both letter and symbol stimuli for both deaf and hearing subjects as averaged across series (first and second) and stimulus delay (0, 250, and 500).

than at either of the other two delays (0 or 500).

The differences occurring between the 0 and 250 msec ISIs may have resulted from several factors. It is possible that the poor performance found with no delay betweeen the stimulus display and the probe resulted from masking. The stimulus and probe were not presented at the same spatial location on the display, however, and therefore the probe itself could not have masked the stimulus (due to the fact that two different retinal locations were stimulated). Nevertheless, because the probe remained on the screen for one second and the stimulus was presented for only 50 msec, it is possible that the probe′s energy masked the earlier presented stimulus display.

Turvey (1973) showed that when central processes were involved, a specific amount of time between stimulus onsets was necessary to identify the target stimulus. It is possible that in the no delay condition, the stimulus onset asynchrony between the stimulus display and the probe was shorter than this critical period, causing the information in the probe to "overtake" the information from the stimulus display. If this type of energy masking occurred, then the information from the probe would have interrupted the information from the stimulus display, thereby reducing the availability of information from the stimulus display.

A second possible explanation for the superior performance at 250 msec is that this delay may be the optimal time interval for this particular task: at 250 msec, information is assumed to be transferred out of iconic memory for further processing, but at the same time the stimulus display is still available in iconic memory. Therefore, if the item has not already been transferred, it can still be retrieved from iconic memory. At a 0 delay, only iconic memory processes are available for outputting information. At a 500 msec delay, only information that has already been transferred is available for output. Thus, the advantage seen at 250 msec may be related to a combination of the availability of the stimulus array as well as a subset of items having received additional processing and thus having a higher probability of being outputted. Comparisons of deaf and hearing subjects at all delays revealed no significant differences in the number of correct responses at any ISI. This finding suggested that the early stages of deaf and hearing subjects' perceptual processing, or iconic memory, appeared to be comparable.

Analysis of Position Effects. One source of information concerning processing strategies used by deaf and hearing subjects was an analysis of position effects (e.g., number of correct responses at each position within the circle array (see Figure 7 for numbering of each position)). Two split plot analyses of variance were performed on the number of correct responses at each stimulus position, one for letter stimuli and one for symbol stimuli. Each analysis had two between-subject factors (hearing status and order of stimulus presentation) and two within-subject factors (series and stimulus position).

As can be seen in Figures 8 and 9, a significant hearing status by position interaction occurred in both letter presentation, $F(7,84)=2.96$, $MSe=3.68$, and symbol presentation, $F(7,84)=4.48$, $MSe=1.84$. Newman Keuls

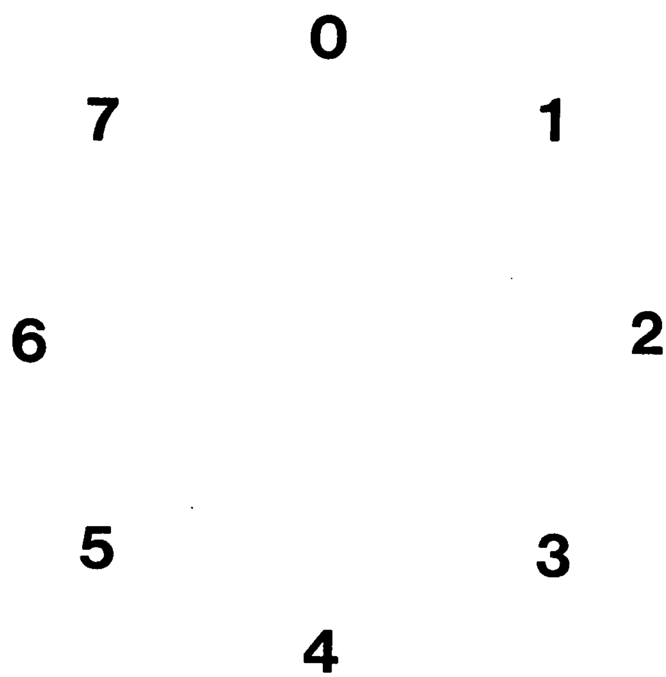

Figure 7. Numbering for each stimulus position within the stimulus array.

