8008269

ROBINSON, DENNIS JAY

NEUROPSYCHOLOGICAL TEST DIFFERENCES BETWEEN CONGENITALLY BLINDED, ADVENTITIOUSLY BLINDED, AND SIGHTED ADULT VOLUNTEERS

The University of Arizona ED.D. 1979

University Microfilms International 300 N. Zeeb Road, Ann Arbor, MI 48106 18 Bedford Row, London WC1R 4EJ, England

NEUROPSYCHOLOGICAL TEST DIFFERENCES BETWEEN CONGENITALLY BLINDED, ADVENTITIOUSLY BLINDED, AND SIGHTED ADULT VOLUNTEERS

by

Dennis Jay Robinson

A Dissertation Submitted to the Faculty of the

DEPARTMENT OF REHABILITATION

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF EDUCATION

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 7 9

THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

I hereby recommend that this dissertation prepared under my direction

by Dennis Jay Robinson

entitled NEUROPSYCHOLOGICAL TEST DIFFERENCES BETWEEN CONGENITALLY BLINDED, ADVENTITIOUSLY BLINDED, AND SIGHTED ADULT VOLUNTEERS

be accepted as fulfilling the dissertation requirement for the Degree

of Doctor of Education.

Dissertation Director ____________ Date 10/23/79

As members of the Final Examination Committee, we certify that we have read this dissertation and agree that it may be presented for final defense.

____________ Date 10/23/79

Bob G. Johnson ____________ Date 10-19-79

____________ Date 10/22/79

Glen O. Nicholson ____________ Date 10/24/79

____________ Date

Final approval and acceptance of this dissertation is contingent on the candidate's adequate performance and defense thereof at the final oral examination.

11/78

STATEMENT BY AUTHOR

This dissertation has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this dissertation are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the copyright holder.

SIGNED:

ACKNOWLEDGMENTS

The author would like to express his gratitude to Drs. Paul Leung, Bob Johnson, Amos Sales and Glen Nicholson for their help and encouragement as members of the author's committee. However, special indebtedness must be reserved for Dr. Paul Leung, who as chairman helped make an idea into a reality; Dr. Bob Johnson, whose inquiring mind provided motivation for the author; and, Dr. Glen Nicholson, whose open door and free exchange of ideas encouraged this project to its conclusion.

Sherry Robinson has been a more than encouraging and supportive wife. She has been my counselor, financial backer, unquestioning soundingboard and most intimate friend, who on more than one occasion has convinced the author to continue when quitting was the only thought he had in mind.

Recognition must be given to Ms. Carol Stogsdill, a friend, whose patience as an informal experimental subject helped in the construction of the test instrument. She also demonstrated her patience, over countless cups of coffee, while the author ventilated his thoughts and ideas.

A special acknowledgment must be given to Dr. Lawrence V. Majovski of the University of California at Los Angeles Neuropsychiatric Institute. Dr. Majovski offered useful procedural advice to the author without need for formal introduction or knowledge of the author's background. Of equal importance was Dr. Majovski's communication of the personal values and attitudes about neuropsychology held by his teacher, the late Professor Aleksandr R. Luria.

Recognition must also be given to Mr. Ken Gavitt, Director of the Tucson Association for the Blind, Dr. George Mayo, Director of the Services for the Blind--Department of Economic Security of the State of Arizona, and Dr. Ralph Hoag, Director of the Arizona School for the Deaf and Blind. Without their help many of the subjects in this study might never have been found.

The author is grateful for the assistance given by Mr. Allen Woody, Director of the Phoenix Center for the Blind,and William and Jeanette Scheerer of Phoenix, Arizona. It was only with their help that the author was able to conduct his research in the Phoenix area.

The author would like to communicate his gratitude to his mother, Mrs. Sylvia Anderson, for her many years of support and encouragement.

Further, a very special thank you must go to the more than 200 students and citizens of Arizona who gave of their time and experience so this project could be completed.

Finally, the author desires it to be known that this project is the culmination of a series of events set into motion by the author's grandfather. The encouragement received was given unconditionally and faithfully until the day of Marinus Knut Anderson's death.

TABLE OF CONTENTS

TABLE OF CONTENTS--*Continued*

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS--Continued

LIST OF TABLES

ABSTRACT

This study was concerned with the neuropsychological functions of adventitiously blinded adult volunteers (blind at seven or older), congenitally blinded adult volunteers (blind at birth or within eight weeks following) and sighted adult volunteers. The Robinson Adaptation for the Blind: Luria's Neuropsychological Tests (RBNT), constructed by the investigator, and patterned after the test items developed by A. R. Luria, was the instrument used by the investigator in this study.

The purposes of this study were as follows:

1. Do blinded adults differ from sighted adults on a neuropsychological measure?
2. Do congenitally blinded adults differ in their neuropsychological functioning from adventitiously blinded adults?

Of additional importance was the underlying assumption that people blinded either early or late in life would have different neuropsychological performance abilities because of their differently altered brain-behavior environments. This assumption was based on A. R. Luria's theoretical concept of a Dynamic Localization of Functional Systems of the Cerebral Cortex.

The number of subjects in this study was 90, equally distributed between congenitally blinded, adventitiously blinded and sighted adults. The subjects were all between the ages of 17 and 40.

The results of this study were as follows:

1. Fourteen Null Hypotheses, based upon the performance of the three groups on the RBNT Test Sections and Subsection, were rejected at the $p < .01$ level of confidence or greater. Nine of these hypotheses were rejected at the $p < .0001$ level of significance.

2. A Tukey's Test of Group Comparisons supported the first purpose of this study. The sighted adults, and often the adventitiously blinded adults, had better performance levels as compared to the congenitally blinded adults.

3. The second purpose of this study was supported by the results. The adventitiously blinded adults consistently performed better than the congenitally blinded adults. However, on tasks of phonetic hearing, the adventitiously blinded overlapped with both the sighted and congenitally blinded adults. The result was that the adventitiously blinded subjects mixed equally into the other groups creating only two separate brain-behavior performance groupings.

4. Finally, based upon an analysis of the 95 percent confidence intervals about the means of each group on the 14 hypotheses, support was shown for A. R. Luria's theoretical concept. On eight hypotheses, testing neuropsychological performance, the adventitiously blinded adults showed overlaps with the sighted adults and not with the congenitally blinded adults. On three hypotheses, the adventitiously blinded did not demonstrate performance overlaps with either congenitally blinded or sighted adults. Instead, they occupied a middle ground between these two groups. On three other hypotheses, the adventitiously blinded adults

showed performance overlaps with both the congenitally blinded and the sighted adults.

CHAPTER 1

THE PROBLEM

Introduction

The field of neuropsychology has recently gained recognition as an area of study separate from the areas of physiological and experimental psychology. At the same time, neuropsychology relied heavily upon the findings of both physiological and experimental psychology. The primary focus of neuropsychology is to assess a client's level of performance on various tasks which have a relationship to the functions of specific areas of the brain. The client's level of performance on a given task is compared to the level of performance achieved by persons who have suffered known injury to the brain. This results in a measure of functional brain-behavior performance which implies either a damaged or intact brain. In the United States, two of the outspoken proponents of the use of brain-behavior relationship measurements have been Reitan and Davison (1974). In the Soviet Union, Aleksandr R. Luria (1966, 1973) had promoted neuropsychological assessment in the applied setting.

Unfortunately, there has been no attempt to apply neuropsychological measurement methods to those who are handicapped with a loss of vision. Lezak (1976), in her review of current psychological and neuropsychological instruments states:

> Almost all psychological tests have been constructed with physically able persons in mind. When patients are handicapped, the examiner often has to find reasonable alternatives to the

> standard tests the patient cannot use, or he has to juggle test norms, improvise, or in the last resort, do without (p. 97).

Malikin and Freedman (1968) concluded that, aside from intellectual tests and tests of manual dexterity, little has been done in the area of psychological testing with the blind. Arbit (1968) suggested one of the reasons for the lack of neuropsychological test development for the blind is that such tests are of a different order than are other measures of brain organization. That is, neuropsychological tests were different from the tests psychologists have been traditionally trained to use, and different from the measures used to assess the brain in medical settings. However, evidence coming from brain wave studies of blinded persons and sighted persons point to differences in brain wave patterns (Lairy, 1968). Also, there was evidence of a possible shifting in the organization of the brain based upon blindness and the age at which blindness occurred (Parmelee, 1968). Lairy (1968) maintained that evidence is still lacking in order to be able to draw diagnostic statements concerning blinded persons.

The area of neuropsychological testing offers a potential for providing additional evidence so far lacking in the brain wave studies and in the psychological tests currently being used with the blind. The writings of Aleksandr R. Luria provide the most flexible means for measuring functional brain-behavior relationships with blinded adults. Many of the measures described by A. R. Luria (1966, 1973) do not require direct vision, and often they require very little verbal response in order to determine if an item has been answered correctly or incorrectly. Additionally, A. R. Luria (1966, 1973) provided statements indicating areas of the brain involved in the performance of the tasks he described.

Rationale for the Study

A review of the literature surrounding current neuropsychological assessment instruments revealed that there has been no attempt to adapt and apply these methodologies and instruments to persons who had suffered the loss of their visual sensory system. Despite this lack of adaptation and application, there exists within the writings of Reitan and Davison (1974) and A. R. Luria (1966, 1973) neuropsychological tests which do not require the visual sensory system to be used. There continues to exist in the literature statements to the effect that blinded persons need more appropriate measures of functioning and measures of estimating potentials (Rusalem, 1968).

Statements continued to be made that the blind person experiences physiological as well as psychological influences which results in a different developmental and functional picture (Elonen, 1968). Unfortunately, because of these influences blind persons were often incorrectly labelled as either mentally retarded, brain-damaged or autistic when subjected to prevailing psychological evaluation methods. Also, there continues to be references in the literature to the possible presence of cerebral dysfunction, resulting from conditions present before, during or after birth with blinded persons. Much of the evidence of possible cerebral dysfunction came from a lack of normal indications as opposed to presence of abnormal indications (Arbit, 1968; Cohen, 1968). Cohen (1968) saw a greater lack of normal cerebral indications (electroencephalogram alpha rhythms as compared to mu rhythms) with persons who were blinded at birth, and he saw greater normal EEG patterns with persons blinded after age four. The result was a suggestion of a difference in cerebral structure based upon the age that blindness occurs, not upon the presence of abnormal indications. Blakemore (1977) provided supportive evidence for Cohen's (1968) position of greater cerebral normalcy with greater age at the time of blindness by pointing to the phenomenon of "blindsightedness". The essence of the "blindsightedness" phenomenon is that during the time of direct vision, in concert with muscular movements toward objects in space, the subcortical visual areas established a degree of visual-spatial expertise independent of the conscious visual perception found with the occipital cortex. The result was that even with the conscious visual processes removed, the person was capable of precise movement in a given spatial direction as if he were sighted. There was no mention made, but possibly here lies part of what is called the "mind's eye". From the rehabilitation point of view, it makes good sense to be able to assess the degree of "mind's eye", or visual-spatial imagery, a blind client possesses. If this were done the client's visual-spatial imagery can be utilized in his rehabilitation training in assessing his potential for preferred occupations, and in comparing the client's functioning to sighted competitors. Assessing clients with tasks that have a functional relationship to an area or areas of the brain could offer evidence for cerebral differences between blinded clients and evidence of cerebral impairment other than blindness.

Theoretically, this study examined performance on a neuropsychological instrument patterned and expanded after those tests developed by A. R. Luria (1966, 1973). A. R. Luria (1966) put forth a theory which can best be described as a Theory of Dynamic Localization of Functional Systems of the Cerebral Cortex. A. R. Luria maintained that the concept of dynamic localization calls for a rejection of the concept of function, and a rejection of the notion of centers within the cortex being directly responsible for specific processes. A. R. Luria (1966, p. 24) stated it as follows:

> According to this view, a function is, in fact, a functional system directed toward the performance of a particular biological task and consisting of a group of interconnected acts that produce the corresponding biological effect. The most significant feature of a functional system is that, as a rule, it is based on a complex dynamic 'constellation' of connections, situated at different levels of the nervous system, that, in the performance of the adaptive task, may be changed with the task itself remaining unchanged.

While A. R. Luria saw the functional task as being invariant, he saw the system through which the act of achieving the task moves, as being plastic. A. R. Luria (1966, p. 27) states:

> The loss of any one link of this system immediately affects the end result and leads to the reorganization of the whole system, with the object of restoring the disturbed act.

The Dynamic Localization aspect of A. R. Luria's theoretical view of the cerebral cortex appeared initially to be a contradiction of terms. However, A. R. Luria explained that functions, or biological tasks, which include mental tasks were localized not in fixed cortical areas, but rather functions were fixed in dynamic or plastic systems whose elements retained a good deal of autonomy. This allowed them to play specialized roles during the process of performing the functional task.

The importance of understanding A. R. Luria's theoretical view of the cortex is that it provides statements which would account for the differences between persons blinded at birth and persons blinded later in life, as seen thus far in the research literature. In terms of persons suffering a sensory system disability at birth, A. R. Luria (1966, p. 37) states:

> In the early stages, . . . disturbances of the relatively elementary processes of sensory analysis and integration, necessary, for example, for the further development of speech, will be decisively important in early childhood, for it will cause underdevelopment of all the functional formations for which it serves as a foundation.

Regarding those individuals deprived of the use of a sensory system later in life, A. R. Luria (1966, p. 37) states:

> Conversely, the disturbance of these forms of direct sensory analysis and integration in the adult, in whom the higher functional systems have been formed, may have more limited effect, compensated for by the differentiated systems of connections.

A. R. Luria's theoretical view of the functional structure of the human cortex and his statements concerning the effects of sensory system loss at different ages, provided the basis, with support from the research literature, for the general hypotheses contained in this study.

The rehabilitation process can profit by being provided with the foundation for the development of a brain-behavior assessment tool for the blind. This in turn should provide valuable data about blinded clients to both rehabilitation professionals and the clients themselves.

Statement of the Problem

This study was designed to examine the differences in brain-behavior functioning, as measured by an expanded version of A. R. Luria's Neuropsychological Tests (1966, 1973), between blinded and legally blinded adult volunteers as compared to sighted adult volunteers.

This study examined the neuropsychological test differences between those blinded and legally blinded adult volunteers who lost their vision at birth or within the first eight weeks following birth, and those who lost their visual ability at or beyond the age of seven (Zaidel, 1975; Gesell and Amatruda, 1969). Finally, this study examined the neuropsychological test differences of blinded, legally blinded and sighted adult volunteers in terms of the areas of the brain involved as indicated by A. R. Luria (1966, 1973).

Research Questions

This study was designed to obtain information which can be used to answer the following questions:

1. Do blinded and legally blinded adult volunteers differ from sighted adult volunteers (when blindness is held constant through the use of a blindfold) on an expanded neuropsychological measure based upon the research of A. R. Luria (1966, 1973)?
2. Do blinded and legally blinded adult volunteers who lost their sight at birth or within eight weeks following birth differ in neuropsychological functioning from blinded and legally blinded adult volunteers, who lost their sight at or beyond the age of seven?

Hypotheses

The following general hypotheses were tested in this study:

1. Blinded and legally blinded adult volunteers achieve lower scores on the six sections of an expanded neuropsychological

instrument as compared to a group of sighted adult volunteers.

2. Blinded and legally blinded adult volunteers who lost their vision at birth or within eight weeks following birth achieve lower scores on the expanded neuropsychological instrument than either the blinded and legally blinded adult volunteers blinded at age seven or older, or the sighted adult volunteers.
3. Blinded and legally blinded adult volunteers who lost their sight at age seven years or older demonstrate greater variance in their mean scores between each of the six sections of the neuropsychological instrument than either the blinded and legally blinded adult volunteers blinded at birth or within the first eight weeks after birth, or the sighted adult volunteers.

Definition of Terms

The following terms, used in this study, were defined for the purposes of this project.

Internal Consistency-Sighted Adult (ICS): An adult who claimed to have never experienced any nervous system disorder or symptom. An adult whose vision was normal or correctable to 20/20, and whose responses on the test instrument, used in this study, helped to determine the final form of that test instrument.

Congenitally Blinded Adult (CBV): An adult who was either totally blind or legally blind, and whose visual disability occurred either at birth or within eight weeks following birth.

Adventitiously Blinded Adult (ABV): An adult who was either totally blind or legally blind, and whose visual disability occurred either at age seven or older.

Random Sighted Adult (RSV): An adult whose vision was normal or correctable to 20/20, and who was selected at random from the Tucson telephone directory.

Assumptions Underlying the Study

The following assumptions must be noted in the execution of the study:

1. ICS individuals were considered to be neurologically pure for the purposes of accepting or rejecting items for the final form of the test instrument.
2. Prior experiences in mobility training had no influence on the blinded person's performance on the dependent variables or scores on the test instrument and its sections.
3. The condition of total blindness as opposed to legal blindness had no influence upon the individual's performance on the dependent variables or scores on the test instrument and its sections.
4. The experiences the blinded persons received through the agencies and institutions, established to provide rehabilitation services to the blind, had no influence upon the dependent variables or scores on the test instrument and its sections.
5. Finally, being a volunteer participant, after having been randomly selected, had no influence upon the dependent variables or scores on the test instrument and its sections.

Limitations of the Study

The proposed study has limitations which restricted the generality of the results:

1. Those persons who made up the ICS, CBV, ABV and RSV groups were randomly selected volunteers.
2. The randomized CBV and ABV volunteers were those who had affiliation or contact with the local and state agencies and institutions dealing with the blind. Due to limitations of time and money, attempts at contacting non-affiliated blinded persons was not made.
3. Those volunteers who either lived within the cities of Tucson or Phoenix, Arizona, and their surrounding communities, or agreed to commute to either Tucson or Phoenix, Arizona, were included in this study. This was primarily due to financial and time limitations.

CHAPTER 2

REVIEW OF THE LITERATURE

Neuropsychological Tests

Assumptions concerning relationships between anatomical structures and observable human behaviors have existed for many hundreds of years. Until the work of Franz Joseph Gall (1758-1828), the precise body structures claimed to govern specific human behaviors had varied greatly. Gall's work brought a concern for skull formations and resulting behaviors. There was an implied cerebrum relationship to skull formations, which at best resulted in an organized observational approach to skull-behavior relationships.

The accidental injury to the left frontal lobe of Phineas Gage in September of 1848, and the recorded observations of Dr. John Harlow, documented an actual cerebrum tissue injury to altered behaviors. The documented observations of Pierre-Paul Broca (1824-1880), John Hughlings Jackson (1835-1911), and Karl Wernicke (1848-1905), heralded an end to Gall's skull-behavior relationship study or Phrenology. Their observations began the more direct study of brain-behavior relationships. The focus was upon the brain and its cortical structures as the basis for behavior. Conversely, observations of behaviors were seen as statements concerning the brain's cortical integrity. This latter statement was the basis for Neuropsychological Tests and Measurements. Accordingly,

A. R. Luria (1973, p. 34) stated the fundamental goal of neuropsychology as being,

> . . . to ascertain by careful analysis which groups of concertedly working zones of the brain are responsible for the performance of complex mental activity; what contribution is made by each of these zones to the complex functional system; and how the relationship between these concertedly working parts of the brain in the performance of complex mental activity changes in the various stages of its development.

The initial movement toward assessment of brain-behavior functions, and consequently the integrity of the brain, took the form of global test instruments. These instruments attempted to answer the question of cerebral integrity as if it were an either-or question. The result was the establishment of the misconception that persons performing well on these tests possessed healthy look-alike brains, and those who performed poorly possessed injured and/or dissimilar brains.

The outstanding example of such an instrument was the Bender Visual Motor Gestalt Test. Although Bender's (1938) original work acknowledged cerebral localization, as expressed through visual motor gestalt functions, the degree of localization addressed was confined to the broad functions of sensory phasia and organic brain diseases. However, Bender (1938) failed to relate performance to the brain's topography and the functions related to cerebral topography. Much of Bender's omission was understandable in view of the lack of brain-behavior research preceding her work. Hutt's (1969) adaptation of the Bender Gestalt Test also failed to consider the research in neuropsychology concerning functional attributes of the various cerebral cortex structures. Hutt's work at best provided a scoring index for the Bender Gestalt Test, and the ability to distinguish between normals and neurotics, as a group, from schizophrenics and organics, as a group.

The usefulness of the Bender Gestalt Test is therefore limited by a failure to consider brain-behavior variations based upon functions of different cortical areas, and by the very global nature of the visual motor approach to brain-behavior functions. Despite this, the Bender Gestalt Test was widely used in the attempt to behaviorally assess organicity. Bauman (1976, p. 258) stated, ". . . because blindness is often part of a multiple handicap in which brain damage is either definitely known or strongly suspected, the more familiar use of the Bender for evaluation of brain damage is probably its most productive application in work with visually handicapped clients."

The work of Halstead (1947, 1951), which was begun in the middle 1930's, announced the idea of Biological Intelligence and the quantitative aspects of known injury to the brain. Halstead observed and measured levels of mental, sensory and motor performance in persons with known injury to left and right hemispheres of the brain, as well as, frontal (anterior) and back (posterior) injuries to the hemispheres of the brain. Halstead's assessments of brain-behavior functions, along with the work of his pupil Ralph M. Reitan, resulted in a battery of tests designed to assess brain-behavior functions over circumscribed topographical areas of the cerebral cortex. The Halstead-Reitan Neuropsychology Test Battery (H-RB) provided not only an assessment based upon performance observed in known brain-injured persons but a global index or Halstead Impairment Index which answered the either-or question concerning organicity. Most importantly it gave a picture of client performance in comparison to non-brain injured persons and known brain injured persons, and it demonstrated that persons with different brain injuries exhibit different behaviors. The concept of injured brains being similar as well as healthy or non-injured brains being similar was not supported.

