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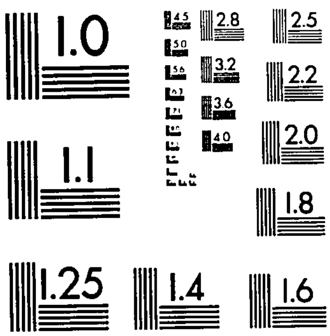

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Daves, Michael Frank

POSSIBLE MISDIAGNOSIS OF BRAIN IMPAIRMENT IN PREOPERATIONAL CHILDREN

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The University of Oklahoma

Graduate College

POSSIBLE MISDIAGNOSIS OF BRAIN IMPAIRMENT IN PREOPERATIONAL CHILDREN

A Dissertation

Submitted to the Graduate Faculty

in partial fulfillment of the requirements for the

Doctor of Philosophy

By

Michael Frank Daves

Norman, Oklahoma

1985

POSSIBLE MISDIAGNOSIS OF BRAIN IMPAIRMENT

IN PREOPERATIONAL CHILDREN

Approved by:

Dissertation Committee

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ABSTRACT

Differences in neuropsychological functioning in eleven areas (motor skills, rhythm, tactile, visual, receptive speech, expressive language, writing, reading, arithmetic, memory, and intelligence) were measured in order to determine the influence of cognitive levels of development (preoperational, transitional, and concrete operational). The Luria-Nebraska Neuropsychological Battery-Children's Revision (LNNB-CR) (Golden, 1980a) was used to measure neuropsychological development and functioning. The LNNB-CR, developed by Golden, is based on Luria's theory (1973 and 1980) of neurological development. The Concept Assessment Kit-Conservation (CAK-C) (Goldschmid and Bentler, 1968), based on Piaget's developmental model, was used to determine cognitive developmental level. A total of 30 subjects were assigned to three groups according to developmental level. Analysis of variance was used to determine differences in neuropsychological results between groups.

Significant differences on the LNNB-CR were found to exist between preoperational and concrete operational groups. The preoperational group scored in the brain-damaged range even though all subjects were screened to eliminate those with any indicator of brain injury. Results indicate that the LNNB-CR is overly sensitive to brain damage. The biasing variable appears to be neuropsychological development as reflected by cognitive level of functioning. A relationship was found to exist between Luria's stages of neurological development and Piaget's levels of cognitive development.

INTRODUCTION

Luria developed a theoretical model of brain functioning involving five sequential neurophysiological developmental stages (Luria, 1973, 1980). The developmental stages are characterized behaviorally by increasing complex motor, visual-spatial, and verbal abilities. Based upon Luria's work, Golden has developed a test for children, the Luria Nebraska Neuropsychological Battery-Children's Revision (LNNB-CR) which assesses these abilities (Golden, 1980). It is designed to differentiate brain damaged from non-brain damaged children.

Piaget's theory of cognitive development (1936, 1937, 1963, 1964) emphasized the role of concept formation in the reasoning process. His model is divided into four sequential stages of cognitive development that closely approximate Luria's neurological states both in terms of chronological sequence and related behaviors. Golden (1980b) has postulated a relationship between these two developmental theories.

The LNNB-CR offers an opportunity to address this possible relationship by virtue of its target population, stage four children. Further, such a potential relationship poses the possibility of a variable other than brain damage that may significantly alter LNNB-CR results. Thus the possibility exists that the LNNB-CR is sensitive not only to brain-damage but also to cognitive developmental levels. If this relationship exists then a preoperational child, presumably at stage three of neuropsychological development, may appear to be brain-damaged on the LNNB-CR even in the absence of any medical indicators.

Luria's developmental model is based on the sequential development of what he identified as the three basic units of the brain; the arousal unit, the sensory input unit, and the output/planning unit (Luria, 1973). Each of these units is further subdivided.

Insert Table 1 about here

The sequential development is divided into five stages, some of which overlap. These stages are specified in terms of behavioral patterns associated with chronological periods which vary somewhat from individual to individual (Golden, 1980a).

Insert Table 2 about here

Stage one begins prior to birth and lasts up to twelve months after conception. It consists of the development of unit one of the brain, the arousal unit, which is the diffuse network of the Reticular Activating System. Rutter

(1980) attributes organic hyperactivity to impairment occurring during this time period.

Stage two develops concurrently with stage one. It involves the primary sub-areas of the second unit (sensory input) and the primary sub-area of the third unit (output/planning). These primary areas dominate the infant's behavior during this period until the secondary sub-areas begin to affect behavior around age two. During this stage basic motor movements epitomize behavior (Van der Vluzht, 1979).

The development of stage three also begins at conception but extends to approximately five years of age. During this stage the secondary sub-areas of the brain mature. These secondary sub-areas have a dominating influence on behavior to approximately eight years of age. It is in these secondary areas that the main site of learning occurs prior to age five (Wilkening and Golden, 1982). Behaviors associated with this stage include infantile discrimination among individuals, language acquisition and motor development such as crawling and walking.

During stage four, five to eight years, the tertiary sub-areas of the second unit, which lead to cross-modality integration, mature. Once the tertiary sub-areas are fully developed toward the end of stage four at age eight, they dominate behavior to approximately age twelve. Golden (1980a) attributes the acquisition of most major educational skills at this age to the functioning of the tertiary parietal areas of the brain at stage four of development.

Stage five is the highest level of brain development. It involves the development and functioning of the pre-frontal areas of the tertiary sub-area of unit three, output/planning. It begins after age twelve and is not complete until the early twenties. Functioning involves such processes as abstract reasoning, creativity, and long-term planning (Golden, 1980a).

Piaget's developmental model in many ways has a striking resemblance to Luria's neurological developmental sequencing. Piaget focused on the role of categorization and concept formation on cognitive development (Bronowsky, 1953). In this regard Piaget offered a comprehensive theory of cognitive development with the emphasis on the acquisition of knowledge and age-related changes in the process of concept formation (Elkind, 1969).

Piaget's (1936, 1937, 1963, and 1964) developmental theory consists of four stages. While there is variation from individual to individual in terms of age of entry and exit from stage to stage, the sequence is invariant (Renner, Stafford, Lawson, McKennon, Friot, and Kellogg, 1976).