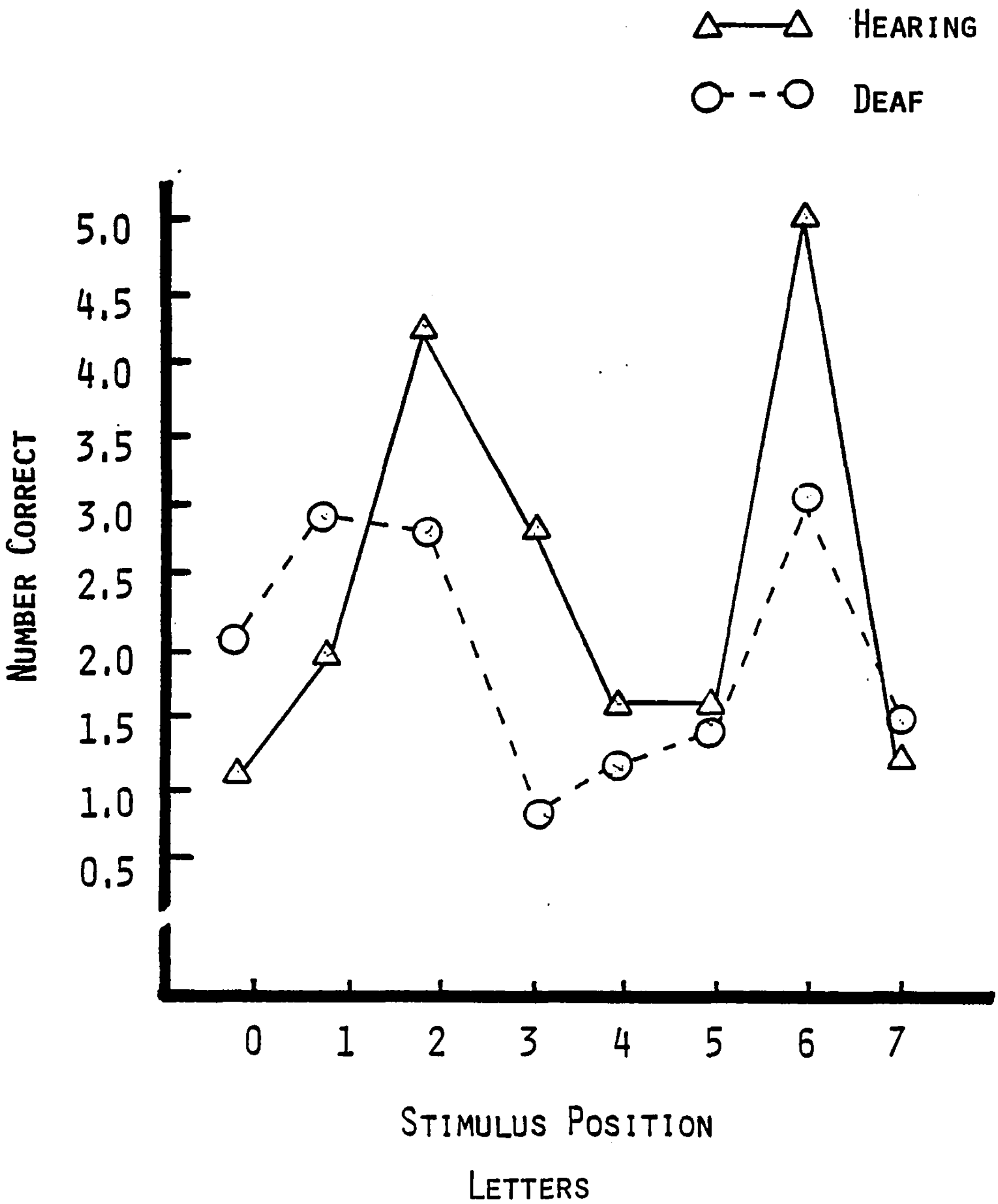

Figure 8. Mean number of correct responses to letter stimuli at each position of the stimulus array for both deaf and hearing subjects.