Goldstein, Deysach and Kleinknecht (1973) found that the use of the H-RB by inexperienced clinicians provided a perfect identification of organicity with brain injured clients and a correct identification in nine out of ten control or non-injured clients. On the other hand, experienced clinicians using traditional assessment instruments did much worse. Furthermore, Goldstein and Shelly (1972) discovered that the H-RB could significantly differentiate between clients with lateralized, diffuse or no brain damage. The only identification difficulty, using the H-RB, was between right hemisphere and diffuse brain injury.

The H-RB has limitations that make it of questionable value. Lezak (1976) saw the H-RB limits as being: (1) it was unwieldly, requiring a great deal of time to move, and often restricting it to clients who can come to the test rather than the reverse; (2) it took a great deal of time to administer, ranging from four to eight hours or more depending upon the client and his injuries; and, (3) it was not suitable for examining the client with sensory or motor handicaps. As if the last of Lezak's criticisms weren't enough, Marsh and Marsh (1976) indicated that the H-RB and its subtests may still be too global in the brain-behavior functions it taps, resulting in a failure to adequately differentiate between injuries to differing cortical structures. The Marshes suggested the use of the neuropsychological tests developed by the Russian, A. R. Luria.

The work of Dr. A. R. Luria began in the 1920's with investigation of speech functions. Although his initial interest was in traumatic aphasia, he moved into the study of cerebral injuries as expressed through behavior, publishing several books based upon his observations of the behaviors of brain-injured persons (A. R. Luria, 1963, 1966, 1973, 1976).

A. R. Luria's approach exemplified the general attitude of Soviet Psychology, where the mentalistic was seen as another form of behavior, behavior was seen as a manifestation of the activity of a functional neural system, and the functional neural system was a product of the conditions of the social environment. Consequently, A. R. Luria's tests (1966, 1973) were designed to assess the processing methods of a client's functional neural system by making selective demands for performance on the various cortical components of the neural system. The more the performance or behavior resembled the behaviors of persons with injury to the cortical components, the greater the likelihood of actual cortical disarrangement as a function of either injury or development. A. R. Luria's use of the word development suggested historical variations in the social environmental conditions. Specifically, assessment of cortical component processing was conducted through the areas of motor functions (hands, oral praxis and speech regulation), acoustico-motor coordination (pitch relationships and rhythmic structures), cutaneous and kinesthetic functions, visual functions, receptive speech functions, expressive speech functions, writing and reading, arithmetical skill, amnestic processes, and intellectual processes.

To date Christensen (1975) has put together the Luria Neuropsychological Tests, but no norms have been reported. Lezak (1976), in her book Neuropsychological Assessment, only made passing comments to the fact that A. R. Luria's tests had been brought together. However, Ben-Yishay et al. (1970) found that brain-damaged individuals tended to respond to tasks, having supplemental cues, in a manner that supported many of A. R. Luria's concepts. A review of the Luria tests (1966, 1973) suggested that each section of tests were fairly short and economical to administer and construct. Little in the way of special material was required, which provided mobility in taking the tests to the client. Many of the tests in each section did not require strong verbal skills, as a simple conditioned response would suffice as an answer. With the exception of the visual and writing and reading functions sections, many of A. R. Luria's tests did not require direct visual sensory analysis. However, many of the tests suggested that the ability to conjure up mental images was of help in correctly responding to the tests.

Congenital Blindness

The literature suggested that differences exist between blinded or legally blinded persons as a function of the age at which visual loss was experienced. Although the use of the word congenital means at birth, many workers with the blind had expressed a belief that a person can have vision for a period of time after birth and still perform as if they had been blind since birth. The feeling was, good visual acuity in the newborn notwithstanding, the infant lacks the concerted oculo-motor and skeleto-motor ability to fixate, track and tactually identify objects and object positions in space. The result being a failure to establish a spatial-motor frame of reference useful in later blinded life. Gesell and Amatruda (1969, p. 188), in their observations of newborns, state:

> Definite fixation, with convergence, focus, and shifting of focus begins to appear at about 8 weeks of age. Overconvergence (strabismus) is frequent at this age, because the ocular muscles are still used disco-ordinately. Visual following of a moving object is jerky, the eyes move too slowly to keep up, or move faster than the object, and so it is frequently lost.

While this statement was based upon direct observations, it offered good reason to establish a behavioral definition of congenital blindness of birth plus eight weeks.

When addressing congenital blindness from the physiological position, the idea of blindness at birth was the most frequent position taken in the research literature. However, Cohen (1968), in his electroencephalogram studies of young blinded children, accepted a liberal definition of "soon after birth" (p. 112). Cohen's EEG findings demonstrated a distinct difference between those blinded at or soon after birth and sighted children with their vision temporarily blocked. Cohen's blind youngsters failed to show alpha rhythm brain wave activity over the vision areas of their skull as opposed to the normal exaggerated brain waves found with his control subjects. Furthermore, he discovered that a normal, but rare, mu rhythm brain wave had established itself in an abnormally dominant way over the parietal areas of the blinded children's skulls. This was not found in the parietal brain wave readings of his control subjects. Parmelee (1968, p. 129) suggested that this mu rhythm in blinded children was a compensative reorganization or ". . . shift in normal organization of the brain from one area to another when a sensory modality is missing." Additionally, Cohen, Bashes, and Snider (1961) conducted an EEG study of prematurely born children who suffered blindness due to retrolental fibroplasia caused by the administration of pure oxygen at birth. All the subjects exhibited EEG abnormalities, but they could only speculate that, " . . . a major correlative of behavioral retardation in these children is neurological abnormality" (p. 914).

Chase (1974) agreed that there must be a connection between too much oxygen and nerve cell function just as there is between too little oxygen and poor nerve cell performance. However, since those blinded by pure oxygen were also prematurely born, it would be difficult to separate which factor contributed the most to poor behavioral performance. Symonds and McKenzie (1973) looked directly at vision loss in young children due to damage of the occipital or vision areas of the brain. They concluded that despite various known physiological causes for blindness, blindness may be one of the signs of a generalized structural damage to the brain.

Direct evidence of brain changes due to sensory loss at birth came from research with laboratory animals. Woolsey and Van der Loos (1977, p. 89) discovered the following:

> The arrangement of barrels [of nerve cells] across the cortex [4th layer in the sensory cortex] matches exactly the pattern of whiskers in the mouse's moustache, so it is thought that each barrel might be the cortical representation of a single whisker. In fact, if one row of whiskers is removed in a newborn mouse, the appropriate row of barrels is missing in its cortex later in life.

While it was not always possible to be able to generalize from animals to humans, it was possible to speculate that the reactions in the human brain to the loss of a sensory system early in life could be no less complex than that of a mouse's brain.

The studies which had focused upon behavioral or task performance and early blindness had concluded that the longer a person had vision the more the person was able to successfully perform complex tasks, whether the tasks be muscular or mental (Fisher, 1964; Warren, 1974; Malmo, 1975). Freedman (1971) and Gillman (1973) believed that the behavioral developmental lag seen with congenitally blinded children was based upon factors not related to vision loss. Arbit (1968) admitted to a lack of evidence, but he concluded that prenatal and birth conditions leading to blindness had a good likelihood of producing either transient or long lasting minimal neurologic effects.

Adventitious Blindness

The literature was vague as to what constitutes an adventitious point of development beyond which, if blindness occurs, non-visual performance and behaviors would demonstrate gains over performance and behaviors of those blinded at birth or shortly thereafter. The age at which adventitious experiences and gains began varied as to the modality being investigated.

Gesell and Amatruda (1969) found that association of visual experience to objects with visual experience of representations of objects was established between the fifteenth and eighteenth month after birth. However, it was also found the association and discrimination of abstract word symbols for representations of objects did not become apparent until five years later or about six to seven years after birth. Cohen (1968) found that visual areas of brain wave activity continued in those blinded after three to four years from birth, and that this alpha rhythm or vision brain wave activity continued until the age of ten. The work of Zaidel (1975), using his Z-lens, supported Gesell and Amatruda (1969) in that abstract word symbols developed equally in both right and left hemispheres of the brain until the age of five, and after that age the left hemisphere dominated in language development resulting in greater and finer conceptual distinctions between objects and actions.

Parmelee (1968), in his review of the work of Cohen (1968) and Lairy (1968) concerning visual area brain wave activity with those blinded in middle childhood, suggested that the functional reorganization of the brain to blindness was accomplished by adolescence. However, blinded persons who claimed to visualize far into adulthood continued to exhibit brain wave activity over the visual areas of the brain. Lezak (1976) supported Parmelee's review by indicating that in adults injury to the visual cortex of the brain, with a resulting total loss of vision, had little if any effect on emotional control, reasoning, and visual conceptualizations.

The results of the research suggested that a decided advantage was obtained if blindness occurs after a complex verbal abstract system had been established and associated with objects and spatial coordinates. The apparent minimum age at which gains could be realized appears to be the age of seven with a considerable amount of adventitious effects continuing into adolescence or adulthood.

The studies dealing with behavioral observations and performances of adventitiously blinded or those blinded in later life, suggested that prior visual ability alone did not account for the advantages these persons had over congenitally or early blinded persons. Jones (1972) and Hampshire (1975) stressed that auditory, cutaneous and proprioceptive systems developed specific and specialized strengths that were mutually supportive of each other, and that the visual system, although important, was but only one element in the total sensory system. Millar (1975) found that with older persons, both blinded and sighted, there was a marked tendency to utilize verbal strategies, based on prior information, in performing tasks dependent upon cuing conditions and stimulus position in space. Furthermore, both Warren (1974) and Hallenbeck (1968) stated that there was a presence of efficient visual imagery resulting in a visual frame of reference which, when added to adult verbal mediation, accounted for much of the mobility and spatial orientation successes of the adventitiously blind. Finally, Lezak (1976) and Klien (1962) concluded that cognitive achievements and abstract spatial concepts involve the use of vision as a medium for informational input, but the vision medium was not seen as indispensible. Rather, areas other than the visual areas of the brain played a major role in cognition and abstract spatial conception.

Implications of the Literature

The area of brain-behavior assessment, or neuropsychological testing, had shown itself to be of use in adding evidence to support the diagnosis of brain injury. Most importantly, neuropsychological assessments provided information directly related to the behaviors and levels of functions expected of those who may have suffered injury. Although neuropsychological instruments had not been adapted or constructed for use with persons handicapped by a loss of vision, the basis existed for constructing a neuropsychological measure to aid in the assessment of blinded persons. The work of A. R. Luria (1963, 1966, 1973 and 1976) provided well documented brain-task performance correlations, as well as a broad and flexible approach for the construction of a neuropsychological instrument for blinded persons.

The literature concerning early or congenitally blinded persons and late or adventitiously blinded persons suggested that there were functional differences in their brain structure and methods of processing environmental data. Various researchers had directly stated that there seem to be differing and reorganized cortical systems between the congenitally and adventitiously blinded. In general, the research supported the general hypotheses of this study. There was as yet no direct neuropsychological or brain-behavior performance data to support either this study's hypotheses and the notion that congenitally blinded persons cortically organize their environment differently from adventitiously blinded persons. The present study was an attempt to add to the literature and aid in rehabilitation assessment by providing neuropsychological data concerning adults blinded early in life and those adults blinded late in life.

CHAPTER 3

RESEARCH METHODOLOGY

General Design of the Study

The study was based on the Static-Group Comparison Design (Campbell and Stanley, 1963, p. 12). This design was described as a pre-experimental design, and was based on the assumption of group equivalency had it not been for the effects of variable (X), congenital blindness or adventitious blindness. Although there was no formal certification of group equivalency using randomization procedures, group equality was established by applying identical selection procedures and standards. The selection assured that all participants were volunteers and all were between 17 and 40 years of age. Furthermore, equivalency was based upon the possibility of exposure to variable (X), congenital blindness or adventitious blindness, being a function of random or accidental occurrence. The subjects for the study were selected from the blinded adult clients being served by rehabilitation counselors working for the Arizona Department of Economic Security, Services for the Blind, Arizona School for the Deaf and Blind, the Tucson Association for the Blind and the Phoenix Center for the Blind. These blinded adult volunteers were grouped as to their age at the time of loss of vision, being either at birth or within eight weeks following birth (Congenital Blindness), or at age seven or older

(Adventitious Blindness). The volunteer control group was selected at random from the telephone directory of Tucson, Arizona, and consisted of volunteers between the ages of 17 and 40. The observations (0), test performance on the test instrument, and the variable (X), congenital blindness or adventitious blindness, was administered to the adult volunteer groups in the following way:

1st Comparison Group:	X	0	(Group A: Adventitious Blindness-ABV)
2nd Comparison Group:	X	0	(Group B: Congenital Blindness-CBV)
3rd Comparison Group:		0	(Group C: Volunteer Control-RSV)

The major focus of the design was to compare a "variable (X) exposure" group performance on (0) to a "no-variable (X) exposure" group performance on (0).

The Setting

The settings for the study were the Department of Economic Security, Services for the Blind, Tucson, Arizona. This was the local office for the state rehabilitation agency which provided services to eligible applicants who had a visual disability. The subjects were selected from the counselors assigned to this office. Additionally, the Phoenix Center for the Blind, Inc., Phoenix, Arizona, the Tucson Association for the Blind, Tucson, Arizona, and the Arizona State School for the Deaf and Blind (ASDB), Tucson, Arizona, were testing sites.

The Subjects

The population in which the researcher was interested were blinded persons from the ages of 17 to and including the age of 40. These were subjects who suffered vision loss congenitally, within eight weeks after birth, or adventitiously, at age seven or older. These subjects were volunteers who were asked to participate, after being grouped by age and age of vision loss. These subjects may have been either students at ASDB or they may have been rehabilitation clients in any of the following rehabilitation statuses:

1. Status 06 or extended evaluation for eligibility to receive services.
2. Status 10 or eligible for services.
3. Status 12 or rehabilitation plan completed.
4. Status 14 or receiving rehabilitation counseling.
5. Status 16 or receiving restoration services to improve their physical ability.
6. Status 18 or receiving vocational training.
7. Status 20 or receiving vocational placement services.
8. Status 22 or engaged in trial employment.
9. Status 26 or successful employment but continuing to either be monitored by the agency or receiving additional followup services.

The control population was composed of selected volunteers taken from the telephone directory of Tucson, Arizona. They were adult volunteers, between the ages of 17 and 40, who had either normal or correctable vision.

Groups

The selected volunteer adult subjects were divided into one of four groups in this study. These groups were

Internal Consistency-Sighted Adult Volunteers (ICS): The ICS group consisted of 20 adults between the ages of 17 and 40 years of age, who claimed to have never experienced any of the nervous system disorders or symptoms. The family physician of each participant was contacted and asked to confirm their patient's claimed neurologic negative position. The family physicians responded to and confirmed 19 of these adults. The twentieth participant's family physician failed to respond to the confirmation request. In no cause was a participant's claimed neurologically symptom free condition refuted by a physician. All the persons in the ICS group were capable of ambulating under their own power, and had intact vision and hearing. Finally, all the members of the ICS group volunteered to be blindfolded and take the RBNT. The results of the ICS group's performance on the RBNT determined the final form of the RBNT.

Congenitally Blinded Adult Volunteers (CBV): The CBV group consisted of persons who were either totally blind or legally blind. All the members of the CBV group were between the ages of 17 and 40 at the time of their testing. The CBV group was composed of only persons who, to the best of their knowledge, suffered their visual disability either at birth or within eight weeks following their birth. The CBV members were selected at random from the clients handled by the state and local agencies for the blind, and who volunteered to participate.

Adventitiously Blinded Adult Volunteers (ABV): The ABV group consisted of blinded or legally blinded adult volunteers who met the same criteria as the CBV group, with the exception that these participants suffered visual impairment at or beyond the age of seven.

Random Sighted Adult Volunteers (RSV): This group consisted of adult volunteers between the ages of 17 and 40 with intact vision. They were selected at random from the Tucson telephone directory.

Procedure

(a) Variable (X): The groups were differentiated into comparison groups A (ABV), B (CBV), or C (RSV), based upon the presence or absence of vision, and the age of blindness onset if there was an absence of vision.

(b) Evaluation (O): The groups of adult volunteers were evaluated in terms of their performance on each section and each test subsection of the Robinson Adaptation for the Blind: Luria's Neuropsychological Tests (RBNT).

Evaluation Instrument

The Robinson Adaptation for the Blind: Luria's Neuropsychological Tests (RBNT)

The Robinson Adaptation for the Blind: Luria's Neuropsychological Tests (RBNT) consisted of six test sections, with three of the test sections containing test subsections. Each test section or test subsection consisted of from two subtests to 19 subtests. The RBNT was the product of the test items described by A. R. Luria (1966, 1973) and an internal item analysis study conducted at The University of Arizona upon 20 college students between the ages of 17 and 40. The items in each subtest of the RBNT were those items answered correctly by 95 percent of the ICS group. This group was composed of persons who claimed to have no history of nervous system disorders or blatant symptoms of nervous system disorders. The family physicians of this group confirmed or failed to refute each group member's symptom-free condition. They were then asked to voluntarily take the draft RBNT while blindfolded.

The RBNT contained the following test sections, test subsections and subtests:

1. Motor Functions Test Section (MFT) with nine subtests.
2. Acoustico-Motor Coordination Test Section (AMC) contained 11 subtests.
3. Cutaneous Sensory Perception Test Section (CSP) consisted of six subtests.
4. Receptive Speech Function Test Section (RSF) contained the following:
   (a) RSF Sound Perception Subsection with six subtests;
   (b) RSF Word Comprehension Subsection with two subtests;
   (c) RSF Simple Sentences Subsection composed of four subtests;
   (d) RSF Logical-Grammatical Structures Subsection with six subtests.
5. Expressive Speech Function Test Section (ESF) consisted of the following:
   (a) ESF Articulation Speech Subsection contained nine subtests;
   (b) ESF Nominative Speech Subsection with ten subtests.
6. Arithmetical Skills Function Test Section (ASF) was composed of the following:
   (a) ASF Arithmetic Functions Subsection with four subtests;
   (b) ASF Arithmetic Operations Subsection with five subtests.

Correctly responding to an item on the RBNT resulted in achieving at least one point. The higher the scores the greater the integrity of the cortical area seen as responsible for successfully performing the required task. The lower the scores the more questionable the integrity of the cortical area of the brain seen as responsible for the successful performance of the task.

Hypotheses (Specific)

The specific hypotheses being tested in this study were in the Null Hypothesis form. There was no difference in Group A (Adventitiously Blinded, ABV), Group B (Congenitally Blinded, CBV) and Group C (Control, RSV) on the following measures.

Hypothesis 1: The Total Motor Functions Test Section (MFT) score as measured by the RBNT.

Hypothesis 2: The Total Acoustico-Motor Coordination Test Section (AMC) score as measured by the RBNT.

Hypothesis 3: The Total Cutaneous Sensory Perception Test Section (CSP) score as measured by the RBNT.

Hypothesis 4: The Total Receptive Speech Function Test Section (RSF) score as measured by the RBNT.

Hypothesis 5: The Total Sound Perception Subsection Test score, of the RSF, as measured by the RBNT.

Hypothesis 6: The Total Word Comprehension Subsection Test score, of the RSF, as measured by the RBNT.

Hypothesis 7: The Total Simple Sentences Subsection Test score, of the RSF, as measured by the RBNT.

Hypothesis 8: The Total Logical-Grammatical Structures Subsection Test score, of the RSF, as measured by the RBNT.

Hypothesis 9: The Total Expressive Speech Function Test Section (ESF) score as measured by the RBNT.

Hypothesis 10: The Total Articulation Speech Subsection Test score, of the ESF, as measured by the RBNT.

Hypothesis 11: The Total Nominative Speech Subsection Test score, of the ESF, as measured by the RBNT.

Hypothesis 12: The Total Arithmetical Skills Function Test Section (ASF) score as measured by the RBNT.

Hypothesis 13: The Total Arithmetical Function Subsection Test score, of the ASF, as measured by the RBNT.

Hypothesis 14: The Total Arithmetical Operations Subsection Test score, of the ASF, as measured by the RBNT.

Statistical Analysis of the Data

The test scores collected on the instrument used in the study were analyzed by a one-way analysis of variance for each hypothesis. Those hypotheses refuted at the $p < .01$ level of significance would be subjected to a Post Hoc Tukey's Test for scored data as a test of comparison (Linton and Gallo, Jr., 1975). Lastly, an Eta Correlation Coefficient (η) and Eta Squared (η^2) strength-of-association was performed. The (η) statistic carries with it the same level of significance as the analysis of variance upon which it was based. The (η^2) statistic, when multiplied by 100, results in the amount of variance in the dependent variable that could be accounted for by the independent variable in the samples studied. The following is the Eta Correlation Coefficient statistic:

$$\eta = \sqrt{\frac{(dfa)\ (F)}{(dfa)\ (F) + df\ error}}$$

CHAPTER 4

RESULTS

Introduction

The first sets of data discussed in this chapter deal with the descriptive characteristics of the samples of subjects investigated. The descriptive data deals with the distribution of Sex, Vision (visual acuity or lack thereof), Handedness or Laterality, Age, Education and Racial/Ethnic identification across the three groups studied.

The next sets of data discussed in this chapter deal with the performance of the three groups on the various sections and subsections of test instrument (Robinson Adaption for the Blind: Luria's Neuropsychological Tests-RBNT). The measured performance of the groups on each section and subsection of the RBNT constitutes a test of one of the hypotheses stated in the preceding chapter. The findings for each hypothesis is described in the following format:

1. Restatement of the hypothesis is made.
2. A statement of the brain-behavior functions assessed by sections or subsections of the RBNT, as a test of the given hypothesis is made. In hypotheses that utilized performance on various sections of the RBNT, a statement of the developmental sequence leading to the brain-behavior functions is given.