Insert Table 3 about here

The sensory-motor stage covers the period in development from zero to two years. During this period the individual moves from a basic reflexive response level of organization wherein the infant can perform coordinated actions upon the immediate environment. During the final portion of this stage the child begins to be able to solve problems in a manner that goes beyond simple trial and error. This is made possible by the beginnings of rudimentary concept formation in terms of symbolic representations of sensory-motor problems (Flavell, 1963). This is demonstrated by the child's ability to conceive that once an object is removed from sight, it still continues to exist.

The next stage, preoperational, lasts approximately from two to seven years of age. Lavatelli (1969) described this stage as characterized by "perceptual boundedness". The decisions a child makes are determined by perception, and they cannot reason beyond this perception or direct experience. The ability to go beyond this perceptual boundedness is made possible by what Piaget (1966) refers to as conservation reasoning.

Conservation reasoning characterizes the stage of concrete operations that takes place from approximately seven to eleven years of age. A variety of approaches have been developed to identify and distinguish the perception-bound preoperational mode of thought from the representational mode of thought of concrete operations. The recurrent theme is identifying whether a child performs conservation reasoning. Renner (1976) refers to this differentiation as follows: "Mentally holding the original image of an object is called conservation reasoning, and preoperational children do not conserve--that is, they make decisions about the distortion of the object on the basis of what they perceive" (p. 32).

Piaget developed several tasks that are used to identify conservation reasoning and thereby distinguish between the preoperational and concrete operational child. Goldschmid and Bentler (1968) have developed a quantitative and normed instrument, Concept Assessment Kit-Conservation (CAK-C), with which to identify conservation reasoning. This allows one to identify children in terms of cognitive development into Piaget's levels of preoperational, concrete operational, and transitional to concrete operational.

The final stage of Piaget's developmental theory is the formal operations period which ranges from approximately eleven to fifteen years of age and beyond. It involves abstract conceptualization in which the individual goes from what is real to what is possible (Inhelder and Piaget, 1958). Flavell (1963) refers to this form of conceptualization as propositional logic.

A comparison of the chronological sequential behaviors between Luria's neurological phases and Piaget's developmental model supports Golden's (1980b) hypothesis of a relationship. Luria's stage one and two, preconception to two years, are similar to Piaget's sensorimotor stage both in terms of chronological approximation as well as related behaviors. The same holds true for Piaget's preoperational level and Luria's stage three. While stage three develops from conception to five years, the typical stage three behaviors are not exhibited until the secondary sub-areas are fully functional during the later portion of this stage and continue to dominate behavior until the tertiary sub-areas of stage four are well developed toward the end of the stage four period, five to eight years. The stage four behaviors typify functioning from approximately age eight until adolescence when stage five begins. This is the period that coincides with Piaget's concrete developmental period. Stage five, pre-frontal lobe development, corresponds closely with Piaget's formal operational level both in terms of age as well as function, abstract reasoning and long-term planning.

This study focused on the possible relationships between the preoperational level of development and stage three of neuropsychological development as well as the concrete operational level and stage four. The LNNB-CR assesses stage four development. Children who are at stage four are expected to score in the normal range on the LNNB-CR. Children who score below are expected to be brain-impaired. Children in this age group, eight through twelve, are also expected to function at a concrete operational level.

One select population of children deviates from these expectations. These are children from an inpatient psychiatric population who fall into the brain impaired range on the LNNB-CR even though there is no current or historical medical indicator of brain-damaging trauma or disease. They also are in the age range wherein they are expected to be at a concrete operational level and function at stage four of neuropsychological development.

This study focused on the above stated population to test Golden's hypothesis of the relationship between neuropsychological levels and Piaget's cognitive levels, as well as to address important issues related to treatment that depend upon accurate diagnosis. It may very well be that these children who test in the brain-impaired range are performing at a preoperational level due to delayed neuropsychological development rather than brain damage. One way to address this hypothesis was to control for medical trauma, disease and age while assessing performance of preoperational, concrete operational, and transitional to concrete children on the neuropsychological measure. Since the age range of the sample was from eight through twelve, with no history of brain damage, the children were expected to be in the normal range for psychiatric patients on the neuropsychological measure and in Luria's stage four of development. However, if the preoperational children performed significantly poorer than the concrete operational children on the LNNB-CR, this was considered to support Golden's hypothesis. Since brain damage was eliminated as a factor, poor performance of preoperational children could be attributed to delayed neuropsychological development.

The purpose of this study was to verify the likelihood of false positives on the LNNB-CR by (1) measuring neuropsychological performance related to Luria's stages three and four of neuropsychological development, and (2) measuring cognitive development in terms of Piaget's preoperational, transitional, and concrete operational functioning.

HYPOTHESIS

1. There will be a significant difference in neuropsychological performance between preoperational and concrete operational children of the same age group even though there is no medical evidence of brain-damaging trauma or disease. A transitional group's scores will lie between preoperational and concrete.

METHOD

Participants

The participants of this study were 30 inpatient psychiatric patients from a major southwestern psychiatric institution. Ages of participants ranged from eight through twelve years with a mean of 10.43 and standard deviation of 1.46 years. Children with a medical or social history of brain-damaging trauma or disease, as well as those with current neurological anomalies as indicated by medical and/or neurological examination, were previously excluded from this study. Twenty-two participants were male and eight were female. Sex difference is not considered a factor in terms of neuropsychological performance.

Independent Measures

The independent variable was cognitive development in terms of preoperational, transitional, and concrete operational levels as measured by the CAK-C. Three groups of subjects were determined on the basis of their performance on the Concept Assessment Kit-Conservation (CAK-C), Form A. The CAK-C is a six-item measure of conservation reasoning. The items measure whether a child conserves in terms of two-dimensional space, number, substance, continuous quantity, weight, and discontinuous quantity. Children who conserved two or less items were considered to function at a preoperational level. Children who conserved five or six items were considered to be concrete operational. Transitional children were identified by conserving three or four items.

The CAK-C was normed on a sample of 142 children using Forms A, B, and C. Loevinger, Kuder-Richardson, and Bentler coefficients were used to determine adequacy of items and reliability. Homogeneities of the three forms were maintained on cross-validation with Bentler indices ranging from .97 to .99, and K-R 20 internal consistency reliabilities ranging from .95 to .97. The Loevinger index serves the same function as Gutman's coefficient of reproduceability. The range from .75 to .84 is considered quite acceptable.

Insert Table 4 about here

Dependent Variables and Measures

The dependent variable in this study was neuropsychological level of development as indicated by functioning in eleven neuropsychological areas: motor skills, rhythm, tactile, visual, receptive speech, expressive language, writing, reading, arithmetic, memory, and intelligence.

