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Title: The Impact of Hearing Loss on the Development of Visual Perception: Developmental Trends in Graphic Strategies Used to Copy the Rey-Osterreith Complex Figure

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The way in which subjects of different ages copy a complex design gives an indication of the relative levels of visual perception and the related developmental trend of overall cognitive development and left-right hemispheric functioning. The purpose of this study was to investigate the impact of severe to profound hearing loss on the above perceptive abilities. The subjects were chosen from the Oregon State School for the Deaf in Salem and ranged in age from 8 to 17. Additional personal characteristics were documented: sex, degree of hearing loss, age of onset of deafness, cause of deafness, other handicapping conditions, and handedness. The subjects were asked to first copy the Rey-Osterreith Complex Figure and then reproduce it from memory. Scores were derived from the graphic strategies used to initially start both reproductions, complete the initial drawing, and from the accuracy and error measurements. The hypotheses were formulated which allowed crosstabulations between each of the scores and each of the personal characteristics. The results were subjected to chi-square tests, the Kruskal-Wallis H test, and two- and three-way analyses of variance. Differences were significant at the $p < .10$ level. The age of the subjects proved to be the most significant factor in the study. The youngest group used adult strategies to complete the drawing, but with more errors than would be expected from adults. Loss of efficiency was noted with the 11-13 year old group and then the expected trend of increased sophistication in perception with advanced age proved true for the three older age groups. It was suggested that the early dependence on vision in lieu of auditory stimulation was responsible for the early strengths of the youngest group. Also right-handed subjects used more complex graphic strategies than did the left-handed subjects. This finding was expected based on other studies concerning cerebral assymetries relative to handedness. The sex of the subject, however, had no main effect on the results. Some interactions among variables were noted. There were no significant differences relative to age, onset, degree of hearing loss, etilogy, or other handicapping conditions.

The Impact of Hearing Loss on the Development of Visual Perception: Developmental Trends in Graphic Strategies Used to Copy the Rey-Osterreith Complex Figure

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Nancy Marie Eldredge

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Chairman of department of Counselor Education

Redacted for Privacy

Dean of Graduate School

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TABLE OF CONTENTS

CHAPTER

1	INTRODUCTION	1
	Background to the Study	1
	Statement of the Problem	5
	Purpose of the Study	7
	Need for the Study	8
	Limitations of the Study	9
	Definition of Terms	10
	Summary	13
2	REVIEW OF LITERATURE	14
	Hemispheric Lateralization	14
	Cognitive Capacities in the Brain	17
	Cognitive Development	21
	Rey-Osterreith Complex Figure	25
	Brain Research on Deafness	27
	Summary	31
3	METHODOLOGY	32
	Instrumentation	34
	Hypotheses	36
	Data Collection Procedures	37
	Treatment of the Data	40
	Statistical Analyses	42
	Summary	44
4	DATA ANALYSIS	46
	Analyses of the Hypotheses	49
	Analysis of Variance--Test for Interactions	62
	Concordance of Strategy	65
	Summary	66
5	DISCUSSION OF FINDINGS	68
	Analysis of the Independent Variables	69
	Recommendations	82
	Summary	89
BIBLIOGRAPHY		92
APPENDICES		96

LIST OF TABLES

Table		Page
2.1	Language functions in the left and right hemisphere.	28
4.1	Age group categories.	47
4.2	Number of subjects according to sex categories.	47
4.3	Degree of hearing loss according to age group.	47
4.4	Age of onset of deafness according to age group.	48
4.5	Cause of deafness.	48
4.6	Other handicapping conditions.	48
4.7	Handedness according to age group.	49
4.8	Starting strategies of the initial copy: p values of scores.	51
4.9	Percentage of segregated starting strategies used according to age group, p = .0091.	52
4.10	Percentage of combined starting strategies used according to age group, p = .1259.	52
4.11	Percentage of segregated starting strategies used according to handedness, p = .0523.	54
4.12	Percentage of combined starting strategies used according to handedness, p = .0118.	54
4.13	Progression strategies: p values of scores.	55
4.14	Memory starting strategies: p values of scores.	55
4.15	Percentage of segregated starting strategies for the memory drawing according to handedness, p = .0365.	56
4.16	Percentage of combined starting strategies for the memory drawing according to handedness, p = .0901.	56
4.17	Presence of units on initial copy: p values of scores.	58
4.18	Presence of units on memory copy: p values of scores.	58
4.19	Placement errors: p values of scores.	59

Table		Page
4.20	Mean rank of placement errors according to age group.	60
4.21	Duplication errors: p values of scores.	61
4.22	Rotation errors: p values of scores.	61
4.23	Rotation errors according to age group.	62
4.24	Duplication errors: Interaction between age and degree of hearing loss, p = .055.	63
4.25	Duplication errors: Interaction among age, sex, and handedness, p = .077.	64
4.26	Rotation errors: Interaction between age and age of onset, p = .029.	65
4.27	Concordance of strategies: Start 1 and Start 2.	65
4.28	Concordance of strategies: Start 1 and Progression.	66
5.1	Placement errors according to age group.	72
5.2	Duplication errors according to age group.	73

The Impact of Hearing Loss on the Development of Visual Perception: Developmental Trends in Graphic Strategies Used to Copy the Rey-Osterreith Complex Figure

CHAPTER 1

INTRODUCTION

In the normal-hearing population, the ability to perceive and reproduce shapes reflects the increasing capacity of the brain to understand a figure--the whole shape and the unconnected parts and details. The ability to hear affects the whole brain development and, therefore, the development of function involving vision. But even more important, loss of hearing requires reliance on other senses, particularly vision, to provide the input necessary for brain development. Perhaps this reliance produces an early strength for processing visual material. Therefore, this research investigated the developmental pattern of copying strategies used by hearing-impaired subjects in order to identify:

1. The effect of hearing impairment on the development of normal visual perception, and

2. The effect of hearing impairment on the development of enhanced right hemisphere copying strategies.

Background to the Study

The stimulation received from the major senses, provide the brain with material for classifying and understanding the surrounding environment, for forming thoughts and ideas of the self in relation to the environment, and for developing that particular world view that is unique to each person. At a structural level, the information of the senses is encoded as neural energy and stored in a specific part of the brain for each sense. The retrieval and interpretation of these neural impluses is what researchers refer to as perception. Although the field of brain research is relatively new, the relationship has been established between the process of encoding/decoding information and the structure and development of the brain itself.

In most people, and, in fact, most animals, the structure of the nervous system is essentially symmetrical. "The symmetry is made more striking by the prominence of the uppermost part of the brain: the cerebral hemispheres" (Kimura, 1973). These two hemispheres, which in terms of evolution are the most recently developed and, consequently, more sophisticated parts of the brain, are identical in structure but not in function.

Some of the functions dominant in the left hemisphere of the cerebrum are: control of the motor functions of the right side of the body, articulation and motor abilities of language (Broca's area), vocabulary, syntax, meaning and understanding speech (Wernike's area), analytical organization, propositional and sequencing abilities, serial propositioning of incoming information, and an advantage for processing auditory stimuli. Some of the functions attributed to the right hemisphere are: control of the motor functions of the left side of the body, emotive responses, abilities to perceive synthetic relationships, holistic and appositional perceptions, ability to recognize faces and respond to music, and an advantage for processing visual stimuli. Except in certain controlled testing situations, when the brain reacts to a stimulus, the whole brain is involved, not just one hemisphere. The communication between the hemispheres is instantaneous through the connective tissues of the corpus collosum, which transmit information from one hemisphere to the other.

Although the separation of the hemispheric functions has been emphasized, one important fact to consider is that the dominance or lateralization discussed here does not mean that any particular ability is segregated within either hemisphere, but rather that there is a tendency for dominance, or a demonstrated advantage, for one hemisphere to process that stimuli faster than the other. In fact, scientists, such as Witelson, caution us against allotting a greater importance to dominance theory, in favor of realizing that "the distinctiveness of hemispheres lies not so much in what functions each hemisphere mediates, that is, what stimuli or task each processes, as in how the information is processed, that is, what cognitive mode each hemisphere used" (Witelson cited in Sharp, 1977).

One of the common cognitive modes of processing and learning new material is through the development and understanding of increasingly complex rules. For example, children when learning language will impose their own grammatical rules on an utterance to generalize and create order, as they understand it, in the language. At a certain age children, after learning the rule for past tense, tend to regularize the verb forms such as "I runned all the way" or "Daddy catched me." The children have learned the rule and generalized it to all utterances. Later more complex rules for the transformation are learned, replacing the ones used previously (Slobin, 1979).

The same type of rule extension and generalization method of language acquisition can be observed in the way that motor patterns, such as writing, are developed. In studies involving children copying geometric shapes, Goodenow and Levine (1976) noted that the process seemed to be rule-governed, meaning that a pattern or rule was learned, then mastered, and finally generalized to produce new skills.

The rule-based learning concept is central to this discussion primarily because of the changes that subjects exhibit over time. A general trend noticed across disciplines is that individuals progress from relatively elementary organization of information (or rules of learning) to increasingly complex organization at identifiable maturational stages. These stages reflect a developmental process in the brain allowing for growth in intellectual and cognitive abilities. Piaget (1969) spoke about these observable changes at discernable stages as changes in intellectual development which allow for mastery of increasingly complex tasks. Not surprisingly, the field of neuroscience offers substantiation of cognitives stages of development. Epstein has reported "brain growth spurts" which are a result of increased myelination of axons and increased axonal and dendritic processes among existing cells (1978). Noting the high correlation between the age group categories of both groups of researchers, Epstein and others maintain that the concurrent neurological and intellectual growth spurts are accountable for the increased learning capacity and the ability to assimilate and synthesize information at the given stages (Arlin, 1978; Catell, 1971; Rosenthal and Jacobson, 1968).

The consideration that there are stages of intellectual and neurological development, and that there is lateralization of function apparent within each cerebral hemisphere, leads to the question of whether the functions dominant within each hemisphere that develop concurrently also develop simultaneously. As a result of the developmental pattern, there should be observable differences at different stages of maturity in the way subjects complete a chosen task and these differences should reflect lateralization of function.

Statement of the Problem

In research involving visual-motor capabilities, the differences noted in the copying of a design reflect the relative maturity of the hemispheric skills, such as the ability to perceive propositional qualities or the ability to view the figure as a unified whole with attendant parts. The test instrument used by Kirk for assessing cognitive functioning across age groups was the Rey-Osterreith Complex Figure, a geometric design which when copied gives an indication of the subject's ability to perceive a figure and the sophistication of the perception. By studying the copying strategies used by individuals of different ages, developmental changes can be identified and analysed. One of the developmental trends noted by Kirk (1981b) was that the ability to perceive the figure and, consequently, reproduce it became more sophisticated and accurate as the subject matured.

In the case of an impairment to the auditory network, where ability to hear is impaired to the degree that the capacity to encode auditory information was severely to profoundly limited, individuals develop a reliance on other sensory sources for cognitive development. Research findings indicate that in Western cultures, deaf people do not process information in the same way as do hearing people. It has been inferred that the ability to hear provides a means for developing the language centers of the left hemisphere, Wernike's and Broca's areas, which in turn shows an advantage for processing information which is sequential and propositional in nature (Kelly, 1978; Kelly and Tomlinson-Keasy, 1977; Poizner and Lane, 1979). Therefore, a concern of researchers has been to determine whether deaf people, born without the auditory input have a disadvantage in developing the left hemisphere capabilities, or whether they would merely show a right hemisphere advantage for processing all information. The latter would reflect the compensatory functioning suggested by Rudel (1978).

Because language is the primary means we have of identifying and communicating about our environment, there is a possibility that in deaf subjects the right hemisphere is the more sophisticated of the two hemispheres, just as in most hearing people the left hemisphere seems to be more highly developed. One other possibility is that deaf people would show an advantage for completing tasks of a right hemisphere nature, such as the ability to process visual information.

Unfortunately, most neuroscientific tests not involving surgery, anesthetization, or a tachistoscope, generally rely on language proficiency (English) which precludes their use with profoundly deaf subjects. Therefore, it becomes critical to use a measurement that will not only assess the normal development of cognitive capacities involving right and left hemisphere processes, but also does not require proficiency in English.

Purpose of the Study

This research project was designed to test a normal developmental process with a population of children whose main information system, the auditory network, was impaired.

The problem was fundamentally a neuroscientific one: the ability of the brain to compensate and develop normal functions without full auditory input, and the developmental changes which occur in the functioning level of the hearing-impaired subjects over time.

The first purpose was to determine whether the hearing-impaired population would show a developmental trend in their responses to the test design, relative to the different age groups taking the test. The second purpose was to identify any patterns of results relative to the degree and nature of hearing loss. The two suppositions for this research are as follows:

1. Although sensory input to the brain is impaired, the subjects will reflect a normal pattern of devlopment of visual perception because of the brain's ability to compensate for the loss, and

2. Due to the reliance on vision for information, the hearing-impaired subjects would show a right hemisphere advantage in perceiving the design.

Need for the Study

This research will provide information in three areas. First, in the field of cognitive development and physical impairment studies have been limited. The subjects have been victims of trauma or birth defects which have directly impaired brain functioning. By contrast, this study involves subjects whose mental capacities are intact but whose *means* of sensory input are impaired, an important distinction. Second, within the field of deafness, the research relating cognitive development and hearing impairment is limited. This study will add to the current knowledge by drawing together these two fields in a new way.

The third reason this research is needed is a practical one. This study is of potential importance to educators because of the significant promise from brain research for the development of curricula compatible with the capabilities of the learner. It has been shown that during the brain growth spurt, the brain is capable of assimilating new information and concepts. Conversely, during the intervening plateau periods, the brain is able to master existing concepts perhaps through rote learning methods (Epstein, 1978). This study will begin to identify these periods of growth, thereby helping educators plan curricula accordingly.

Limitations of the Study

1. This study was limited to a population of hearing-impaired subjects whose only disability was hearing loss.

2. This study was limited to a population attending a residential school for the deaf, Oregon State School for the Deaf (OSSD), which permits the children the greatest access to American Sign Language (ASL).