3. Statements concerning brain-behavior impairment relationships are given, either in terms of the subtests on which they most likely occurred or in terms of the test sections or subsections as a whole.
4. Descriptions of the subtests within the involved subsections are made. However, in situations dealing with hypotheses tested by a section of the RBNT this is omitted. The reason for this is that the hypotheses investigated through performance on the RBNT test sections were summed scores, and the hypotheses focused around RBNT subsections contain the descriptions of the subtests involved.
5. A discussion of the statistical results of the hypotheses, as measured by either the RBNT sections or subsections is given. Each hypothesis has a similarly labelled figure, illustrating the mean scores of each group and their 95 percent confidence interval about their mean scores.
6. Finally, a discussion of the results of the Eta (η) Correlation Coefficient and Eta Squared (η^2) Strength of Association is made.

<u>Descriptive Data</u>

Table 1 illustrates the distribution of the three subject samples across sex, vision and handedness or laterality. Information is also given for all the subjects in this study, taken as a whole, across the three variables. A chi square statistic to determine level of significance is presented. Finally, there was no attempt to select subjects

Table 1. Distribution of sex, vision and handedness across the three samples in this study

Variables	Adventitiously Blinded Adults (ABV) N = 30	Congenitally Blinded Adults (CBV) N = 30	Control Adults (RSV) N = 30	Overall N = 90	Chi Square (X^2) p
<u>Sex (%)</u>					
Male	56.7	46.7	46.7	50.0	.67
Female	43.3	53.3	53.3	50.0	
<u>Vision (%)</u>					
Blinded	56.7	53.3	0.0	36.7	.0001
Light Perception	43.0	46.7	0 0	30.0	
20/20 Correctable	0.0	0.0	100.0	33.3	
<u>Handedness (%)</u>					
Right	93.3	76.7	90.0	86.7	.29
Left	6.7	20.0	10.0	12.2	
Mixed	0.0	3.3	0.0	1.1	

based upon either sex or handedness, but vision or lack thereof was a critical criteria for selection.

In terms of sex, the Adventitiously Blinded Adult Volunteer (ABV) Group A demonstrated a slight bias towards males of 6.7% over females. This means that there were two more male participants than female participants. However, the females outnumbered the males by one person in both the Congenitally Blinded Adult Volunteer (CBV) Group B and Control Adult Volunteer (RSV) Group C. The result had an offsetting effect giving an equal split between the sexes in terms of all the participants. This fifty-fifty split would be expected if random selection had been employed, and the Chi Square Statistic argued favorably for this by failing to demonstrate an acceptable level of significance.

Vision or the lack of vision was a criteria used for selecting participants. The C Group (RSV) demonstrated the desired bias for good vision, and the members of the blinded groups A and B (ABV and CBV) showed a small tendency toward those totally without vision. The overall percentage distribution was close to the desired separation of equal thirds, with six more totally blind subjects than light perception only participants. The chi square p-value of .0001 confirmed that the criteria for selection, based upon vision, was adhered to, and suggested that such a distribution could only have occurred by chance one time in ten thousand.

Various writers have suggested that the preference for right-handedness was common with 81% to 90% of the normal population (Groden, 1969; Milner, 1974). Reitan (1979) has suggested that the actual preference, when viewed in terms of the cerebral hemispheric laterality of language dominance, was upwards of 95% of the adult population. Handedness for all participants, A Group (ABV) and C Group (RSV) were similar to the different estimates mentioned. Also, the chi square p-value promoted the contention of similarity to what might be expected from randomly selected subjects. Less than normal looking handedness distribution was found for the (CBV) Group B subjects. The marked tendency toward left handedness (20%) with Group B (CBV) exceeded the left handedness (6%) found with normals (Groden, 1969). This suggested the presence of a less than normal laterality difference with Group B (CBV) as opposed to the other two groups. Reitan and Davison (1974) stated that brain-damaged persons tended more often to be left handed for both writing and their general manual preference. Also, Reitan (1979) suggested that the excessive presence of left handed subjects may be one indication of cerebral injury early in life, which forced the subjects to switch to the left hand as a compensation measure. The purpose being to facilitate efficiency in dealing with the environment. Since the subjects involved were those either born blind or who lost vision within eight weeks following birth (Group B, CBV), this might have been a possibility. Finally, handedness or laterality was determined by asking the subjects which hand they preferred, having them write their names and observing the hand they used when attempting to draw some designs and move some objects as part of their testing.

Table 2 illustrates the composition of the three groups with regard to age and education. In all cases, the B Group (CBV) exhibited the lowest mean on these two variables. However, viewing the groups in terms of the range of plus and minus one standard deviation,

Table 2. Mean ($\bar{X}$) and Standard Deviation (S.D.) of age and education of the samples studied

Variables	Adventitiously Blinded Adults (ABV) N = 30	Congenitally Blinded Adults (CBV) N = 30	Control Adults (RSV) N = 30	Overall N = 90
Age (years)				
$\bar{X}$	29.6	24.1	26.3	26.6
S.D.	5.9	4.7	6.2	6.0
± 1 S.D. Range	23.7 - 35.5	19.4 - 28.8	20.1 - 32.5	20.6 - 32.6
Education (years)				
$\bar{X}$	13.7	10.1	14.9	12.9
S.D.	2.5	5.5	2.4	4.2
± 1 S.D. Range	11.2 - 16.2	4.6 - 15.6	12.5 - 17.3	8.7 - 17.1

about their respective mean scores, a considerable degree of overlap is noted. The ABV or A Group carried the advantage of experience, as expressed in terms of age, but the C Group (RSV) had the benefits of exposure to formal education as expressed in the number of years in school.

The final table, Table 3, compares the racial/ethnic distribution of the three groups, in this study, to the racial/ethnic distribution of those living within their geographical area, Pima County, Arizona and the State of Arizona respectively. Arizona and Pima County demonstrated a dominant Caucasian (White) American majority (72.43% and 70.14%) with an Hispanic (Spanish) American minority, 18.32% and 23.60% respectively. The remaining three racial/ethnic minorities were relatively small with regard to their percentages within the two Arizona geographic areas. The Caucasian (White) American members of the groups in this study were slightly more in number than that found within their geographical location. The Hispanic (Spanish) American figures ranged in-between the figures for Pima County, Arizona and the State of Arizona. One point of departure was with the Control Group (C or RSV), where the Hispanic (Spanish) American population was under-represented. Overall, however, the percentages of Caucasian (White) and Hispanic (Spanish) members of this study were rather similar to that seen county and state wide. It is unfortunate that no Negro (Black) Americans, Native (Indian) Americans, or Other (Asian) Americans were represented. No attempt was made to guarantee proportionate racial/ethnic representation, and the relatively small number of persons involved placed an inflated percentage value for each participant. The Caucasian (White)

Table 3. Racial/ethnic distribution of the samples compared to Pima County and State of Arizona*

Variables	Adventitiously Blinded Adults (ABV) N = 30	Congenitally Blinded Adults (CBV) N = 30	Control Adults (RSV) N = 30	Overall N = 90	Pima County AZ N=502,700	State of Arizona N=2,547,000
Racial/Ethnic (%)						
Caucasian (White) American	76.7	76.7	83.4	78.9	70.14	72.43
Negro (Black) American	0.0	0.0	0.0	0.0	2.98	2.85
Hispanic (Spanish) American	23.3	23.3	16.6	21.1	23.60	18.32
Native (Indian) American	0.0	0.0	0.0	0.0	2.57	5.78
Other (Asian) American	0.0	0.0	0.0	0.0	.71	.62
Total	100	100	100	100	100	100

* Population estimate of the State of Arizona, Arizona Department of Economic Security, Report No. 11, as of July 1, 1978, Published June, 1979.

American percentages and the Hispanic (Spanish) American percentages, being so similar to the percentages found within Pima County, Arizona and the State of Arizona, was rather remarkable. It argued well for the possibility that the members of the groups in this study were representative of those found in the geographical areas mentioned, with respect to general racial/ethnic composition.

Hypothesis 1

The Total Motor Functions Test Section (MFT) Score, as measured by The Robinson Adaptation for the Blind: Luria's Neuropsychological Tests (RBNT), did not demonstrate differences between Group A (Adventitiously Blinded-ABV), Group B (Congenitally Blinded-CBV) and Group C (Control-RSV) Subjects.

A. R. Luria (1966) maintained that four conditions were necessary in order to properly carry out an assigned motor or muscle movement. First, one must have had adequate muscle strength and tone. Second, there must have been the presence of an uninterrupted system of afferent nerve fibers through which any complex movement generated a flow of kinesthetic afferent impulses. Impulses adequate to direct and correct the motor efferent impulse toward its destination were required. Third, motor movements required an intact optic-spatial afferent system in order to provide external space coordinates. This coordination was carried out by the occipitoparietal divisions of the cortex of the brain. Fourth, a system of organizing motor (muscle) innervations in the most generalized sense was needed. The system provided goals and motoric programs which were converted into plastic (correctable) kinetic (active muscular movements) melodies (proper simultaneous and sequential gross and fine muscle activation). Finally, the importance of the frontal lobes (generalization and discrimination capacity) and the premotor divisions of the cortex (simultaneous and sequential programming of gross and fine muscles) to successful muscle movement must not be underestimated (Luria 1966, pp. 324-325).

The MFT Test Section was composed of nine subtests. The first subtest was designed to measure or at least indicate possible articulatory insufficiency. The subject was required to extend his tongue beyond his mouth, and to move or hold the tongue in various positions. Increased tension and spasms of the tongue suggested articulation and pronunciation difficulties. Subtests two to four were constructed to measure selectivity of action to verbal instructions. The subject's actions were directed by the external spatial memory images evoked by the particular verbal instructions received. The fifth subtest was a test of the dynamic organization of movement coming from the contralateral premotoric cortical areas. It required a smooth and uninterrupted contraction and extension of the arm while simultaneously alternating the positions of the fingers of the involved hand. The subject was required to count aloud the number of each completed movement cycle. The sixth subtest measured reciprocal coordination of bimanual movements, involving the premotoric cortical systems along with a smooth coordination between cerebral hemispheres utilized by both the anterior corpus callosum and parasgittal areas. The subject was to tap his hands on a table top using a given and continuous pattern of two taps with the right hand followed by one tap with the left hand.

When the command "reverse" was spoken, the subject was to smoothly switch to one tap with the right hand and two with the left hand. This continued throughout four separate tapping series. The seventh subtest assessed external space coordination, using memory of spatial images associated with the inferoparietal and the occipitoparietal cortexes. Secondarily, an indication of appropriate planning and organization of muscle movement was made by observing the manner of the subject's performance. The subject was asked to pick up a pencil by its point using the first three fingers of his hand. He was then asked to extend his arm outward in front of himself at shoulder level with the blunt or eraser end pointing toward the tester. Finally, the subject was asked to, "Point the blunt end in the following directions moving your hand at the wrist only but not your fingers, and do not bend your arm but you may rotate your arm." The eighth subtest measured kinesthetic and afferent apraxia contralateral to the involved hand. The subject's hands were placed upon a table and the fingers of the involved hand were passively placed into a set position. The subject was to then place the corresponding fingers of the opposite hand into the same position. Finally, the ninth subtest measured lateralized motoric speed, precision and coordination using self-verbalized regulation. The subject was asked to touch each finger of the designated hand with the thumb of the same hand. The subject started with the forefinger, moved to the littlefinger and continued again with the forefinger, while giving each finger touched a number, until he got to the number 20. The subject should have ended with the littlefinger on the number 20 after five continuous thumb to finger series over the hand.

The subject was made aware that he was being timed, and the subject was to begin with his dominant (usually right) hand.

Table 4 indicates that there was a significance difference ($p < .0001$) in the means of the three groups in this study, on the MFT Test. Therefore, the hypothesis was refuted and the groups are seen as different from each other, in terms of the MFT Test. However, in Tukey's Test of Group Comparison, (Table 4) the actual difference between Group B (CBV) and the two other groups, who were not considered to be significantly different from each other. Figure 1 graphically displays a common or overlapping MFT performance between Groups A (ABV) and C (RSV), as well as the distinct separation in performance exhibited by the B Group (CBV).

Hypothesis 2

The Total Acoustico-Motor Coordination Test Section (AMC) Score, as measured by the RBNT, did not demonstrate differences between Group A (Adventitiously Blinded-ABV), Group B (Congenitally Blinded-CBV) and Group C (Control-RSV) Subjects.

This hypothesis was tested by exposing the groups to a series of measures that tap motoric functioning by way of the auditory system, as opposed to the occipitoparietal system. All the items in the AMC Test Section were presented to the subjects through a prerecorded cassette tape. This assured standardization of administration.

A. R. Luria (1966) maintained that audiomotor coordination measurement was necessary for any proper diagnosis and assessment of circumscribed lesions of the cerebral cortex. These tests required a

Table 4. A fixed-effects one-way analysis of variance (ANOVA) and Tukey's Test of Group Comparisons of the three samples in this study by hypotheses

Hypothesis	Mean	Standard Deviation	F-Ratio	F-Prob.	Tukey's Test (group comparisons)
1. Total Motor Functions Test Section (MFT)					
ABV	214.10	9.98	24.82	.0001	CBV < ABV & RSV
CBV	160.56	58.95			
RSV (Control)	216.73	8.18			
2. Total Acoustico-Motor Coordination Test Section (AMC)					
ABV	143.76	17.46	7.15	.001	CBV < ABV & RSV
CBV	120.43	45.09			
RSV (Control)	145.53	11.45			
3. Total Cutaneous Sensory Perception Test Section (CSP)					
ABV	303.53	12.16	6.45	.002	CBV < ABV & RSV
CBV	283.80	40.94			
RSV (Control)	304.23	7.14			
4. Total Receptive Speech Function Test Section (RSF)					
ABV	179.20	10.92	13.30	.0001	CBV < ABV & RSV
CBV	156.96	38.34			
RSV (Control)	186.70	5.29			
5. Total Sound Perception Subsection Test (RSF)					
ABV	71.50	4.76	4.50	.01	CBV & ABV < ABV & RSV
CBV	67.03	13.73			CBV < RSV
RSV (Control)	73.66	4.15			
6. Total Word Comprehension Subsection Test (RSF)					
ABV	19.63	1.03	4.84	.01	CBV < ABV & RSV
CBV	18.30	3.36			
RSV (Control)	19.80	.40			

Table 4, continued

Hypothesis	Mean	Standard Deviation	F-Ratio	F-Prob.	Tukey's Test (group comparisons)
7. Total Simple Sentences Subsection Test (RSF)					
ABV	30.43	2.67	12.95	.0001	CBV< ABV & RSV
CBV	25.83	8.06			
RSV (Control)	32.13	1.25			
8. Total Logical-Grammatical Structures Subsection Test (RSF)					
ABV	57.63	4.46	20.44	.0001	CBV<ABV & RSV
CBV	45.80	15.94			
RSV (Control)	61.10	3.00			
9. Total Expressive Speech Function Test Section (ESF)					
ABV	155.56	12.55	11.43	.0001	CBV<ABV & RSV
CBV	136.60	34.71			
RSV (Control)	162.33	6.19			
10. Total Articulation Speech Subsection Test (ESF)					
ABV	72.80	7.37	7.88	.0007	CBV< ABV & RSV
CBV	66.83	14.55			
RSV (Control)	76.60	3.23			
11. Total Nominative Speech Subsection Test (ESF)					
ABV	82.76	6.21	12.08	.0001	CBV<ABV & RSV
CBV	69.76	21.92			
RSV (Control)	85.73	4.20			
12. Total Arithmetical Skills Function Test Section (ASF)					
ABV	91.50	12.70	17.95	.0001	CBV< ABV & RSV
CBV	64.90	35.56			
RSV (Control)	96.83	6.40			

Table 4, continued

Hypothesis	Mean	Standard Deviation	F-Ratio	F-Prob.	Tukey's Test (group comparison)
13. Total Arithmetical Function Subsection Test (ASF)					
ABV	37.10	4.02	11.32	.0001	CBV < ABV & RSV
CBV	28.46	13.84			
RSV (Control)	37.93	3.20			
14. Total Arithmetical Operations Subsection Test (ASF)					
ABV	54.40	9.90	19.68	.0001	CBV < ABV & RSV
CBV	36.43	22.84			
RSV (Control)	58.90	5.10			

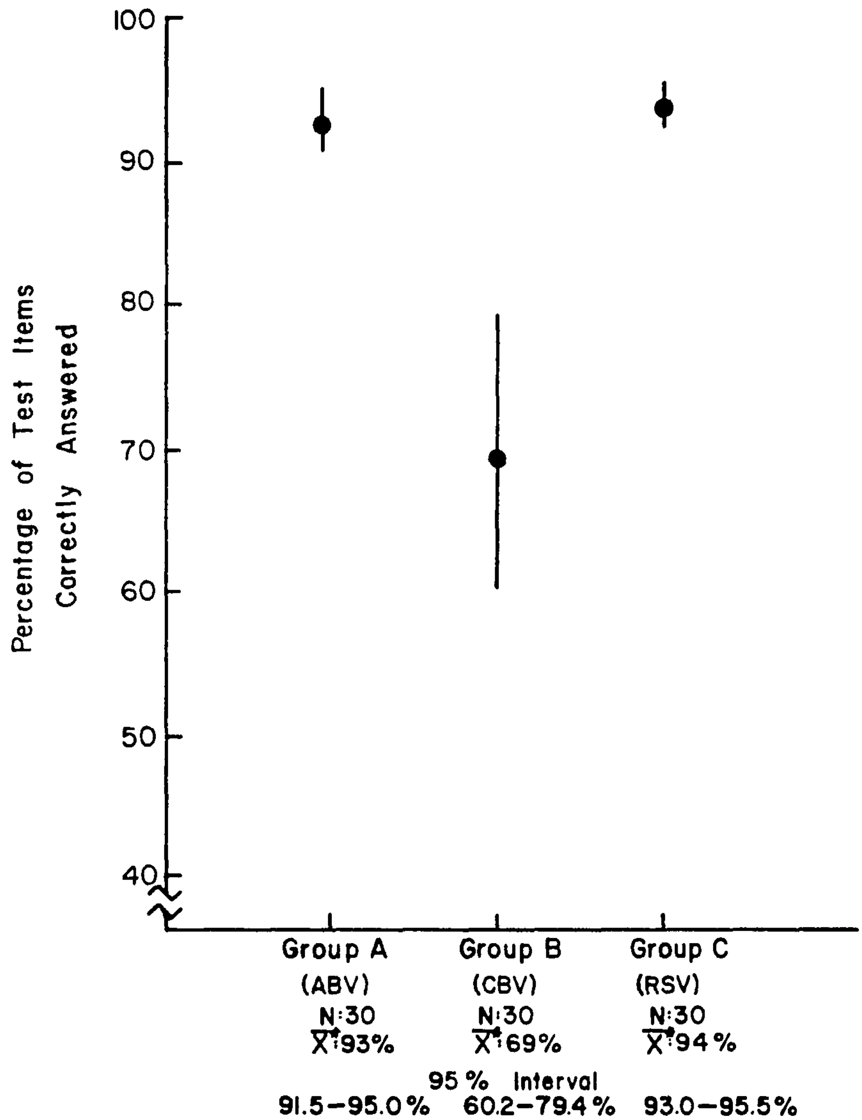

Figure 1. Means and 95% confidence intervals about the means of the three groups on the Motor Functions Test Section (MFT) of the RBNT

series of motor acts dependent upon the auditory afferent system. The correct performance of these motor acts was contingent upon a precise serial organization consisting of "motor melodies" in sequential form, based upon time intervals. The proper assessment of audiomotor activities necessitated two separate approaches. The first was the measurement of auditory perception and auditory pitch relationships, which were contained in the AMC Subtests one through five. The second assessment approach was one of auditory perception as a basis for motoric reproduction of rhythmic structures. Inherent in the demand for rhythmic reproduction was the involvement of the frontal lobes, particularly the premotor cortex. It was within these cortexes that the essential requirements for precise reproduction was generated -- generalization, discrimination and organization, respectively.

AMC Subtest one was a straight forward auditory perception and pitch discrimination test. The subject was given two musical notes, E and G, or any combination of the two in succession. The subject was then to state if the second note was the same, higher or lower than the first note. The second subtest was comprised of two sets of three notes, but continued to use combinations of the notes E and G. The subject was to state if the second set of three notes were the same or different from the first set of three notes. Subtests three and four had the same format except that the combination of the notes were expanded to sets of four notes and five notes, respectively. Also, the pitch discrimination task was made more difficult by changing the two notes involved from the full tonal step (E to G) to a tonal half-step (E to F). The fifth subtest was more complex expansion of comparing two groups of tonal series.

It covered a seven note range from C to G with all the half-note steps in-between. These first five subtests dealt primarily with the receptive capacity of the temporal lobes and to a lesser degree with the premotor divisions of the frontal lobes.

Subtest six through eleven dealt with the reproduction of rhythmic structures, which also meant testing the functions of the temporal lobes beyond the projection or primarily auditory perception zones. These tests forced the subject to count or categorize the auditory stimuli as well as provide semantic labels consistent with the categories used. Additionally, demands were placed upon the subject to discriminate and organize his responses, as was implied by the use of categories, in such a manner as to have pulled the frontal lobes and premotor cortexes into play before a proper motor rhythm reproduction could be achieved. Subtest six required the subject to listen to a series of monotone taps of a sharp object upon a table top. The subject was to give the number of taps heard. Subtest seven was similar except that the length of each item was increased and broken up into auditory subunits which needed to be identified and retained until the item was completed. Whereupon, the subject was to sum the subunits and give the numerical category representing the total taps presented. The eighth subtest was of a higher order of complexity. The subject was given a sample of taps and told to identify the auditory taps with a contradictory verbal label. That is, hollow sharp taps were to be called "strong taps" and blunt low pitched taps were to be verbally labelled as "weak taps". This required the subject to suppress the tendency to align the verbal labels with the perceived auditory stimuli.