The dependent measure was the Luria Nebraska Neuropsychological Battery-Children's Revision (LNNB-CR) (Golden, 1980). The LNNB-CR is a 149 item battery divided into eleven sub-areas measuring brain-related behavior of children from eight through twelve years of age. Norms were established for each age by year. Sub-areas falling above one standard deviation are considered to be in the impaired range. Psychiatric norms were used for the purposes of this study. These norms are more conservative requiring two instead of one standard deviation before reaching levels of significance. More than two elevated scores are considered indicative of brain impairment in the individual. Children in this age group who scored within the normal range were considered to be functioning at stage four of neuropsychological development.

Initial norming by Golden used a sample of 100 children. Fifty were medically diagnosed as brain-damaged and fifty were non-brain-damaged controls. Results indicated significant differences between performance of the two groups on the LNNB-CR at the .05 level. Follow-up double blind studies indicated equivalent diagnostic validity to the adult battery ranging from 86% to 93% in correctly identifying brain-damaged subjects. Test-retest reliability per sub-item ranges from .77 to .96 with mean reliability of .88.

Design

Three groups of ten subjects each were determined according to cognitive developmental level: preoperational, transitional, and concrete operational.

Analysis of variance was used to compare the means of the three groups on the dependent measure, LNNB-CR.

Power was calculated to be .81 with an alpha level at .05 against the hypothesis of 1.5 standard deviation difference between any two groups.

Procedure

Children were screened to eliminate any individual that had a medical history or current indicator of brain damage. All children were medically examined and received EEGs and neurological screening before inclusion. Each child was placed in one of three groups dependent on performance as measured by the CAK-C. Each subject was then assessed using the LNNB-CR.

RESULTS

An Anova on the dependent measure of the LNNB-CR was performed on the three groups, preoperational, transitional, and concrete. The LNNB-CR results were analyzed in two ways. One analysis was performed using the number of LNNB-CR subtests elevated beyond the critical level (T-score of 70 and above) and summed by groups. In addition, results were analyzed using Golden's cutoff of three or more subtest elevations beyond the critical level as indicating brain-damage in the individual. These were then summed and compared across groups.

Insert Tables 5 - 7 about here

Analysis of variance results were significant beyond the .05 level using either the number of LNNB-CR elevations by group or brain damage/non-brain damage cut-offs. Further analysis using pairwise comparisons was performed to determine which group was significantly different from the others.

Insert Tables 8 - 13 about here

All pairwise comparisons each controlling types I and II error rate differently indicated that the preoperational group was significantly different from the concrete operational group at a .05 level using both number of LNNB-

CR critical elevations as well as using Golden's brain damage cut-off.

Insert Table 14 about here

Table 14 indicates mean LNNB-CR subtest scores by group. As indicated, the preoperational group has five subtest means elevated beyond the critical level for psychiatric patients: Receptive Speech, Expressive Language, Writing, Reading, and Math. The transitional group had two elevations above the critical level: Writing and Math. The concrete group had no elevated means.

Insert Table 15 about here

Post hoc correlations representing additional findings were done on all variables and are shown in Table 15. Number of CAK-C items conserved is correlated with number of LNNB-CR elevations at -0.512 and is significant beyond .05 level. Number of CAK-C items conserved is correlated with number of LNNB-CR brain damage indicators (Golden cutoff) at -.466 and is significant at .05 level. Additional analysis was also performed using chi-square measures on brain damage versus non-brain damage among the three groups. This yielded results significant at the .05 level (x^2calc=7.5, for df=2, x^2.05=5.99).

DISCUSSION

These results indicate that cognitive developmental levels do significantly affect LNNB-CR results. Preoperational children appear to be brain damaged even in the absence of current or historical brain-damaging disease or trauma. The LNNB-CR is sensitive to this cognitive level using either the brain damage cut-off or overall differences in total number of neuropathological subtest elevations. The correlation between LNNB-CR results and developmental level is substantial both in terms of brain damage and number of subtest elevations beyond the critical level.

The LNNB-CR was formulated to assess level four of neuropsychological development. As previously indicated children who function in the brain damaged range on the LNNB-CR are considered to have suffered brain injury. However, these results support an alternative possibility that there is a relationship between Piaget's cognitive developmental levels and neuropsychological stages of development. Therefore, preoperational children may indeed be at stage three of neuropsychological development even though chronologically they are expected to be at stage four. Thus the preoperational children may appear brain-damaged on the LNNB-CR due to delayed neuropsychological development rather than disease or trauma.

These results indicate that the LNNB-CR over-diagnoses brain damage. Results suggest that the biasing variable is a cognitive developmental factor related to neuropsychological development not yet at the expected stage as measured by the LNNB-CR. Piaget's cognitive developmental levels appear to be the observable manifestation of Luria's neurological stages. Luria's stages appear to reflect the physiological component of the environmental-biologically determined Piagetian cognitive levels.

Additional findings suggest that the following subtests on the LNNB-CR are more sensitive to the developmental variable: Receptive Speech, Expressive Language, Writing, Reading, and Math. Although Rhythm has been considered most sensitive to elevations in psychiatric populations, the present results indicate otherwise.

Findings in this study indicate that when using the LNNB-CR to assess brain damage, one must also consider whether the subject is at stage four of neuropsychological level of development. A good indicator of neuropsychological stage development appears to be Piaget's cognitive levels. Thus, a preoperational child, even at the appropriate age for the LNNB-CR, will appear brain damaged. Pathological elevations on the indicated scales may not reflect brain damage but rather developmental change in the absence of documented disease or trauma. Therefore when using the LNNB-CR, results should be considered in conjunction with identification of the subjects' cognitive developmental level, preoperational or concrete operational. An area for further study would be the development of a neuropsychological battery that combines measures of cognitive level with items exclusively sensitive to neuropsychological deficits. This would expand the utility of the neuropsychological instrument into areas where developmental factors are of particular concern. This would not only make such an instrument more precise in terms of diagnosis of brain damage, but also provide a means to assess growth associated with arrested neuropsychological development. This would have particular value with children with learning disabilities and organically based hyperactivity, as well as a variety of other psychiatric syndromes, i.e., pervasive developmental disorder.