3. This study was limited to school-age children from ages 8 to 17.

4. This study was limited to children whose parents permitted them to participate in the testing.

5. This analysis of data was limited by the instruments used in the study.

Definition of Terms

accuracy of placement: a numerical count of errors in the placement of part or parts of the Rey-Osterreith Complex Figure.

American Sign Language: (ASL): the visual language having complex and abstract symbols with syntax, grammar, and a lexicon unique to the language.

combined progression strategies: the graphic strategy groups combined into three designations:

1. Piecemeal: completing the drawing with 29+ lines.
2. Part-Whole: completing the drawing with either 26-28 or 24-25 lines.
3. Configurational: completing the drawing with either 21-23 or 17-20 lines.

combined starting strategies: the graphic strategy groups combined into three designations:

1. Piecemeal: either "juxtaposing details without any organizational principle beyond proximity" or drawing small subunits, then connecting them.
2. Part-Whole: either drawing of the outer contour, then filling in the center of the design; or completing the drawing main unit by main unit.
3. Configurational: drawing either the outer contour or the base rectangle.

concordance of strategy: refers to the same level of graphic strategy used for (1) the starting strategies of both the initial copy and the memory drawing, and (2) the starting and progression strategies of the initial copy.

configuration strategies: a representation of the highest level of organizational complexity indicating a perception of the unity or gestalt of the Rey-Osterreith Complex Figure.

<u>corpus callosum</u>:	a massive commissure connecting the right and left cerebral cortices, thus allowing the two halves to communicate directly with one another.
<u>duplication errors</u>:	a numerical count of the duplication of lines or segments of the Rey-Osterreith Complex Figure.
<u>holistic perception</u>:	with respect to cognitive functions, the simultaneous processing of a configuration of information, rather than the sequential processing of its separate parts.
<u>lateralization</u>:	the differentiation of the two cerebral hemispheres with respect to function.
<u>marking</u>:	with respect to language use, changing the word to fit the part of speech or tense used in context.
<u>myelinization</u>:	the process by which a myelin sheath forms about an axon or collection of axons.
<u>neuroscience</u>:	the multidisciplinary study of the structure, chemical composition, and function of the nervous system.
<u>Part-Whole strategies</u>:	representation of an intermediate level of perception characterized by drawing the Rey-Osterreith Complex Figure unit by unit or drawing half of the entire contour.
<u>perception</u>:	the retrieval and interpretation of neural impulses leading to a unified awareness.
<u>Piecemeal strategies</u>:	representation of the lowest level of cognitive perception characterized by drawing different parts of the figure and then putting them together or drawing unconnected details without integration.
<u>presence of units</u>:	a numerical count of the 18 possible units of the Rey-Osterreith Complex Figure.
<u>profound hearing loss</u>:	hearing loss of 91+ dB in the speech range, 500-2000 hz.

<u>progression strategy</u>: the graphic strategy used to complete the Rey-Osterreith Complex Figure, i.e., the number and directionality of lines used.

<u>rotation errors</u>: a count of the rotation on the page of all or part of the Rey-Osterreith Complex Figure.

<u>segregated progression strategies</u>: the five different graphic strategy groups as separate scores:

1. Piecemeal: completing the drawing with 29+ lines.

2. Part-Whole (2): completing the drawing with 26-28 lines.

3. Part-Whole (1): completing the drawing with 24-25 lines.

3. Configurational (2): completing the drawing with 21-23 lines.

5. Configurational (1): completing the drawing with 17-20 lines.

<u>segregated starting strategies</u>: the five different graphic strategy groups as separate scores:

1. Piecemeal: either "juxtaposing details without any organizational principle beyond proximity" or drawing small subunits, then connecting them.

2. Part-Whole (2): drawing of the outer counter, then filling in the center of the design.

3. Part-Whole (1): completing the drawing main unit by main unit.

4. Configurational (2): drawing the outer contour.

5. Configurational (1): drawing the base rectangle.

<u>severe hearing loss</u>: hearing loss registered from 71-90 dB in the speech range, 500-2000 hz.

Signed English: the visual language which uses complex and abstract symbols using the syntax and grammar of English as it is spoken.

starting strategy: the way the subject initially reproduced the Rey-Osterreith Complex Figure characterized by the portion of the drawing initially represented.

Summary

In summary, this research explores the impact of severe to profound hearing impairment on the normal development of visual perception as measured by the chosen instrument. The graphic strategies used by a hearing population to copy a complex geometric design gives an indication of the level of visual perceptive abilities and overall cognitive development relative to the ages of the subjects. Similar information can be obtained when the same design is presented to a hearing impaired population. Additional information can be gathered related to the degree to which the brain is able to compensate for the lack of auditory input and develop normal functioning. The results of such a study has implications for the education and socialization of deaf children in our society.

CHAPTER 2

REVIEW OF THE LITERATURE

The problem of relating deafness to overall cognitive development, in particular visual perception, requires a review of the literature in the following areas:

1. the normal organization of information processing in the brain where all of the functions are intact;
2. the usual development of cognitive capacities, including learning patterns;
3. background on the use of the Rey-Osterreith Complex Figure; and
4. the research in the fields of deafness relative to brain functioning.

Hemispheric Lateralization

The recent studies in neuroscience, focusing on the localization of specific functions in the brain, are important to the discussion of cognitive processes. The research indicates that the cerebral cortex contains two halves which are identical in appearance but which develop at different rates and demonstrate dominance for particular functions.

The sources of knowledge concerning hemispheric lateralization, that is, the propensity of one or the other hemisphere to develop dominance for an ability or characteristic, are from five general categories of research: (a) neurosurgery involving the separation of the two cerebral hemispheres, (b) study of victims of localized cerebral trauma, (c) anesthetization of one or part of a hemisphere, (d) electrode stimulation, and (e) inferential research.

The first results were an apparent by-product of the commisurotomy operations done in the late 1960's to provide a way to stem the spread of epileptic seizures from one side of the brain to the other. After the connecting tissues, the corpus collosum, were severed, the patients appeared normal in every respect (including both the cognitive and affective domains), but upon closer inspection they showed curious responses to specific testing. For example, in a "blind" test, a subject would be asked to feel a pair of scissors with either the right or left hand. When held with the right hand, the subject could name the object; when the left hand was used, the subject could explain the function of the object but could not name it.

Test results and case studies of victims of cerebral trauma who experienced loss of functions particular to the localization of damage, spurred neuroscientists to experiment further--to use anesthetization to induce a pseudo-injury or suspension of function--to again pinpoint the locations of particular processes in the two hemispheres. After describing general lateralization tendencies in the human brain, the next step was to hypothesize the causes and the rate of development of these tendencies. We do know, from studies involving children with cerebral damage, or those born with only one hemisphere, that we are not born with a fully lateralized brain. Instead, the brain is able to develop other neural networks to maintain functioning level depending on the size and location of the trauma and, in particular, the age of the subject. Figure 2.1 presents a schematic representation of how the functions of the brain become lateralized within each age category.

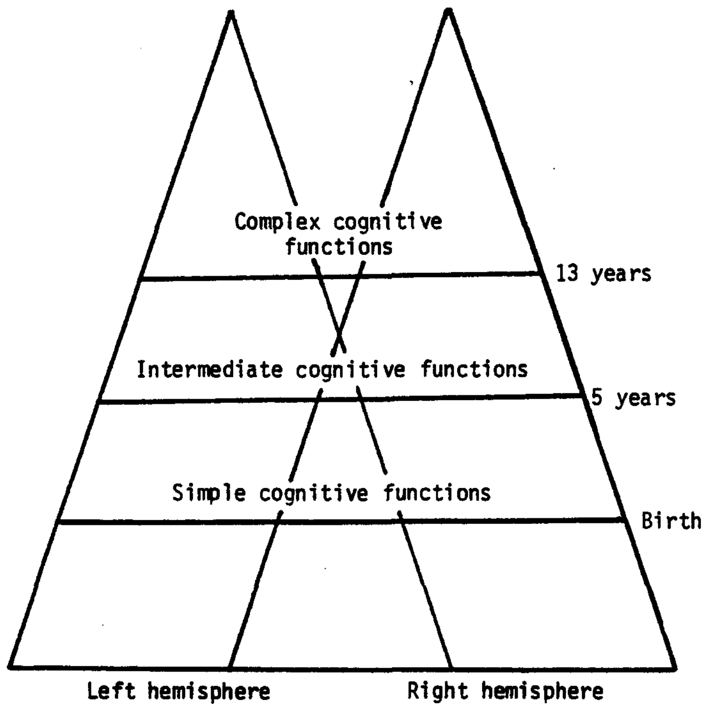

Figure 2.1. A model of the development of cognitive function in the left and right hemispheres of the unimpaired human brain. (Kolb and Whishaw, 1980:407)

At the earliest ages, cognitive functions are relatively simple (e.g., for language, simple functions include babbling and the use of simple nouns) and the functions of the two hemispheres overlap considerably. After age 11-13 in most people, the cognitive functions become very complex and the functions of the two hemispheres do not overlap at all (e.g., for language, complex functions include the use of adult language structure).

> It is important to note that the hemispheres are not themselves becoming more lateralized with respect to a given function; rather they are developing new functions that are more specialized. Since both hemispheres show functional overlap in the early years of life, each can adopt the functions of the other if brain damage has occurred at an early age. (Kolb and Whishaw, 1980)

The degree of lateralization within each hemisphere depends on age, and the process in each hemisphere is concurrent, though not necessarily simultaneous. In other words, while the brain becomes more sophisticated and specialized with age, the development of the left and the right hemisphere progresses at different rates. Presumably, the sequences are universal, and the rates between individuals, although not specific to a particular age, fall into predictable categories with mean age divisions.

These neuroscientific data are important for this particular study because they support the use of inferential results from non-medical research. The advantages of this type of research are apparent in that we are able to study vast numbers of subjects, design tests which test specific functions and do not pose any physical insult or threat to the subject.

Cognitive Capacities in the Brain

To reiterate the position of Witelson (cited in Sharp, 1981) which was presented in the first chapter, the concept of hemispheric lateralization should not be emphasized to the point of disregarding the workings of the whole brain. This section will describe in a general way some of the organizational patterns of thinking as the brain matures.

Cognitive development can be seen as the utilization of increasingly complex rules to master and create behavior. The overall tendency in humans when learning is to first learn a pattern and then to exercise the freedom to generalize. The concept of rule-based learning has been demonstrated in several fields, with a particular similarity noted between language acquisition and visual-motor tasks such as copying geometric shapes.

Slobin (1979) summarized the rules of language acquisition in Psycholinguistics as a progression of operating principles. These principles are quoted below:

A. Pay attention to the ends of words--children learn early that endings offer the most salient meaning relationships between words.
B. There are linguistic elements which encode relations between words--children discovered that words not only related to each other but to some concrete reality.
C. Avoid exception--this leads to the overgeneralization of past tense and regular endings.

Futhermore, according to Slobin (1979), the universal development strategy of discovering and creating reflects this trend of becoming more complex as children mature:

1. using words without marking [i.e., changing the word to fit the part of speech or tense used in context],
2. using appropriate marking in limited cases,
3. overgeneralizing the marking,
4. using full adult system.

In other words, language acquisition, when viewed from a developmental perspective, becomes less rigid in terms of following rules, and more complex in use of words, discovering relationships among words, combining words into simple sentences, and transforming deep structure propositions into questions and compound sentences.

The same type of developmental process of increasing complexity has been noted by researchers studying the acquisition of perceptual motor skills. For example, Kirk (1980) documented similarity of rule-based strategies between learning linguistic tasks and the development of perceptual motor skills. In particular her study investigated how children develop strategies for graphic tasks requiring the copying of letters and geometric shapes, chiefly concerned with identifying and discriminating between the starting and progression strategies used by children in copying letters and geometric shapes. Although there was no attempt to identify the greater developmental patterns evident at each age group, Kirk established that in learning a new graphic skill, with or without practice, children use cognitive rules in copying, rather than merely learning a motor habit. The results she recorded followed closely the testing done by other researches (Goodenow and Levine, 1973).

The specific strategies or rules that children used in these tasks were first identified as concordant with phrase structure in grammar by Goodenow and Levine (1973), who asked children to copy simple rectangular figures. Their rule structures for starting the copy were identified according to the developmental trend relative to age group as:

1. Start at the top.
2. Start at the left.
3. Start with a vertical.

The progression strategies, that is, the way the children continued to draw to complete the shape, were:

1. Draw verticals from top to bottom.
2. Draw horizontals from left to right.
3. Draw with a continuous line, that is, "thread."

Furthermore, the authors noted that these strategies tended to stablize over time with the increasing age of the subjects.

In a similar study investigating the copying strategies as a kind of linear model of grammar, Ninio and Lieblich (1976) reported the developmental nature of these graphics tasks, particularly as determined by the complexity of the total design. That is, the authors demonstrated "a developmental trend in preference for more complex combinational of rules or 'phrase structures' of drawing."

Kirk (1980) described copying as "a complex task that requires visual analysis of component parts, recognition of the relationship between parts and the whole, and a plan of action." As the cognitive capacities of children develop, presumably as they mature, their ability to process information and physically respond to the process increases.

Cognitive Development

Rule-based learning is one of the patterns humans follow to assimilate new information. The relationship between brain growth and the development of increasing mental abilities with advanced age has been noted as occurring in a stage fashion, that is, growth periods followed by plateau periods. These stages, both of actual physical growth spurts and skill levels, are discussed in this section.

Probably the most famous cognitive psychologist to advance the theory of cognitive stages of development was Piaget (1969). He used a clinical interview format which required children to verbally explain their reasoning process while solving particular problems. He noticed an age dependent variable in the abilities of children to accommodate and assimilate new information. From these analyses, Piaget documented four relatively discrete stages of thinking which, he believed, represented a positive trend of complexity in organization. The age group categories and attendant skills associated with each cognitive stage are as follows:

1. Sensorimotor Stage, 0-2 years: The child begins to develop schemes (similar to the use of the term "rule behavior," referring to the organization of the thought and resulting behavior), primarily through sense impressions and motor activities. These schemes provide the basis for mental and physical activity, in particular the trial and error behavior typical of stage two.