However, the task was further complicated by asking the subject to subtotal each type of tapping sound until the item presentation was completed. The subject was then to give the subtotal number of the defined "weak taps" and "strong taps", regardless of the original order they were presented. Finally, the subject was to give the total number of taps heard in the item as a whole. AMC Subtests nine, ten and eleven were each given twice. Subtests nine and ten were first given with the subject using the forefinger of the dominant hand, followed by the forefinger of the non-preferred hand. The subject was told not to give a verbal response, rather purely a motoric response to verbal or semantic commands. Subtest nine demanded a response to a single category verbal command such as "tap once". Subtest ten increased in difficulty by presenting a verbal command containing two categories, which the subject was to discriminate and organize so as to perform the needed muscle movements in conformity with the categories. For example, "Tap three groups of four taps" should have resulted in four distinct groups of taps, separated by silent periods, until the required twelve taps were given. It must be noted that in the above example an implied third category (twelve total taps) was assumed to be generated if perseveration was to be avoided and the task completed successfully. This third category could be seen as a generalized entity coming from adequate temporal lobe perception of serial semantic stimuli in concert with frontal lobe capacity to generalize. The final subtest (eleven) was a highly complex modification of the previous two subtests requiring bimanual motor manipulation. The subject was given a pen to be held in one hand and tapped upon the top of a table. The sound made by the pen was defined as a "strong tap". The forefinger of the subject's other hand, when tapped on the table, was defined as a "weak tap". At this point, the subject was asked to perform in a manner consistent with a verbal stimulus, containing three separate verbal categories. For example, "Make a series of two strong taps and three weak taps." At the end of the first administration of subtest eleven, the subject was asked to switch hands. This required afferent-efferent flexibility in discriminating between the afferent or tactile nature of the task and the efferent or motoric demands required to precisely perform the task, given adequate auditory discrimination of the commands with frontal and premotoric generalization and organization of the task.

Table 4 shows that the performance of the subjects on the AMC Test Section suggested that the groups were not from the same population. Hypothesis 2 was consequentially rejected. Both the Tukey's Test (Table 4) and Figure 2 indicated that the A (ABV) and C (RSV) groups were so similar in their AMC performance that they should be considered the same. However, Group B (CBV) was dissimilar enough to be seen as separate from the other two groups, despite the fact that they showed a very slight overlapping with Group A (ABV).

Hypothesis 3

The Total Cutaneous Sensory Perception Test Section (CSP) Score, as measured by the RBNT, did not demonstrate differences between Group A (Adventitiously Blinded, ABV), Group B (Congenitally Blinded, CBV) and Group C (Control, RSV) Subjects.

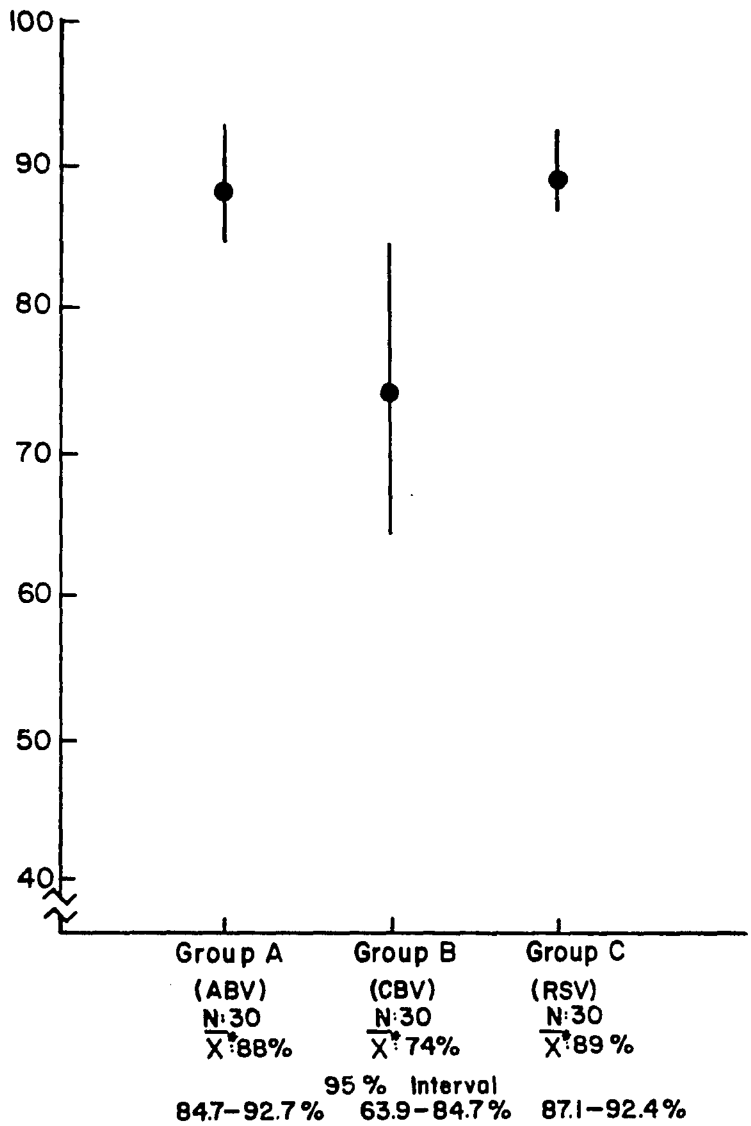

Figure 2. Means and 95% confidence intervals about the means of the three groups on the Acoustico-Motor Coordination Test Section (AMC) of the RBNT

This hypothesis was tested by exposing the subjects, in this study, to a series of measures which required normal touch perception or tactile gnosis to be successfully completed. During the course of administering this section of the RBNT it was necessary to warn the subjects they would be touched by either a sharp or dull object (the head or point of a straight pin).

A. R. Luria (1966) indicated that the appropriate method for testing the sensory system was by testing the elementary indicators, i.e., single tactile cutaneous sensations without other cutaneous interference, and later by studying the more complex forms such as simultaneous touch perception. The final and most complex form required testing the capacity to learn a tactual-spatial task and/or associate appropriate verbal (semantic) labels to specific tactual object forms. Failure with the tasks of an elementary nature suggested brain-behavior dysfunctions within the postcentral or sometimes parietal divisions of the contralateral cerebral hemisphere. Difficulties with tests of simultaneous tactile perception suggested that contralateral sensory areas of weakness were overwhelmed by competitive sensory data. It suggested possible problems in inter-hemispheric cerebral communication and discrimination capacity, which involved the corpus callosum and its communicating or homotopic connections. Finally, problems with tests requiring the ability to learn a tactual-spatial tasks and/or to associate verbal (semantic) labels to specific object forms, strongly pointed to dysfunctions in the back or posterior part of the parietal lobes where images were evoked based upon touch. Only when these tactile images were presented could either a spatial map be constructed, to facilitate learning, or an appropriate verbal label be conjured up.

Subtest one of the CSP Section required the tester to lightly touch the subject in a random order. The subject was to be touched eight times, to the same areas, on opposite sides of the body without a competitive touch sensation. The subject was also touched at random, four times to the same areas, on opposite sides of the body simultaneously. The areas of the body touched were right hand and left hand, right hand and left face, left hand and right face, right shoulder and left shoulder, right forearm and left forearm, stomach and central back, right side of the lower midriff and left side of the lower midriff, right thigh and left thigh, and right calf and left calf. The second subtest measured unilateral tactual perception first with the fingers of the preferred hand and then with the non-preferred hand. Each finger was touched five times in a separate and non-consecutive manner. The subject's fingers were all given a numerical label (the thumb being numbered one continuing to the little finger numbered five), and the subject was to respond by giving the number of the finger touched. The subject's hands were placed palm down on a table, and he was not allowed to move them during the test. Subtest three was conducted in a similar manner except the subject's fingers were touched by either a sharp or dull object in the middle of the fleshy pads of each finger tip. Enough pressure was applied to force a white color to the skin around the contact point; whereupon, the object was removed. The subject was to indicate if the object was sharp or dull. CSP Subtest four was the same, but was applied to the midline of each calf of the legs 15 cms below the bottom fold of skin behind the knee. Subtests two to four did not involve simultaneous stimulation. It must be noted that parts of subtest one, all of subtest two, and to a degree subtests three and four were either directly taken from the Sensory-Perceptual Examination of the Halstead-Reitan Neuropsychological Test Battery (HRB), as outlined by Reitan and Davison (1974), or were essentially similar to the tests found on the HRB.

CSP Subtests five and six were tests of the capacity to evoke and utilize tactile imagery to assist either tactile learning or the association of verbal identifiers. Subtest five measured the ability to establish a tactile based body-space map of the location of various touch sensations. The subject was then to retain these images in such a manner as to relocate the points of sensation on his body with increasing accuracy. The specific tactile points were established by placing mirror-image dots on the skin over the brochioradialis and extensor carpi radialis longus muscles of both forearms. This was accomplished by creating a straight line around each forearm starting and ending with the center of the elbow (alecramon). A flexible and irregularly cut cloth (brachiotrack) was draped downward over the arm, using the line as a reference. Point A on each arm was placed 8 cms from the elbow and 5 cms downward. Point B was placed 11 cms from the elbow and 9 cms downward. Point C was positioned 15 cms from the elbow and 10 cms downward. Each point was approximately labelled and made with a black washable ink pen. During the learning phase of this subtest, the subject was prodded with the point of a pin at random three times on each marked position of the arm. He was then to place the point of a green ink pen, held in the hand of the uninvolved arm, on the perceived location of the stimulus of the involved arm. Finally, the distance between the reference point and the subject's location point was measured by a thin plastic metric ruler in units of mm's. The sum of the subject's location points variance from each reference point was then divided by three resulting in an averaged location variance from each reference point. This averaged variance was then compared to the range of variance from each reference point, of the involved arm (either right or left), achieved by the best scoring half or the least scoring half of the 19 highest scoring Internal Consistency Sighted Adult Volunteers (ICS). The ICS Subjects were assumed to be neurologically pure. The subject was then given two points if his averaged variance was similar to the highest scoring half of the ICS Group, one point if within the lowest scoring half of the ICS Group, and no points if he was beyond the range of the ICS Group. Finally, the subject was re-tested in order to measure the degree of learning which took place during the learning phase. To minimize practice effects, the subject was to locate the mirror-image reference point, on the unstimulated arm, using the involved or stimulated arm as source of direction and his previous learning (body-space map) as a guide. Once more the subject's distance from the mirror-image reference point was measured, the averaged mm variance was calculated, and a score was given by comparison with the performance of the ICS Group on the same task. The final subtest (6) measured the ability to construct a tactile-spatial image of each of three common object shapes. Either a comb, a key, or a small matchbox were placed in the palm of the subject's hand. The subject was told to feel the object and as quickly as possible verbally label the object. Each hand of the subject was separately and alternately measured beginning with the preferred hand. The subject was given two scores. The first was for correctly selecting the appropriate verbal label for the object, based upon recognition for its shape. In this way misnaming or dysnomia was assessed as opposed to tactile amonia or failure to name, which indicated a problem in establishing a tactile object image. Second, the capacity for efficient use of acquired tactile-imagery was measured by timing the speed with which he selected and produced a verbal label. This speed of word or name selection should have increased with each successive trial; otherwise, dynamic or expressive verbal inertia, in the face of accurate naming, was assumed. Points were given for both the correct naming of objects, as well as for the speed of naming based upon the upper and lower half performance of the ICS Group.

Table 4 indicates that one chance in five hundred could result in a CSP performance as coming from members of one distinct group. Therefore, there were differences between the groups of subjects which rejected the third hypothesis. The Tukey's Test (Table 4) and Figure 3 demonstrate that Group A (ABV) and Group C (RSV) were essentially alike, but Group B (CBV) was different with considerably lower scores. Figure 3 also suggested a possibility of performance overlap between Group A (ABV) and Group B (CBV).

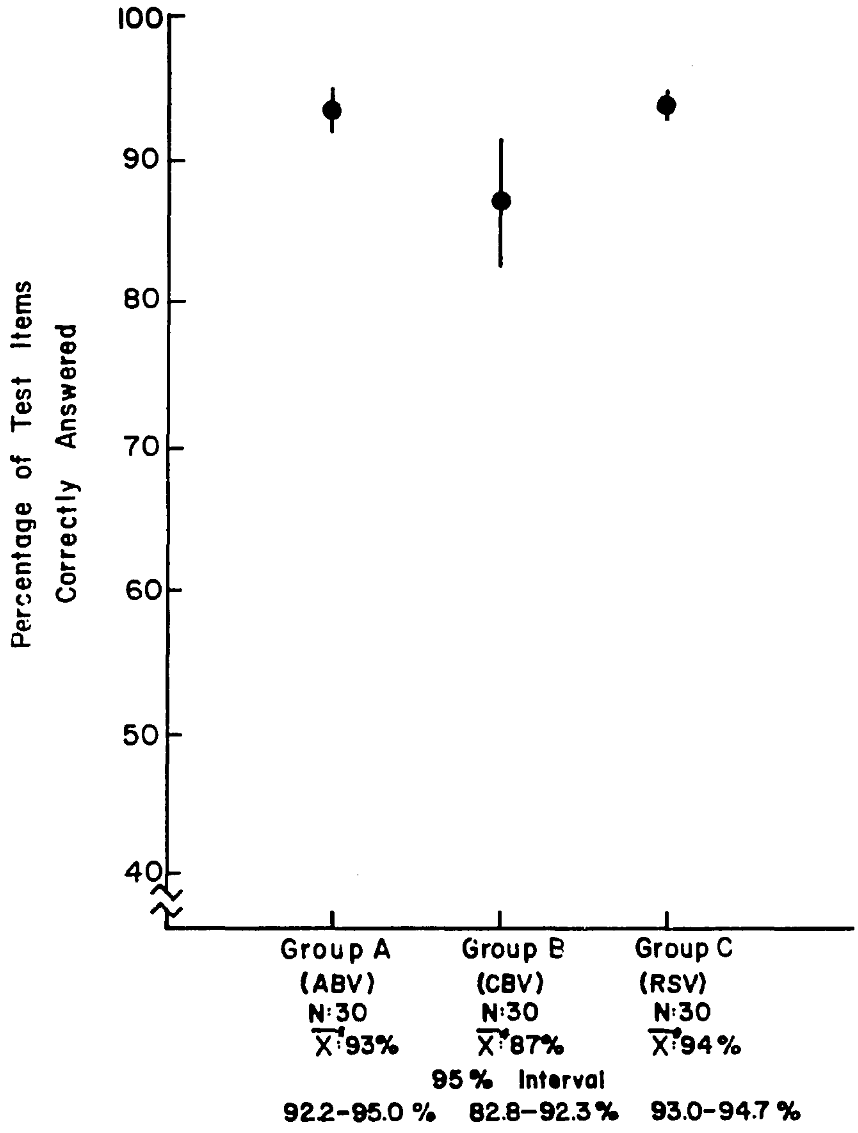

Figure 3. Means and 95% confidence intervals about the means of the three groups on the Cutaneous Sensory Perception Test Section (CSP) of the RBNT

Hypothesis 4

The Total Receptive Speech Function Test Section (RSF) Score, as measured by the RBNT, did not demonstrate differences between Group A (Adventitiously Blinded-ABV), Group B (Congenitally Blinded-CBV), and Group C (Control-RSV) Subjects.

The importance of receptive speech function measurement, as well as the components within such an assessment, were stated by A. R. Luria (1966, p. 373) as follows:

> The investigation of speech functions comprises a very important part of the study of a patient with a defect in higher cortical functioning. This is true because a very large proportion of man's higher mental activities is formed and functions in close association with the second signal system and because speech has such an important function in human social intercourse and intellectual activity.
>
> It is generally accepted that the speech functions fall into two clearly defined categories -- receptive and motor. The former usually refers to the perception of the sounds of speech, the understanding of the meaning of words and phrases, and, ultimately, the understanding of consecutive speech. Reading is a particular form of receptive speech.

A. R. Luria (1966) went on to outline the general nature of the tasks or tests necessary for the measurement of receptive speech function. Inherent in A. R. Luria's description was the underlying developmental processes for the establishment of complex receptive speech ability. A. R. Luria's neuropsychological tests followed the process outlined.

> . . . the grasping of the emotional tone of speech or of well-established forms of address or words is simple enough and may remain unimpaired even in the presence of gross cortical lesions, the understanding of the nominative aspect of speech (its objective categorization) is a far more complex process. The understanding of complex categorical systems of associations, represented by words, is still more complex, while the analysis of logical-grammatical constructions (like the understanding of

> the meaning of a short text or of the 'general sense' of a fragment) requires activity organized at a far higher level.
>
> The whole of the subsequent investigation of speech must, naturally, be based on the composite findings, taking into account the previously discerned abnormalities in the sensory and motor functions and in the general behavior of the patient (p. 375).

The specific aspects of receptive speech function, in order of their increasingly more complex developmental level, were expressed in the results of hypotheses five, six, seven and eight. The sum of the performance of the subjects, in this study, on the above mentioned hypotheses constituted the data for testing this hypothesis -- Hypothesis 4.

Hypothesis 4 (Table 4) was rejected after a one-way analysis of variance (ANOVA). Groups A (ABV) and C (RSV) were similar to each in their performance. The Tukey's Test of Group Comparison indicated that Group B (CBV) achieved the lowest performance level of the three groups, in a manner which set them significantly apart from the other groups. A close inspection of Figure 4 illustrates that the three groups had a negligible chance of overlapping with each other. Therefore, in terms of overall receptive speech function, Group C (RSV) performed better than the other groups, but in a separate and nonsignificant way from Group A (ABV). Groups A (ABV) and B (CBV) performed in a separate manner from each other, and in a significant manner, with Group B (CBV) being the lesser of the two.

Hypothesis 5

The Total Sound Perception Subsection Test Score of the RSF, as measured by the RSF, did not demonstrate differences between Group A

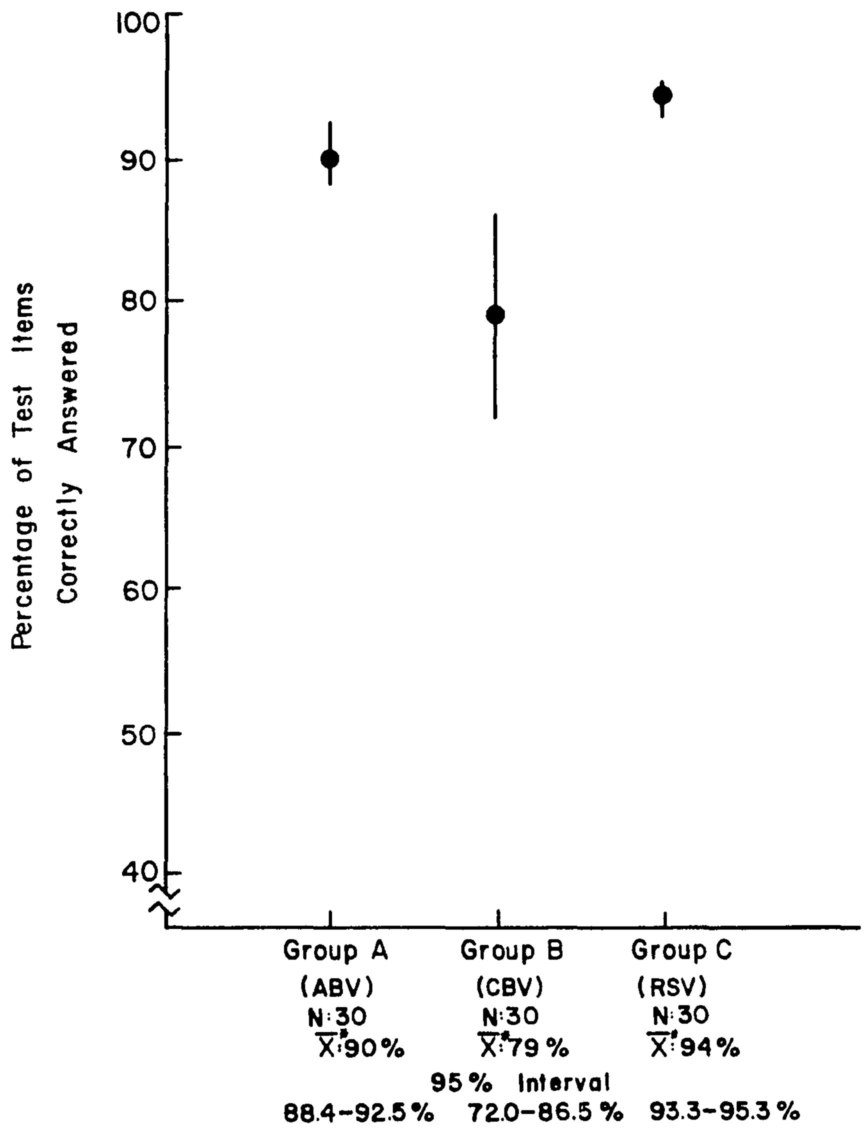

Figure 4. Means and 95% confidence intervals about the means of the three groups on the Receptive Speech Function Test Section (RSF) of the RBNT

(Adventitiously Blinded-ABV), Group B (Congenitally Blinded-CBV) and Group C (Control-RSV) Subjects.

This subsection was composed of six subtests which were geared to assess the subject's capacity to receive and retain the essential elements of receptive speech or phonemic hearing. The cortical site of such activity was understood to be the posterosuper region of the temporal lobe of the dominant hemisphere (A. R. Luria, 1966). The subtest items were given by tape recorder, and the subjects were instructed to repeat verbatim what they heard.