Areas for further study would be the replication of this design on other special populations such as learning disabled children or non-specialized "normal" children. Another area of further study would also be to compare the relationship between Luria's stage five and Piaget's formal level. This might entail the use of the adult LNNB which is sensitive to stage five. A similar design might be used to compare LNNB results from concrete operational adolescents with formal operational adolescents. The hypothesis would be that concrete level adolescents would do poorer on the LNNB due to the limitations of physiological development rather than brain-damage which would be controlled. This study was based upon results from a psychiatric population where these diagnostic issues are not uncommon. Generalization from this population to a non-specialized population is not possible. However, the hypothesized relationship between cognitive level and neuropsychological stage would seem likely to hold true.

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TABLE 1

Units of Neuropsychological Development

1st Unit (Arousal)

2nd Unit (Sensory Input)

Sub-Areas:

	Primary	Secondary	Tertiary
Sensory Organs	Auditory	-------->	Cross-Modality Integration
	Visual	-------->	
	Tactile	-------->	

3rd Unit (Output/Planning)

Sub-Areas:

Primary	Secondary	Tertiary
discrete movement	continuous movement	conceptualization

Note: Compiled from The Luria-Nebraska Children's Battery: Theory and Initial Formulation by C. J. Golden, 1980a.

TABLE 2

Luria's Neuropsychological Developmental Stages

Stage	Location	Physiological Development	Dominant Period in Behavior
1	Diffuse	Conception to Twelve Months*	Ongoing Influence
2	Primary Sub-Areas of Units 2 and 3	Conception to Twelve Months*	Conception to two years
3	Secondary Sub-Areas of Units 2 and 3	Conception to five years	Two to eight years
4	Tertiary Sub-Area of Unit 2	Five to Eight years	Eight to twelve
5	Tertiary Sub-Area of Unit Three (Pre-frontal)	Twelve to Twenty-four years	Twelve and above

* Twelve months following conception

Note: Compiled from The Luria-Nebraska Children's Battery: Theory and Initial Formulation by C. J. Golden, 1980a.

TABLE 3

Units in the Development of Intelligence According to Piaget

Sensorimotor Period-six stages	
Exercising the ready-made sensorimotor schemes	0- 1 mo.
Primary circular reactions	1- 4 mo.
Secondary circular reactions	4- 8 mo.
Coordination of secondary schemes	8-12 mo.
Tertiary circular reactions	12-18 mo.
Invention of new means through mental combinations	18-24 mo.
Preoperational Period	2- 7 yr.
Concrete Operations Period	7-11 yr.
Formal Operations Period	11-15 yr.

Note: From Piagets Theory: A Primer by J.L. Phillips, Jr., 1981, p. 45.

TABLE 4

Design for Study

Independent Variables

	Conservation Scores
Preoperational	1 or 2
Transitional	3 or 4
Concrete	5 or 6

Dependent Variables

Number of Elevated LNNB-CR Subtests

Number of Brain Damaged vs. Non-Brain Damaged Subjects (LNNB-CR cutoff BD $\geq$ 3 elevated subtests)

TABLE 5

Summary of LNNB-CR Results By Subject Indicating; Number of Subtests Elevated, Brain Damage vs. Non-Brain Damage, and Number of Conservation Tasks Conserved

Group	Subject	Number Elevated	Diagnosis of Brain damage/ Non-Brain damage	Number Conserved
Preoperational	03	6	BD	1.0
	16	5	BD	0.0
	06	9	BD	0.0
	08	3	BD	1.0
	20	7	BD	2.0
	23	8	BD	0.0
	24	1	NBD	1.0
	25	7	BD	0.0
	27	4	BD	1.0
	28	6	BD	1.0
Transitional	05	6	BD	4.0
	04	8	BD	4.0
	07	0	NBD	4.0
	12	4	BD	4.0
	22	0	NBD	3.0
	21	8	BD	4.0
	10	0	NBD	3.0
	11	7	BD	4.0
	26	1	NBD	3.5
	29	4	BD	4.0

TABLE 5 (Continued)

Group	Subject	Number Elevated	Diagnosis of Brain damage/ Non-Brain damage	Number Conserved
Concrete	01	4	BD	6.0
	02	0	NBD	6.0
	09	0	NBD	6.0
	15	0	NBD	6.0
	17	2	NBD	6.0
	18	3	BD	5.0
	13	2	NBD	5.0
	14	5	BD	5.0
	19	0	NBD	5.0
	30	1	NBD	6.0

TABLE 6

Analysis of Variance
Number of Elevated LNNB-CR Subtests
By Group

Source	DF	SS	MS	F	PR > F
Group	2	76.200	38.100	5.59	0.0093
Error	27	184.100	6.819		

TABLE 7

Analysis of Variance of Brain Damage vs.
Non-Brain Damaged By Group

Source	DF	SS	MS	F	PR > F
Group	2	1.800	0.900	4.50	0.0206
Error	27	5.400	0.200		

TABLE 8

Student-Newman-Keuls Pairwise Comparison
for Elevated LNNB-CR Subtests by Groups

Group	Mean
Preoperational	5.60*
Transitional	3.80
Concrete	1.70*

* Significant at .05 level

TABLE 9

Ryan-Einot-Gabriel-Welsch Multiple
Range Test for Elevated LNNB-CR
Subtests by Group

Group	Mean
Preoperational	5.60*
Transitional	3.80
Concrete	1.70*

* Significant at .05 level

TABLE 10

Tukey's Studentized Range (HSD) Test
for Elevated LNNB-CR Subtests By Group

Group	Mean
Preoperational	5.60*
Transitional	3.80
Concrete	1.70*

* Significant at .05 level

TABLE 11

Student-Newman-Keuls Pairwise Comparison for LNNB-CR Brain Damaged vs. Non-Brain Damaged By Group

Group	Mean
Preoperational	0.90*
Transitional	0.60
Concrete	0.30*

* Significant at .05 level

TABLE 12

Ryan-Einot-Gabriel-Welsch Multiple Range Test for LNNB-CR Brain Damaged vs. Non-Brain Damaged By Group