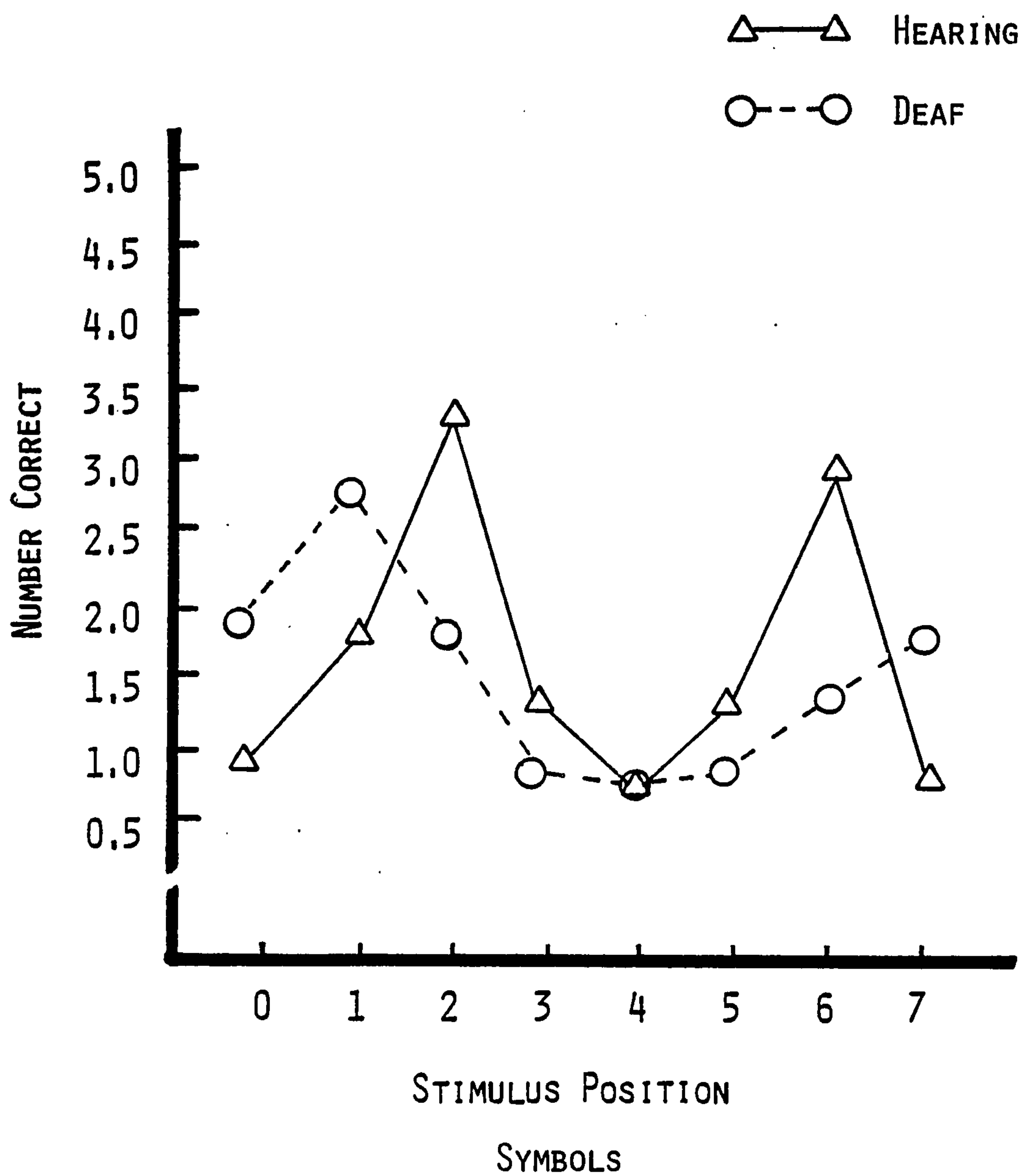

Figure 9. Mean number of correct responses to symbol stimuli at each position of the stimulus array for both deaf and hearing subjects.

analyses revealed that hearing subjects' scores on the letter presentation at positions 2 and 6 were significantly better than at all of the other positions except position 3 (p =.05). Positions 2 and 6 were on the horizontal, to the right and left of fixation and appeared to benefit from a tendency in hearing subjects to scan left to right (see Figure 8). Deaf subjects showed no significant differences in their scores at the different positions though scores for positions 0, 1, 2, 6, and 7 were elevated. These elevated positions correspond to positions in the top half of the circle array. Newman Keuls analyses showed no other significant differences between positions in the deaf subjects' data. These results suggested that deaf subjects appeared to use a more holistic scan of the array whereas hearing subjects appeared to use a sequential scan.

