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DEAF CHILDREN'S HEMISPHERIC PROCESSING OF WORDS AND PICTURES VISUALLY PRESENTED TO THE HEMIFIELDS

by

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Deaf Children's Hemispheric Processing of Words and Pictures

Visually Presented to the Hemifields

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CHAPTER I

INTRODUCTION AND PURPOSE OF THE STUDY

Introduction

Children who are born deaf, or lose their hearing before language patterns are established, face formidable obstacles in their total development and adjustment to life. Of prime importance to educators is the fact that early hearing loss adversely affects the learning potential of deaf children. At first glance the main problem appears to be the inadequate development of language which hinders the ability to learn.

> When the deaf child enters school he is usually without speech or an understanding of language. It takes approximately three years to prepare the child for the first grade and a total of from ten to twelve years to complete the eight elementary grades (Silverman, Lane and Doehring, 1965, page 426).

Indeed, numerous studies have documented the disappointing educational progress of deaf children and have identified the lack of language as the major handicapping factor (Oléron, 1953; Babbidge, 1965; Kohl, 1966; Wrightstone, Aronow and Muskowitz, 1963). As a result, school programs for the deaf in the United States have consistently emphasized language development. Traditionally these schools have used either auditory-oral methods or visual-gestural

methods to teach language to the deaf. Unfortunately, no educational methodology to date has been very successful in overcoming the limitations imposed by early deafness (Myklebust, 1964).

Obviously, the loss of hearing at an early age affects one's ability to acquire language via the auditory channels. Although this does not preclude the deaf from learning language in another sensory mode (Bellugi and Klima, 1972), for the most part it does place severe limitations on their development of speech and spoken language. Aside from preventing the deaf from fully participating in the verbal communication used in our schools and society, there is the more basic question of what else an early hearing loss affects.

When comparing the deaf and hearing, one is struck by the differences in input which they are able to process. Hearing people easily process visual and auditory information simultaneously and store it in both modes (Bower, 1972; Paivio, 1971, 1972; Paivio, Rogers and Smythe, 1968). As a result, the hearing have dual storage modes which contain information that is easily integrated into a verbal communication system. In contrast, the deaf must process most information (speechreading, signing, pictures, print, etc.) in a visual mode, supplemented at best by a distorted and inadequate auditory input. Even when someone is speaking, the deaf probably code an oral verbal message visually in the form of lip movement and other observable body characteristics in order to process it (Myklebust, 1964). In fact, the results of a recent

study indicated that young hearing children dual coded word and picture stimuli which were visually presented, in contrast to young deaf subjects who appeared to process all the stimuli in a visual manner (Kelly and Tomlinson-Keasey, in press). Thus, the early loss of auditory input can apparently hinder one's ability to dual code information for cognitive processing.

As important perhaps as the loss of auditory information processing is the seeming inability of young deaf children to transform an object into its label, or a label into its object. It has been shown that deaf children experience more difficulty in processing word to picture stimulus pairs and vice versa, than either word to word or picture to picture stimuli (Kelly and Tomlinson-Keasey, in press). This interchange of a symbol with its image is a critical aspect of cognitive development (Piaget, 1962). Hence, the transformation problem may well be the source of many obstacles in the information processing and communication of deaf children (Odom and Blanton, 1967).

Furthermore, it has previously been suggested that congenitally deaf individuals may develop cognitive structures that differ from those of normal hearing people (Tomlinson-Keasey and Kelly, 1974). Due to their lack of auditory input, deaf children may not process (code, store, and retrieve) information in the same manner as their hearing counterparts. The processing combination of sight and sound could theoretically result in the development of a cognitive system which is structurally different from one developed

primarily through visual input. This position is supported by Luria's (1966) contention that the structural organization of the human brain consists of complex functional systems which are interrelated throughout the cortex. Therefore an early sensory deprivation to one or more functional systems could affect others due to the interrelationships. Even more important is the fact that Luria (1966) considers speech and language to be the most important feature in the formation of higher mental functions. Myklebust (1964) also theorizes that when one sensory perception is missing, it alters the integration and function of others.