Group	Mean
Preoperational	0.90*
Transitional	0.60
Concrete	0.30*

* Significant at .05 level

TABLE 13

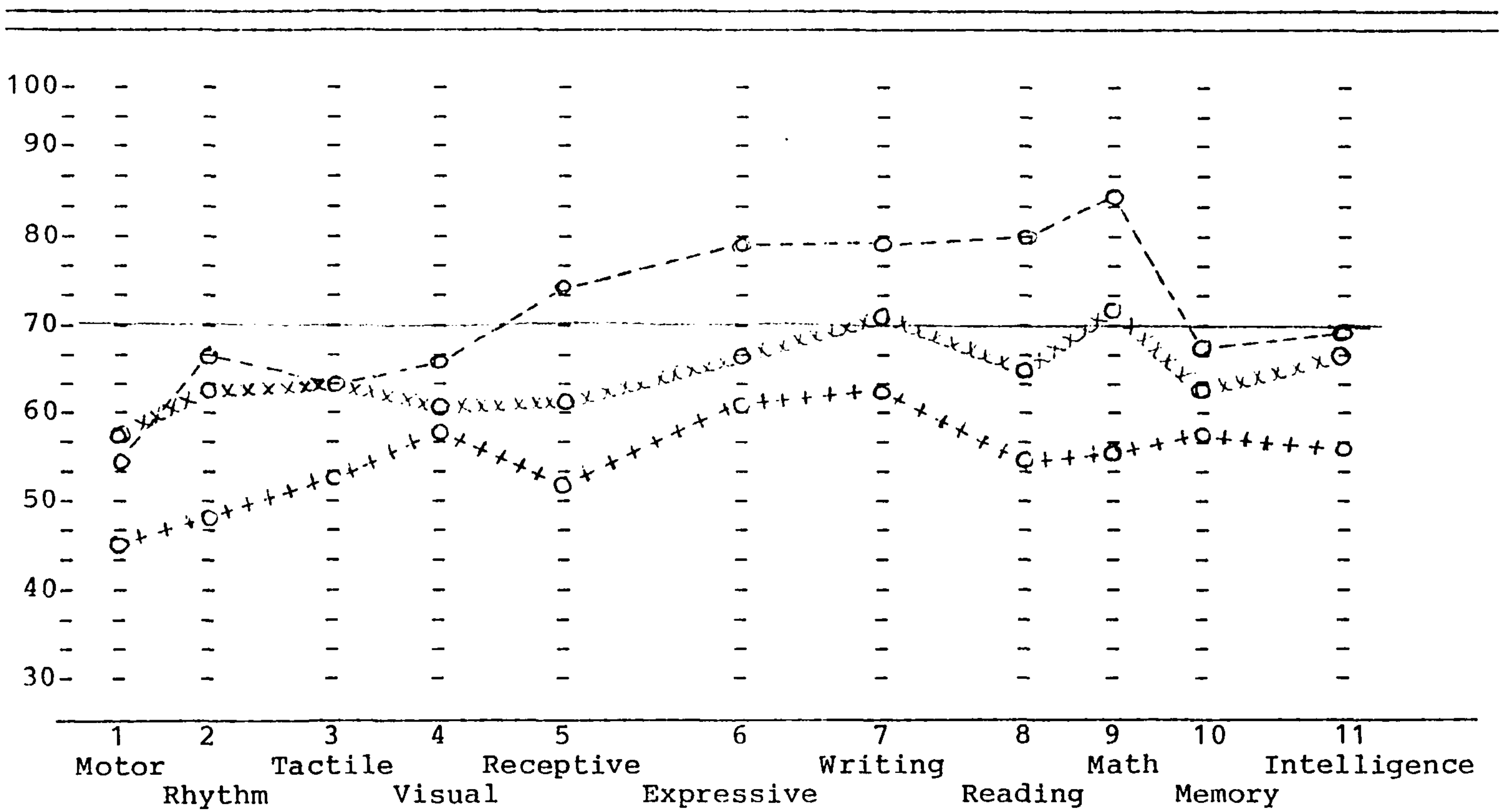
Tukey's Studentized Range (HSD) Test for LNNB-CR Brain Damaged vs. Non-Brain Damaged By Group

Group	Mean
Preoperational	0.90*
Transitional	0.60
Concrete	0.30*

* Significant at .05 level

TABLE 14

Mean T-Score Elevations for Preoperational,
Transitional, and Concrete Groups on the LNNB-CR



o-------------o Preoperational

o-xxxxxxxxxxx-o Transitional

o-+++++++++++-o Concrete

TABLE 15

Correlation for All Variables

Correlation Coefficients/Probability (N = 30)

	Group	Subject	Number Conserved	Brain Damage/ Non-Brain Damage	Number of Elevations
Group	1.000	-0.198	0.959**	-0.500**	-0.541**
Subject	0.294	1.000	-0.223	-0.063	-0.040
Number Conserved	0.001	0.236	1.000	-0.466**	-0.512**
Brain Damaged/ Non-Brain Damage	0.005	0.741	0.009	1.000	0.864**
Number of Elevations	0.002	0.834	0.004	0.001	0.000

* Significant at .05 level

** Significant at .01 level

APPENDIX A

PROSPECTUS

Delworth (1977), addressing the issue of counseling psychology's professional identity, emphasized the importance of normal development as a foundation for counseling psychology. She made the following statement; "Developmental stage theories are increasingly becoming an area of attention for counseling psychologists (Parker, 1973; Widick, 1977; Sprinthall, 1977). We need to seriously study these theories and approaches ..." (p. 45). This study is one attempt to do so by assessing developmental issues in a special population in order to better understand these same issues with broad ramifications for "normal" populations. To investigate the possibility of mistakenly categorizing a subject as "brain impaired" when the underlying issue may be a developmental process is a concern which fits with counseling psychology's emphasis on learning and development (Nathan, 1977).

PROSPECTUS

I. INTRODUCTION

A. Objective

The objective of this proposed study is to analyze the nature of the relationship between neuropsychological development and cognitive development in children. Neuropsychological functioning will be investigated by examining eleven specific areas of functioning: motor skills, rhythm, tactile, visual, receptive speech, expressive language, writing, reading, arithmetic, memory, and intelligence. Cognitive developmental levels will be determined in terms of sensory motor, preoperational, concrete operational, and formal operational levels.

B. Background

1. Definition

a. Developmental Neuropsychology

Neuropsychology is the study of brain-behavior relationships (Wilkening and Golden, 1982). Between the 1940's and the 1960's considerable research was generated in the development of specific tests for the assessment of brain functioning (Chadwick and Rutter, 1983). As researchers' sophistication increased, emphasis began to be placed on the development of neuropsychological test batteries that included a variety of tests designed to assess a wide range of brain functioning. The innovators of this form of research were Halstead (1947) and Reitan (1964, 1968). During the late 1960's and the 1970's attention began to shift toward the studies of Luria (1973, 1980), a Russian neurologist. Luria's theoretical approach offered a developmental model for understanding brain-behavior relationships that went beyond the empirically-based American psychologists' approach. This engendered considerable interest, particularly in the study of brain functioning in children.