As can be seen in Figures 8 and 9, both deaf and hearing subject groups showed the same general patterns of responding in the symbol presentation as in the letter presentation. In comparing the two groups of stimuli, Newman Keuls tests revealed a similar pattern of significant differences, in that hearing subjects had better scores at positions 2 and 6 while deaf subjects had no significant differences among the positions though scores at positions 0, 1, 2, 6, and 7 were elevated. These results suggest that similar recognition scores do not require similar information processing strategies in deaf and hearing subjects.

In summary, three of the four predictions for this experiment were confirmed. (1) Hearing subjects were found to show a significant effect of stimulus familiarity, with overall higher recognition scores for letters than for symbols. (2) Overall, deaf subjects showed no significant differences between their recognition scores on letter and symbol presentations. (3) Hartung's (1971) suggestion that prior studies had confounded perceptual and linguistic abilities thus was supported. Novel symbols, which precluded tapping prior linguistic skills, produced non- significant differences in performance between deaf and hearing subjects'.

The prediction of a structure-function interaction in the time parameter of deaf subjects' iconic memory was not supported. The similarity between deaf and hearing subjects' recognition scores at each of the three ISIs suggested that the time parameters of their iconic memories were similar. An apparent strategy difference was found between the deaf and hearing subjects, however, as reflected in the analyses of position effects. Deaf subjects appeared less dependent than hearing subjects on a left to right scan for dealing with input of visual information but rather appeared to use a strategy of scanning a whole area.

Findings of alternative strategies between deaf and hearing subjects may be related to a structure-function interaction and help explain the findings of different cerebral lateralization (Kelly & Tomlinson-Keasey, 1981; Phippard, 1978) and patterns of VEPs (Neville et al., 1983) in deaf and hearing subjects. If a structure-function interaction occurs, it may alter not the actual physical structures of the cortex, but the way in which the structures are utilized. Studies by Hebb (1949) and Greenough and Green (1981) have indicated how this interaction could occur. Greenough and Green (1981), for example, found that an animal kept in a typical laboratory experimental cage had significantly fewer cortical dendritic branches than a similar animal that had been kept in an enriched environment (i.e., one that had toys available to encourage play and exploration of the environment).

Findings such as these make it somewhat less surprising that deaf subjects in the present study showed significantly different patterns of performance when similar results were obtained. Unfortunately, results of this study are not able to answer the question of whether the different strategy used by deaf subjects is related to an underlying physiological cause or different information processing strategies. Further research with different methodologies may find that Greenough and Greens (1981) results are directly comparable to deaf subjects' behavior.

CHAPTER III

EXPERIMENT 2

Introduction to Experiment 2

Several studies, such as that of Von Wright (1968) involving a partial report procedure, have suggested that the information in iconic memory is precategorical. The task in Von Wright's study was to report letters or numbers from a mixed stimulus matrix. Results from his study showed no partial report advantage when a category label was used as the cue, suggesting that reporting category information requires processing of the meaning of the information in iconic memory. Therefore, this type of research suggests that iconic memory is a brief system for storing veridical information that is received by the sensory receptors (see Ellis & Hunt, 1983 for further details). An interesting problem arising from an effect of famiiliarity within iconic memory is that this effect implies that information within the icon can be categorized--the recall of information from one category is presumed to be better because it is more familiar.

Results of Experiment 1 supported the findings of Robinson et al. (1964), who found an effect of stimulus familiarity when tachistoscopic identification of a response was required. Both Robinson et al's (1964) data and those of Experiment 1 conflict with those of Morrison et al. (1974) who did not find an effect of stimulus familiarity in iconic memory. Consequently, Experiment 2 was designed to further examine the conflict.