The dual coding dimension mentioned earlier is one illustration of the possible cognitive processing differences between hearing and deaf people. Another potential cognitive area that could be affected by an early hearing loss is lateral specialization of the cerebral hemispheres. For hearing subjects, considerable evidence exists in the psychological and neurological literature to show the lateral specialization of the left and right hemispheres of the human brain. There is little doubt that under certain experimental conditions the left hemisphere is dominant in language oriented functions, while the right hemisphere exhibits a propensity for visual spatial information, and non-verbal ideations (Gazzaniga, 1967; Sperry, 1974). Hemispheric lateralization has been documented with commissurotomized patients (Nebes, 1974) as well as with normal subjects (McNeil and Hamre, 1974). Furthermore, consistent hemispheric differences have been demonstrated with both

auditory and visual input of information (Berlucchi, 1974; Curry, 1967; Ellis and Shepherd, 1975; Kimura, 1966, 1967, 1973c; Knox and Kimura, 1970).

If the deaf are less adept at dual coding, or the transformation of symbols and images, does that have implications for hemispheric lateralization? Is it possible that an early hearing loss could influence the development of one's cerebral hemispheres? For example, it has been hypothesized that the language hemisphere is specialized (for hearing people) to deal primarily with the grammatical codings involved in speech perception (Liberman, 1974a). If this is true, then there are obvious implications for the deaf. Myklebust (1964) has pointed out that deafness in infancy impedes language development, thereby limiting the verbal processes characteristically localized in the left cerebral hemisphere; but it should not preclude development of the nonverbal processes generally localized in the right hemisphere. Of course, the real question is whether this left-right specialization of hemispheres identified in the normal hearing would also exist for the deaf. Assuming that the hemispheres are developed, rather than genetically determined, the lateral specialization of hearing people would be based on the coordinated processing of auditory and visual information. In contrast, the deaf's major sensory input is essentially visual. Therefore, perhaps deaf people would develop a hemispheric laterality different from the normal hearing.

Based on the literature cited above, it is tempting to conclude that early deafness affects more than one's development

of oral language and speech. Obviously there are many areas which require further exploration, in spite of Furth's (1966, 1973) contention that the deaf are not cognitively different from the hearing. To date, hemispheric data on deaf children is almost nonexistent. Although at least one hemispheric study has been conducted with hearing-impaired subjects (not deaf), it involved a dichotic listening task (Ling, 1971). No significant differences in ear performances were obtained for the hearing-impaired subjects in that study. As yet, no hemispheric data is available on deaf children's processing of visual information, even though laterality in the deaf has been previously suggested by Myklebust (1964) as an area that requires further study.

Purpose of the Study

This study examined hemispheric laterality of young deaf children. The experimental task involved visual processing of word and picture stimuli. A visual processing task was selected because (a) deaf children must essentially rely on sight for their major sensory input, and (b) a severe hearing loss would preclude the collection of reliable data under a dichotic listening experiment. If deaf children have hemispheric specialization, it should logically be related to their major sensory processing mode.

Of primary concern was whether the deaf subjects would demonstrate any cerebral lateralization at all. And if so, would the laterality be similar to the hemispheric results documented for hearing people?

This question is important because no one today really understands why an early hearing loss is so devastating to one's cognitive and psychological growth. Even though it has consistently been demonstrated that the deaf have potentially normal mental and cognitive abilities (Furth, 1966, 1973; Hiskey, 1956; Myklebust, 1964; Vernon, 1968), their academic achievement continues to be poor (Babbidge, 1965; McClure, 1966; Wrightstone, Aronow, and Muskowitz, 1963). The central issue, therefore, must be concerned with why the deaf in general do not perform up to their mental capabilities. How do the deaf differ from their hearing counterparts? Is the major differance essentially a language problem as suggested by so many (Davis and Silverman, 1970; Levine, 1962, 1960; Moores, 1970), or does it also involve more subtle cognitive deficits?

It is extremely difficult to rule out the possibility that an early hearing loss may affect the development of cognitive structures. This study is an attempt to examine the hemispheric dimension of cognitive processing for young deaf children in relation to visual input. Hopefully, the data from this research will contribute to the body of knowledge that will someday provide an accurate psychological analysis of deaf children's learning abilities.