Pediatric neuropsychology is made particularly difficult due to the developing nature of the child's brain, wherein all skills do not exist at any given age. Therefore, any assessment must depend upon an understanding of what skills or brain-behavior functioning is expected to exist at any one time in a child's development (Golden, 1980). Luria's theoretical model of brain development and functioning is particularly valuable in identifying stages of neurological development as well as the behavior or skills associated with each stage of development (Luria, 1980a).

b. Cognitive Development

Early theorists approached cognition from a philosophical perspective with emphasis on cognitive or intellectual characteristics as contrasted with affective or conative aspects of the personality. It was not until the early 1900's that objective measurement was introduced with the works of Galton, Binet, Thorndike and Kohler, who made use of experimental paradigms and statistical analysis (Cattell, 1957). This was a prelude to Binet's development of the intelligence test which emphasized the use of verbal symbols, analogies, abstraction, mathematical ability and causal relationships to measure cognitive development (Terman and Merrill, 1937).

Other researchers were more interested in the effects of biological conditions on cognitive development. This led to studies by researchers such as Terman and Burt who studied the effects of age and inheritance (Cattell, 1967). Associated with this area of research was a movement toward the importance of understanding the process of the acquisition of intelligence rather than the measurement of the content of knowledge. Here the focus turned more toward the role of categorization and concept formation on cognitive development (Bronowsky, 1953). In this regard Piaget offered a comprehensive theory of cognitive development with the emphasis on the acquisition of knowledge and age-related changes in the process of concept formation (Elkind, 1969).

2. Characteristics

a. Neuropsychological Development

Luria was first recognized in the United States with the translation and publication in 1966 and 1973 of his earlier works. Christensen (1975) provided more detailed information on Luria's neuropsychological theory and clinical approach. However, Christensen's work was criticized by some, particularly Reitan (1976), for its lack of standardization and supporting experimental data. Golden introduced in 1978 a standardized version of Luria's neuropsychological assessment incorporating Christensen's earlier work (Golden, 1978). Subsequent research led to the finalized version in 1979 by Golden of the Luria-Nebraska Neuropsychological Battery (LNNB).

Early research on the LNNB emphasized its utility in the differential diagnosis of brain-damaged versus non-brain damaged subjects. The LNNB was found to be effective in discriminating control from neurological subjects (Golden, Hammeke, and Purisch, 1978; Hammeke, Golden, and Purisch, 1978; Moses and Golden, 1979; and Duffala, 1978). The reported rate of correct diagnosis ranged from 86% to 93% in terms of identifying neurologically impaired subjects.

Additional research using the LNNB also focused on differential diagnosis between brain damaged and a variety of other clinical syndromes, such as schizophrenia (Purisch, Golden, and Hammeke, 1978; Golden, Hammeke, and Purisch, 1978; and Moses and Golden, 1979), alcoholism (Chmielewski and Golden, 1980), epilepsy (Berg and Golden, unpublished), and Multiple Sclerosis (Golden, 1979). Results support the finding that the LNNB is a sensitive instrument to a variety of neurological disorders.

More recent research has lead to the application of a specialized version of the LNNB to children. In this regard Luria's theories of neuropsychological development are particularly relevant in terms of identifying behaviors and skills associated with the neurological development of the child.

In terms of brain functioning Luria identified three basic units of the brain; the Arousal Unit, the Sensory Input Unit, and the Output/Planning Unit (Luria, 1973). An understanding of this aspect of Luria's theory is pertinent as it forms the basis for the further identification of developmental phases.

The Arousal Unit consists of all those parts of the brain that form the Reticular Activating System (RAS). This is a diffuse system of neurons in the medulla and higher brain areas involving increasing behavioral arousal (Kalat, 1981). In addition to arousal, RAS is also responsible for stimulus filtration or selective attention. Deficits in this area are observed at or near birth and during the first twelve months of development. Golden (1978) attributes some forms of hyperactivity or withdrawal to RAS impairment.

Insert Table 1 about here

The second unit, Sensory Input, is involved with sensory reception and integration (Luria, 1973). This area is identified with learning of early life skills as well as abilities measured by intelligence tests (Golden, 1980a).

There are three sub-areas within the Sensory Input unit: primary, secondary and tertiary. The primary sub-area receives input from the various sensory organs catagorized as auditory, visual and tactile. Corresponding to each of these three primary sub-areas are secondary sub-areas which analyze and integrate the information transmitted to the respective primary areas (Luria, 1980). It is in this secondary area that hemispherical specialization begins to occur (Goldstein, 1974). In most individuals the left hemisphere dominates in the analysis of verbal material, while the right hemisphere predominates in the analysis of non-verbal material (Reitan and Davison, 1974).

It is the tertiary sub-area of the second unit that plays such an important role in the skills often assessed by intelligence tests (Golden, 1980a). The tertiary sub-area is located predominately in the parietal lobe. It is this area where information gathered from previous levels, primary and secondary sub-areas, is integrated across modalities. Thus auditory and visual information from the primary and secondary sub-areas is integrated in terms of the visual-spatial processing necessary for reading. Likewise, auditory-tactile integration occurs in the tertiary sub-area necessary for writing. Golden (1980a) states:

> Indeed with only a few exceptions, all of the skills measured by the Wechsler Adult Intelligence Scale are

> mediated by the tertiary area of the second unit. (p. 67)

The third unit, the Output and Planning Unit, as with the second unit, is composed of three sub-areas; primary, secondary, and tertiary.

The primary sub-area is the motor output area of the brain. Messages are transmitted from this area to particular muscles required in any form of movement from gross motor to fine motor movement including speech production and visual tracking. Closely related is the secondary sub-area which organizes sequential motor movement. Thus while the primary sub-area transmits discrete, individual commands, the secondary sub-area organizes and sequences these discrete messages over time.