2. Preoperational Stage, 2-7 years: The child is able to think in terms of symbols (rather than requiring the physical, direct manipulation necessary for thought in the younger years). This allows for the development of more schemes, although the attention is generally limited to processing one characteristic at a time, and the child is unable to mentally reverse actions.

3. Concrete Operational Stage, 7-11 years: In this stage the child, while still limited to generalizing experiences from concrete manipulations and actual experiences, either present or past, is able to mentally reverse actions.

4. Formal Operational Stage, 11+ years: This stage reflects the child's ability to form a structure for thinking which allows for dealing with abstractions, forming hypotheses, and engaging in mental manipulations not dependent on prior concrete experience.

While the stages of development and the increasing complexity of thought processes are central to this study, the major criticism involves the verbal nature of the task Piaget proposed. The ability to reason, then to verbalize the reasoning process presupposes that the two abilities are developed simultaneously and to the same degree. This paper challenges that presupposition by studying first a non-verbal complex task and secondly a population historically noted for its lack of verbal skill--a hearing-impaired population, whose main form of communication is American Sign Language. It is suspected that developmental cognitive stages indicated by increasing complexity of action are identifiable regardless of the lack of verbal skill. In other words, the perceptual motor skill develops in a parallel way, although not necessarily in the same way or at the same rate with verbal language abilities.

Another researcher, Arlin (1978), affirmed the four stages outlined by Piaget and added a fifth stage of cognitive development which she termed the "Problem Finding Stage," occurring at age 15-16. During this stage, the subjects of her studies exhibited more complexity of thinking, for example, by inferring relationships between seemingly disparate entities.

Arlin's research, supported by that of Epstein (1978), indicates that as growth in organizational thinking ability occurs, the brain is actually increasing in size and weight. This growth does not involve the production of nerve cells but rather is an indication that the existing cells are enlarging and increasing the axonal and dendritic connections. The ensuing myelination of the axons and the increased complexity of the nerve networks in the brain allows for increasingly complex thinking.

In comparing the data of Eichorn and Bayley (1962) detailing the increments of brain size inferred from head circumference with that of the mental age growth stages of the Harvard Growth Study by Shuttleworth (1939), Epstein demonstrated a positive correlation between the two variables of mental and biological brain growth. The significant point here is that for both studies, and including Epstein's own work, the stages of development are roughly parallel with those documented by Piaget. That is, there are correlated brain and cognitive growth spurts at 3-10 months and during 2-year spans centered at 3, 7, 11 or 12, and 15 years.

The assumption that children are capable of more complex thought at advanced ages has also been supported by researchers specifically studying perception of visual stimuli and graphic representation. The results of these studies, describing the specific changes occurring between the developmental stages, have shown responses falling into three categories labeled progressively as Piecemeal, Part-Whole, and Configuration strategies.

For example, in a study by Vurpillot (1968) requiring 78 children between the ages of 3 and 9.6 years to study a pair of drawings, the subjects were to decide whether they were the same or different. The responses were recorded non-verbally, and the measurement by Vurpillot recorded eye-movement scanning strategies. The purpose of this was to record areas of the drawings on which the children fixated, and the order and sequence of the eye contact. The general results indicated that under 6 years of age, the children scanned only a portion of the figures, were unable to relate the parts to the whole figure, and made judgments based on insufficient information (Piecemeal). After that age the children were able to relate the parts to the whole more effectively and to identify the units (Part-Whole). Thus, children at about age 6 have developed a consistent competency to respond to a visual diagrammatic test and that the competencies reflect an overall trend toward complexity from piecemeal strategies to perceiving the relationships of the parts to the whole, and finally synthesizing all parts of the figure (Configuration). In addition, Vurpillot's results support the plan to begin visual-motor testing with school-age children. Presumably, before that age the children do not have the motor or cognitive abilities to perceive and copy a drawing.

The general trend towards holistic perception with advanced age has also been substantiated by the work of Kirk (1981a, 1981b) in developmental studies using the Rey-Osterreith Complex Figure, studies which are serving as the model for the present research. The experiment tested 192 children, 24 in each of eight age groups which represented a balance of boys and girls. Kirk substantiated that the copying strategies, including the degree of accuracy and type of error, change with age, following the Piecemeal to Configuration categories identified above. In particular, the most significant changes occurred at ages 7 and 8, 11 and 12, the ages which correspond to the cognitive and biological growth periods studied by Piaget (1969) and Epstein (1974; 1978).

Rey-Osterreith Complex Figure

The Rey-Osterreith Complex Figure has been used successfully to assess the style of copying strategies which reflect the dominant processing mode of the left and the right hemisphere (Kirk, 1981b). By categorizing these strategies, we are able to infer which hemispheric function is dominant at each of the chosen age categories which are tested. In fact, results of Kirk's study showed that children at certain ages copy the complex figure with strategies which reflect the differential hemispheric involvement. In particular, the 5- and 6-year-old children in Kirk's study demonstrated a Piecemeal approach, loss of the overall Gestalt, similar to adults suffering from damage to the the right hemisphere. "Although 32% preserved the Gestalt by drawing the contour first, an approach reminiscent of the left-damage adult, they completed the figure in the piecemeal style of the right-damaged adult" (Kirk, 1981b).

Furthermore, strategies which reflect integrated functioning of the hemisphere began to emerge with 7- and 8-year-olds when the children began to perceive and copy at least part of the Gestalt with Part-Whole strategy. That is, the children tended to divide the figure into more complete subunits rather than using Piecemeal strategies used by the younger group. According to Kirk, the improvement in "alignment of structural elements" at this age reflected that "left hemispheric capabilities were beginning to be coordinated" with those of the right hemisphere. Sharp increases in the number of errors made by this group was interpreted as consistent with a transition period of cognitive development or, perhaps, a plateau of growth (Epstein, 1978).

The bilateral thought processes were strongly evident in the 11-12 age group subjects in Kirk's study in that the more sophisticated Configurational strategy emerged with the starting and progression strategies, and with the concordance of strategies in the performance of the 11-year-olds. Significant reduction of errors, particularly with 12-year-olds was seen as evidence of "increased ability to align elements and to take into account the proportional elements. The capabilities demonstrated here continued to improve with the older ages, with the subjects maintaining a low error rate, and configurational starting and progression strategies." Furthermore, Kirk (1981b) inferred that because these capacities "emerged only after the time the corpus collosum is generally thought to be myelinated" they reflect the "integrated function of both hemispheres."

Brain Research on Deafness

Although the body of literature confirming the lateralization of hemispheric function grows daily, a question of concern to researchers remains as to the causes of these lateralization tendencies. Several factors have been noted to influence certain functions, for example, loss of sight at an early age may preclude development of normal vision capabilities in the brain despite a correction of the impairment in the eye. As has been stated previously, the left hemisphere shows an advantage for processing language, although limited language functions in the right hemisphere have been documented by Zaidel (1976). There is considerable research indicating that the age of traumatic insult is a critical factor in hemispheric lateralization of language. At an early age, the non-language hemisphere can take over the language functions. Table 2.1 presents a summary of the hemispheric language functions for 90 percent of all hearing subjects.

Table 2.1. Language functions in the left and right hemisphere.

Left Hemisphere	Right Hemisphere
Words	Nonspeech sounds
Letters	Melodic patterns
Syntax	Visuospatial tasks
Intonation	Face recognition
Rhythm	Parallel processing
Stress	Some speech perception and comprehension (not production)
Lexical decisions	
Temporal perception	
Phonemic analysis	
Speaking	
Calculating	
Writing	
Reading	
Serial processing	

Source: Kelly (1978).

Regarding these cerebral asymmetries for processing language, there are several hypotheses as to what causes the left hemisphere advantage for processing most linguistic material (Kimura, 1966; Tomlinson-Keasey, Kelly, and Burton, 1978). One of the most convincing is from Liberman (1974a; 1974b), who proposes that the Left Hemisphere Advantage (LHA) in hearing people for linguistic material develops as a result of processing the sequential grammatical constructs necessary for understanding the English spoken language. In fact, several researchers have noted that early severe to profound hearing loss influences the lateral organization of the brain for processing certain information, particularly that which involves verbal language tasks, even when presented visually (Kelly and Tomlinson-Keasey, 1977; 1978).

Research involving hearing-impaired subjects includes the presentation of visual material in five different categories: (a) signs from American Sign Language (ASL) presented statically to each hemifield, (b) signs from ASL which move, (c) handshapes of the manual alphabet, (d) English words, and (e) non-linguistic material. The results of the studies are conflicting in regard to a conclusive left or right hemisphere dominance for linguistic material. The reasons for the variability of results of the early studies has been determined as the selection of subjects with various etiologies, ages of onset, native or primary languages used in the home environment (ASL or English), type of communication method used in the school (oral, manual English, ASL), and degree of hearing loss. Presumably a continuum of language competency from profound, prelingually deafened, native ASL users to postlingually, mildly deafened English users could be drawn with the above factors as the primary variables which would influence the test results.

In most of the studies reviewed, the congenitally deafened native ASL users exhibited a degree of Right Hemisphere Advantage (RHA) for processing static ASL signs (Kelly, 1978; Manning, Goble, Markham, and LaBreche, 1977; McKeever, Huemann, Florian, and Vandeventer, 1976; Poizner, Battison, and Lane, 1979), while English items consistently reflected a Left Hemisphere Advantage (LHA) for the whole range of deaf to hearing respondents. These studies indicate that the spatial qualities of the linguistic input affects the organization and processing. One problem with this research, however, is that American Sign Language is never static and also includes complex facial and gestural expressions as morphological items in the lexicon (Padden, 1980). To date, the only research attempting to investigate these properties has been through the presentation of a series of static photos representing a moving sign (Kimura et al., 1976; Poizner, Battison, and Lane, 1979). Unfortunately, the processing of the blend of static signs still requires a sequential process of presentation so it is not surprising that a LHA has been reported. American Sign Language, however, is perceived simultaneously (Padden, 1980). For example, the words "A vehicle wound its way through the trees and up a great hill. It almost did not make it up the hill" require the reader to make the linguistic associations in a particular order to understand the message. While in ASL the meaning can be presented ideographically and be processed in a holistic mode simultaneously, which is considered to be a right hemisphere capability.

The current research on the cerebral dominance of deaf people is incomplete and may not, in fact, measure what it purports to be investigating. A central point to consider is the assertion by Brown and Jaffe (1975) that any discussion of cerebral dominance must be clarified as "dominance for what function at what age under what conditions of testing." The related literature cited above generally supports the idea of cerebral asymmetries between deaf and hearing subjects for particular capabilities and recognition of form whether linguistic or non-linguistically based. One cognitive researcher (Kelly, 1980; 1981) hypothesized a <u>differential</u>

development of left hemisphere capabilities (e.g., language function) to explain the general lower academic achievement of the deaf population. This offers a different implication than developmental lag, the usual term used by educators when discussing academic standards. But none of the researchers attempted to define any developmental trends.

Summary

This chapter summarized relevant literature related to the instrument used in the study, with a focus on the three conditions inherent in the discussion, that is, cognitive stages of development, cerebral dominance theory, and the role of audition in the development of normal cerebral organization. The results reflect that not only do cognitive capacities change with a positive trend toward complexity over time but there is also an inference that the capabilities reflect either the right or left hemisphere development relative to age and task. The study by Kirk represents one of the few attempts to investigate the cognitive developmental patterns of each cerebral hemisphere.

Finally, the influence of profound hearing loss on the development of cerebral hemispheres, in particular the capacities of the left hemisphere, was discussed. Although research results have not been conclusive due to the variety of test situations and individual characteristics within populations, there do seem to be cognitive differences between hearing-impaired and hearing subjects which warrant further study.

CHAPTER 3

METHODOLOGY

The educational philosophies underlying the teaching methods used by educators of deaf students are by no means standardized but are independently determined by each school. For this reason a residential school for the deaf was selected to gain optimum conformity of educational and early language experiences among the subjects.

The students were selected from the Oregon State School for the Deaf in Salem, Oregon, a school with a Total Communication policy and an approximate school population of 220. Because only those students without major physical or mental impairment were to be chosen for this study, the revised population was estimated to be 170 students. Furthermore, students below the age of 8 and older than 17 were excluded. The total number of students contacted for inclusion in the study was 150.

The parents of these students were contacted by a letter which included an abstract of the study and a permission slip to be returned by mail (see Appendix A). A pre-addressed, stamped envelope was included for their convenience. Because the response to the letter was rather low, this researcher contacted the parents by phone to gain their permission. A second mailing then went out to get written verification of the permission. The total number of parent respondents who allowed permission was 89 (59%).

Other research which has been been done in the area of educational achievement and emotional development of deaf subjects indicates that certain factors related to the deafness are important considerations when undertaking research that poses deafness as a major variable (Schlesinger, 1969; Vernon, 1969, 1972; Vernon and Koh, 1970). These variables are age, degree of hearing loss, cause of deafness, age of onset of deafness, and the presence of other handicapping conditions. Furthermore, research done by Kirk using the Rey-Osterreith Complex Figure (ROCF) noted that the principal variables were the age, sex, and handedness of the subjects (Kirk, 1981b). Using information gleaned from the parents, interviews with the students, school files, and audiological reports, data in these areas were compiled in the following manner:

1. Age--number of respondents in each age category 8 to 17, enabling clustering into age groups.

2. Sex--number of male and female subjects in each group.

3. Degree of Hearing Loss--number of subjects in four categories of loss: mild, moderate, severe, and profound.

4. Age of Onset--number of subjects in three categories: birth, birth to 3, unknown.

5. Cause of Deafness--number of subjects in the following categories:
   a. maternal rubella
   b. heredity
   c. meningitis
   d. high fever
   e. measles, mumps, infection
   f. other
   g. cause cannot be determined
   h. data unavailable.