The order of presentation confound in the Morrison et al. (1974) study becomes crucial when interpreting the order by stimuli interaction found in Experiment 1. In review, Experiment 1 showed an effect of stimulus familiarity with the symbol-letter presentation order, but not the letter-symbol order. In the Morrison et al. study, the order of presentation was either (a) letters, geometric forms, and then abstract forms or (b) abstract forms, geometric forms, and then letters. If the effect of familiarity is related to the ease of codability, then it is possible that geometric forms reduce the contrast between the letters and the abstract forms. That is, in the first experiment, it appeared as if the unfamiliar stimuli received some benefit from facilitation occurring in the processing of familiar stimuli. This resulting order effect also would explain the conflicting findings between the first experiment, and the Robinson et al. and Morrison et al. studies. The following study therefore was conducted to test the hypothesis that the obtained order by stimulus interaction resulted from the ease of codability of the stimulus.

Because the order by stimulus presentation interaction was the same for both deaf and hearing subject groups, only hearing subjects were included in the second study, due to their accessibility. Experiment 2 was a partial replication of Experiment 1 but with the addition of a third set of stimuli, such that order of presentation was either letters/symbols/letters or symbols/letters/symbols. This additional set of stimuli was included to evaluate the effect of stimulus types without the confound of order. The predictions for this study were that (1) the order of presentation, letters/symbols/letters (L/S/L) would yield similar recognition scores between the first two sets but significantly higher scores on the third set and (2) the order of presentation, symbols/letters/symbols (S/L/S) would show a significant difference between the first two sets but not between the second and third sets (see Figure 4).

Method

Subjects. Sixteen hearing subjects participated in the study (ages 22 to 38, mean=26.7). All subjects were volunteers from the local community.

Design and Procedure. All materials were the same as in Experiment 1. The procedure was the same as that of Experiment 1 except for the addition of the third set of trials. Order of presentation was either letters/symbols/letters or symbols/letters/symbols. One half of the subjects received the first order and the remaining half received the second order. Order of presentation was counterbalanced across subjects.

Results and Discussion

Two multifactor, repeated measures analyses were performed on the recognition scores (i.e., the number of correct responses within each block of 20 trials). The first analysis was on the letter/symbol/letter data. Factors were stimulus set, series, and delay of cue presentation. Performance at delays of 250 msec and of 500 secs was found to be better than at no delay, yielding a main effect of delay, $F(2,14)=5.65$, $MSe=3.97$. A significant interaction of series with delay also occurred, $F(2,14)=6.22$, $MSe=2.02$, in that recognition scores at no delay showed significant improvement between the two series while scores at delays of 250 or 500 msec did not show this improvement. These results were similar to those found in Experiment 1 and will not be discussed here further.

A main effect of stimulus set was found $F(2,14)=21.62$, $MSe=2.61$, and Newman Keuls analyses showed that, as predicted, in the L/S/L condition the first set of letters (mean=5.94) and the symbols (mean=4.94) had non-significantly different mean recognition scores, but the second set of letters had a significantly higher mean score (mean=7.10) than the symbols. The similarity between the first set of letters and the symbols replicates the results of the letter/symbol order in Experiment 1. The finding of a significant increase in recognition scores on the second set of letters supported the prediction for this experiment that when a set of symbols preceded a set of letters, the letters would have significantly higher recognition scores than symbols. This contrasts with the letter-symbol similarity between the first two sets and the symbol-letter similarity observed in Experiment 1.

The second analysis was on the symbol/letter/symbol data. Again, factors were stimulus set, effects of series, and delay of cue presentation. The only significant effect was a main effect of stimulus set, $F(2,14)=26.50$, $MSe=3.70$. Newman Keuls analyses revealed that the letters (mean=6.54) had significantly higher recognition scores than either set of symbols (mean=3.79 and 4.42). The significant difference between the first set of symbols and the letters replicates the results from Experiment 1 in the symbol/letter order of presentation.