The tertiary sub-area of the third unit is composed of the pre-frontal brain lobes of the cerebral cortex. Its functioning is quite different from the aforementioned sub-areas. It is primarily involved in planning (long term), evaluation, temporal continuity, impulse and emotional control, attention focusing and creativity (Golden, 1980a). This area of the brain is relatively late to develop and usually does not begin to function until well into adolescence (Kalat, 1981). As a result the tertiary sub-area of the third unit has little behavioral influence in neuropsychological development until adolesence and early adulthood.

These three units and their respective sub-areas as defined by Luria form the foundation for Luria's concept of developmental sequencing. It is this concept of progressive stages of brain development and associated increasingly complex behavior that makes his contribution to neuropsychological development unique and, as will later be indicated, so relevant to Piaget's theory of cognitive development.

Five stages of neuropsychological development are defined and associated with certain periods of chronological development. The chronological periods are specified in terms of behavioral patterns and vary some from individual to individual (Golden, 1980a).

Insert Table 2 about here

Stage one begins prior to birth and lasts up to twelve months after conception. It consists of the development of unit one of the brain, the Arousal Unit, which is the diffuse network of the Reticular Activating System. The brain is particularly sensitive to impairment during this stage which may result in defects in stimuli filtration and attention focusing. Rutter (1980) attributes organic hyperactivity, as opposed to environmental determinants, to impairment occurring during this time period.

Stage two develops concurrently with stage one. It involves the three primary sub-areas of the second unit (Sensory Input) and the primary sub-area of the third unit

(Output/Planning). These primary areas dominate the infant's behavior during this period of life until the secondary sub-areas of the brain develop. During this stage basic motor movements such as crying and grasping epitomize behavior (Van der Vluzht, 1979).

Stage three also begins at conception but extends to approximately five years of age. During this stage the secondary sub-areas of the brain begin functioning. It is in these secondary areas where the main site of learning occurs prior to age five (Wilkening and Golden, 1982). Behaviors associated with this stage include infantile discrimination among individuals, language acquisition and motor development such as crawling and walking.

Stage four develops from five to eight years and involves the tertiary sub-areas of the second unit, Sensory Input. Golden (1980a) describes this stage as follows:

> The tertiary area parietal is responsible for efficient performance in most major educational skills: reading, writing, arithmetic, grammar, syntax, drawing, logic, analogies, naming, categorizing, dimensionality and other similar skills. Not surprisingly, most major IQ tests tap skills to this tertiary unit. (p. 25)

While this stage develops from five to eight years, it dominates cognitive development from age eight through twelve until stage five. It is this developmental group, stage four, that is assessed by the Luria Nebraska Neuropsychological Battery-Children's Revision (LNNB-CR).

This stage also falls within the same age range as Piaget's level of concrete operations.

Stage five is the highest level of brain development. It involves the development and functioning of the pre-frontal areas of the tertiary sub-area of unit three, Output/Planning. It begins after age twelve and is not complete until the individual reaches the early twenties in age. Functioning involves such processes as abstract reasoning, creativity, and long-term planning (Golden, 1980a).

As will be indicated subsequently the concept of developmental stages, the associated brain-behavior relationships, and the sequence and chronological patterns all bear a striking resemblance to Piaget's concept of stages of cognitive development.

b. Cognitive Development

A major emphasis among researchers and theorists in the area of intellectual functioning has been on categorization and concept development. Kagan (1966) refers to the role of concepts as:

> ... the fundamental agents of intellectual work ... whose theoretical significance parallels the seminal role of valence in chemistry, gene in biology, or energy in physics. (p. 97)

Elkind (1969) defined concept in the following manner:

> Psychologically speaking, concepts are mechanisms by which we attempt to cope with the multiplicity of

> nature. By means of concepts, we are able to deal with new events in terms of past experience, and thus effect a psychic economy through the avoidance of additional efforts at adaptation. (p. 172)

Associated with an interest in concept formation is the influence of age-related changes upon the individual in terms of intellectual development. Diamond (1982) reviewed the literature pertaining to the nature of concepts and the abstraction process and in so doing emphasized Piaget's specification of age related changes in terms of concept acquisition and organization.

Piaget's (1936, 1937 a, b, and 1947) developmental theory consists of four stages. While there is variation from individual to individual in terms of age of entry and exit from stage to stage, the order or sequence is invariant (Renner et al, 1976).

Insert Table 3 about here

As Table Three indicates there is a substantial correlation between Piaget's stages of cognitive development and Luria's stages of neuropsychological development in terms of age approximations. This relationship also exists in terms of behaviors associated with each stage.

The sensory-motor stage covers the period in development from zero to two years. During this period the individual moves from a basic reflexive response level to a level of organization wherein the infant can perform coordinated actions upon the immediate environment. This period is divided into six substages. During the final substage the child begins to be able to solve problems in a manner that goes beyond simple trial and error. This is made possible by the beginnings of rudimentary concept formation in terms of symbolic representations of sensoriotor problems (Flavell, 1963). This is demonstrated by the child's ability to conceive that once an object is removed from sight, it still continues to exist. Languages also begins to develop during this period.

The next stage, preoperational, lasts approximately from two to seven years of age. Piaget (1963) identified five basic characteristics of the preoperational child; egocentrism, irreversibility, centering, states and transformation, and transductive reasoning. Lavatelli (1969) described this stage as characterized by perceptual-boundedness. The decisions a child makes are determined by perception, and they cannot reason beyond this perception or direct experience. The ability to go beyond this perceptual-boundedness is made possible by what Piaget (1966) refers to as conservation reasoning.

Conservation reasoning characterizes the stage of concrete operations that takes place from approximately seven to eleven years of age. Piaget (1966) defined an operation as "an action that can return to its starting point, and that can be integrated with other actions also possessing this feature of reversibility" (p. 36). The concrete aspect of this period refers to the inability of the child to form concepts of an abstract nature that eclipse personal experience. Flavell (1963) distinguishes between preoperational and concrete operational stages in the following manner: "It is simply that the older child seems to have at his command a coherent and integrated cognitive system with which he organizes and manipulates the world around him" (p. 165). A variety of approaches have been developed to identify and distinguish the perception-bound preoperational mode of thought from the representational mode of thought that characterizes concrete operations. The recurrent theme is identifying whether a child performs conservation reasoning. Renner et al, (1976) defines conservation as follows: "Mentally holding the original image of an object is called conservation reasoning, and preoperational children do not conserve--that is, they make decisions about the distortion of the object on the basis of what they perceive" (p. 32).