Subtest one contained simple phonetic units or letters of the alphabet, presented one at a time. The morphemes "sh" and "th" were included for the purpose of assessing the subject's tendency for inertia. The precise or exact pronunciation of these morphemes was not of critical importance. The second subtest was comprised of items made up of two phonetic units such as "m-p". The subject was to repeat them separately in a smooth and clear manner, resisting the tendency to consolidate them into a meaningless morpheme such as "mp". Subtest three was again composed of sets of two phonetic units. However, half of the items were made up of correlative phonemes (p-b) where an error is likely because of the similarity of the vocal-motor movements required to produce each sound. These types of errors were resisted by accurately discriminating the received sound. The remaining half of the items were oppositional phonemes (g-k). They were more easily discriminated, and errors did occur as a function of either poor auditory reception or poor pre-motor and motor differentiation through to vocal-motor apparatus. Subtest four was identical to the third subtest, except that each item was expanded to three phonetic units. This increased the performance demands on the subject. The fifth subtest required the subject to discriminate between two phonetic units, essentially correlative in nature, in terms of either being the same (t-t) or different (d-t). This subtest was more difficult and more dependent upon temporal lobe phonemic hearing. This was due to the fact that the subject was forced to suppress vocal-motor feedback, by placing his tongue between his teeth so movement was visible to the tester. The subject was then instructed to establish a conditioned response to different phonemes by lifting the left hand and the same phonemes by lifting the right hand. Errors on this subtest indicated an inability to distinguish articulemes based upon phonemic properties only (A. R. Luria, 1966). The final or sixth subtest allowed the subject to respond verbatim to the items. However, the difficulty was one of smooth articulation only after phonetically discriminating between three different vocal phonemes associated with an invariant consonant. For example, "bi-ba-bo" or "be-bo-bi". The task was to discriminate the phonetic units within each morpheme (bo, bi, be or ba) and then to accurately establish articulemes with variable endings while enervating any possible tendency toward inertia.

Hypothesis 5 (Table 4) was rejected, but at the minimum level of significance acceptable for this study. In short, the differences in the means of the performance, on this RSF Subsection, of the subjects suggested that they were members of different populations. However, the distinction was not clear. Tukey's Test of Comparison (Table 4) and Figure 5, indicate that Group B (CBV) and Group C (RSV) touched each other at their respective high and low points of their 95 percent

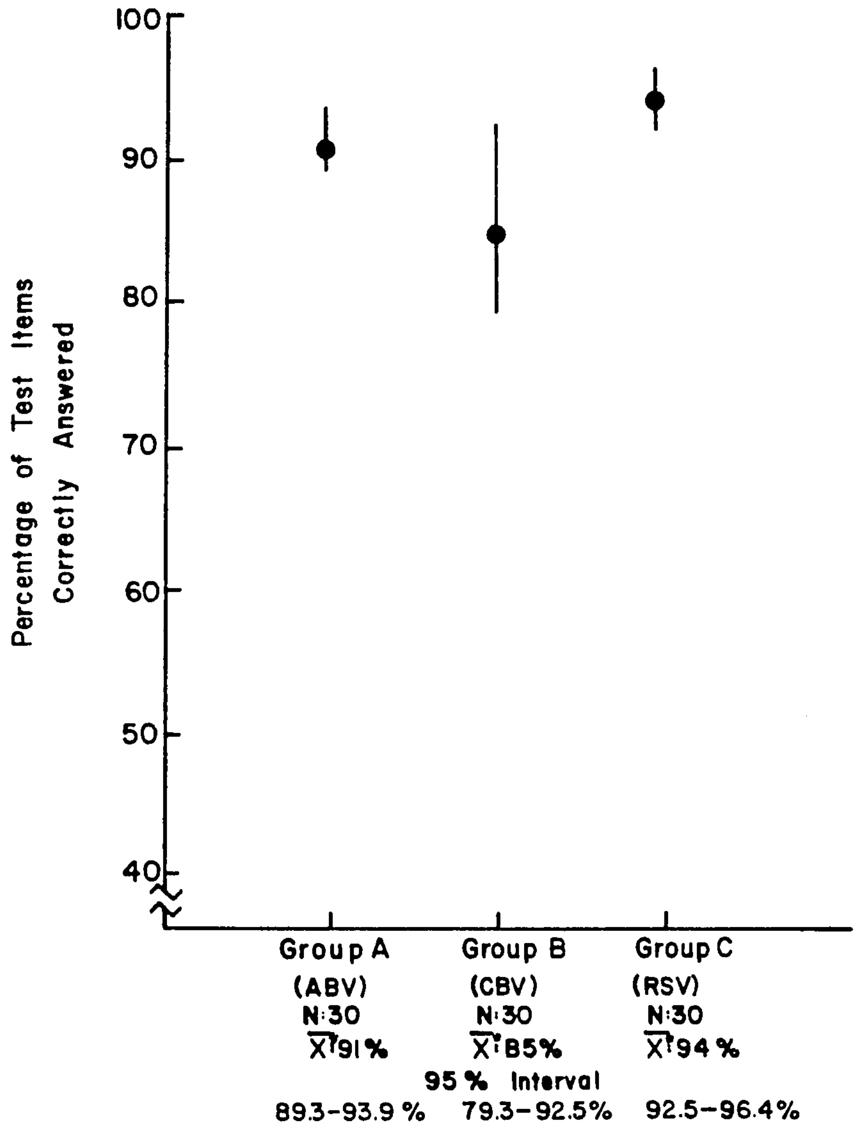

Figure 5. Means and 95% confidence intervals about the means of the three groups on the Sound Perception Subsection Test, of the R&F, on the RBNT

confidence intervals about their group means. This left no middle ground for the Group A (ABV) performance variance. This meant Group A (ABV), in terms of Sound Perception Subsection Test performance, was as much like Group B (CBV) at the low end of their performance variance as they were like Group C (RSV) at the upper end of their performance variance. The only reasonably, and significantly, clear distinction was between Groups C (RSV) and B (CBV).

Hypothesis 6

The Total Word Comprehension Subsection Test Score of the RSF, as measured by the RBNT, did not demonstrate differences between Group A (Adventitiously Blinded-ABV), Group B (Congenitally Blinded-CBV) and Group C (Control-RSV) subjects.

Describing this investigation, A. R. Luria (1966, p. 379) stated,

> . . . to understand words there must be, first, adequately precise and stable phonemic hearing and, second, adequate association between these groups of sounds and the objects, qualities, actions, or relationships denoted by them.

Difficulty or errors on such investigations were caused either by defective phonemic hearing, as the previous hypothesis indicated, or by dysfunctions coming from the temporoccipital cortical areas. The difficulties, encountered in the latter case, were one of confused sound traces or associations of sound groups. However, if perception of individual words were intact but extinction of word meaning occurred, with an increase in the number of words, then the cortical site of dysfunction was within the middle portions of the temporal lobe. The result was a syndrome of acoustico-mnestic aphasia.

The subtests of the RSF Subsection were few and brief. The subject was not required to engage in verbal expression, but rather to respond non-verbally to the items. Subtest one was made up of simple requests to touch a named part of the subject's body. For example, "Touch your 'ear'" or "Touch your 'elbow'." This subtest was of such an elementary nature as to be successfully performed by normal ten year olds (A. R. Luria, 1966). The second subtest was the same but with two or three parts of the body being named. The subject was given two points for a correct performance, one point if he located the parts named but neglected the order stated in the item, and no points were given if the subject either omitted or substituted a location.

Hypothesis 6 (Table 4) was rejected at the least acceptable level of significance (.01). Tukey's Test demonstrated a significant difference between Group B (CBV) as opposed to Groups A (ABV) and C (RSV), which were similar to each other. Figure 6 further illuminates the group comparisons. Groups C (RSV) and B (CBV) demonstrated no overlap of the confidence intervals about their respective means or averaged scores. On the other hand, the Group A (ABV) confidence interval did overlap with the Group B (CBV) interval, but Group A's (ABV) confidence interval engulfed the entire confidence interval of Group C (RSV). The result was an overlapping picture similar to that seen with Hypothesis 5. It was because of the fact that Group C's (RSV) interval range was within Group A's (ABV) interval range so that Group A (ABV) and C (RSV) were clustered together and separated from Group B (CBV); rather than, Group A (ABV) being split between and grouped with the other two samples of subjects.

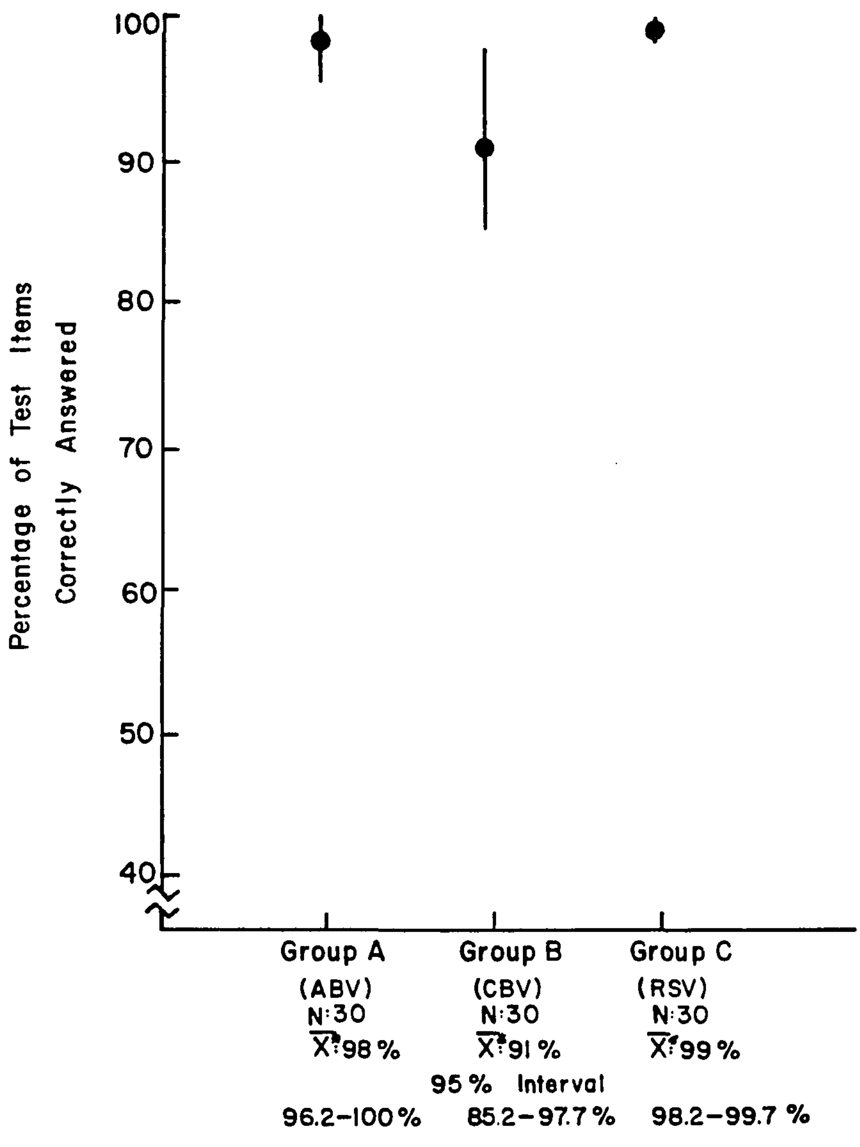

Figure 6. Means and 95% confidence intervals about the means of the three groups on the Word Comprehension Subsection Test, of the RSF, on the RBNT

Hypothesis 7

The Total Simple Sentences Subsection Test Score of the RSF, as measured by the RBNT, did not demonstrate differences between Group A (Adventitiously Blinded-ABV), Group B (Congenitally Blinded-CBV) and Group C (Control-RSV) Subjects.

A. R. Luria (1966, p.382) described the processes and conditions underlying successful Simple Sentences Subsection performance as follows:

> To understand sentences (or, in other words, complete expressions) one must understand individual words, but this is not all. Besides appreciation of the fundamental grammatical structures uniting words into sentences, the ability to retain traces of word series forming sentences in memory and the ability to inhibit premature conclusions regarding the meaning of an expression drawn from only one fragment of the whole phrase are also necessary. If the last condition cannot be satisfied, true understanding of an expression is replaced by a simple guess at its meaning.

Special attention was paid to the presence of difficulties in comprehension of meaning with an increase in sentence length, which suggested problems in the temporal lobe divisions. However, if the difficulty was one of appreciation for only part of a sentence and failure to account for the whole semantic context, problems with the frontal or frontotemporal areas could have been argued for. Although, general brain dysfunction could also have resulted in a similar performance. Finally, if a lack of appreciation for the selective meanings of words, suggesting spatial relationships ("beneath", "above", "before" and "after"), was observed, the conclusions regarding cortical dysfunctions in the parieto-occipital regions within a semantic aphasia syndrome would have been made. Throughout this subsection overt verbalization of the performance instructions, by the subject, was not encouraged. The subject was given three wooden blocks in the shape of a triangle, cross and circle. The subject was told to place them on the table anywhere he would like so long as he was able to remember where the blocks were.

Subtest one required an understanding of simple verbal instructions calling for a single movement toward one of the objects. For example, "Lift the triangle" and "Place one hand on the circle." This also helped to establish the location of the blocks on the table, so subsequent subtests were less a spatial location task and more a test of verbal-semantic understanding, as expressed through the manipulation of the blocks. The second subtest required two movements involving two of the blocks, such as "Hold up the circle and put your hand on the cross." The preferred and correct procedure was one using bimanual manipulation in the stated order. Subtest three was a three level task involving either spatial-object or object-object movement associations. An example would be "Take the circle, put it under the triangle, and hand me the cross." The final subtest (4) was the most complex set of test items. It was composed of a series of statements overtly indicating the movement or use of two of the objects, with an unstated requirement of utilizing the third object within a spatial context. For example, "Put your hands on the blocks with the triangle on the bottom, and the circle in the middle." The unstated condition was that in order for the circle to have been in the middle the cross must have been on the top, since the triangle was on the bottom. The subject must have then placed his hands upon the unmentioned cross not the triangle or circle.

Hypothesis 7 (Table 4) indicated a significant difference in the means of the three groups in this study. The analysis of the variance (ANOVA) suggested that the three groups were not members of a common group. As a consequence, Hypothesis 7 was rejected.

The test of group comparisons, Tukey's Test found on Table 4, points to Group B (CBV) as having been significantly different and low in their Simple Sentences performance as compared to the other two groups. However, Figure 7 clearly shows that both Group A (ABV) and Group C (RSV) did not occupy the same percentage of correct items spread. In short, all three groups were separate from each other, in terms of their respective 95 percent confidence intervals. Yet, Group A (ABV) and Group C (RSV) were seen as being similar because their combined range of correct items answered, accounting for 95 percent the possible movement of their mean scores at any given time, represented the highest 34 percent of the total range of all three groups. Group B (CBV) possessed the lowest 66 percent of the above range without any overlapping with the other groups.

Hypothesis 8

The Total Logical-Grammatical Structures Subsection Test Score of the RSF, as measured by the RBNT, did not demonstrate differences between Group A (Adventitiously Blinded-ABV), Group B (Congenitally Blinded-CBV) and Group C (Control-ABV) Subjects.

A. R. Luria (1966) indicated that this subsection dealt with the most complex form of higher cortical receptive speech activity. It went beyond the identification of objects, actions or qualities

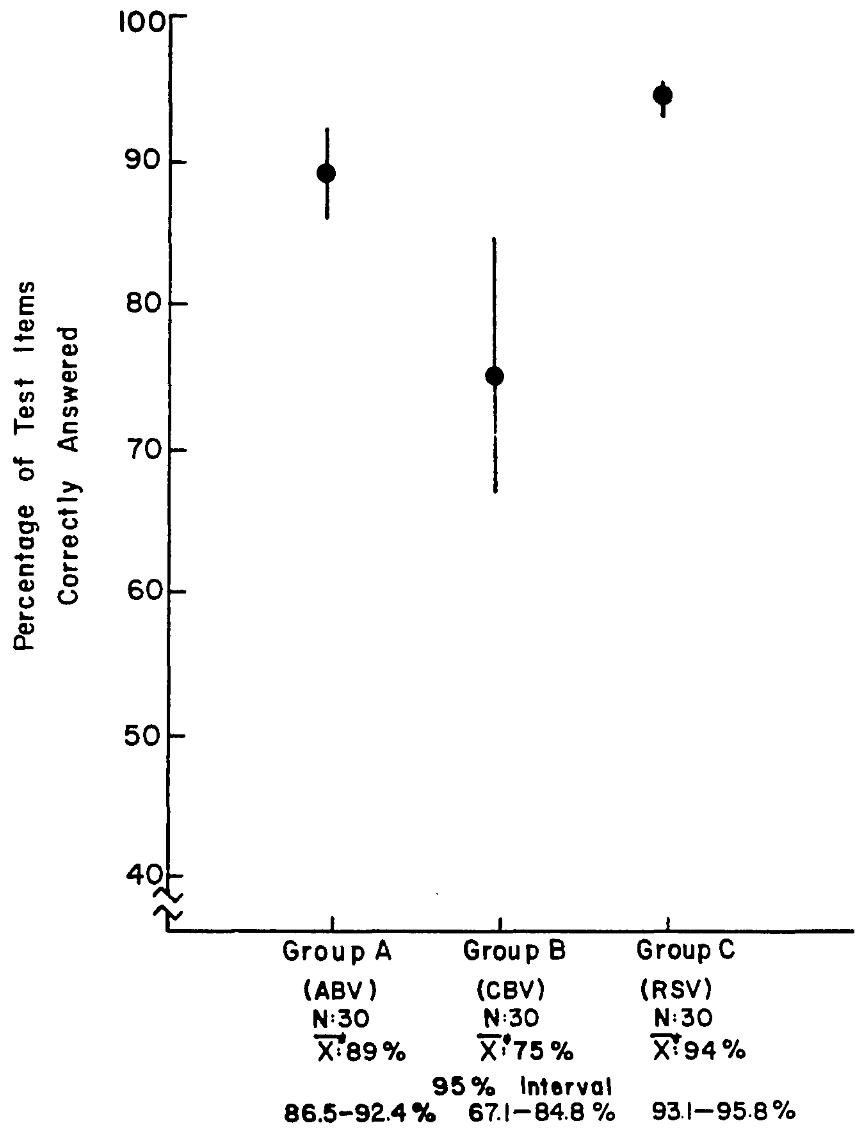

Figure 7. Means and 95% confidence intervals about the means of the three groups on the Simple Sentences Subsection Test, of the RSF, on the RBNT

indicated in a semantic (verbal language) structure. The utilization of special language tools (auxiliary words placed throughout a semantic program) forced the subject to move into areas of connotation of relationships, and deductive logic in deriving extra-semantic or implied characteristics of the relationships, coming from the units making up a given language message.

A. R. Luria (1966) also suggested that persons with deficits of the left hemisphere temporal lobe, resulting in acoustical aphasia, have difficulty with the simple modification of a sentence meaning when a preposition is moved to a different position in the sentence. This difficulty would have been evident on the third subtest. However, subjects with a parieto-occipital problem would have begun to experience deficits in the fourth subtest, when they confront simple semantic data requiring them to orient themselves in relationship to the items language. Finally, those with lesions of the anterior parts of the brain (frontal divisions) or generalized increasing of intracranial pressure (degenerative conditions or similar states) would have begun to have marked problems on the last two subtests, five and six, respectively. It was with these last two subtests that the organization of discrimination (deductive reasoning) came into play, which of course implied adequate generalization ability.

The first subtest was simply for the purpose of acquainting the subject with the physical conditions upon which the subsequent tests were based. The subject was given three objects (a comb, a pencil and a common house key) and told to place them on the table so as to remember their locations. The subject was asked to either point or touch, "two objects in turn by their name." The items were simple statements of two of the objects, such as "comb-key". The second subtest was composed of a series of semantic programs (sentences) using the auxiliary or preposition in such a manner as to dictate a response in the order the objects were named. For example, "Point with the comb to the key." This also required the physical use of one of the objects. Further, this subtest created a semantic based response set which was tested in the third subtest. The third subtest simply moved the preposition so that the formerly established response set was no longer appropriate. It forced the subject to ignore the concrete order of objects being named and to respond to the altered relationship indicated by the special language device (prepositions). For example, "Point to the comb with the key." In short, a semantic-behavior conflict was created. Subtest four required the ability to orient oneself in terms of the relationship(s) indicated by the test item. This orientation of self in terms of the semantic relationship(s) resulted, or should have resulted, in a response pointing to a different relationship and a different verbal label not stated in the item. A sample item was, "Who is your father's brother?" which results in a subject-uncle relationship and the title "Uncle". Subtest five carried the semantic-spatial or sequential relationship analysis to a more complex level. Verbal labels were given for two objects or semantic entities in a particular relationship order, then the same labels were given in a manner suggesting a different order. The subject was to understand the nature of each relationship, compare them against each other, and then select the one which was most appropriate. An example would be, "'Mrs. comes before Mister' or 'Mister comes before Mrs.' which is correct?" These items contained the essential elements of deductive reasoning or comparative analysis. The sixth, and final, subtest increased the semantic or language based relationship comparisons to a level of analysis calling for Logical-Deductive Reasoning predicated upon a capacity for establishing a generalized or common characteristic. Without the ability to glean a common characteristic, from the semantic relationship data, no deductive logic would have been possible. " Olga is lighter than Kate but darker than Sonia, who is the darkest?" was a typical item found in this subtest.

Hypothesis 8 (Table 4) was rejected based upon the results of the one-way analysis of variance (ANOVA) of the three group's performance on this subsection. The Tukey's Test of Group Comparison and Figure 8 pointed to a clear separation between the three groups in terms of a 95 percent confidence interval about their respective means. Because Groups A (ABV) and C (RSV) had a narrow range about their means and occupied little of the total range, as compared to Group B (CBV), they could have been dealt with as one group. It is the B (CBV) group that was markedly different and lower in performance.