Another prediction for this experiment was that scores on the letters and the second set of symbols would not be significantly different. As is evident from the mean scores (3.79, 6.54, and 4.42 for S/L/S, respectively) even though the mean score for the second set of symbols was significantly different from the letters, the former was more similar to the letters than was the first set of symbols. This increase on the second set of symbols was in the direction of the prediction but was not large enough to show a non-significant difference between the means of the letters and second set of symbols. Apparently, letters did not have as much of a facilitative effect on the second set of symbols in the L/S/L condition as symbols did on a second set of letters in the S/L/S condition. This finding suggests the following account of stimulus set effects: in the S/L/S order, there is no readily available coding strategy when symbols are presented first and hence relatively poor performance is observed. When letters are then presented, a coding (i.e., labelling) strategy is "suggested." With a second set of hard-to-label stimuli following the letters, however, the coding strategy may be transferred to the symbols, enhancing performance relative to the first set. In the L/S/L order, the labelling strategy would be "suggested" during the first set and readily transferred to the following set of novel symbols. This labelling strategy would then explain why in the first experiment only the symbol-letter order of stimulus presentation showed an effect of familiarity.

CHAPTER IV

GENERAL DISCUSSION

The purpose of the present experiments was to evaluate how visual information processing strategies and capabilities impact iconic memory. Experiment 1 examined the parameters of deaf individuals' iconic memory with two manipulations evaluating (1) the information processing capabilities of deaf subjects and (2) the time parameters of deaf subjects' iconic memory. Both letters and novel symbols were presented at one of three ISIs (0, 250 msec, or 500 msec) in a tachistoscopic task.

Overall, subjects had higher recognition scores for letters than for symbols in Experiment 1. This finding was qualified by an order by stimulus type (letters or novel symbols) interaction whereby in the letter-symbol condition, scores were similar for the two stimulus types but in the symbol-letter condition, subjects had significantly higher scores on letters than on symbols. Results of this study also indicated that on this task deaf and hearing subjects had similar information processing capabilities on a tachistoscopic task when stimulus familiarity was equated: that is, the two groups had similar scores in the symbol condition even though hearing subjects had higher scores in the letter condition. With regard to time parameters, both deaf and hearing subjects obtained similar scores at all three ISIs, which did not support the suggestion that deaf subjects would show higher recognition scores at the 500 msec delay than hearing subjects, due to a structure-function interaction. Although deaf and hearing subjects obtained similar recognition scores, they demonstrated different strategies in performance, in that alternate positions of the stimulus display were more salient to the two groups. Therefore, Experiment 1 demonstrated that in behavioral tasks of iconic memory, both deaf and hearing subjects appear to have similar capabilities even though they showed differences in the types of strategies they utilized.

Experiment 2 allowed a test of the hypothesis that the stimulus familiarity effect obtained in Experiment 1 resulted from differences in the availability of labels for coding the stimuli. A third set of stimuli, either an additional set of letters or an additional set of symbols, were added to the design of Experiment 1 to evaluate the effect of labelling. The addition of this third set of stimuli allowed an investigation of how both letters and symbols affected each other in both a forward and a backward order. Results supported the idea of a labelling effect in that when symbols following letters they had higher recognition scores than if they preceded letters. These results were interpreted to mean that letters suggested a readily available labelling strategy that was then applied to the novel symbols.

Taken together the results of these two experiments confirm many of the original predictions. In Experiment 1, hearing subjects showed an effect of stimulus familiarity, in that their recognition scores on the English letters were significantly higher than their scores on the novel symbols, thus supporting the first prediction. Deaf subjects, in contrast, did not show any significant overall difference between their scores on the letter and symbol conditions, supporting the second prediction that they would not obtain a familiarity effect. This lack of a familiarity effect is qualified by the finding of a practice effect with letters for deaf subjects but not for hearing subjects. This suggests that English letters do not have the same associations for deaf subjects as they do for hearing subjects. Therefore, deaf subjects were found capable of similar performance on a test of brief identification of English letters, if they were given sufficient exposure to the task. With novel symbols, deaf and hearing subjects showed no significant differences in performance, supporting the third prediction that with novel symbols the two groups would show similar recognition scores.