6. Other handicapping conditions--number of subjects in the following categories:
   a. no other conditions
   b. brain damage or injury
   c. cerebral palsy
   d. mental retardation
   e. emotional/behavioral problem
   f. other--not including heart disorder, legal blindness, uncorrected vision problem, epilepsy, orthopedic, or specific learning disability.

7. Handedness--number of subjects demonstrating right or left preference.

The information of variables 3 through 7 was obtained by a survey done by the Office of Demographic Study at Gallaudet College in Washington, D.C.

Instrumentation

The Bender-Gestalt Test (1938-46)

The Bender-Gestalt Test, first published under the title "Visual-Motor Gestalt Test" by Bender (1938), was used as an additional tool to initiate the testing period of this research study. With its unique reputation as a projective and a non-projective test, the Bender-Gestalt is a popular tool among researchers and clinicians. The benefits of choosing the Bender-Gestalt are understandable considering the "simplicity of materials and speed of administration" (Blakemore, 1965). Examiners have tended to find that, for whatever purpose of testing, the simple, non-verbal nature of the test is non-threatening and an excellent method to begin an entire test battery. The fact that the demand on the subject to copy a single-line drawing similar in nature to the main test instrument was an additional factor in choosing it for this present research.

The Bender-Gestalt Test has another advantage, however, and that is its use as a valid measurement of gross neurological impairment, particularly when used in conjunction with other tests for the same purpose. In fact, the use of the Bender-Gestalt as a reliable and valid test for organicity seems to be one area that most examiners do agree (Blakemore, 1965; Billingslea, 1965; Kitay, 1970).

The scoring guides by Paschal and Suttel for adult protocols and Koppitz's adaptions for children's responses have acceptable correlations of .70 for test-retest performances and reported reliability scores of .90 between trained examiners. These are the scoring systems used by this researcher and a consulting psychologist for the study.

Rey-Osterreith Complex Figure (1944)

The Rey-Osterreith Complex Figure (ROCF) was initially devised as a means to classify subjects' perception of visual material. According to Osterreith (1944), the advantage of using a drawing of something which does not exist in nature, is that the subject will not rely on a fixed pattern already in memory, but will draw from a relatively unbiased perspective. This perspective, he maintained, will give a more clear clue to the mental organization, at least with a population over 5 or 6 years of age.

The ROCF, although not widely used in the United States, has been used for four purposes. The original intent was to assess the development stages of visual perception, which is also the way the test will be utilized for this research project. Second, the ROCF was used by Ducarne and Pillon (1974) as a diagnostic tool for assessing neurological impairment. In this country the most common use of the test is for the second purpose. In other discplines, the test has been used as a part of a series to determine the IQ of schizophrenic patients (Sutter et al., 1971) and as a validity measurement for a battery of mathematical tests (Kosc, 1979).

The scoring guide for the ROCF which was used in the present study was developed by Kirk and Gulde in 1980.

Hypotheses

As children get older, the strategies that they use to copy a design will change in that they will become more complex and reflect more holistic thinking (Kirk, 1981; Osterreith, 1944). This developmental trend indicates a growing capacity in the brain to organize information in a more sophisticated manner. The following hypotheses are related to the question of how a severe to profound sensory loss affects this developmental period.

H_1: There is no difference in the starting strategies the subjects used to initially copy the design.

H_2: There is no difference in the progression strategies the subjects used to copy the design.

H_3: There is no difference in the starting strategies the subjects used to draw the design from memory.

H_4: There is no difference in the overall accuracy of the copy as measured by the presence of the essential units.

H_5: There is no difference in the overall accuracy of the memory drawing as measured by the presence of the essential units.

H_6: There is no difference in the number of placement errors found in the copying of the design.

H_7: There is no difference in the number of duplication errors found in the copying of the design.

H_8: There is no difference in the number of rotation errors found in the copying of the design.

The following characteristics are the independent variables associated with each of the hypotheses:

a. Age of the subjects,

b. Sex of the subjects,

c. Degree of hearing loss,

d. Age of onset of the hearing impairment,

e. Etiology (cause of the hearing impairment),

f. Presence of other handicaps, and

g. Handedness of the subjects.

Data Collection Procedures

Each subject was escorted from the classroom by the researcher to a small room normally used for storage but which was ideally free from visual and auditory distractions. When seated at a table containing several sheets of unlined 8 1/2 x 11 inch white paper and a pencil, the student was given an orientation to the testing procedure, actually a rapport building exercise before continuing with the actual test administration.

Following the instructions set in the Bender-Gestalt Test manual, although with some modifications in language necessary for translation into American Sign Language, the student was instructed to copy the various designs as they were presented. When the student had completed all of the drawings, they were set aside out of sight.

To continue on with the testing, the researcher then placed another sheet of unlined 8 1/2 by 11 inch white paper horizontally in front of the subject, and gave each one a red pencil to use for the next drawing. Each student was given the following instructions in American Sign Language:

> I will show you a drawing which I want you to copy the best way you can. Start with the red pencil and later I will ask you to change and I will give other pencils to use.

During the testing, the researcher changed the pencils as unobtrusively as possible. For example after the student had completed what seemed to be a section of the design and was pausing before continuing, the researcher would quietly offer the next pencil without further directions. The pencils were changed in a specific order according to color, however, to maintain and to give an immediate visual clue as to the order and direction of the student's drawing. The order followed was red, orange, yellow, green, blue, and brown.

After the student completed the copying task, this sheet was also hidden from sight. The next part consisted of a three-minute interval during which standard interview information was gathered, including age, age of entrance to the school, the hearing status of the parents and siblings, and confirmation of the findings of the previously mentioned reports of the administration. The three minutes also served as a mental distraction for the students to be thinking of something other than the design of the test, because in the next period, they were asked to reproduce the figure from memory.

The students were given one more piece of paper, again horizontally in front of them, and instructed in American Sign Language:

> Do you remember the drawing you just finished? I would like you to draw it again yourself, without copying.

After the drawing from memory was completed, the student was escorted back to class. The average testing time per student was 20 minutes.

The scoring procedure for the ROCF required that the unique methods of drawing for each student be identified, that is, the starting and progression strategies. Therefore, during the actual drawing, the researcher was noting on a separate sheet on which was printed the design, the starting and stopping point of each line, and the direction and length of each line. Also any unusual behaviors and questions or exclamations were recorded, such as rotation of the paper--either of the original drawing or the copy (see Appendix B).

Treatment of the Data

As has been stated previously, the direction and order of lines were recorded by the researcher during the test administration. Later, the results were tabulated according to a modification of Kirk and Gulde's "Scoring scale for the Rey-Osterreith Complex Figure" (1980). The criteria for the scoring are as follows:

The categories for starting strategies for the initial copy and memory test, representing descending levels of organizational complexity, were identified using a 5-point system.

1. Configurational--These indicate a perception of the unity of the figure gestalt.

   (5 points) beginning with the base

   (4 points) beginning with the outer counter

2. Part-Whole

   (3 points) drawing unit by unit

   (2 points) drawing half of the entire contour

3. Piecemeal

   (1 point) drawing different parts or units and then putting them together

   (0 point) drawing unconnected details without integration.

The second step of the scoring process was to define the individual progression strategy used for the initial drawing. This was done by counting the number of lines used to complete each of the units of the design:

1. base rectangle - 8 minimum
2. cone - 2 or 3 minimum
3. inner rectangle - 3 minimum
4. lower box - 2 minimum
5. two outer segments - 1 minimum each

Then, based on the total number of segments used, the scores were classified into the same three categories above but in the following way:

Configurational - 17 to 23 lines

Part-Whole - 24 to 28 lines

Piecemeal - 29+ lines

These scores, indicating the starting and progression strategies, were then crosstabulated with the personal characteristic categories of age group, sex, degree of hearing loss, age of onset, etiology, other handicapping conditions, and handedness and subjected to further statistical analysis which will be discussed in the next section.

In addition to the analysis of starting and progression strategies, other measures of accuracy and error were scored. Accuracy was defined as the presence or omission of the essential units of the design, and was established in the following manner:

presence of units--a numerical count of the 18 possible units of the design.

In addition three kinds of errors were noted and scored as follows:

accuracy of placement--a numerical count of errors in the placement of part or parts of the design,

duplication errors--a numerical count of the duplication of lines or segments of the drawing, rotation--a count of the rotation on the page of all or part of the design.

As above, these measurements of accuracy and error were subjected to further analysis relative to the personal characteristics listed previously.

Statistical Analyses

The statistical analyses discussed in this section consisted of three main parts: (a) analysis of the hypotheses, (b) a discussion of the meaningful interactions among the independent variables, and (c) a discussion of the concordance between the starting strategies, and the starting and progression strategies used by the subjects.

Analysis of the Hypotheses

In this study there were eight dependent variables and seven independent variables. The dependent variables included the following: the starting strategy for the initial copy (Start 1), the progression strategy used to complete the figure, the starting strategy for the memory drawing (Start 2), the accuracy measure of presence of units for the initial copy, the presence of the units for the memory drawing, and the error measurements of placement, duplication of lines, and rotation errors found in the initial copy of the ROCF.

Each of the dependent variables was paired with each of the independent variables to determine the main effect of the explanatory variable on the production of the copy. The independent variables are personal characteristics of each of the subjects, namely: age, sex, degree of hearing loss, age of onset of the loss, etiology, presence of other handicapping conditions, and handedness. In other words, one hypothesis includes one dependent variable, such as the progression strategy, in relationship with each of the seven personal characteristics.

The first three hypotheses (H_1, H_2, H_3) were subjected to a chi-square test to determine the categories of subjects grouped according to each of the independent variables, for example, a crosstabulation of each of the possible starting strategies; Piecemeal, Part-Whole, and Configurational strategies; and the five age categories.

The other hypotheses of the accuracy and error measurements used the same type of crosstabulations as above but because of the nature of the data the Kruskal-Wallis H test was used. The Kruskal-Wallis is a non-parametric test in which there is no assumption made about the scores being evenly divided in each age group. In other words, for the analysis of variance one assumes that each of the five age groups would have a particular number of duplication errors and the null hypotheses would be rejected if the groups were different. The Kruskal-Wallis is used with smaller samples where no such assumption is made and tests whether all of the samples are from the same population, that is, if each score is different from the whole population. Thus, for this sample, the Kruskal-Wallis was judged to be the test with stronger statistical power.

The level of confidence which was selected in consultation with a research consultant for this study was .10. The determination was based on the fact that this was a relatively small population (N = 89) and the study was a first in the field of the Development of Visual Perception--and Deafness.

Interaction Among Independent Variables

The Kruskal-Wallis is a good test for discovering how one independent variable affects the production of the ROCF, but it does not allow for a test of the interactions among two or three variables. Therefore, analyses of variances (one-, two-, and three-way) were performed on each of the accuracy and error measures with each of the independent variables. Once again for the reasons listed previously, a .10 level of confidence was accepted as significant.

Concordance of Strategies

The "incidence of concordance" (Kirk, 1981b) was established to determine the percentage of subjects who (a) used the same starting and progression strategies for the initial copy of the ROCF and (b) used the same starting strategies for both the initial copy and the memory drawing. These results were grouped according to age categories.

Summary

The parents of students at the Oregon State School for the Deaf in Salem, Oregon, were contacted, requesting permission for their children to particiate in this research study. The respondents' children were asked to complete the Bender-Gestalt test and to reproduce the Rey-Osterreith Complex Figure twice, once to copy it directly from the design in front of them, then after an interval of 3 minutes to reproduce it from memory.

The results of the test were scored according to starting strategies for both reproductions (Start 1 and Start 2), progression strategy for the initial drawing, and accuracy and error measurements of presence of units (1 and 2), duplication of lines, and Rotation errors. These measures were the dependent variables.

Other information that was collected on the subjects included their age, sex, degree of hearing loss, age of onset, etiology, presence of other handicapping conditions, and handedness. These characteristics were the independent variables.

Statistical analysis included crosstabulations between each of the independent variables and each of the dependent variables. Also a test of interactions among the independent variables to determine their combined effect on the test scores (dependent variables) was performed.

The three types of statistical procedures used were: chi-square test, Kruskal-Wallis H test and analysis of variance (two- and three-way). In Chapter 4, a detailed discussion of results is presented.

CHAPTER 4

DATA ANALYSIS

In order to distinguish the effect of a major sense deprivation on cognitive development, we must have a large group with that physical characteristic. The students who participated in this research project, while from a variety of social and economic backgrounds, were relatively homogenous for the most important factor under consideration of study--the degree of hearing loss. All of the participants in the testing had hearing losses in the severe to profound range. Also, all of the students had lost their hearing before the age of 3 years, a significant age for the development of speech. Thus, the goal of determining the relationship between hearing loss and the development of visual perception is a valid one with this study.

There were a number of independent variables which are summarized through the use of the following tables. Based on the similarity of results of testing, the age groups were combined into groups, I to V, to increase the number of students in each cell. This would tend to increase the statistical power of the chi-square and ANOVA tests.

Table 4.1. Age group categories.

Group	I			II			III		IV	V
Age	8	9	10	11	12	13	14	15	16	17
Number	5	4	6	6	8	8	8	9	22	13

Table 4.2. Number of subjects according to sex categories.

	Group					
	I	II	III	IV	V	Total (%)
Males	10	13	9	13	8	53 (59.6)
Females	5	9	8	9	5	36 (40.4)
Total						89 (100)

Table 4.3. Degree of hearing loss according to age group.

	Group					
	I	II	III	IV	V	Total (%)
Severe	1	5	5	1	6	18 (20.2)
Profound	14	17	12	21	7	71 (79.8)
Total						89 (100)

Table 4.4. Age of onset of deafness according to age group.

	Group					
	I	II	III	IV	V	Total (%)
Birth	8	16	11	16	11	62 (69.8)
0-3 yrs	4	1	5	4	2	16 (17.9)
Unknown	3	5	1	2	0	11 (12.3)
Total						89 (100)

Table 4.5. Cause of deafness.

Cause	Number
Maternal rubella	24
Heredity	19
Meningitis	16
High fever	0
Infection	0
Cause undetermined	13
Data unavailable	17

Table 4.6. Other handicapping conditions.