Hypothesis 9

The Total Expressive Speech Function Test Section (ESF) Score, as measured by the RBNT, did not demonstrate differences between Group A (Adventitiously Blinded-ABV), Group B (Congenitally Blinded-CBV) and Group C (Control-RSV) Subjects.

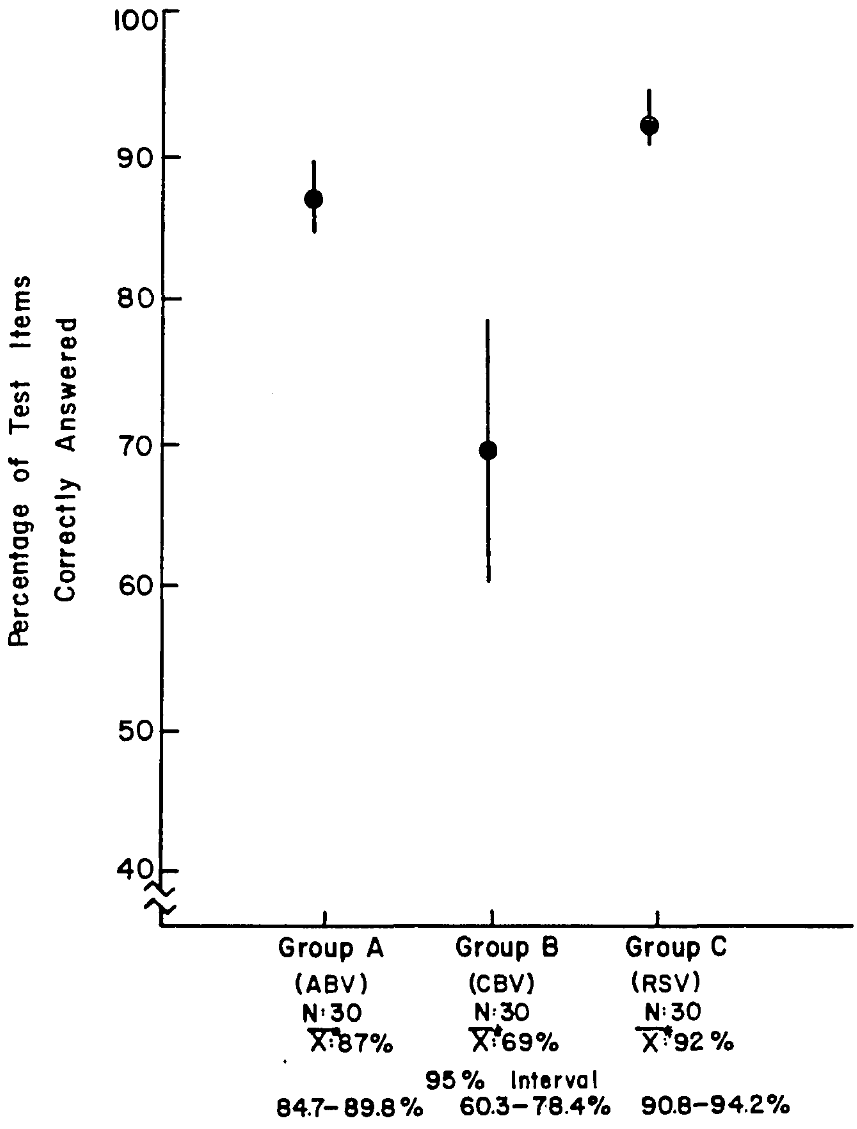

Figure 8. Means and 95% confidence intervals about the means of the three groups on the Logical-Grammatical Structures Subsection Test, of the RSF, on the RBNT

The neuropsychological investigation of expressive speech ability was a less than simple task. Expressing language is a highly developed skill of which writing was seen as a special form by A. R. Luria (1966). Obviously, such a complex cortical function is necessarily a consequence of elementary brain-behavior tasks upon which and from which a succession of brain-behavior tasks of greater complexity are built. This developmental building of cortical functions, facilitated by brain behavior performance consolidation for the purpose of increasing task efficiency, has resulted in what is called speech.

A. R. Luria (1966, p. 390) succinctly described many of the elements, with respect to their order of development as the following:

> The pronounciation of speech sounds and their combinations, . . . takes place on the basis of phonemic hearing; however, the articulation of sound itself plays an active role in the formation of phonemic hearing. The pronounciation of the sounds of speech calls for precision in motor activity, which is possible only when impulses of considerable mobility are accurately directed to their destinations. The pronounciation of words requires a well-established serial organization of consecutive articulations, with adequate inhibition of previous movements and smooth transition to those following; these processes must be accompanied by adequate plasticity in modifying the articulation of a particular sound to conform to its position in the word. The evolution from pronounciation of a word to pronounciation of a whole phrase, and then of a whole sentence, requires, in addition, retention of the general scheme of the phrase or sentence and integrity of the whole of the complex path from the thought to the serially constructed spoken expression; . . . We know that internal speech contributes to this process . . . , although the exact nature of its participation has not been adequately studied.
>
> As was stated previously, expressive speech may be formed at different levels, starting from simple ejaculations or affective exclamations (which may be possible even for patients with the most extensive lesions of the cerebral cortex) and ending with the most highly organized forms of developed speech, as exemplified by monologues.

The sum of the scores from the ESF subsections, obtained by the three groups in this study, constituted the data used for testing this hypothesis.

Hypothesis 9 (Table 4) demonstrated a significant difference in the means of the three groups in this study in terms of their total ESF Test Section performance. The chance of a similar performance being a misrepresentation of their actual performance was one in ten thousand. Therefore, this hypothesis was rejected. The results of Tukey's Test were similar to that found with Hypothesis 8. Finally, Figure 9 showed Group B (CBV) to be the lowest scoring with no overlap with the other two groups. However, Groups A (ABV) and C (RSV) had some minor overlapping and could have been seen as similar to each other.

Hypothesis 10

The Total Articulation Speech Subsection Test Score of the ESF, as measured by the RBNT, did not demonstrate differences between Group A (Adventitiously Blinded-ABV), Group B (Congenitally Blinded-CBV) and Group C (Control-RSV) Subjects.

The first four subtests, of this subsection, dealt with simple articulatory ability (subtests 1, 2 and 3) and with phonemic retention skills while exhibiting articulation (subtest 3). This latter aspect was achieved by having the subject suppress repetition, of a tape recorded word, for five seconds before being asked to clearly repeat what he heard. Subtest four dealt with essential articulatory mobility by having the subject immediately repeat words, which were either unfamiliar or have had a low frequency of use, such as "Anthropomorphic".

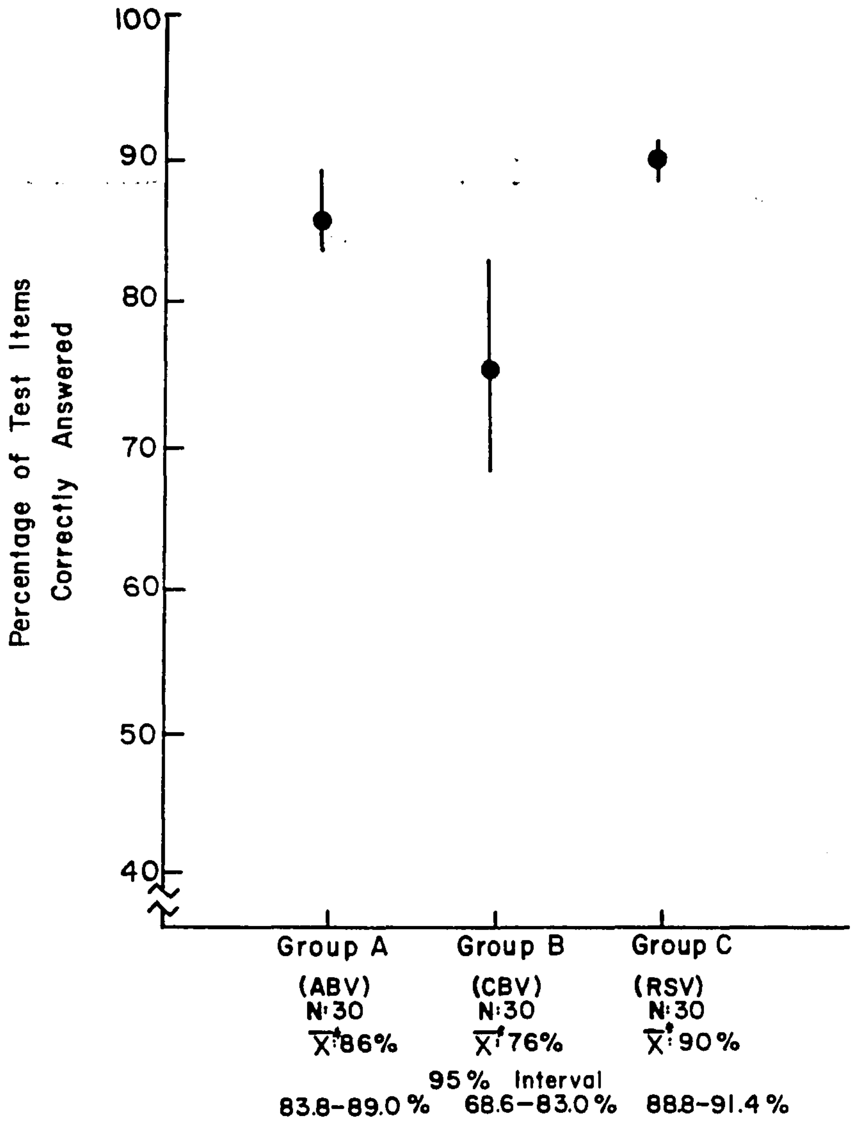

Figure 9. Means and 95% confidence intervals about the means of the three groups on the Expressive Speech Function Test Section (ESF) on the RBNT

A. R. Luria (1966) stated that difficulties were encountered with the first three subtests; particularly, when there was a loss of precise articulation and confusion of similar sounding articulemes. This problem pointed to areas in the inferior parts of the sensorimotor and postcentral zones of the brain. However, problems with the fourth subtest suggested difficulties with the premotor parts of the expressive speech areas, when it came to flexibility and mobility in switching from one articuleme to another.

Subtests five through nine investigated the integrity of word order and range of retention of word traces. These tests revealed pathological conditions such as weakness of acoustic traces, disordering of serial organization, and inertia resulting in stereotype behaviors. Some of the tests were made more difficult by imposing a five second interval between presentation and reproduction.

A. R. Luria (1966) indicated that word repetition difficulties took many forms based upon the type and extent of cerebral impairment. Persons with severe lesions of the left temporal lobe would have been unable to repeat even simple words. Those who knew the word meaning but could not grasp the phonetic composition had a lesser form of this injury. The result was either word substitution (paraphasia) or talking around the target word. Residual forms of this type of injury resulted in successful immediate repetition of word series, but exhibited either perseveration or forgetfulness after a period of delay. Also, difficulties in repeating whole sentences were commonly seen, but the general meaning was often understood. However, problems with serial word repetition could have been observed with subjects having injury to the middle left temporal area or the lower (inferior) temporal zones. Subjects with efferent or motoric aphasia could usually repeat single simple sounds, but they experienced problems with whole words. This was often seen when the ability to switch from one articuleme to another was required. Lesser forms of this impairment (motoric aphasia) exhibited problems in smoothly moving from word to word, but the essential phonetic quality was often retained. Finally, subjects with injury to the left frontal temporal parts of the brain did well in repeating individual words, but they often deranged words presented in a given serial order. These persons tended to have marked difficulty in learning by heart a series of words, despite frequent repetition.

Subtest five asked the subject to immediately repeat three word items, and subtest six was the same except they were to wait five seconds before repeating the words. Subtest seven required the subject to immediately repeat four word items. The eighth subtest demanded of the subject an immediate verbatim repetition of a whole word series (sentences), and subtest nine was the same except it required a five second response delay.

The second, third, sixth and ninth subtests were presented to the subjects by way of a tape recording.

Hypothesis 10 (Table 4) was rejected. The chance that the three groups in this study could have performed on this subsection the way they did and still be members of the same population were one in one thousand four hundred (1,400). The test of group comparisons, Tukey's Test, demonstrated that Group B (CBV) was considerably different and low in their Articulation Speech Subsection performance, as opposed to the other two groups. However, Figure 10 illustrated the nature of the three group's performance, and suggested a less than clean separation between the groups of subjects. The separation between Group C (RSV) and Group B (CBV), in terms of the 95 percent confidence internal about their means, was so small as to allow little room for Group A (ABV). Therefore, Group A (ABV) had a confidence interval that overlapped the other two groups, Group B (CBV) to a greater extent than Group C (RSV).

Hypothesis 11

The Total Nominative Speech Subsection Test Score of the ESF, as measured by the RBNT, did not demonstrate differences between Group A (Adventitiously Blinded-ABV), Group B (Congenitally Blinded-CBV) and Group C (RSV) Subjects.

The Subsection Test actually dealt with two higher order expressive speech abilities.

First, nominative speech functions were briefly tested with the first subtest. A. R. Luria (1966, p. 397) described the processes of nominative speech as follows:

> To refer to objects, actions, or qualities by a particular word demands, first, the integrity of the phonetic composition of the word, a stable association between it and the object that it denotes, and the ability to find easily the required word on presentation of the corresponding visual image. However, the nominative function of speech is also associated with far more complex processes. It assumes that, of all the possible qualities of an object, its special, essential properties will be denoted by a word, i.e., that this object will be analyzed and placed in a particular category.

The second, more complex expressive speech form, was that of narrative speech. Subtests two to ten assessed this skill. A. R. Luria

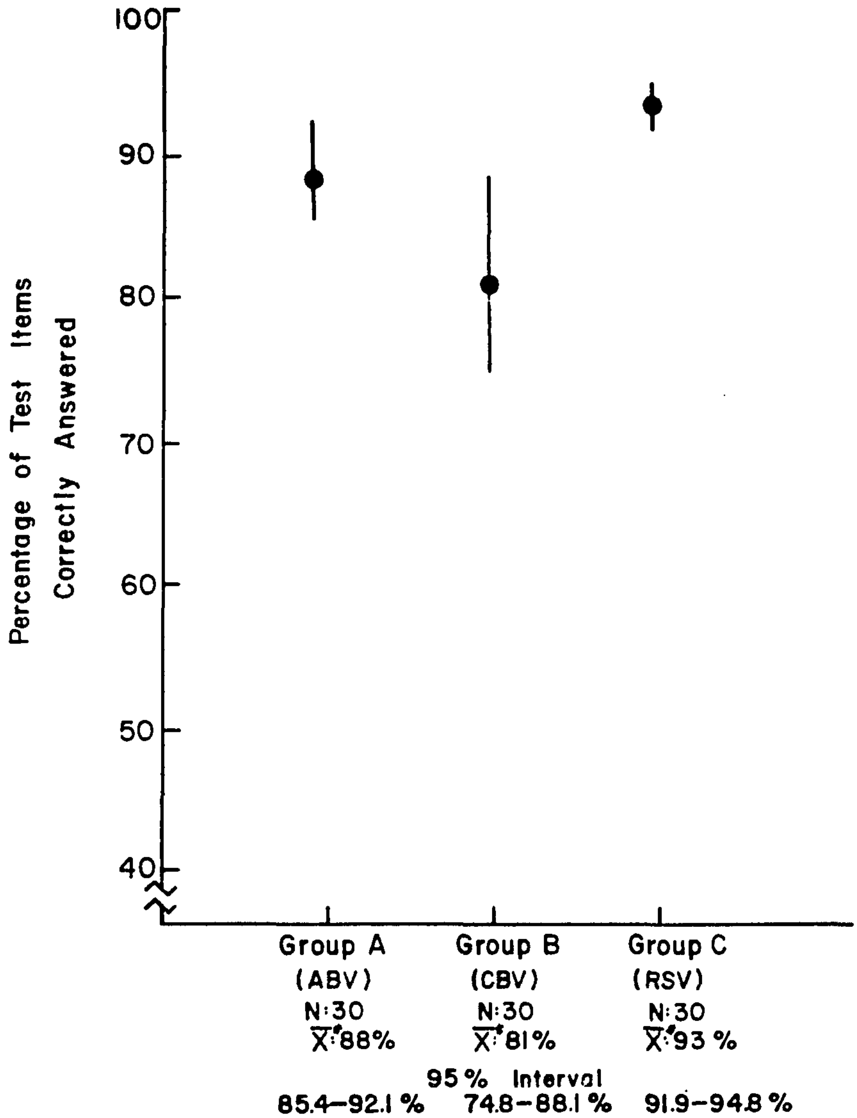

Figure 10. Means and 95% confidence intervals about the means of the three groups on the Articulation Speech Subsection Test, of the ESF, on the RBNT

(1966, pp. 400-402) outlined the nature and development of narrative speech as follows:

> Language, used as a means of communication and intellectual activity, not only gives names to objects, actions, and qualities, but also describes events and expresses thoughts, it does so by means of the mechanism of the syntagma -- the elementary link between two words in a subject-predicate relationship.
>
> It should be added here that predicative speech can express not only events, but also relationships.
>
> Predicative expressions begins when the child's speech consists of a single word; however, with full justification, psychologists assert that this stage is really the stage of the lone-word sentence, ...
>
> It is not until the next stage that the relationship of subject and predicative begins to be introduced into speech itself. This development takes place in the form of a dialogue, in which the complete syntagma (the relationship between subject and predicate) is often shared between two people; the sentence starts off with a question asked by an adult and is finished by the child's reply. It is only in the last stage of development that dialogic speech ceases to be the only form of speech and monologic (narrative) speech in the true sense of the term begins to be formed.
>
> The characteristic feature of the monologic (and, later, of discursive) speech is the nature of the signal prompting its appearance. This signal is no longer a question asked by an interlocutor. It may be either a situation that is perceived and analyzed or a system of pre-existing speech associations formed in his memory as condensed traces and capable of expanding into a monologic expression when a particular situation or intention arises.

Regarding brain-behavior deficits couched in nominative expressive speech dysfunction, temporal lobe injuries within a syndrome of sensory (acoustic) aphasia, were exhibited by word finding difficulty and often utterances of fragmented words of a similar sound. Subjects with extra-auditory division lesions frequently replace the word they are seeking with other words, demonstrating a "talking around the issue" effect. However, if the subject had this "talking around" behavior but quickly found the correct word if given a hint as to the correct sound of the word, then injury to the inferoparietal or parieto-occipital system was suspected. On the other hand, if auditory prompting had little effect, but tactual presentation of an object representing the word resulted in selection of the correct word, injury to the temporo-occipital system was likely. This was similar to optic aphasia. Frontal lobe injury or post-frontal deficits caused problems in spontaneously completing sentences or engaging in spontaneous conversation; although, naming of concrete objects presented no problem. Finally, loss of word traces (forgetting) and object naming difficulty also occurred with generalized injury to the brain, but frequently rapid onset of fatigue and slow sluggish response styles gave clues to this condition.

In terms of narrative expressive speech deficits, one saw problems in reciting common word series, such as the days of the week or months of the year. This disorder of the temporal system was particularly evident when double-tracking or reciting in reverse. Often one saw the subject as having a grossly inadequate vocabulary despite good speech rhythm and intonation. Lesions to the premotor cortical systems manifested themselves as a slowness and unevenness in speech, with a disorganization of speech order or a randomness within the context and framework of the task. Often this was seen as a telegraphic speech style. Attempts at narrative production in the face of left frontal lobe impairment resulted in clear articulation but a marked tendency toward a parrot-like reproduction of questions and test items--echolalic repetition. A lesser form of echolalic speech was seen with patients who tended to imitate the examiner's style and rhythm of speech. However, when these subjects were asked to produce spontaneous speech, not guided by clearly defined questions, they frequently stated they forgot what to do or gave isolated and fragmented expressions.

Subtest one asked the subject to name an object which was not directly named but referred to. For example, "What do you call the thing you use to dry yourself off with after taking a shower?" Subtest two asked for serial speech such as counting from one to ten, and subtest three forced the subject to double-track by counting backwards. Subtest four required the subject to respond in a limited "yes" or "no" fashion, which he determined from the nature of the item. A sample was, "Did you eat this morning?" Subtest five asked the same question in an open-ended manner, "What have you eaten today?" The subject was to elaborate spontaneously within the confines of the question's category -- foods. Subtest six was a simple sentence completion test requiring a response which conformed to the stem by naming the object, event or person described. Subtest seven was similar except now the subject was to spontaneously select a descriptive word suggesting a quality dictated by the stated events or relationships. For example, "He was frustrated and angry, and he acted like a ____ man." Subtest eight demanded the ability to recognize that either a part of speech or an auxiliary grammatical unit was necessary such as, "John may ____ been disappointed after the election." Subtest nine placed increased narrative demands on the subject, requiring the full range of expressive grammatical ability and organization. The subject was given three words and told to use the exact words (emphasized) and whatever additional words necessary to make a complete sentence. At first it was easy, but items near the end of the test were more demanding of the ability to construct a sentence without having given in to the tendency to rearrange their order and simplify the task. Examples of these items were, "autumn - trees - brown" as opposed to "bird - branch - nest". The final subtest was most demanding of the subject's ability to retain specific words and to formulate a general semantic framework (theme and organization) upon which to base an appropriate response. The subject was given a deranged sentence one word at a time, and told to rearrange the words to make a complete sentence.

Hypothesis 11 (Table 4) was rejected. The Tukey's Test of Group Comparison showed the B (CBV) Group to be significantly different and lowest in performance level, on this Subsection Test, as compared to Groups A (ABV) and C (RSV). Figure 11 showed Group A (ABV) and C (RSV) having some overlap with respect to their 95 percent confidence interval about their means. On the other hand, Group B (CBV) was seen as distinctly different from the above mentioned groups.