A second possible reason for deaf subject's lack of a stimulus familiarity effect is a lack of speech recoding. This lack of an acoustic recoding strategy may be related to the finding of no significant differences between English stimuli and symbol stimuli for deaf subjects. Therefore, it is possible that on tasks using English stimuli, deaf subjects are demonstrating an inability to rapidly recode information acoustically rather than a lack of familiarity with English.

One possible way to evaluate whether the deaf subjects have an inability to recode information into a speech code or are not as familiar with English stimuli is to evaluate their ability to use acoustic recoding strategies. This ability could be detected by using Conrad's error ratio. In this way, it would be possible to access whether or not deaf subjects who were able to recode information acoustically demonstrated an effect of stimulus familiarity. If these subjects showed the effect, with higher scores on English stimuli than on symbols, the overall lack of a stimulus familiarity effect found in this study would be related to the subjects inability to use a speech code, rather than difficulty with English per se.

The present results support the suggestions of Furth (1966) and Liben (1978) that deaf individuals' poor performance on many cognitive tasks may be related to experiential deficiences rather than cognitive deficiences. The lack of a familiarity effect in deaf subjects' recognition scores, suggested that English letters may not be the overlearned stimuli for these subjects that they are for hearing subjects. Many people express surprise that this is the case, and cite the enormous amount of time that teachers spend teaching English to deaf students in school. Nonetheless, the general poor reading abilities observed within the deaf population further indicates their lack of fluency with English input. Many deaf individuals never attain proficiency with English and do not develop the ability to read. As a result, English letters would not gain the same level of familiarity for deaf individuals as they would for hearing individuals.

On the basis of findings of different hemispheric lateralization and VEPs between deaf and hearing subjects, a structure-function interaction was hypothesized to occur within the time parameters of deaf individual's iconic memory. That is, deaf subjects were hypothesized to demonstrate higher recognition scores at the 500 msec delay than would hearing subjects. The methodology of this study assessed this question at a behavioral level, however, and the results thus do not address the issue of cortical organization per se. The finding of no performance differences between deaf and hearing groups due to delay of cue presentation suggested that the time parameters of deaf subjects' iconic memory were comparable to those of hearing subjects. Therefore, the fourth prediction of an increase in the duration of deaf individual's iconic memory was not supported. This evidence does not suggest that deaf individuals' iconic memories are identical to those of hearing individuals', only that on this measure no significant differences were found between the two groups. With a methodology that accesses cortical processing, the original hypothesis might be supported.

In contrast to the similarities found in information processing capacities, deaf and hearing subjects did show significant differences in their information processing strategies across the different positions in the circular array. Hearing subjects had higher scores at the positions that were to the left and right of fixation, suggesting a reading strategy in which information was scanned in a left to right fashion. Deaf subjects, in contrast, had elevated scores for positions at the top of the array. The deaf subjects thus appeared to have focused on a larger part of the stimulus display than did hearing subjects, using either parallel inputs to the visual system or more global processing strategies (Siple, Hatfield, & Caccimise, 1978).

The strategy demonstrated by deaf subjects on this task was similar to a parallel type of encoding, rather than a sequential type. This result may explain why deaf subjects tend to recall shorter sequences in comparison to hearing subjects (see for example, Blair, 1957): sequential tasks may not allow the use of the deaf subjects' optimal visual processing strategies. Deaf subjects' inferior performance as compared to the hearing subjects in prior studies may have resulted from the use of tasks that did not allow the use of strategies that maximized their abilities. In evaluating deaf subjects performance on Piagetian tasks, Furth (1966) suggested that they often are more competent than their performances suggested. Ornstein (1978) found evidence of a competence-performance problem in young children's memory and problem solving abilities and Furth (1966) compares the poor performance of deaf subjects to this competence-performance issue. He demonstrates this higher performance when task instructions are carefully explained. Therefore, task demands and characteristics are extremly important when evaluating the performance of deaf subjects.

The findings of both Conrad (1979) and Lichtenstein (1983) that deaf students who were good readers had internal speech, may be related to the fact that these students are among the few deaf students proficient in oral skills. Deaf students with high reading abilities thus may have acquired the ability to utilize sequential encoding strategies, at least on tasks of English input. This suggestion is supported by the results of Phippard (1977) who found differences in hemispheric lateralization between oral and manual deaf subjects. An interesting question thus remains: Do these oral deaf subjects use sequential strategies when visual-spatial information is presented?