Other Condition	Number
None	68
Emotional or behavioral problem	10
Brain damage or injury	1
Cerebral palsy	0
Mental retardation	0
Other--not including heart disorder, legal blindness, uncorrected visual problem, epilepsy, orthopedic, specific learning disability	10

Table 4.7. Handedness according to age group.

	Group					
	I	II	III	IV	V	Total (%)
Right	12	15	16	17	12	72 (80.89)
Left	3	7	1	5	1	17 (19.11)

Analyses of the Hypotheses

In the analyses of the results done in Kirk's (1981b) study, the basic strategy groups for copying the ROCF were combined into three designations: Piecemeal, Part-Whole, and Configuration. The three categories actually encompassed five different strategies in the following manner:

Starting strategies:

1. Piecemeal - either "juxtaposing details without any organizational principle beyond proximity" or drawing small subunits, then connecting them;
2. Part-Whole (2) - drawing half of the outer contour, then filling in the center of the design;
3. Part-Whole (1) - completing the drawing main unit by main unit;
4. Configurational (2) - drawing the outer contour;
5. Configurational (1) - drawing the base rectangle.

Progression strategies:

1. Piecemeal - completing the drawing with 29+ lines;
2. Part-Whole (2) - completing the drawing with 26-28 lines;
3. Part-Whole (1) - completing the drawing with 24-25 lines;
4. Configurational (2) - completing the drawing with 21-23 lines;
5. Configurational (1) - completing the drawing with 17-20 lines.

In the results of the present research, there appeared to be differences among the five original categories of starting and progression strategies. For the sake of clarity, and also to be consistent with previous research, the results are reported in two ways: (1) the five categories as segregated groups: Piecemeal, Part-Whole 1 and 2, Configurational 1 and 2; and (2) the results of the analyses where the categories were combined following the scoring guide as Piecemeal, Part-Whole, and Configurational. In the case of conflicting results, for example, significant results with the segregated scores but non-significant with the combined scores, the null hypothesis is retained. The tables of significance levels illustrate the findings. The retention or rejection of the null hypothesis is addressed in each instance. All tables of scores for the starting and progession strategies (H_1, H_2, H_3) present the significance levels with the segregated groups to the left and combined groups to the right.

Starting and Progression Strategies

> HYPOTHESIS 1: There is no significant difference in the Starting strategy the subjects used to initially copy the design relative to the subjects' age, sex, age of onset, degree of hearing loss, other handicapping conditions, etiology, and handedness (variables a-g).

The results of the chi-square test for all of the independent variables are shown in Table 4.8.

As shown in Table 4.8, variables b-f were not significant, meaning that subjects in each of those categories used the same starting strategies or at least the differences among groups were not great enough to be considered statistically significant. Therefore, in each instance, the null hypothesis is retained.

Table 4.8. Starting strategies of the initial copy: p values of scores.

	Group	
Independent Variable	Segregated	Combined
a. Age	.0091 *	.1259
b. Sex	.8729	.8113
c. Age of onset	.2994	.3282
d. Degree of hearing loss	.5413	.2369
e. Other handicapping conditions	.7463	.7287
f. Etiology	.2516	.8493
g. Handedness	.0523 *	.0118 *

* Significant at $p < .10$.

Age (a) appeared to be a determining factor in the graphic strategies used for starting the initial copy, although the differences were significant, $p = .0091$, only when the starting strategies were segregated into the five categories: Configurational 1 and 2, Part-Whole 1 and 2, and Piecemeal. When the categories were combined according to Kirk and Gulde's (1980) Scoring Guide, the differences in strategy were not statistically significant, p = .1259. In order to clarify the trend of scores, the following tables are presented. Table 4.9 represents the percentage of starting strategies according to age group for the segregated categories. Table 4.10 represents the combined strategy categories.

Table 4.9. Percentage of segregated starting strategies used according to age group, p = .0091.

	Group				
Strategy	I	II	III	IV	V
Piecemeal	0	13.6	5.9	0	0
Part-Whole 1	0	18.2	5.9	0	15.4
Part-Whole 2	6.7	9.1	35.3	31.8	7.7
Configuration 1	80.0	50.0	35.3	54.5	30.8
Configuration 2	13.3	9.1	17.6	13.6	46.2

Table 4.10. Percentage of combined starting strategies used according to age group, p = .1259.

	Group				
Strategy	I	II	III	IV	V
Piecemeal	0	13.6	5.9	0	0
Part-Whole	6.7	27.27	41.17	31.8	23.07
Configuration	93.33	59.09	52.94	68.18	76.92

From Table 4.9, one can see that across all age groups the most common strategy used to start the copy was Configurational. Although for the first four age groups the majority of subjects drew the <u>outer contour</u> first (Configurational 1), at age 17 the higher (Configurational 2) level predominated. The highest incidence of Piecemeal strategy occurred in the age range for group II (11-13). Also at this age, there were an equal number of Part-Whole 2 and Configurational 2 responses. The differences among groups were statistically significant at the .0091 level.

The trend of scores is reflected in both tables but more clearly in Table 4.10, showing the combined scores. One can see that across all age groups there were relatively few Piecemeal responses, a greater number of Part-Whole strategies, and Configurational strategies were used most frequently. In the older age categories, Part-Whole and Piecemeal strategies decreased while the percentage of Configurational strategies steadily increased. While the trend of scores demonstrating higher levels of organization with the older groups was similar to that of Table 4.9, the differences between groups were not statistically significant, $p = .1259$.

As for handedness of the subjects, Tables 4.11 and 4.12 show that there were statistically significant differences in the starting strategies used by the right- and left-handed subjects, $p = .0523$ and $p = .0118$, respectively. Of particular interest is the relatively smaller number of right-handed subjects who used a Piecemeal strategy (1.4%) as compared to the left-handed group (17.6%). Also the higher percentage of Configurational strategies used by right-handers is important. The Part-Whole responses were about equal in both groups.

Table 4.11. Percentage of segregated starting strategies used according to handedness, p = .0523.

Strategy	Right	Left
Piecemeal	1.4	17.6
Part-Whole 1	8.3	5.9
Part-Whole 2	18.1	23.5
Configuration 1	54.2	35.5
Configuration 2	18.1	17.6

Table 4.12. Percentage of combined starting strategies used according to handedness, p = .0118.

Strategy	Right	Left
Piecemeal	1.4	17.6
Part-Whole	26.4	29.4
Configuration	72.3	52.9

As a result of these significant differences, then, the null hypothesis is rejected.

HYPOTHESIS 2: There is no significant difference in the Progression strategies used by the subjects to copy the Rey-Osterreith Complex Figure, relative to the independent variables a-g.

The results of the chi-square analyses of the differences in progression strategies used by the subjects used were found to be not statistically significant, with the following p values recorded in Table 4.13.

Table 4.13. Progression strategies: p values of scores.

Independent Variable	Group Segregated	Group Combined
a. Age	.3085	.443
b. Sex	.8046	.4582
c. Age of onset	.3847	.1377
d. Degree of hearing loss	.1925	.2783
e. Other handicapping conditions	.9210	.5667
f. Etiology	.5219	.4564
g. Handedness	.2020	.8132

In each case, therefore, the null hypothesis is retained.

HYPOTHESIS 3: There is no difference in the starting strategies used by the subjects to draw the ROCF from memory relative to the independent variables a-g.

The results of the chi-square test are recorded in Table 4.14.

Table 4.14. Memory starting strategies: p values of scores.

Independent Variable	Group Segregated	Group Combined
a. Age	.1670	.1544
b. Sex	.2570	.2466
c. Age of onset	.5901	.3508
d. Degree of hearing loss	.3960	.1718
e. Other handicapping conditions	.5216	.3581
f. Etiology	.2190	.2287
g. Handedness	.0365 *	.0901 *

* Significant at $p < .10$.

As shown in Table 4.14, the chi-square test results showed no significant differences in memory starting strategies for any of the variables a-f. On the basis of these analyses, then, the null hypotheses were retained.

In the analysis of the handedness of the subjects, the chi-square test showed significant differences in the starting strategies used by the subjects relative to the dominant hand for both the segregated groups and the combined groups of strategy measures, p = .0365 and .0901, respectively. The analysis of scores for the groups are reported in Table 4.15 and 4.16.

Table 4.15. Percentage of segregated starting strategies for the memory drawing according to handedness, p = .0365.

Strategy	Right	Left
Piecemeal	4.2	5.9
Part-Whole 1	0	11.8
Part-Whole 2	9.7	17.6
Configuration 1	52.8	35.3
Configuration 2	33.3	29.4

Table 4.16. Percentage of combined starting strategies for the memory drawing according to handedness, p = .0901.

Strategy	Right	Left
Piecemeal	4.16	5.88
Part-Whole	9.72	29.42
Configuration	86.12	64.7

In the tables, one can see that the trends for both handedness groups are similar: a small number of Piecemeal strategies, more Part-Whole responses, then the highest percentage of Configurational strategies. The differences between groups, however, are reflected in the incidence of Configurational strategies used among right-handers and the higher proportion of Part-Whole strategies used by left-handers.

For the crosstabulations of handedness and memory starting strategies, the null hypothesis is rejected.

Accuracy and Error Measures

The accuracy measurement of the design, as determined by the presence of units for both the initial and memory drawings, and the error measurements of placement, duplication, and rotation were each subjected to two different statistical analyses. First, a Kruskal-Wallis H test was done on each of the dependent variables in relation to the independent variables a-g. Next, two- and three-way analyses of variances were performed to test for interactions among the variables. In this section the one-way analyses will be reported with each hypothesis, followed by a description of the significant interactions in a separate section.

HYPOTHESIS 4: There is no significant differences in the overall accuracy of the initial copy as measured by the presence of units of the ROCF, relative to the independent variables a-g.

The results of the Kruskal-Wallis test showed no significant differences with regard to any of the variables. The p values found are listed in Table 4.17.

Table 4.17. Presence of units on initial copy: p values of scores.

Independent Variable	p
a. Age	.161
b. Sex	.230
c. Age of onset	.301
d. Degree of hearing loss	.736
e. Other handicapping conditions	.767
f. Etiology	.397
g. Handedness	.759

Therefore, for this measure, the null hypothesis is retained in each instance.

HYPOTHESIS 5: There is no significant difference in the overall accuracy of the memory drawing as measured by the presence of units of the ROCF, relative to the independent variables a-g.

The significance levels of the Kruskal-Wallis are reported in Table 4.18.

Table 4.18 Presence of units on memory copy: p values of scores.

Independent Variable	p
a. Age	.918
b. Sex	.097 *
c. Age of onset	.549
d. Degree of hearing loss	.644
e. Other handicapping conditions	.308
f. Etiology	.752
g. Handedness	.659

* Significant at $p < .10$.

For the variables a, c-g, the results of the Kruskal-Wallis indicate that there are no significant differences in performance of the memory copy. In all of these cases, there is no reason to reject the null hypotheses.

Relative to the sex of the subjects, however, the results of the Kruskal-Wallis were found to be significant, p = .097. For this measure, male subjects had the significantly higher incidence of accuracy compared with the females. The mean rank used in the Kruskal-Wallis, based on the raw scores, was 48.73 for males and 39.51 for females.

HYPOTHESIS 6: There is no significant difference in the number of placement errors found in the initial copy of the design, relative to the independent variables a-g.

The results of the Kruskal-Wallis analyses are given in Table 4.19.

Table 4.19. Placement errors: p values of scores.

Independent Variable	p
a. Age	.027 *
b. Sex	.815
c. Age of onset	.204
d. Degree of hearing loss	.758
e. Other handicapping conditions	.767
f. Etiology	.612
g. Handedness	.745

* Significant at $p < .10$.

The results of the Kruskal-Wallis test indicate that there were significant differences in the number of placement errors made by the subjects in different age groups, p = .027, thereby rejecting the null hypothesis.

The range of placement errors was between 0 and 6 for all of the students' responses. As for all Kruskal-Wallis analyses, the scores in Table 4.20 represent the mean ranks of the responses. As this figure indicates, placement errors increased in the 11-15 age range, then sharply decreased at age 16. Of interest, also, is the increase in errors at age 17. Further discussion related to these findings will be found in Chapter 5.

Table 4.20. Mean rank of placement errors according to age groups.

Group (age)	Mean Rank (%)
I (8-10)	47.67
II (11-13)	52.91
III (14-15)	52.44
IV (16)	31.57
V (17)	41.54

For all of the remaining six variables, b-g, the null hypotheses are retained resulting from insignificant scores on the Kruskal-Wallis analyses.

HYPOTHESIS 7: There is no significant difference in the number of duplication errors found in the initial copy of the design relative to the independent variables a-g.

The results of the Kruskal-Wallis H test indicate that the independent variables had no main effect on the number of duplication errors. In all cases, therefore, the null hypotheses are retained. The p values for the variables are shown in Table 4.21.

Table 4.21. Duplication errors: p values of scores levels.

	Independent Variable	p
a.	Age	.164
b.	Sex	.725
c.	Age of onset	.254
d.	Degree of hearing loss	.315
e.	Other handicapping conditions	.683
f.	Etiology	.645
g.	Handedness	.151

HYPOTHESIS 8: There is no significant difference in the number of rotation errors found in the initial copy of the ROCF relative to the independent variables a-g.

The results of the Kruskal-Wallis one-way ANOVA indicate that none of the variables proved statistically significant in the production of the design; therefore, in all instances, the null hypotheses are retained. The p value for each variable is listed in Table 4.22.

Table 4.22. Rotation errors: p values of scores.

	Independent Variable	p
a.	Age	.815
b.	Sex	.545
c.	Age of onset	.717
d.	Degree of hearing loss	.306
e.	Other handicapping conditions	.571
f.	Etiology	.611
g.	Handedness	.116

The raw scores for the number of rotation errors are given in Table 4.23.

Table 4.23. Rotation errors according to age groups.