Hypothesis 12

The Total Arithmetical Skills Function Test Section (ASF), as measured by the RBNT, did not demonstrate differences between Group A (Adventitiously Blinded-ABV), Group B (Congenitally Blinded-CBV) and Group C (Control-RSV) Subjects.

A. R. Luria (1966) alluded to the functional cortical units or structures involved in the development of arithmetical skill in the following:

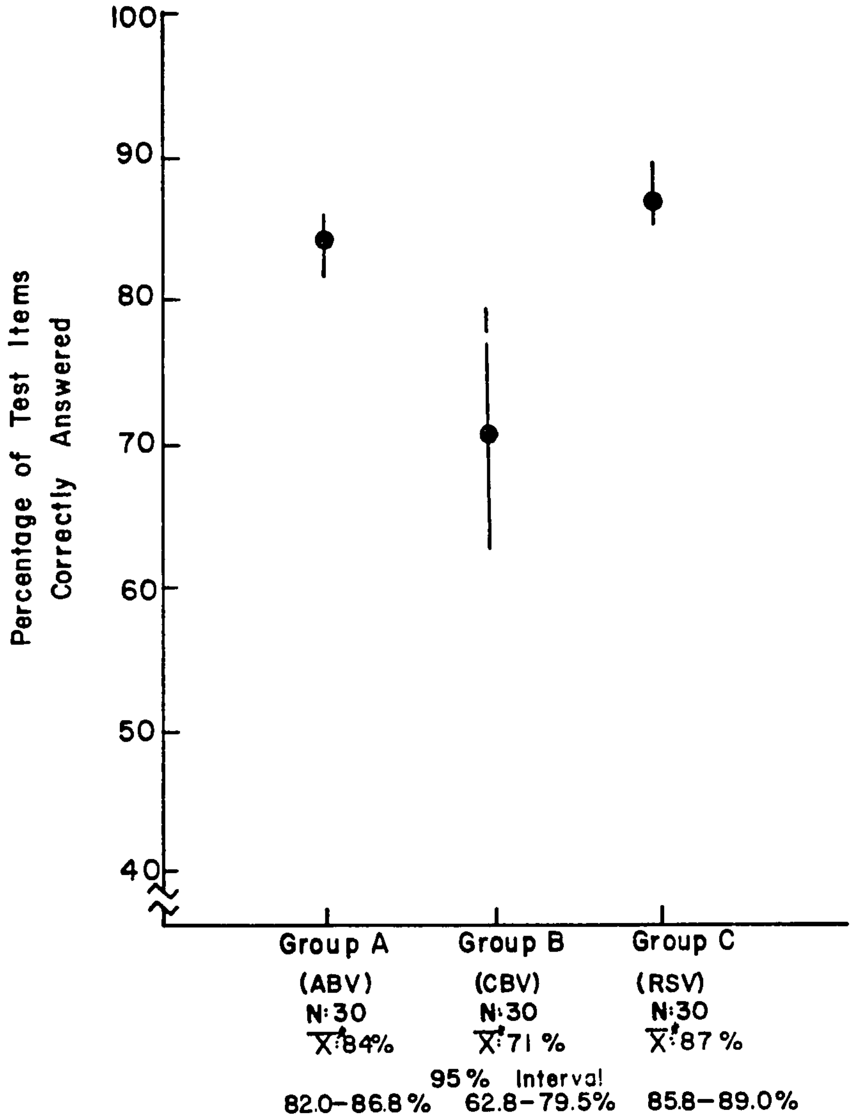

Figure 11. Means and 95% confidence intervals about the means of the three groups on the Nominative Speech Subsection Test, of the ESF, on the RBNT

The reason for this is that arithmetical operations are based on spatial relationships that, in the early stages of mathematical development, were expressed in three-dimensional form in surveying and mensuration. Mathematics only gradually acquired the character of abstract, symbolic processes; despite this fact, however, it maintained its genetic connection with these spatial operations. . . . the stages through which the preschool child passes in developing number concepts, starting with material operations with objects arranged in space, passing through a phase of actions 'materialized' with the hand and gaze, and ending with the formation of tabular calculation, the basis of the true concept of number and of the mental activities fundamental to fully developed arithmetical operations.

The notion of number always rests, to a greater or lesser extent, on some system of spatial coordinates, which may be linear in character or arranged in a tabular system. On this spatial grid the complex system of relationships determined by the decimal system is erected, and it thus provides the true basis of the concept of number and of the operations carried out with its use.

During addition (14+3) or of the symmetrical but opposite operation of subtraction (14-3), we always act within a definite internal spatial field. If this operation necessitates carrying over from units to tens or vice versa (for example, 31-4 or 28+5), the process becomes incomparably more complex. Although it retains its spatial organization, it begins to operate within the framework of a system of graded categories; this adds considerably to the difficulty of the mnestic tasks confronting the person carrying out this operation. The person performing the arithmetical operation must break up the number concerned in order to make it possible to carry out the operation within a single series of ten; only when this has been done can he proceed with the second part of the operation -- adding on the remainder. Initially, this operation is inevitably performed stage by stage -- breaking up the numbers concerned and subsequently adding the remainder while maintaining the correct spatial orientation of the operation. Not until later stages do these operations take on a shortened, direct character; finally, an experienced person performs them automatically.

Although they are based on spatially oriented schemes, the different arithmetical operations differ in the degree to which they retain their association with such schemes. Whereas simple addition and subtraction exhibit this association to the full extent, the simple operations of multiplication and division, based on the multiplication table learned at school, begin to acquire a verbal character and to rest on established verbal stereotypes. The spatial components are relegated to the background and now become obvious only when the process is made more complex and ceases to be automatic in character. This arises, for example,

> if a number containing one digit is multiplied by one containing two digits (still more, if both contain two digits) and in most of the nonautomatized operations of division (pp. 432-433).

The ASF Test Section contained two Test Subsections. The first dealt with an investigation of the understanding of number structure. The second investigated the ability to actually perform arithmetical operations. The total of the scores from these two subsections was the data base for evaluating this hypothesis.

Hypothesis 12 (Table 4) analysis of variance ANOVA) resulted in rejection of this hypothesis. The Tukey's Test of Comparison, also found on Table 4, suggested dissimilarity in the performance of the B (CBV) Group from the other two groups. However, looking at Figure 12 the separation of the B (CBV) Group is clearly seen. Group A (ABV) exhibited some overlap with Group C (RSV) but not to the degree that Group A (ABV) and C (RSV) could have been considered identical. In fact, only the upper 19 percent of Group A's (ABV) total 95 percent confidence internal about its mean overlapped with Group C (RSV). The remaining 81 percent occupied a position of its own between Group C (RSV) and Group B (CBV).

Hypothesis 13

The Total Arithmetical Function Subsection Test Score of the ASF, as measured by the RBNT, did not demonstrate differences between Group A (Adventitiously Blinded-ABV), Group B (Congenitally Blinded-CBV) and Group C (Control-RSV) Subjects.

This subsection was made up of four subtests aimed at assessing the ability to comprehend increasingly more complex forms of numerical structures. The ability to appreciate numerical categorical units was

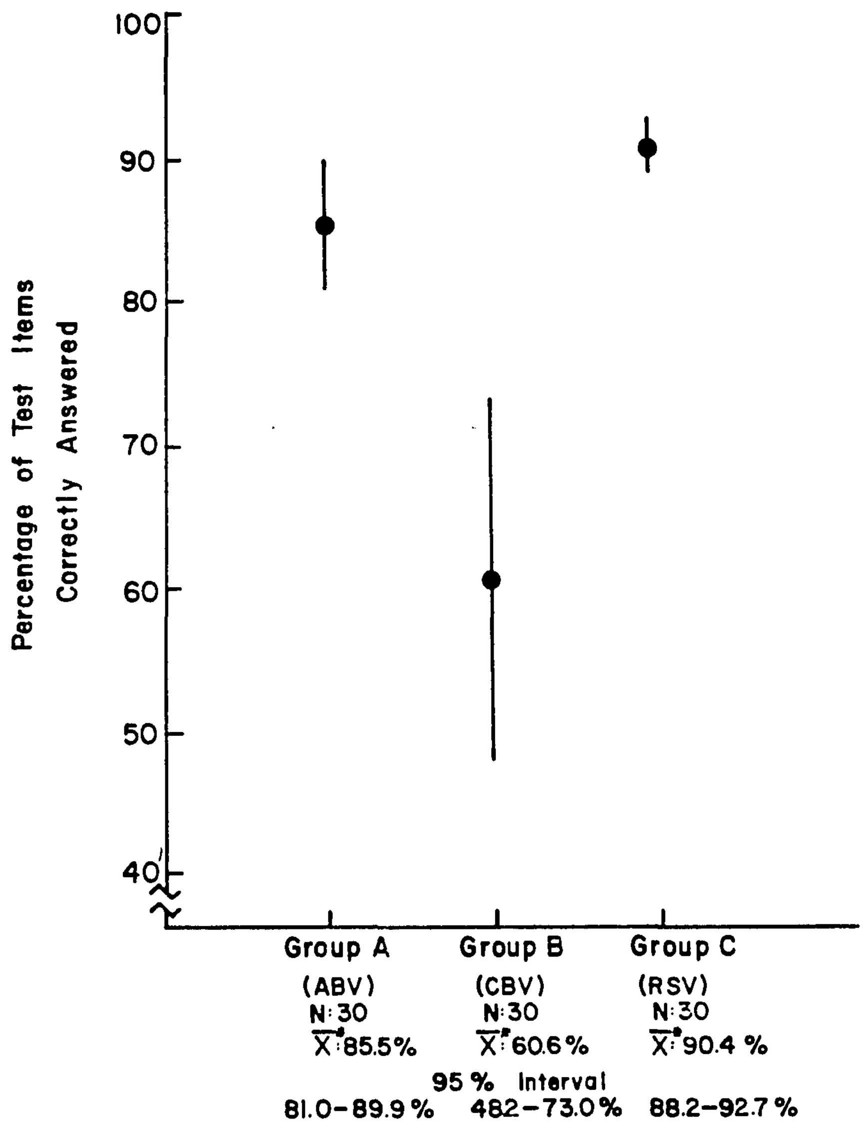

Figure 12. Means and 95% confidence intervals about the means of the three groups on the Arithmetical Skills Function Test Section (ASF) of the RBNT

the primary purpose of this investigation. Subjects with injuries or dysfunctions of cortical structures did, of course, exhibit various difficulties in the appreciation of number categories based upon the location and extent of their lesions. If, for example, there was a failure to understand a number when pronounced, a sensory (temporal lobe) aphasia was seen as present. However, if these persons could still use numbers accurately when calculating then an occipital syndrome or visual-imagery deficit was considered to be absent. Further testing of these individuals demonstrated an ability to select a given number when the parietal system or touch mode of presentation was used. On the other hand, when injury to either the inferoparietal and parietal or parietal-occipital devisions occurred (left hemisphere) serious categorical confusions and numerical miscomprehension of categories were manifested. This was strikingly so when more than one digit or poly-unit numbers were given to the subject. Additionally, the subject with this form of injury had difficulty differentiating directions and/or discriminating right from left. For example, these persons might have selected the numbers 1869 as representing a higher categorical value than 2012. Finally, subjects with a frontal lobe syndrome responded to test items in a sluggish and inactive manner suggesting a loss of spontaneity. Behaviors such as either echopraxic or echolalic (parrot-like) calculations or verbalizations were often seen with the frontal lobe syndrome subject.

The first subtest required the ability to comprehend individual members, when they were nested within a number having a larger numerical category value, and in a correct spatial order consistent with the larger value. A sample of such an item would have been to repeat the larger numerical value of 73 in terms of its constituent numeral categorical values seven and three. The second subtest was a more complex variant where the individual digits, of the larger numerical category, had to be repeated in a mirror-image manner so as to conform to the structure of the larger categorical values. For example, 25 and 52 required a single unit repetition of two five and five two. The third subtest demanded retention of individually stated numerical units, in a left to right spatial order, so as to allow comprehension of the higher value category implied by the number series. One of these test items was six seven eight and one, which when understood became six thousand seven hundred eighty one. The final subtest (4) was a stronger form of the preceding subtest. The subject had to remember two single unit series, convert them into their separate larger numerical categories, and then respond with the larger of the two categorical values. For example, the units four eight nine and the numbers three nine nine should have resulted in the larger numbers four hundred eighty nine and three hundred ninety nine from which the subject should have expressed the former larger categorical value.

Hypothesis 13 (Table 4) was rejected. The Tukey's Test of Group Comparisons pointed to a significantly different and lowered level of performance for Group B (CBV) on this subsection test, as compared to Groups A (ABV) and C (RSV), who were essentially similar to each other. Figure 13 clearly demonstrated Group B's (CBV) separation from the other two groups, with reference to their 95 percent confidence interval about their mean scores. Also, the similarity of Groups A (ABV) and

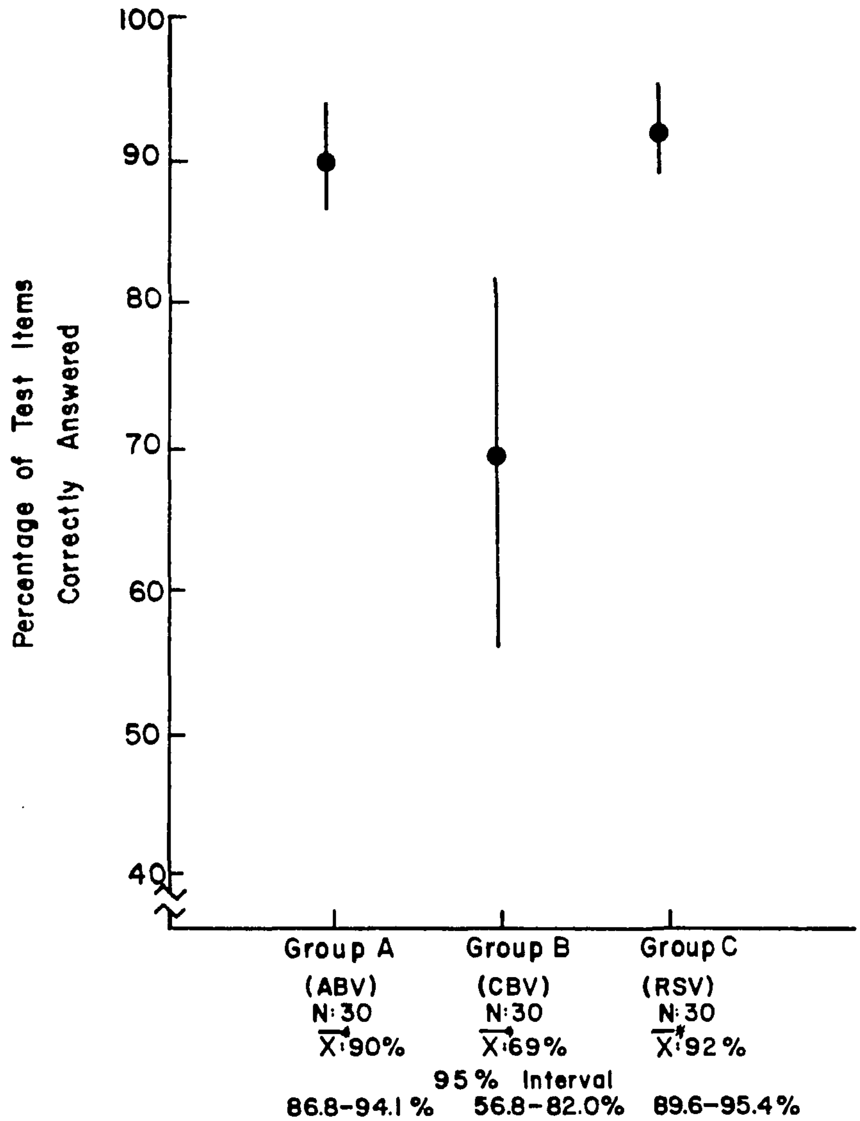

Figure 13. Means and 95% confidence intervals about the means of the three groups on the Arithmetical Function Subsection Test, of the ASF, on the RBNT

C (RSV) was clearly visible, with the upper 61 percent of Group A's (ABV) interval having overlapped with the lower 78 percent of Group C's (RSV) interval. It was within this distinct overlap area that the means of both groups reside.

Hypothesis 14

The Total Arithmetical Operations Subsection Test Score of the ASF, as measured by the RBNT, did not demonstrate differences between Group A (Adventitiously Blinded-ABV), Group B (Congenitally Blinded-CBV) and Group C (Control-RSV) Subjects.

This subsection was built upon the previous subsection. Its purpose was to assess the subject's skill at using categorical numerical structures, so as to correctly perform various arithmetical operations. The brain-behavior correlates demonstrated variability, based upon the cortical site and range of a lesion or dysfunction, in the nature of the difficulties observed. The presence, for example, of primary acalculia or inability to calculate, using simple operations, was evident with inferoparietal or parieto-occipital injury. Since categorical structure was grounded in the spatial position a number occupied, with regard to other numbers, and since lesions in the above mentioned areas effected spatial orientation, the ability to perform arithmetical operations became compromised. This was due to the tendency for the subject to lose control of the number's categorical value during the intermediate steps in the calculation process. On the other hand, a temporal lobe lesion, often part of an acoustic aphasia syndrome, resulted in the subject losing numbers while calculating aloud. However, when these subjects were allowed to use tactile calculating techniques (use of their fingers), the numbers were less likely to be lost and calculation successfully completed. This was because the subject was using a numerical tactile association causing the number to be stabilized by an intact reference system. Yet, even these secondary reference systems broke down under the demands of a complex polydigital arithmetical operation. Subjects with severe frontal lobe dysfunctions often exhibited difficulty with categorical conceptualization and arithmetic operation steps. A common deficit, seen with persons having latent or long standing frontal lobe injuries, was the tendency to engage in outburst of either irrelevant or fragmentary intermediate calculations during the course of an arithmetic operation. The result was not an error in either understanding a numerical value or using the correct mathematical operation, but allowing a contaminated number to creep into the operation process causing an inappropriate conclusion. Finally, when these subjects were faced with a continuous series of calculations, where the repeated ability to hold a new numerical resultant was demanded, they often resorted to a simplification of the correct operational processes or perseveration. For example, when subtracting sevens from one hundred they simplified by holding one unit consistent (97, 87, 77, 67 and 57 . . .) or exhibited outbursts of this behavior during the process. Individuals who suffered from generalized cortical injuries often performed in a wave-like manner. That was, periods of marked quickness and accuracy followed by rapid exhaustion, slowness and operational errors. Finally, it was felt (A. R. Luria, 1966) that motoric or expressive aphasia could have been an adverse effect upon the brain-behavior processes required to adequately perform arithmetical operations.

This was based upon the assumption that much of the intermediate calculations, required in such operations, were influenced by internal speech labels for the various numerical categories involved. However, there was virtually no data or research in this area to support or refute this assumption.

The first subtest asked the subject to demonstrate, verbally, the ability to use the four arithmetical operations on a set of simple automatized mathematical problems. The second subtest involved the more complex mathematic operations, using numbers requiring spatial transfer of numbers from right to left and the altering of numerical category values. Subtest three assessed the subject's awareness of the nature of arithmetic operations, as indicated by the numerical context in which a missing operation was nested. The subject was to provide the missing operation so as to give the calculation meaning. Subtest four demanded of the subject the ability to retain stable memory traces of multiple operations and the necessary steps needed to obtain the correct answer. Each item was a serial mathematical problem. The final subtest demanded stability, selectivity and mobility of operational arithmetic functioning. It assumed good comprehension of numerical categories. The emphasis was placed on the ability to control perseveration or random activity while subtracting a consistent unit value from each preceding stage of the overall operation. In short, it called for the subtraction of a successive series of sevens downward starting from 100. This was called Serial Sevens.

Hypothesis 14 (Table 4) and the Tukey's Test of Comparisons demonstrated findings similar to that seen with the previous hypothesis.

Therefore, this hypothesis was rejected. Furthermore, Figure 14 exhibited a configuration not very different from that found with the preceding hypothesis and its figure. The only difference was that Groups A (ABV) and C (RSV) did not overlap each other as much and their respective mean scores did not rest within the overlap area.

Strength of Association

The Eta (η) Correlation Coefficient was performed on the data from the 14 hypotheses. The results were r's from .30 to .60 with levels of confidence from .01 to .0001. Nine of the hypotheses obtained r's at or above .45 and all at the .0001 level of significance. Squaring the Eta (η) statistic and then multiplying by 100 produced strength of association percentages from 9.3 to 36.3. The Eta Squared (η^2) percentages indicate the amount of variance in test scores accounted for by membership in one of the three groups studied. Table 5 illustrates these results.