Overall, the results from Experiment 1 suggested that previous findings of poor visual perceptual skills in deaf subjects did not result from deficits in deaf individuals' perceptual skills per se. When deaf subjects are tested with English stimuli the findings of visual perceptual deficits appear to be the result of a confound in tests of linguistic and perceptual abilities (Hartung, 1971). Results from the present study demonstrate that when this confound is eliminated, performance of deaf subjects can be similar to that of hearing subjects.

It appeared that stimulus familiarity affected the types of processing that occurred in iconic memory. These results supported the Robinson et al. (1964) findings that when identification of a stimulus is required, stimulus familiarity affects reaction times. One possible reason for this effect is that for recognition and identification, a stimulus has to be labelled. In the context of the tachistoscopic recognition task used here, a logical time for this labelling to occur would be after the information has been selected from the total array. If this is the case, then familiar stimuli would have an advantage over unfamiliar stimuli since unfamiliar stimuli typically have labels readily available. In fact, many subjects in this experiment spontaneously reported that they attempted to label the symbols; this report occurred more often when symbols were presented first. Labels differed between the subjects, but as suggested by Conrad (1979), once a code has been associated with an item, it can serve the function of a label as long as it is used consistently.

The results of Experiment 2 suggested that the availability of a label could account for a stimulus familiarity effect. Here, when symbols were presented first there was a familiarity effect but when letters were presented first this effect was not significant. If unfamiliar stimuli were presented first, there was no readily available label for these stimuli. This lack of a label in turn required the subject to generate an idiosyncratic label or tag for these novel stimuli. The overall effect of familiarity in recognition type tasks then would be the result of the ease of accessibility of a label. This effect appears to account for the discrepancies between the Robinson et al. (1964) and the Morrison et al. (1974) studies.

The stimulus familiarity effect calls into question the idea of iconic memory at the retinal level. Haber (1983) suggested that the concept of an icon or a frozen picture that is located at the level of the retina serves no function, because in a normal perceptual environment (rather than an experimental one using a tachistoscope for presentation of brief flashes) information is directly available from the environment. It was suggested that sucessive icons would mask each other, eliminating any possible advantage of a briefly stored frozen image. Turvey (1973) discussed the possibility that the contents of "iconic memory" may be a description of the object that is suitable for pattern recognition and exists simply as a "conglomerate of 'crude' context-independent features which requires some further operations before it is rendered into a form suitable for classification" (p. 45). He further suggested that iconic storage for a specific item can be viewed as the storage of a decision on peripheral data rather than a storage of peripheral data per se. Turvey proposed that iconic memory was an interface between the context-independent features (perceptual information) and the context-dependent features (final category state). At this point in visual information processing, the item is represented only globally. It is possible that when the incoming information is overlearned, the recognition ′decision′ about the context-dependent features is easier to reach because the features are easily accessed. Turvey′s (1973) view of iconic memory could handle the effect of stimulus familiarity that was found in these studies, by modifying the idea that iconic memory is a precategorical system located at the retinal level to the idea of iconic memory as a centrally located store of decisions regarding perceptual input.

To summarize, the results of the first study evaluated iconic memory at a behavioral level, and demonstrated similarities between the time parameters of deaf and hearing subjects within iconic memory. These results suggested that the iconic memories of deaf and hearing individuals may share some similar characteristics. In contrast, analysis of the position effects within the stimulus array suggested differences between deaf and hearing subjects information processing strategies. Further research is needed to demonstrate whether or not the "hardware" of deaf individual′s iconic memory is similar to that of hearing individual′s while the "software" is different.

Results of the second study suggested that the familiarity of stimulus information does affect processing in iconic memory. Having readily available coding strategies appears to minimize the effect of familiar stimuli, in that when novel information preceded familiar information, a familiarity effect occurred but in the reverse order, familiar-unfamiliar, the effect was not significant. Replication of prior studies (Morrison et al., 1974; 1976) which failed to find an effect of stimulus familiarity, may show the effect when the order of stimulus presentation is completely counterbalanced.

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