Group (age)	N	Number of Errors	Number of Subjects Making Errors
I (8-10)	15	1	1
II (11-13)	22	1	1
III (14-15	17	3	1
IV (16)	22	0	0
V (17)	13	1	1

Analysis of Variance--Test for Interactions

The statistical procedure known as analysis of variance (ANOVA) is used to test the relationship between two variables. Another feature allows a researcher to add other variables to see if there is an association among several factors which influences the results of the testing. For example, an ANOVA is performed to determine the relationship between the age of subjects and the number of rotation errors made. Perhaps the age at which a person performs a task changes depending on the sex of the subject. If so, then age and sex _interact_ to affect the performance of the task. This interaction is discovered by means of a two-way ANOVA. In the same way interaction involving a third independent variable can be tested using a three-way analysis of variance.

In this study certain variables were found to interact when two-way and three-way ANOVAs were used. These interactions will be described according to each accuracy or error measurement. A .10 level of confidence was accepted as significant.

Accuracy

Presence of units 1. All two-way and three-way ANOVAs showed no significant interactions. In Accuracy, therefore, the explanatory variables a-g appear to be independent. The closest interaction approaching significance was the degree of loss by age of onset with a p value of .191.

Presence of units 2. For the memory test of the ROCF, the degree of loss and the etiology were found to have a significant interaction in the accuracy of reproduction at the .002 level of confidence.

Error Measurements

Duplication. The duplication errors, consisting of parts that were repeated in the drawing, showed interactions between independent variables in two instances: one two-way interaction and one three-way interaction. Age and degree of hearing loss interacted with each other in affecting the number of duplication errors, with a p value of .055. Table 4.24 illustrates that association.

Table 4.24. Duplication errors: Interaction between age and degree of hearing loss, p = .055.

	Group				
Loss	I	II	III	IV	V
Severe	1	2	6	1	0
Profound	13	11	1	6	2

Furthermore, the three most important explanatory variables, that is, age, sex, and handedness, appear to interact with each other affecting the number of duplication errors. The level of significance in this instance is $p = .077$. Table 4.25 is a representation of that interaction.

Table 4.25. Duplication errors: Interaction among age, sex, and handedness, $p = .077$.

	Group				
Sex	I	II	III	IV	V
Males					
Right	8	2	5	1	1
Left	1	5	0	2	1
Females					
Right	1	6	2	4	0
Left	4	0	0	0	0

Rotation. The two way ANOVA indicates that the variables of age and age of onset interact to affect the number of rotation errors the subjects made ($p = .029$). In Table 4.26 one can see the graphic representation of the interactions. Also an interaction was detected between degree of hearing loss and age of onset, with a p value of .052. The subjects whose hearing loss was in the severe range made no errors. There were, however, four subjects with profound losses who made errors: three subjects with an age of onset at birth and one subject with an age of onset between birth and 3 years.

Table 4.26. Rotation errors: Interaction between age and age of onset, $p = .029$.

	Group				
Age of Onset	I	II	III	IV	V
Birth	1	1	0	0	1
Birth to 3 years	0	0	3	0	0
Unknown	0	0	0	0	0

Concordance of Strategy

Although not specifically a tested hypothesis, the concordance of strategy was of interest to the researcher. The concordance of strategy, as has been reviewed previously, refers to the use of the same strategy for the Start 1 and Start 2, and for the Start 1 and the progression, respectively. In the Tables 4.27 and 4.28, the scores are reported for only the combined strategy groups in terms of percentages. The results show the percentage of concordance for each age group.

Table 4.27. Concordance of strategies: Start 1 and Start 2.

	Group				
Strategy	I	II	III	IV	V
Piecemeal	0	4.54	0	0	0
Part-Whole	6.66	4.54	5.88	22.72	15.38
Configurational	86.66	54.54	52.94	63.63	76.92

Table 4.28. Concordance of strategies: Start 1 and Progression.

	Group				
Strategy	I	II	III	IV	V
Piecemeal	0	4.54	0	0	0
Part-Whole	0	18.18	72	15.38	
Configurational	73.33	45.45	41.17	45.45	69.23

The trend of concordance is similar for the two starting strategies and for the concordance between the starting and progression strategies. The most common type of concordance across all age groups was Configurational, indicating higher levels of organizational abilities within the brain. Part-Whole concordance peaked at age 16 (Group IV) and decreased at age 17 (Group V). The only incidence of Piecemeal concordance occurred with age group II (11-13).

Summary

The chi-square test was performed to determine the effect of each of the independent variables (a-g) on the starting (Start 1) and progression strategies used by the subjects to initially copy the ROCF, and on the starting strategies used to reproduce the design from memory (Start 2). In these analyses, several pairs of variables were found to be significantly associated: (1) age and Start 1 ($p = .0091$), (2) handedness and Start 1 ($p = .0523$), and handedness and Start 2 ($p = .0365$). These significantly different scores were found when the graphic strategies were separated into the five groups:

Piecemeal, Part-Whole 1 and 2, and Configurational 1 and 2. When the groups were combined following the scoring guide of Kirk and Gulde (1980), only two pairs of significantly associated scores were found, that of handedness and Start 1 ($p = .0018$) and handedness and Start 2 ($p = .0901$).

The accuracy measurement (presence of units 1 and 2) and the error measurements (placement, duplication, and rotation) were analyzed with each of the independent variables (a-g), using the Kruskal-Wallis H test. In these analyses, only two pair of variables were found to be significantly associated: placement and age ($p = .027$) and presence of units 2 and sex ($p = .097$).

There were errors made in the copying and memory reproduction of the ROCF, but the most important finding is in the trend of scores. As shown in the graphs, the number of errors tended to decrease with the older age groups.

In all of the analyses performed, the only variables found to have significant main effects were age, sex, and handedness. Further testing of crosstabulations while controlling for other variables, for example, degree of loss by onset controlling for each age category, indicated that all these variables, including age, sex, and handedness, appear to be independent from one another for the starting and progression strategies.

In the analyses of the accuracy and error measurements, however, some interactions among variables were noted. The variables which were important, particularly in interaction with the age categories were degree of loss (duplication errors), sex and handedness (duplication errors), and age of onset (rotation errors).

CHAPTER 5

DISCUSSION OF FINDINGS

The problem described in this project concerned the development of the subjects' abilities to perceive visually a complex figure: to first copy the figure, then to reproduce it from memory. The subjects in this study were deaf, providing a unique opportunity to assess the impact of a severe sensory deprivation on the development of normal visual perception. The aspect of deafness means that the auditory input was impeded to such an extent that the brain would have to rely on other sensory impressions to develop full functioning.

This study then presents a test of this compensation. In doing this, the researcher was operating under two suppositions:

1. Although sensory input to the brain is impaired, the subjects will reflect a normal pattern of development of visual perception, and
2. Due to the reliance on vision for information, the hearing-impaired subjects would show a right hemisphere advantage for perceiving the design.

In this chapter, discussion of the findings is presented which indicates that there are differences in performance in this visual-motor task which occur over time and that these differences reflect a tendency to become more complex and sophisticated as the subjects mature. One further note, however, which is discussed in detail is the high incidence of mature brain functioning occurring in the earliest age group of these subjects, as evidenced by the high percentage of Configurational strategies used in copying the ROCF, and how this sophistication may reflect a right hemisphere advantage in perceiving the design.

The discussion in this chapter focuses on the independent variables and their relative importance in the study as related to the specific hypotheses. Also included is a discussion of the relationships among the findings of the study to hemispheric functioning, cognitive development and learning theory and, finally, the field of deafness.

Analysis of the Independent Variables

Age

Research similar to this study which has been done in the field of cognitive development and visual-motor skills has shown that three independent variables are crucial to performance in testing: the age of the subjects, their sex, and their dominant hand (Kirk, 1981). Not surprisingly, these three variables also figured prominently in the present study, though not to the degree that might have been expected. For example, Kirk found age to be a significant factor in the starting strategy for both the initial copy, the progression strategy, and all of the accuracy and error measurements as well. In this study, discounting interactions, the age of the subjects was a significant factor only in the initial starting strategy ($p = .0091$) and in the number of placement errors ($p = .027$). The age groups demonstrated significantly different starting strategies only when the strategy groups were segregated. The combined groups' significance level was p = .1259, close enough to warrant further testing with a larger sample population.

The age variable was of further interest, however, in that these results did not follow the expected "gradual shift from a piecemeal to configurational approach [in the] use of starting and progession strategies and in the type of concordance demonstrated at different ages" (Kirk, 1980). Instead, the strategies showed abrupt changes starting with the highest levels of Configurational strategy at the earliest age, 8-10, dropping sharply at age 11-13, continuing to drop at age 14-15, and then following the normal trend of increasing incidence with the two older age groups (see Table 4.10).

Also of interest, the concordance of strategy did follow the expected trend based on Kirk's research with a hearing population, but did not closely resemble the trend for the starting and progression strategies used by the deaf subjects. That is, high levels of Configurational concordance at the early ages, dropping in the second categories and then increasing in the latter age groups.

The greatest concordance level between strategies was with the two starting strategies and at the Configurational level. If, as Kirk (1981b) stated, "we can draw what we see and remember what we know," then we can realize that the perception of the figure goes beyond seeing and into the realm of "understanding." Once again, the highest level of Configurational concordance for the starting strategies occurred in the 8-10 age group (86.66%), surpassing even that of the 17-year-olds (76.92%). Also the Configurational concordance between starting and progression strategies in the younger group was greater than all others, 73.33 percent as compared with 69.23 percent in the 17-year-old group. Complex levels of perception and the integration of brain functions were already evident. One can even state further that the high incidence of Configurational starting strategies for the initial copy and memory drawing shows that the right hemisphere capabilities, that is, perceiving the whole figure and then filling in the propositional relationships or connecting details last, are well-developed at a much earlier age than their hearing counterparts. In Kirk's study, only a little more than 30 percent showed Configurational strategies to start the drawings.

It is important to recognize that this age group had all recently entered formal school and most of them had received little language training at home. In the United States, 90 percent of all deaf children are born to hearing parents whose abilities in sign language are assuredly limited. Thus, early language stimulation is frequently absent until the child enters school. One possible explanation for the high incidence of Configurational strategy is that without formal schooling and formal language development, these children were, in a way, forced to rely on their strongest sense, thus developing a strong visual interpretive capacity (a right-hemisphere characteristic). Carried further, the sudden drop in concordance of Configurational strategy in the next two age categories can be explained by the involvement in a school curriculum which is heavily weighted in English language instruction, of which the sequential, or left hemisphere, properties are widely recognized. And, in fact, these two age categories are the only ones which show an emergence of the Piecemeal strategy (attending to the details without connecting to the whole). There is still a strong Part-Whole response, however, which suggests a reorganization in perceptive functioning where the left hemisphere capabilities are becoming stronger and beginning to integrate with the right hemisphere. This could be due to what Werner and Kaplan (1967) call "gappiness" or sudden change in efficiency which is a result of a normal pattern of reorganization as the brain develops.

Another unexpected finding of the study was the lack of a significant difference between age groups in the accuracy and error measurements. It was anticipated that with the older age groups the accuracy of drawing would increase and the errors would decrease but, with one exception, there were no significant differences between age groups. That exception was with the number of placement errors (putting a part of the drawing in the wrong place). In the following table, one can see that, with the exception of the youngest age group, the number of errors decreased with age. The highest incidence of error occurred between ages 11-13 and 14-15, then abruptly dropped in the latter two age categories.

Table 5.1. Placement errors according to age groups.

Group (age)	Number of Subjects	Raw Score Number of Errors	Number of Subjects Making Errors
I (8-10)	15	23	9
II (11-13)	22	36	16
III (14-15)	17	34	10
IV (16)	22	10	7
V (17)	13	12	7

The differences among age groups were statistically significant, p = .027.

The duplication errors (subjects drawing lines more than once) did follow the expected trend of decreasing errors with advanced age, but the differences among groups were not statistically significant, p = .164. Table 5.2 illustrates the trend.

Table 5.2. Duplication errors according to age groups.

Group (age)	Number of Subjects	Raw Score Number of Errors	Number of Subjects Making Errors
I (8-10)	15	14	7
II (11-13)	22	13	11
III (14-15)	17	7	5
IV (16)	22	7	5
V (17)	13	2	2

In Kirk's study, duplication errors followed this same trend but sharply increased within the 8-year-old age group, then decreased steadily. Only three errors were observed among the 13-year-olds. In the present study, the highest incidence of error occurred in the 8-10 year-old category, then decreased with age, but, contrary to Kirk's findings, the number of subjects committing the errors increased to 11 in the 11-13 age group. Then, as expected, the incidence of duplication errors continued to decrease with the older age groups.

As in Kirk's study, rotation errors, that is, turning a portion of the drawing although maintaining the correct location, were rare across all age groups. There were no significant differences between groups and no clear developmental pattern, p = .815.

Kirk defines the developmental pattern from the young ages (5-6 year old) to adult-type functioning as the changes in the graphic strategies evident at each age group. The accuracy and error measurements are "behavioral markers of the structure--functions relationship [in the brain]. The systematic changes from piecemeal to configurational representation of space suggests that children's performance reflects separate, then coordinated, and finally, integrated functioning of the two hemispheres" (Kirk, 1981b).

The students in the present research project were older; therefore, the graphic strategies that Kirk termed separate or actually similar to right or left brain-damaged adults were not evident with the hearing-impaired group. As for the coordinated strategies, the students aged 11-13 and 14-15 copied the ROCF with a combination of Part-Whole and Configurational strategies which, as has been stated, may indicate a reorganization of hemispheric functioning due to growth periods within each hemisphere. Furthermore, although in the 8-10 age group the predominant graphic strategy was Configuration, there were more errors, meaning that full adult functioning was not yet complete. Conversely, after age 15 the starting and progression strategies became more complex and the number of errors decreased, indicating integrated functioning.

Another important part of Kirk's study concerned evidence of critical ages coinciding with brain growth spurts occurring at ages

7 and 8, and 11 and 12. Certainly in this present study the greatest difference in performance occurred between the 8-10 and the 11-13 year-olds, and between the 14-15 and the 16 year-olds. These distinctions are similar to Kirk's results and also to the cognitive stages of development posited by Piaget (concrete-operational 7-11 and formal operational 11+), Arlin (problem-finding stage 15-16), and Epstein (brain growth spurts 7, 11 or 12, and 15).