Research Questions and Hypotheses

The central theme of the research questions in this study was whether the deaf would exhibit cerebral laterality. In brief, the

questions focused on whether the deaf subjects would demonstrate a propensity to process verbal stimuli in one hemisphere and pictorial stimuli in the other. The four research questions pertinent to this study are as follows:

1. Would the young deaf children exhibit a lateral specialization of the hemispheres for visual processing?

2. If the deaf children showed hemispheric laterality, would the pictorial and verbal nature of the stimuli influence it?

3. Would the yes-no responses required of the subjects to match visual stimulus-pairs affect hemispheric processing?

4. Would the deaf children's grade level placement have any influence on their hemispheric processing?

These questions are important because, to date, there is no evidence available for any deaf population which shows that they have a lateral specialization for visual processing. It is quite possible that deaf people may not even develop a lateral specialization of the hemispheres. Since most language input--speaking, signing, and reading--must be visually coded by the deaf (Myklebust, 1964), it is difficult to say exactly how this would influence their hemispheric laterality. Conceivably, the early loss of auditory input for the deaf could eliminate the left hemisphere advantage for language, resulting in both hemispheres having equipotential for processing all visual input. Or it's possible that the right hemisphere in the deaf could develop a dominance for processing visual information, similar to the hearing,

and that this dominance could include language skills. This position is the most plausible due to the deaf's reliance on visual stimuli for their major sensory input. Without data, there is little reason to assume that the deaf's cerebral hemispheres would not show some lateral organization. However, it may be that the deaf have the same left-right lateral specialization for verbal and visual information that has been documented in the hearing. Such a finding would have considerable implications for the ontogeny of hemispheric lateralization.

Based on the above considerations, two major hypotheses were formulated. It was predicted that the deaf subjects would (a) demonstrate a lateral specialization of the hemispheres, and (b) exhibit a right hemisphere superiority for processing all the information regardless of verbal or pictorial content. In addition, it was hypothesized that the deaf would (c) process the verbal and pictorial stimuli with equal facility; (d) show no differences in processing efficiency for the yes-no decisions when matching the stimulus pairs; and (e) show no differences between grade levels. The deaf should process the verbal and pictorial stimuli equally well if they indeed treat them both in a visual manner. The yes-no match decisions should be processed the same since the deaf's cognitive search activities would logically involve only the visual mode processed in both hemispheres. This is in contrast to the hearing where it has been shown that "no" decisions required longer search times due to dual coding and

hemispheric specialization (Tomlinson-Keasey and Kelly, under editorial consideration). Finally, no grade level differences should result since the age range includes only third, fourth, and fifth grades.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter is divided into two sections. The first section presents research and descriptive information about the deaf, while the second discusses the hemispheric literature. Although the hemispheric review is the major emphasis of this chapter, it is also necessary to have an overall view of the deaf population in the United States in order to put this research in the proper perspective.

Research with the Deaf

The incidence of deafness in the United States is considerably greater than the one per 1,000 that has been regularly cited for so many years. According to recent estimates by the National Census of the Deaf Population, the rate of deafness which occurs prior to the age of three is 100 per 100,000, while prior to the age of 19 it is two per 1,000, or 203 per 100,000 (Schein and Delk, 1974).

The psychological repercussions of early profound deafness reach into every area of life, but particularly those areas in which conversational hearing ability is essential for normal devel-

opment and adjustment (Levine, 1962). The most apparent effects of deafness are on education and communication (Schein and Delk, 1974) -- areas which our society often equates with intelligence and various cognitive functions.

Educators of the hearing impaired have consistently fought the belief that the deaf were "dumb" or mentally deficient in some way. Of course, this does not include the deaf multiple handicapped who are also mentally deficient, blind, or brain damaged. Rather it refers to the "normal" deaf whose only apparent handicap is a severe hearing loss that limits the acquisition of language.

Pintner and his associates (Pintner, Eisenson, and Stanton, 1946) were among the first to suggest a relationship between hearing loss and the growth of intellectual capacities. Their position was based on previous research in which large numbers of deaf children were evaluated with the Pintner Non-Language Mental Test (Pintner and Reamer, 1920). In this study they concluded that, on the average, deaf children were retarded two years mentally and five years educationally. Furthermore, they suggested that this mental and educational retardation could be attributed, in part, to the deaf's mental inferiority. Another reason suggested for this retardation was their language handicap resulting from early deafness.