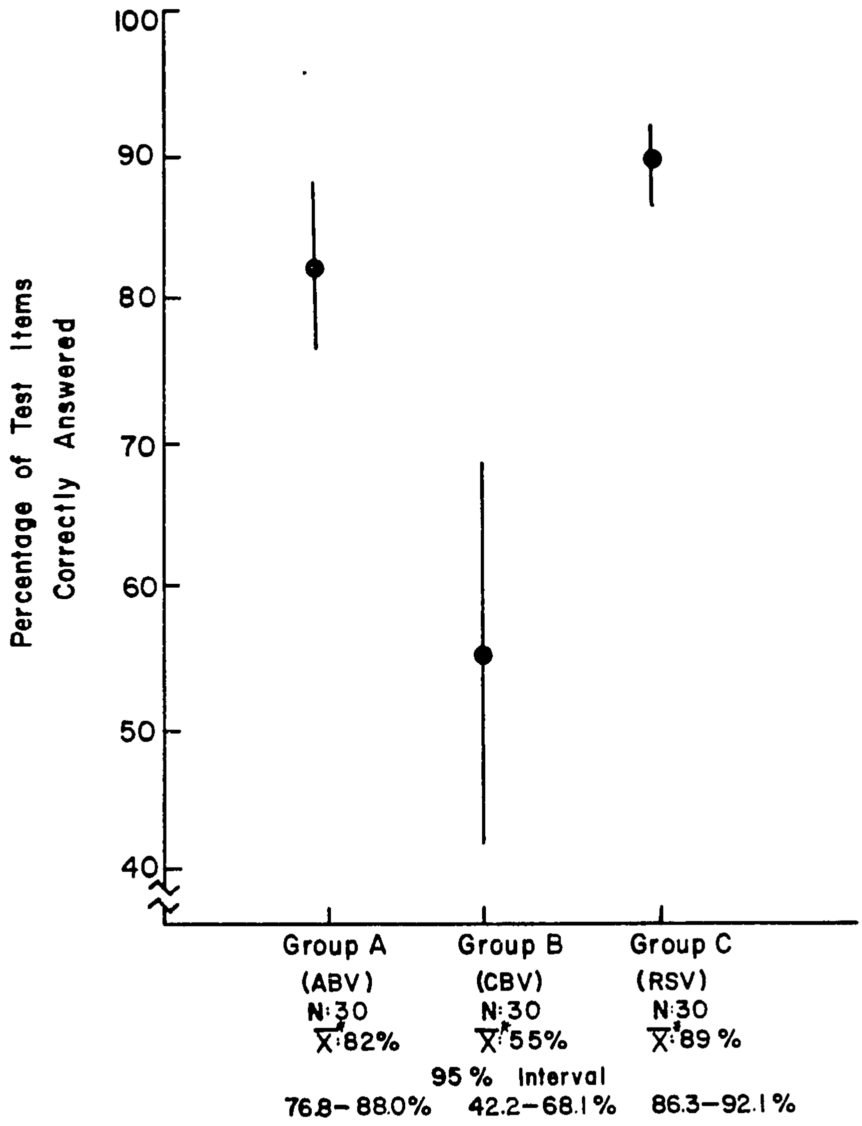

Figure 14. Means and 95% confidence intervals about the means of the three groups on the Arithmetical Operations Subsection Test, of the ASF, on the RBNT

Table 5. Eta (η) Correlation Coefficient and Eta Squared (η^2) strength of association analysis of the three samples in this study by hypotheses. -- (Degrees of freedom: 2 between and 87 within)

Hypothesis	Eta (η) Correlation Coefficient	Eta Squared (η^2) X 100 = Percentage (%) of Variance Accounted for	p Value
1. Total Motor Functions Test Section (MFT)	.60	36.3	.0001
2. Total Acoustico-Motor Coordination Test Section (AMC)	.37	14.1	.001
3. Total Cutaneous Sensory Perception Test Section (CSP)	.35	12.9	.002
4. Total Receptive Speech Function Test Section (RSF)	.48	23.4	.0001
5. Total Sound Perception Subsection Test (RSF)	.30	9.3	.01
6. Total Word Comprehension Subsection Test (RSF)	.31	10.0	.01
7. Total Simple Sentences Subsection Test (RSF)	.47	22.9	.0001
8. Total Logical-Grammatical Structures Subsection Test (RSF)	.56	31.9	.0001

Table 5, continued

Hypothesis	Eta (η) Correlation Coefficient	Eta Squared (η^2) X 100 = Percentage (%) of Variance Accounted for	p Value
9. Total Expressive Speech Function Test Section (ESF)	.45	20.8	.0001
10. Total Articulation Speech Subsection Test (ESF)	.31	10.0	.0007
11. Total Nominative Speech Subsection Test (ESF)	.46	21.7	.0001
12. Total Arithmetical Skills Function Test Section (ASF)	.54	29.2	.0001
13. Total Arithmetical Function Subsection Test (ASF)	.45	20.6	.0001
14. Total Arithmetical Operations Subsection Test (ASF)	.55	31.1	.0001

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

This study was concerned with the neuropsychological or brain-behavior functions of adventitiously blinded adult volunteers, congenitally blinded adult volunteers and randomly selected sighted adult volunteers. The Robinson Adaptation for the Blind: Luria's Neuropsychological Tests (RBNT), as constructed by the investigator, was patterned after and used some of the test items developed by A. R. Luria (1966). It was the neuropsychological instrument used by the investigator to obtain the brain-behavior performance data for this study.

The purpose of this study was to investigate the following:

1. Do blinded adult volunteers differ from sighted adult volunteers on a neuropsychological measure of brain-behavior functions?
2. Do blinded adult volunteers, who lost their sight at birth or within eight weeks following birth differ in their neuropsychology or brain-behavior functioning from blind adult volunteers, who lost their sight at or beyond the age of seven?

The basis for the investigative purposes of this study was two fold. First, a lack of neuropsychological assessment methods with regard to blinded adults. Second, a general hypothesis, formulated by A. R. Luria (1966), arising out of his theoretical concept of a Dynamic Localization of Functional Systems of the Cerebral Cortex, which indicated that blinded adults should exhibit different brain-behavior coming from different functional cerebral cortical systems as a result of their age at onset of blindness.

The total number of subjects was 90, equally distributed between those blinded early in life, those blinded later in life and those with normal vision.

The subjects were between the ages of 17 and 40. There was an even split between the sexes of the participants of this study, and a clear differentiation based upon presence or absence of vision with the participants. Laterality or right handedness versus left handedness distribution was normal with the participants, except for a less than normal tendency for left handedness in the early blinded sample. The early blinded subjects tended to be younger and to have had less exposure to formal education. However, there was a considerable degree of overlap between the three groups on these two variables. Finally, with regard to racial/ethnic membership, the overall picture was one of a near normal percentage of Hispanic (Spanish) American participants and a slight preference for Caucasian (White) American participants, compared with the known racial/ethnic distribution for the geographical area involved in this study. The reason for the larger number of Caucasian (White) American participants was because a lack of representatives from racial/ethnic groups other than Hispanic (Spanish) American.

The 14 hypotheses stated in the Null Hypothesis form -- no difference exists between the mean scores of the three groups of subjects on the RBNT Test Sections and Subsections -- were rejected at the $p < .01$ level of confidence or greater. Nine of these 14 hypotheses were rejected at the $p < .0001$ level of significance. This was based upon a one-way analysis of variance (ANOVA).

A Tukey's Test of Group Comparisons showed that on all the hypotheses, except for Hypothesis 5, Group A (ABV) and Group C (RSV) were not significantly different from each other, and that Group B (CBV) was significantly different and lower in their performance as compared to the other groups. On Hypothesis 5, however, Group A (ABV) was evenly split between the other two groups. Group A's (ABV) lowest scoring half was not significantly different from Group B (CBV) and its highest scoring half was not significantly different from Group C (RSV). The resulting effect was to create two larger groups which were significantly different from each other.

The results of each hypothesis was submitted to an Eta Correlation Coefficient (η). This statistic produced r's from .30 to .60 with levels of confidence of .01 or higher. The Eta (η), when squared and multiplied by 100, produced the percentage of the variance in test scores, by hypothesis, accounted for by membership in one of the three groups in this study. The strength of association percentages ranged from 9.3 to 36.3.

Finally, comparisons of the three groups in terms of their 95 percent confidence intervals about their means, was conducted for each hypothesis. The results showed that on eight of the hypotheses

Group C (RSV) and Group A (ABV) overlapped each other with no overlapping with Group B (CBV). On three hypotheses Group A (ABV) did not overlap either of the other two groups and Group A (ABV) occupied its own middle ground. On the remaining three hypotheses, Group A (ABV) overlapped both Group B (CBV) and Group C (RSV).

Conclusions

Although the subjects in this study were volunteers, the results of the overall descriptive data had characteristics of what would have been expected of a randomization procedure with regard to the following.

1. The equal participation of both of the sexes.
2. Laterality or right handedness with Group C (RSV) and Group A (ABV) only.
3. The percentage of racial/ethnic membership between the majority and predominant minority found in the geographical area where this study was conducted, Caucasian (White) Americans and Hispanic (Spanish) Americans respectively.
4. The ages and formal educational exposure data of the groups, in this study, did not offer enough evidence to rule out the probability of normal representation.

In terms of the purposes for which this study was conducted, it was concluded that the first purpose was only partially answered. Blinded adult volunteers do differ from sighted adult volunteers, but, in general, only if those blinded adult volunteers lost their vision early in life -- at birth or within eight weeks following birth (Table 4, One-Way Analysis of Variance (ANOVA) and Tukey's Test of

Group Comparisons). However, caution must be exercised in assuming that those who lost their vision later in life, at age seven or older, were necessarily similar to the adult sighted volunteers. A good example was the result of the Tukey's Test of Group Comparisons on Hypothesis 5 (Table 4).

The second purpose for which this study was conducted was answered in the affirmative. Adults blinded later in life (age seven or older) did differ considerably from those adults blinded early in life (at birth or within eight weeks following birth), and they did so by exhibiting significantly better neuropsychological or brain-behavior performances. Again, however, this was not an absolute, and Hypothesis 5 (Table 4) demonstrated this fact.

Of equal importance were the conclusions that were drawn from the results of this study, regarding the general hypothesis from A. R. Luria's (1966) theoretical concept of a Dynamic Localization of Functional Systems of the Cerebral Cortex. Applying A. R. Luria's theoretical concept to those blinded early in life as opposed to those blinded later in life, the idea was communicated that those blinded early in life should not perform as well as either normals or those blinded later in life. This contention was, in general, supported by the data which supported the second purpose for this study. However, Luria's theoretical concept also implied that those blinded later in life, although more like normals, should have had brain-behavior functions which had aspects of either those blinded early in life or be separated from both the controls and early blind persons. This second, theoretically based, contention was assessed by looking that the presence or absence of brain-behavior performance overlaps between the three groups of subjects in this study. Looking at Figure 1 to and including Figure 14, which illustrated the 95 percent confidence intervals about the means for each group expressed in terms of percentage of items correctly answered, the presence or absence of neuropsychological performance overlap could be determined. The findings were as follows:

1. On Figures 1, 2, 3, 9, 11, 12, 13 and 14, indicating hypotheses of the same number, Group A (ABV) was similar to Group C (RSV), but Group A (ABV) overlapped with Group C (RSV), not Group B (CBV), and was not distinctly by itself.
2. On Figures 4, 7 and 8, indicating hypotheses of the same number, Group A (ABV) was similar to Group C (RSV), but Group A (ABV) did not overlap with either Group B (CBV) or Group C (RSV) and was distinctly by itself.
3. On Figures 5, 6 and 10, indicating hypotheses of the same number, Group A (ABV) was similar to Group C (RSV), but Group A (ABV) overlapped with both Group B (CBV) and Group C (RSV) and was not distinctly by itself.

Therefore, A. R. Luria's second contention, based upon his theoretical concept of a Dynamic Localization of Functional System of the Cerebral Cortex, was, in general, supported by the results from this study.

In conclusion, there exists, in the form of The Robinson Adaptation for the Blind: Luria's Neuropsychological Tests (RBNT), a neuropsychological assessment method for blinded adults. This is a method based upon a theoretical concept (A. R. Luria, 1966) of how the cortex of the human brain functions, during the performance of a psychological task, which was supported by the results of the study.

Recommendations for Further Research

The research possibilities using the RBNT are endless. However, there are a number of research possibilities concerned with blinded adults.

First, research into determining whether or not differences exist between subjects, meeting the same criteria as those in this study, when age and education is matched or controlled for in some manner.

Second, based upon the less than normal tendency for left handedness with early blinded adults seen in this study, a distinct research project concerned with blindness, laterality and brain-behavior performance should be undertaken. Questions such as: Does left handedness or sidedness tendency prevail with the early blinded? Is left handedness or sidedness with the early blinded a pathognomonic sign of importance for brain-behavior functions?, should be addressed.

Third, re-test reliability research should be undertaken. Most particularly with the Motor Functions Test Section (MFT), Hypothesis 1, and the Cutaneous Sensory Perception Test Section (CSP), Hypothesis 3, because these two hypotheses contain test items which do not lend themselves to other reliability procedures such as, split-half or odd-even analysis.

Fourth, a research project focusing upon the precise nature of the responses of the three groups in this study, on the Sound Perception Subsection Test Subtests and Items (Hypothesis 5) should be undertaken. This is based upon the unusual results of the Tukey's Test of Group Comparisons for this subsection (Table 4).

Fifth, a validity study should be engaged in to compare the findings of this study to the results of neurologic and neurometric investigations of these three groups of subjects or subjects meeting the same criteria.

Sixth, a reliability project should be undertaken to see if the same results occur when testing subjects, meeting the same selection criteria as this study, from different geographical locations.

Seventh, a reliability project, similar to the one mentioned above, should be engaged in with blinded and sighted adults coming from different racial/ethnic groups. However, in such cross racial/ethnic studies care must be taken to assure a good command of the English language on the part of the participants.

Eighth, a research project should be constructed that lends itself to determining if the RBNT would be a suitable instrument for predicting success or failure in mobility training programs for the blind.

Ninth, blind investigations should be embarked upon to determine if performance on the RBNT, by itself, will identify and separate between adults who were blinded early in life or blinded later in life.

Tenth, if positive findings evolve from research projects five, eight and nine, then rehabilitation retraining methods for the blind should be constructed and tested based upon both the RBNT Test results and a thorough understanding of A. R. Luria's (1966) theoretical concept of the functional cortical systems. Such research should involve the use of the RBNT before and after rehabilitation re-training, as well as, following a period of no training in order to measure the effects of and resistance to change from the re-training.

Finally, basic research into other areas of neuropsychological functioning, with respect to blindness, should be continued. These other areas include the neuropsychology of non-visual memory, in its various modes, the neuropsychology of braille reading as contrasted to sighted reading, and many other aspects of neuropsychological functioning not directly related to blindness but with contributory value.

REFERENCES

Arbit, Jack. Evaluation of the Minimal Brain Damaged Syndrome in Blind Children. Proceedings of the Conference on New Approaches to the Evaluation of Blind Persons, New York: American Foundation for the Blind, Inc., 1968, 133-143.

Bauman, Mary K. Psychological Evaluation of the Blind Client. In Brian Bolton (Ed.) Handbook of Measurement and Evaluation in Rehabilitation. Baltimore: University Park Press, 1976.

Bender, Lauretta. A Visual Motor Gestalt Test and Its Clinical Use. New York: The American Orthopsychiatric Association, 1938.

Ben-Yishay, Yehuda; Diller, Leonard; Gerstman, Louis and Gordon, Wayne. Relationship Between Initial Competence and Ability to Profit from Cues in Brain-Damaged Individuals. Journal of Abnormal Psychology, 1970, Vol. 75, No. 3, 248-259.

Blakemore, Colin. Mechanics of the Mind. Cambridge, England: Cambridge University Press, 1977.

Campbell, D. T. and Stanley, J. C. Experimental and Quasi Experimental Designs for Research. Chicago: Rand McNally, 1963.

Chase, Joan D. A Retrospective Study of Retrolental Fibroplasia. The New Outlook for the Blind, 1974, Vol. 68, No. 2, 61-71.

Christensen, A. L. Luria's Neuropsychological Investigation: Text, Manual, and Test Cards. New York: Spectrum (Halsted Press, John Wiley and Sons, distributor), 1975.

Cohen, Jerome. Brain Waves and Blindness. Proceedings of the Conference on New Approaches to the Evaluation of Blind Persons. New York: American Foundation for the Blind, Inc., 1968, 112-125.

Cohen, J.; Bashes, L. D. and Snider, R. C. Electroencephalographic Changes Following Retrolental Fibroplasia. Electroencephalography and Clinical Neurophysiology, 1961, Vol. 13, 914-922.

Elonen, Anna S. Assessment of the Nontestable Blind Child. Proceedings of the Conference on New Approaches to the Evaluation of Blind Persons. New York: American Foundation for the Blind, Inc., 1968, 104-110.

Fisher, G. H. Spatial Localization by the Blind. American Journal of Psychiatry, 1964, Vol. 77, 2-13.

Freedman, D. A. Congenital and Perinatal Sensory Deprivation: Some Studies in Early Development. American Journal of Psychiatry, 1971, Vol. 127, 1539-1545.

Gesell, Arnold and Amatruda, Catherine S. Developmental Diagnosis. New York: Hoeber Medical Division Harper and Row, 1969.

Gillman, Arthur E. Handicap and Cognition: Visual Deprivation and the Rate of Motor Development in Infants. The New Outlook for the Blind, 1973, Vol. 67, No. 7, 309-314.

Goldstein, Gerald and Shelly, Carolyn H. Statistical and Normative Studies of the Halstead Neuropsychological Test Battery Relevant to a Neuropsychiatric Hospital Setting. Perceptual and Motor Skills, 1972, Vol. 34, No. 2, 603-620.

Goldstein, Steven G.; Deysach, Robert E. and Kleinknecht, Ronald A. Effect of Experience and Amount of Information on Identification of Cerebral Impairment. Journal of Consulting and Clinical Psychology, 1973, Vol. 41, No. 1, 30-34.

Groden, G. Lateral Preferences in Normal Children. Perceptual and Motor Skills, 1969, Vol. 28, No. 1, 213-214.

Hallenbeck, Phyllis N. Some Issues Concerning the Use of Standard Personality Tests with the Blind. Proceedings of the Conference on New Approaches to the Evaluation of Blind Persons. New York: American Foundation for the Blind, Inc., 1968, 70-76.

Halstead, W. C. Brain and Intelligence. A Quantitative Study of the Frontal Lobes. Chicago: University of Chicago Press, 1947.

Halstead, W. C. Biological Intelligence. Journal of Personality, 1951, Vol. 20, 118-130.

Hampshire, Barry E. Tactile and Visual Reading. The New Outlook for the Blind, 1975, Vol. 69, No. 4, 145-153.

Hutt, Max L. The Hutt Adaptation of the Bender-Gestalt Test (2nd Ed.). New York: Gume and Stratton, 1969.

Jones, Bill. The Development of Cutaneous and Kinesthetic Localization in Blind and Sighted Children. Developmental Psychology, 1972, Vol. 6, 349-352.

Klien, G. Blindness and Isolation. Psychoanalytic Study of the Child, 1962, Vol. 17, 82-93.

Lairy, Gabrielle C.: Comments; Cohen, Jerome. Brain Waves and Blindness. Proceedings of the Conference on New Approaches to the Evaluation of Blind Persons. New York: American Foundation for the Blind, Inc., 1968, 125-129.

Lezak, Muriel D. Neuropsychological Assessment. New York: Oxford University Press, 1976.

Linton, Marigold and Gallo, Philip S., Jr. The Practical Statistician: Simplified Handbook of Statistics. Monterey, Calif.: Brooks/Cole Publishing Co., 1975.

Luria, Aleksandr R. Restoration of Function After Brain Injury. New York: Macmillan, 1963.

Luria, Aleksandr R. Higher Cortical Functions in Man. New York: Consultants Bureau Enterprises and Basic Books, 1966.

Luria, Aleksandr R. The Working Brain: An Introduction to Neuropsychology. New York: Basic Books, 1973.

Luria, Aleksandr R. The Neuropsychology of Memory. New York: John Wiley and Sons, 1976.

Malikin, David and Freedman, Saul. Test Construction or Adaptation for Use With Blind Adults. Proceedings of the Conference on New Approaches to the Evaluation of Blind Persons. New York: American Foundation for the Blind, Inc., 1968, 7-14.

Malmo, Robert B. On Emotions, Needs, and Our Archaic Brain. New York: Holt, Rinehart and Winston, 1975.

Marsh, James and Marsh, Gayle. The Study and Clinical Assessment of Higher Cortical Functions. Maricopa Society of Clinical Psychologists Workshop, May, 1976.

Millar, Susanna. Spatial Memory in Blind and Sighted Children. British Journal of Psychology, 1975, Vol. 66, No. 4, 449-459.

Milner, B. Hemispheric Specialization: Scope and Limits. In F. O. Schmitt and F. G. Warden (Eds.) The Neurosciences: Third Study Program. Cambridge, Mass.: MIT Press, 1974, pp. 75-89.

Parmelee, Arthur H., Jr.: Discussant; Cohen, Jerome. Brain Waves and Blindness Proceedings of the Conference on New Approaches to the Evaluation of Blind Persons. New York: American Foundation for the Blind, Inc., 1968, 129-132.

Reitan, R. M. Neuropsychology, Learning Disabilities, and Behavioral Disturbances in Children. 1979 Post-Graduate Institute in Psychology, Central Washington University, Department of Psychology, Ellensburg, Washington, 1979.

Reitan, Ralph M. and Davison, Leslie A. Clinical Neuropsychology: Current Status and Applications. Washington, D. C.: V. H. Winston and Sons, 1974.

Rusalem, Herbert. The Assessment of Blind Persons: The Challenge. Proceedings of the Conference on New Approaches to the Evaluation of Blind Persons. New York: American Foundation for the Blind, Inc., 1968, 2-5.

Symonds, C. and McKenzie, I. Bilateral Loss of Vision from Cerebral Infarction. Brain, 1973, Vol. 80, 415-453.

Warren, David H. Early-vs-Late Vision: The Role of Early Vision in Spatial Reference Systems. The New Outlook for the Blind, 1974, Vol. 68, No. 4, 157-162.

Woolsey, Tom and Van der Loos, Hendrik. Map of the Mouse's Whiskers. In Colin Blakemore, Mechanics of the Mind. Cambridge, England: Cambridge University Press, 1977.

Zaidel, Evan. 'Z-lens' Device Aids Brain Research. American Psychological Association Monitor, 1975, Vol. 6, No. 9/10, 19.