Although not reflected in the data, there did seem to be further differences between the progression strategies, that is, sharp decrease in concordance of strategies, but due to the small sample size these differences were not statistically discernable.

In summary, the students in this study showed adult graphic strategies in the 8-10 year-old group but with errors indicating that full integration had not yet occurred. The relative sophistication in functioning was hypothesized to be from early reliance on visual perception due to the hearing impairment.

In the middle age groups, 11-13 and 14-15 year-olds, some Piecemeal strategies emerged as did an increase in Part-Whole strategies, although Configurational strategies still predominated. Presumably the decrease of efficiency was indicative of hemispheric reorganization.

After age 16 integrated functioning was evidenced by a strong use of Configurational strategies and a decrease in the number of errors.

Sex

The results of the statistical analyses of the relationship between sex and the production of the copy and memory drawings were surprising in that the only significant differences were noted in the accuracy measurement of presence of units for the memory drawing, $p = .097$. In fact none of the other scores were even close to significance, ranging from presence of units for the initial copy, $p = .230$, to starting strategy for the initial copy, $p = .8729$. Furthermore, there was only one instance where sex interacted with other variables in influencing results, that is, age, sex, and handedness interacted to affect the number of duplication errors, $p = .077$. These results were initially surprising because of the findings of other researchers that the right hemisphere develops earlier in boys as does the left hemisphere in girls (Levy, 1980), or at least with different strengths apparent at different ages (Epstein, 1978). Kirk found differences between boys and girls only at age 8, with more girls than boys using a configurational strategy when drawing from memory. She found no difference between boys and girls in the initial copy of the ROCF. Kirk's explanation for the sex differences differed from that of either Levy or Epstein, that is, she attributed it to a "general maturational lead [rather than] preferential hemispheric development" (Kirk, 1981b).

In this present study, one might be able to suggest that, with a larger sample, differences would be evident. For example, in the 11-13 year-old group, more boys than girls tried to make something of the design: houses and rockets with stories to fit them. This may indicate perceptual differences that would be significant with a larger group.

One other explanation for the lack of significant differences between boys and girls at critical ages may be the age groupings that were used. Epstein found that one of the most apparent changes in brain growth occurred at ages 11 and 15. The growth around age 11 for girls was twice that of the boys growth; at age 15, boys' growth was twice that of girls. If this can be reflected in non-intrusive studies of cognitive development then the ages would need to be discreet rather than grouped as in this present study. This researcher used groups aged 8-10, 11-13, 14-15, 16, and 17. If differences related to brain growth were evident, then perhaps the groupings precluded detection of those differences.

Perhaps, however, there may be some influence from the deafness which minimizes the differences. This may be in the form of impedence of socialization of gender-based role behavior, particularly at the earliest ages before they fully participate in the social world of the deaf school. Paredes and Hepburn (1976) postulated the relationship between the "role of cultural patterning in human cognition and problem-solving." Perhaps the deafness creates a type cultural expectation of problem-solving that precludes the influence of sex differences.

Age of Onset

In this study the students' productions of the ROCF were not significantly different relative to the age of onset of deafness. These results were not particularly surprising due to the homogenous nature of the group. As have been stated previously in Chapter 4, 87.5 percent of the subjects were deaf by the age of 3. Although the other 12.3 percent were in the "unknown" category, these students probably lost their hearing some time from conception to the age when the parents would expect the child to begin to talk, between age 2 and 3.

The diagnosis of deafness, unless there is a familial reason to be alert to the possibility, is often difficult to ascertain. The typical pattern is that a deaf child will begin babbling at the usual time, but because of the lack of auditory self-stimulation, the child will soon fall silent. As a result, parents are usually not alert to difficulties until the child is approaching the age of 2. Then the typical response is to begin "shopping" from doctor to doctor until finally the reality is either acknowledged or discovered, and the parents realize that the child is deaf. For this reason, a specific age of onset cannot be established.

Therefore, most of the students in the unknown category probably were essentially like the rest of the students in terms of deafness. And as the chi-square test indicated, the differences in fact were not significant.

Degree of Hearing Loss

The subjects' degree of hearing loss appeared to have no effect on the graphic strategies or the accuracy and error measures in the copy of the ROCF. The only analysis which even approaches significance is that of the starting strategies for the memory drawing when the categories were combined, p = .1718.

As was true with the age of onset, a possible explanation for the lack of significant differences is that the groups were too similar. All of the students who participated in this study had severe (71-90 dB) or profound (91+ dB) losses in the speech range (500-2000 hz). The level of severity could mean that the within group differences are comparatively less when the whole group is compared to other groups with little or no hearing loss.

Other Handicapping Conditions

One of the limitations of this study was that the subjects would have no other handicapping condition that would influence the testing other than deafness. In the background information, however, 21 students reported the presence of another physical condition (refer to Table 4.6).

The selection of this physical characteristic as one of the independent variables provided an internal control of the limitation. In other words, if there were significant differences in the reproduction of the figure, then the basic limitation that there were no other handicapping condition to affect the testing would not have been fulfilled. The fact that no other conditions were significant to the results means that deafness was the only physical limitation.

The analyses of the scores indicated that in all crosstabulations, other handicapping conditions were not a significant influence. Therefore, deafness was, in fact, the only major handicapping condition influencing the graphic strategies, and accuracy and error measurements.

Etiology

Often the cause of deafness can cause other handicaps which, even if subtle, could have influenced the results of testing. For example, the maternal rubella epidemic in the 1960's has been held responsible for many disabling conditions, including multi-handicaps ranging from blindness and deafness to brain damage and learning disabilities. Another cause of deafness, high fever during infancy, can cause brain damage in addition to the deafness, which may have altered the perceptive abilities of the subjects.

In this study, the lack of significant findings relative to etiology indicates, again, that the population was free from additional physical influences other than deafness in the testing.

One additional note is that in the United States, the most common "cause" of deafness is unknown. Although this was also true in the present study, on the strength of the findings, one can assume that regardless of the cause, known or not, cognitive development was not impaired or altered.

Handedness

Many years of research involving victims of cerebral trauma, commisurotomy patients and other lateralization studies has shown that for 98 percent of all right-handers, language is processed in the left hemisphere. The research involving left-handers is less clear: only an even chance that either hemisphere dominates (Kinsbourne and Hiscock, 1978). One consideration, however, is that the location of the dominant language functions is usually considered the dominant hemisphere. All of these studies were done with subjects whose hearing was normal.

The variables of handedness was included in this present research because of the implications of cerebral assymetrics found in other similar studies (Kirk, 1981b). It was expected that with a hearing-impaired population, for whom the lateralization of language was still not fully determined, that significant findings would contribute to the existing body of knowledge. For example, there were significant differences found between right- and left-handers in the starting strategies used for both the initial copy and the memory drawings. In the case of the initial copy ($p = .0188$ and $.0523$, segregated and combined, respectively), 72.3 percent of the right-handers used Configurational strategies as compared with 52.9 percent of the left-handers. For the memory drawing ($p = .0901$ and $.0365$, segregated and combined, respectively), 86.12 percent of the right-handers used a Configurational strategy as compared with 64.7 percent of the left-handers. There were no significant differences between the groups in the progression strategies used.

This finding suggests that because Configurational strategies predominated for the right-handed group in starting the drawing, although not necessarily in completing it, there is a right hemisphere advantage for the initial perception of the figure, rather than integrated hemispheric functioning.

Interactions

As has already been stated in Chapter 3, the nature of the data in this study and the assumption inherent in the ANOVA of equal distribution of scores among groups, inappropriate for this population, made the Kruskal-Wallis a test with stronger statistical power. One problem with the Kruskal-Wallis, however, is that it allows only a one-way analysis precluding the testing for interactions among independent variables. Therefore, the ANOVA results of two- and three-way interactions were reported, but a cautionary note is advisable. In the absence of certain validity of the one-way ANOVA, only a weak statistical association can be drawn. Clearly the recommendation is that further testing is necessary using a sample with greater variability and more subjects within each subcategory of the explanatory variables, for example, age of onset: birth, 0-3, 4-8, after 8 years old.

Recommendations

Some years ago, Schesinger and Meadow (1969) proposed a theory of psychological development for deaf people that was patterned on Erickson's theory of personality. The theory, in part, was intended as an explanation for many research findings that variously described deaf people as egocentric, impulsive and lacking in psychological functioning and social functioning (Altshuler, 1962; Meadow, 1968; Stuckless and Birch, 1966; Vernon and Koh, 1970). The reason for this lack of social and psychological maturity was hypothesized to be due to the absence of communication stimuli in the early years.

The formal education of deaf children usually begins at age 5 or 6 and often this is the first time that these children have been in a language-rich environment. By contrast, hearing children know almost all of the essential grammatical structures of English by age 6. By this time also, the hearing children, through interactions with family and society, have developed a foundation for understanding the social rules and acceptable modes of conduct. Among the deaf, however, it is far too common to find college-aged adults without much understanding of the "social, cultural, religious or political views" of those around them, or even of their own family. Futhermore, research on the educational achievement of deaf children indicate a 4-5 year lag behind their hearing counterparts. Yet, clearly there is no inherent intellectual or psychological discrepancy between the two groups. It is widely accepted among educators of the deaf that the lack of reciprocal communication in the early years extending to young adulthood is the basis for the "lag" (Altshuler, 1962).

Yet, one aspect that all of these studies have in common is that they all speak in terms of deficiencies and lags, rather than differences, or maybe even strengths. It seems obvious that social and cultural perception for deaf children is linked to general visual perception. So, instead of describing what deaf children cannot do, perhaps it is possible to describe what they can do.

On the whole, the results of this present study indicated that the visual perception of the deaf children followed an age dependent trend of moving from the ability to perceive simple relationships to an increasing ability to comprehend complex spatial relationships, with one notable exception: the performance of the 8-10 year-old group. This group showed integrated cognitive functioning for the starting graphic strategy (Start 1) and the only difference between their performance and full adult functioning was in the number of errors. It was hypothesized that this sophistication in visual processing of stimuli was a result of early reliance on vision in the absence of hearing and the attendant symbol system language provides.

While the reduction in competency occurring between ages 11-13 may indicate a natural shift in organization, it must be considered that the environment may not be reinforcing and developing the apparent strengths already exhibited by the younger group.

The results of this research, and of others already covered in the review of literature, lead to a number of recommendations, some of which pertain to methodology. Other recommendations concern curriculum development and the need to educate the whole child. These recommendations are as follows.

Methodology

1. The method of recording the graphic strategies with colored pencils and researcher imitation is cumbersome and obtrusive. A better method would involve video-taping or a computer with a graphic pad.

2. In order to get a more powerful comparative study to determine the influence of the explanatory variables on the reproduction of the ROCF, a more diverse population must be used with more subjects in each group. For example, the age groups used here were kept for all analyses and more subtle differences within the groupings were not discernable. Whereas, in Kirk's study the groupings changed according to real differences in strategy, or accuracy and error measurement, with more subjects, at every age, the significant differences could be determined accordingly. Therefore another study would include many (25-30) subjects at each age. Also

included would be a sufficient sample, including a hearing group and a hearing-impaired group with losses in the mild and moderate as well as the severe and profound ranges. The age of onset should be controlled for "before age 3" to provide a more homogenous group in terms of language development in order to test real differences on the basis of hearing loss.

Curriculum

This researcher is not an education specialist or an expert on curriculum design, but it seems apparent that this study has some implications for experts who are in a position to design curricula intended to maximize the potential of each student. The phrase that is currently used for the so-called right-brained approach to teaching/learning is "teach the whole child." This means providing learning situations which elict responses in keeping with both the right and left hemisphere.

In our culture the educational system strongly relies on "left-hemisphere" methods of instruction. Yet, the early strengths exhibited by the youngest age group to perceive the ROCF in a configurational pattern lead one to suspect that the holistic methods of teaching, which would reinforce those right hemisphere strengths, would be more appropriate with this group.

According to Wolfe and Reising (1978), "right-brained learning actually enhances, rather than inhibits, left-brained learning." They suggested that educators "teach using the affective domain and... create a learning environment where students feel good about themselves." Some specific strategies are:

1. play word association games

2. use poetry to stimulate verbal, written and/or visual (artistic) expression

3. use the students expressions to create plays

4. use drama to act out emotions

5. have the students tell stories-in-the-round, where one student stops and the next continues the story

6. let the students create photo-essays and scrap books, and write class histories using their own photographs.

Another researcher, Kelly (1978), has proposed instructional techniques specifically for deaf children that will enhance their right-hemisphere capabilities and visual skills:

1. Provide as much diversity as possible for visual processing. From preschool on, the cognitive structures should be provided increasingly more complex and divergent visual stimuli to process.

2. Provide as much diversity as possible for auditory processing. Although language stimuli would be ideal, any opportunity to cognitively process a relationship between an object and sound would appear to be beneficial.

3. Provide instructional media which utilizes a combined visual and auditory (perhaps even tactual) presentation to show relationships, associations, contrasts, divergencies, and so forth.

4. Use a communication system which does two things: (a) allows the exchange of information in a clear and efficient manner; and (b) enables the learners to monitor their own performance. The stress here should be on information processing and minimum of struggle with the communication system itself.

5. For all of the above suggestions, a continuity of increasing difficulty should be provided. One obviously must start with what a child is capable of processing--but a major objective should be to push the child beyond that point. (p. 642)

As stated previously the loss of competency in copying the ROCF exhibited by the 11-13 year-old group could be attributed to at least two factors: (1) a normal reorganization or plateau period of cognitive development, or (2) a loss due to the nature of the usual instructional methods used in the deaf school and the insistence upon the use of English (signed) as the language of instruction for all topics. Frequently a controversial topic, language instruction for deaf children has been of maximum importance in the schools. Regardless of the educational philosphies regarding mode of communication, manual or oral, it is recognized that the ability to interact with society in English is severely limited for most deaf people. Therefore, the majority of lessons in many schools for the deaf are specific for English language development. According to Epstein, the optimum time to teach language is during the brain-growth spurt between 2 and 4 years. Unfortunately, most deaf children begin language instruction between 5 and 6 years, a time that Epstein hypothesizes as a plateau period in cognitive development.