Zeckel and Van der Kolk (1939) also concluded that deaf children were retarded mentally. However, they attributed this intellectual deficit to a reciprocal effect of deafness, rather than mental inferiority. They believed that deafness influenced

psychological process in general, and that a severe language handicap limited mental development.

The intelligence studies cited above were based on group testing. Other studies which evaluated the deaf with individual performance tests found that deaf children were of average intelligence (Schick, 1934; Streng and Kirk, 1938; Myklebust and Burchard, 1945). More recent studies also found that the deaf had average intelligence (Birch and Birch, 1951; Hiskey, 1956).

However, measuring the overall intelligence of the deaf does not reveal the entire picture. Myklebust (1964) believes that a major sensory loss such as deafness can affect certain mental operations more than others. Thus, in measuring the deaf's mental abilities, one might expect to see certain mental processes affected to a greater or lesser degree. In fact, it has been demonstrated that deaf children fall below average mainly on tests which require abstract or reasoning processes (Heider and Heider, 1941; Oléron, 1953; Templin, 1950).

In spite of the knowledge acquired to date concerning the deaf's intelligence, the question is still open to debate as to why the deaf are generally unable to obtain an achievement level which reflects their potential capabilities. Apparently, no one has been able to identify an educational methodology that would adequately develop the deaf's cognitive structures.

Proponents of the nonverbal aspects of thinking are convinced that the deaf's cognitive abilities are capable of being

developed by the appropriate visual methods (Furth, 1966, 1973; Vernon, 1968). The visual methods emphasized are primarily sign language, or the combined method of signs, speech, and gestures referred to as Total Communication (Mindel and Vernon, 1971; Furth, 1973). It is believed that the deaf are just as capable of abstract thought as the hearing (Furth, 1966; Vernon, 1967), and the way to develop their thought processes is through the communication system most easily used. This appears to be a fairly logical argument, based on the belief that the best way to teach language or other sophisticated cognitive skills to the deaf is through their major sensory input mode.

However, in education of the deaf there is the opposing view that speech and spoken language must be emphasized in all aspects of instruction (Connor, 1971). Advocates of this position do not accept the argument that a visual language system can adequately replace spoken language. It is believed that the key element in teaching the deaf is the association of meaningful spoken language with experience (Davis and Silverman, 1970). Perhaps this position is best illustrated by the following commentary:

> Not to hear the voice is not to hear spoken language. Not to hear spoken language means that a preverbal child will remain in complete ignorance of this basic verbal tool for human communication and communion unless extraordinary measures are taken to teach him that there are such things as words, what words are for, how sounds are combined to form spoken words; how words are combined to form connected language, and how verbal language is applied not only to objects,

> people, activities, and the like but to all aspects of living, feeling, thinking and reasoning (Levine, 1960, page 28).

In fact, there is some theoretical support for emphasizing spoken language with the deaf. Liberman (1970, 1974a) has suggested that spoken grammar is a kind of interface matching the output of the intellect to the vocal tract and the ear. He theorizes that grammatical coding is a conversion of information that distinguishes language from other perceptual and cognitive processes. Grammatical coding restructures information to make it appropriate for long term storage and nonlinguistic cognitive processing at one end of the system, and for transmission via the vocal tract and ear at the other (Liberman, 1974a). Furthmore, Liberman (1974b) emphasizes that if grammatical processes do indeed contribute to one's ability to manipulate ideas in the brain, then the consequences for the effectiveness of the intellect could be great. Thus, the implications for those deaf who never acquire the grammatical codings of spoken language may be considerable.

However, since American Sign Language has been shown to have its own grammar different from spoken language (Bellugi and Klima, 1973), it could be argued that Liberman's hypotheses may hold little relevance for the deaf. In turn, one could ask whether the grammar of sign language is an adequate surrogate for spoken grammar. Or going one step further, one could even ask about the possibilities of teaching spoken grammar via some form of visual signal system. However, perhaps the most relevant question