Moreover, on the topic of language instruction for deaf children, Epstein was less than optimistic for children older than 4 years. His example, however, was that of auditory training, teaching children to recognize speech sounds on the lips, cited by Wadenburg in Sweden. Although educators have a broader view of language and usually have a more hopeful view of their educational processes, some of Epstein's cautions for auditory training should be applied to language learning strategies that might be inferred from the findings of the present study.

The recommendation has already been made that educators should take advantage of early visual-perceptive skills and teach all material in a way to enhance the capabilities of the right hemisphere. But further explanations and recommendations concerning language made are warranted. The usual insistence upon English language instruction and all instruction using signed English has, at base, two problems. First, to reiterate, English is processed primarily by the left hemisphere, the dominant hemisphere of most hearing people and to some extent the subordinant hemisphere of deaf people. Instruction using right-hemisphere methodology to teach all subjects including English should lead to greater proficiency in that subject matter.

The second problem concerns the fluency of the language skill of the teacher. Schlesinger and Meadow (1969) have found that two factors positively affected educational achievement of deaf children: being born to deaf parents, i.e., having fluent communication, ASL, in the home environment; and having hearing parents who could sign fluently, i.e., again having fluent communication in the home environment.

In 1979 the Oregon State School for the Deaf began a program of early identification of deafness and parent training to teach coping skills and sign language for early language development for the children. Even though this variable was not evaluated for the study, the possiblity exists that some of the younger children benefitted from the early training which could have positively influenced the test scores. It is doubtful, however, that the hearing parents who participated in the training are in fact fluent signers because of the length of time necessary to learn the language. One recommendation for further study would be to evaluate the parents' hearing status and ability to fluently communicate in sign language.

The need for fluent communication does not end, however, when the child leaves home to attend school. One of the main criticisms of deaf schools across the nation, including OSSD, is that they do not offer adult role models for sign language (Bounds-Wood, 1984). The missing factor is fluency in communication, regardless whether the sign language is ASL or some form of signed English. Furthermore, as Kimura et al. (1976) documented, static signs are processed by the left hemisphere. In other words, non-fluent signing, even of American Sign Language, requires left-hemisphere capabilities while fluent signs are processed in the right hemisphere. Once again, to take advantage of what seems to be a right-hemisphere visual dominance, fluent adult role models for language must be sought to teach the language. At this point it would be a topic for debate as to whether using fluent American Sign Language as the predominant mode of instruction would significantly enhance learning or if fluency itself is the more important factor.

Summary

The purpose of this study (as defined in Chapter 1) was twofold: (1) to determine whether the hearing-impaired population would show a developmental trend when reproducing the Rey-Osterreith Complex Figure relative to the age groups of the subjects, and (2) to identify any patterns of results relative to the degree and nature of the hearing loss.

The test results show that there is a developmental trend in graphic strategies which moves from less to more complexity with advancing age. The one exception to this is with the 8-10 year-old group who seemed to be using adult, complex strategies to reproduce the design, although with more frequent errors than would be expected from adults.

The other independent variables which seemed to influence the results of testing are sex and handedness. This also was expected based on the results of other neuroscientific studies.

The degree and nature of the hearing loss, etiology, and age of onset were not significant variables in this analysis. The lack of significant differences was due to the homogenous nature of the groups in that all of the subjects had losses in the severe to profound range and the majority lost their hearing before age 3, the significant age for learning language. It was hypothesized that the subjects whose age of onset was unknown actually lost their hearing before two or three, before the age at which their parents would expect them to begin to talk.

A recommendation for further study is made that a larger sample and a more diverse group of students be selected.

This study is important for several reasons, however. It is one of the first in the field to begin to identify critical age periods for stages of cognitive development using a hearing-impaired population which had no other physical or mental impairments. The results have shown that not only do deaf subjects follow an expected developmental trend in using graphic strategies, but they may also show strengths in integrated processing of visual material when compared with their hearing counterparts.

Included in this chapter are some general recommendations from experts in the field, but this is only the beginning. It is the role of the educator to evaluate these findings and to plan curricula that can enhance the strengths and take advantage of the "readiness" of the child during periods of growth. This research should help others recognize the role of hemispheric functioning in schooling. Rather than defining and in some cases perpetuating educational and psycho-social lags, one can think in terms of qualitative differences and educating the whole child.

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APPENDICES

Appendix A

Letter to Parent and Permission Slip

April 28, 1982

Dear Parents:

I am preparing to do a research project at OSSD and am writing for two reasons: to introduce myself to you and to ask your permission to involve your child in this exciting study.

My name is Nancy Eldredge and I have worked with hearing impaired children and adults since 1975 when I was a counselor in the dormitory at the Texas School for the Deaf. Since that time, I have gone on to get a Master of Science degree in Rehabilitation Counseling with the Deaf and have worked for several years as a Vocational Rehabilitation Counselor with a hearing impaired caseload. In addition, I am a fully certified interpreter. Presently I'm back in school working on a Ph.D. in Counseling at Oregon State University and want to do my dissertation research with a hearing impaired, school age population. All of this is to let you know that I have a genuine career interest in this field and that I have some skills to offer the educational system too.

My research proposal is an innovative one, I think, and very exciting for me. I'm interested in the way that different age groups of children perceive complex designs and the way that they think about these visual images. There is a growing body of research which shows a difference in the way deaf and hearing children organize information, and that difference is thought to be related to the hearing loss itself. If we could define that difference, then specific teaching strategies could be developed to plan a better educational program for your child's individual needs.

The test that I will be using is a simple one and will only take 10-15 minutes for each person to finish. It simply requires the child to look at a complex drawing which will be on the table in front of him or her, and to copy it. The copying style will tell us how the age groups of children are perceiving the design.

So the hope for my research is that the results will provide some new information aimed at improving the educational system for hearing impaired children, and I need your help. I do want to tell you though, that I am interested in age group scores, not individual ones. The confidentiality of your child's responses will absolutely be respected. If you are interested in your child's results, however, I would be happy to make arrangements to meet with you after the testing is completed. If you have questions, please do not hesitate to call. You can reach me in Corvallis at 754-2131(work) or 757-0551 (home).

Thank you for your time,

Redacted for Privacy

Nancy Eldredge

Please take a moment to fill out the enclosed permission slip. I have also provided a stamped envelope for your convenience. Thank you again; this means a lot to me.

CHECK ONE OF THE FOLLOWING:

___ I give my permission for my child to be included in this study.

___ I would like to discuss this further before giving my permission.

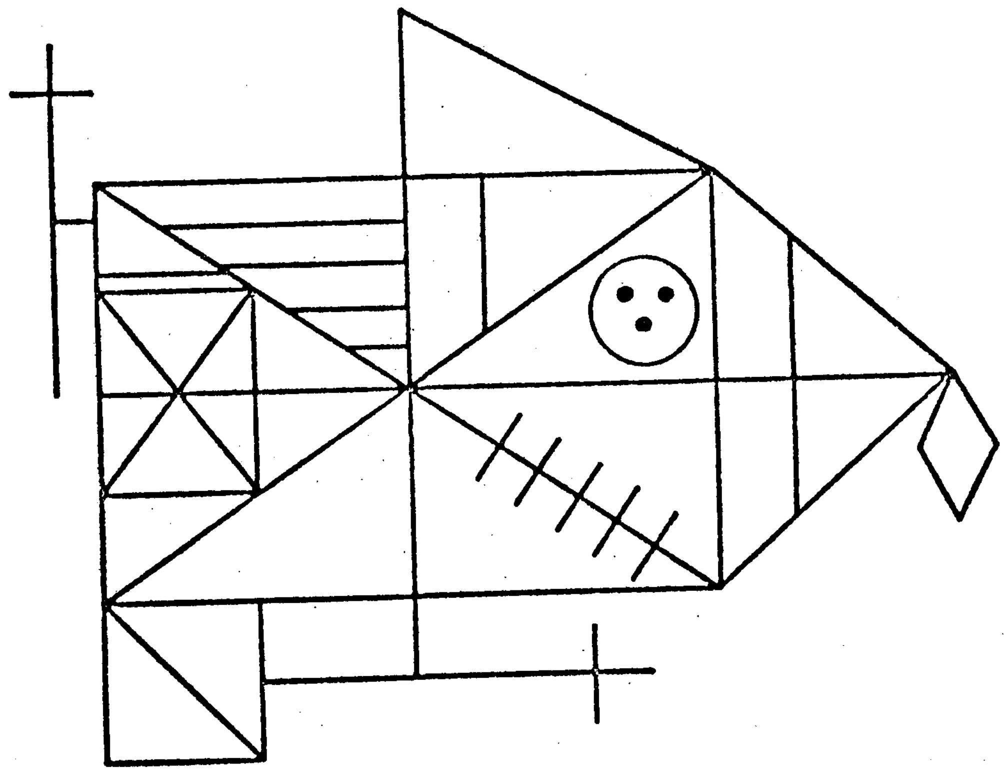
___ I do not wish my child to participate in this study.

My child's name is ______________________________.

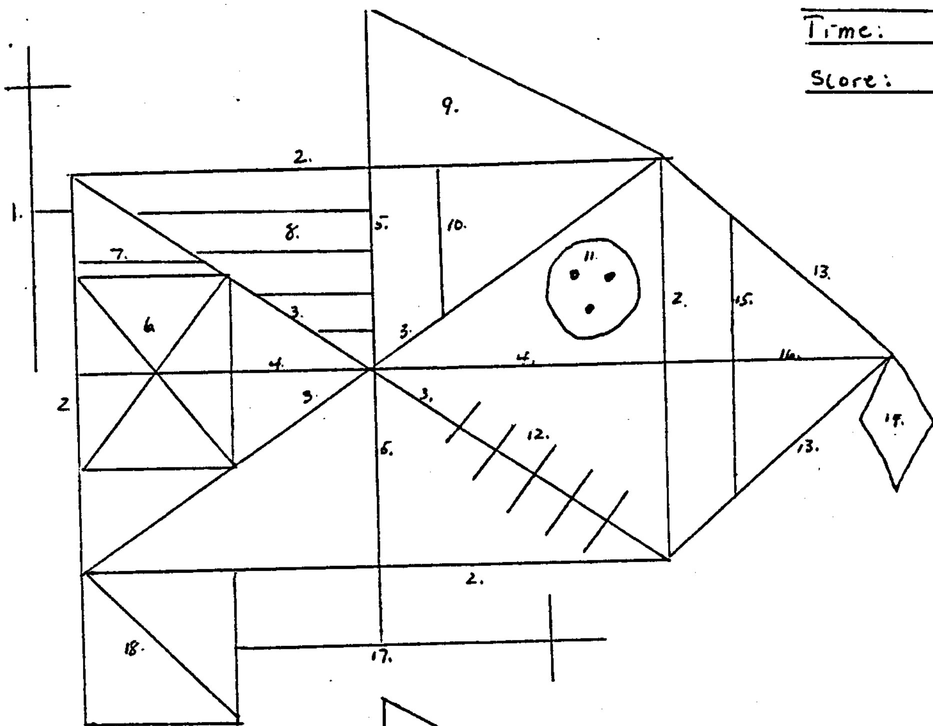
Signature________________________Date___________.

Appendix B

Geometric Design and Scoring Sheet



The Rey-Osterreith Complex Figure (Osterreith, 1944).



Time: ____

Score: ____

1. ____
2. ____
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4. ____
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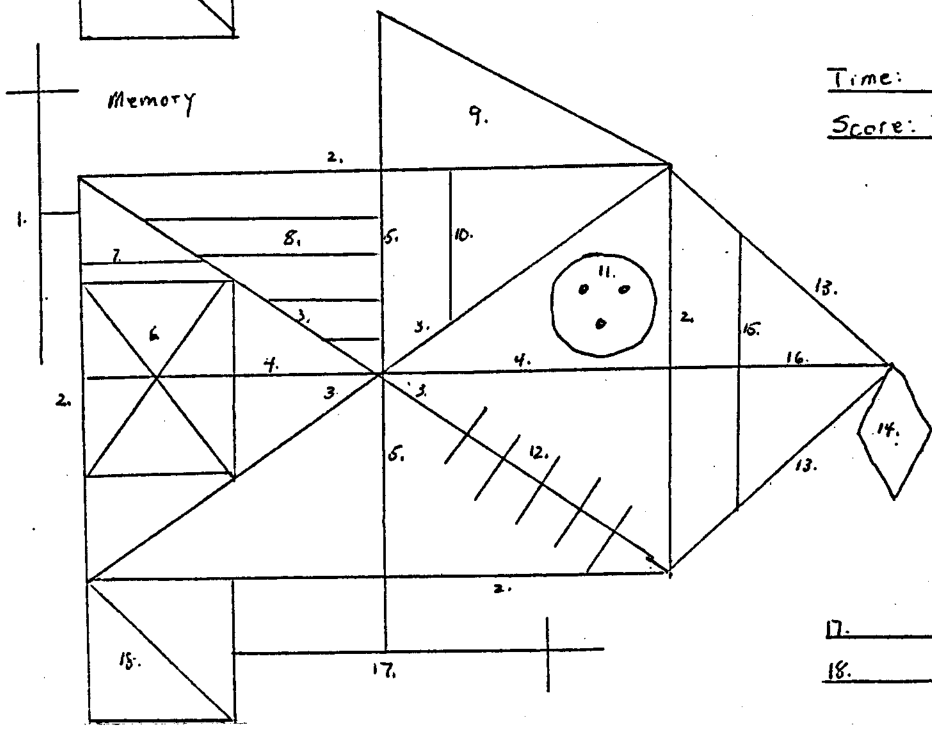
15. ____
16. ____
17. ____
18. ____



Time: ____

Score: ____

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____
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17. ____

18. ____