Piaget developed several tasks that are used to identify conservation reasoning and thereby distinguish between the preoperational and concrete operational child. Some of the criticism of Piaget (Diamond, 1982) has been directed toward his observational methods. This is similiar to Reitan's (1976) criticism of Luria's qualitative methods. As Golden did with Luria, Goldschmid and Bentler (1968) have done with Piaget in terms of offering a quantitative and normed instrument with which to identify conservation reasoning in the form of the Concept Assessment Kit-Conservation.

The final stage of Piaget's developmental theory is the formal operations period which ranges from approximately eleven to fifteen years of age and beyond. This represents the highest form of human intellectual development. It involves abstract conceptualization in which the individual goes from what is real to what is possible (Inhelder and Piaget, 1958). Flavell (1963) defines this form of conceptualization in the following manner:

> The adolescent performs these first-order operations, too, but he does something else besides, a necessary something which is precisely what renders his thought formal rather than concrete. He takes the <u>results</u> of these concrete operations, casts them in the form of propositions, and then proceeds to operate further upon them ... Formal operations, then, are really operations performed upon the results of prior (concrete) operations (p. 205).

These four stages of Piaget's cognitive developmental theory closely parallel Luria's stages of neuropsychological development both in terms of sequence, chronological parameters, and related behaviors or thought processes.

C. <u>Rationale</u>

Based upon the similarities between Luria's and Piaget's theories in terms of age related behaviors, Golden

(1980b) indicated the possibility that the Piaget's stages of cognitive development are related to neuropsychological stages. Luria's stage one and two, preconception to two years, are similar to Piaget's sensorimotor stage both in terms of chronological approximation as well as related behaviors. The same holds true for Piaget's preoperational stage and Luria's stage three. While stage three develops from conception to five years, the typical stage three behaviors are not exhibited until the secondary sub-areas are fully functional during the later portion of this stage and continue to dominate behavior until the tertiary sub-areas of stage four are well developed toward the end of the stage four period, five to eight years. The stage four behaviors typify functioning from approximately age eight until adolescence when stage five begins. This is the period that coincides with Piaget's concrete developmental period. Stage five, pre-frontal lobe development, corresponds closely with Piaget's formal operational level both in terms of age as well as function, abstract reasoning and long term planning.

This study will focus on the possible relationship between the preoperational level of development and stage three of neuropsychological development as well as the concrete operational level and stage four. The LNNB-CR assesses stage four development. Children who perform at this normal level in terms of age-related behaviors are expected to score in the normal range of neuropsychological development. Children who score below are expected to be brain-impaired or functioning at stage three. Children in this age range, eight to twelve, are also expected to function normally at a concrete operational level.

One select population of children deviate from these expectations. These are children from inpatient psychiatric populations who, though in this age range, often continue to be at the preoperational level as well as fall into the brain-impaired range even though there is no social or medical history indicative of brain-damaging trauma or disease.

This study will focus on this population both because of the opportunity to test Golden's hypothesis of the relationship between neuropsychological levels and Piaget's cognitive levels, as well as to address important issues related to treatment that depend upon accurate diagnosis. It may very well be that these children who test in the brain-impaired range are performing at a preoperational level due to delayed neuropsychological development rather than brain damage. One way to address this hypothesis is to control for medical trauma or disease and age while assessing performance of preoperational and concrete operational children on the neuropsychological measure. Since the age range of the sample will be from eight to twelve with no history of brain damage, they will be expected to be in the normal range on the neuropsychological measure and in stage four development. However, if the preoperational children perform significantly poorer than the concrete operational children on the LNNB-CR, this will be considered support for Golden's hypothesis. Since brain damage is eliminated as a factor, the poor performance of preoperational children may be due to delayed neuropsychological development.

This knowledge can greatly effect treatment in terms of patterning intervention on a brain-damaged rehabilitation model or a more cognitive developmental model. In the latter case, the brain-related behaviors in terms of the development of concrete ideation may be expected to develop with appropriate facilitation. In the former case, the behaviors might not be expected to develop and/or alternative behaviors would have to be trained. No specific research has addressed this question.

II. SPECIFIC AIMS AND RESEARCH QUESTIONS

A. Aims

The specific aims of this study are (1) to measure neuropsychological performance related to Luria's stages three and four of neuropsychological development, and (2) to measure cognitive development in terms of Piaget's preoperational, transitional, and concrete operational functioning.

B. Research Statements

1. There will be a significant difference in neuropsychological performance between preoperational and concrete operational children of the same age group even

though there is no evidence of brain damaging medical trauma or disease. A transitional group's scores will lie between preoperational and concrete.

III. METHOD

A. Participants

The participants of this study will be inpatient psychiatric patients from a major southwestern psychiatric institution. Ages of participants range from eight through twelve years. Children with a medical or social history of brain damaging trauma or disease, as well as those with current neurological anomalies as indicated by medical and/ or neurological examination, will be eliminated as participants.

B. Independent Variables

This study will require three groups of subjects: one group functioning at a preoperational level, one group functioning at a transitional level, and one group functioning at a concrete operational level. The Concept Assessment Kit-Conservation (CAK-C), Form A, is a six item measure of conservation reasoning. The items measure whether a child conserves in terms of two-dimensional space, number, substance, continuous quantity, weight, and discontinuous quantity. Children who conserve two or less items are considered to function at a preoperational level. Children who conserve five or six items are considered to be concrete operational. Transitional children will be identified by conserving three or four items.

CAK-C was normed on a sample of 142 children using Forms A, B, and C. Loevinger, Kuder-Richardson, and Bentler coefficients were used to determine adequacy of items and reliability. Homogeneities of the three forms were maintained on cross-validation with Bentler indices ranging from .97 to .99, and K-R 20 internal consistency reliabilities ranging from .95 to .97. The Loevinger index serves the same function as Gutman's coefficient of reproducability. The range from .75 to .84 is considered quite acceptable.

C. Dependent Variables

The dependent variable in this study will be neuropsychological level of development as indicated by functioning in eleven neuropsychological areas: motor skills, rhythm, tactile, visual, receptive speech, expressive language, writing, reading, arithmetic, memory, and intelligence.

The dependent measure will be the Luria Nebraska Neuropsychological Battery-Children (LNNB-CR) (Golden, 1980). The LNNB-CR is a 149 item battery divided into eleven sub-areas measuring brain-related behavior of children from eight through twelve years of age. Norms are established for each age by year. Sub-areas falling above one standard deviation are considered to be in the impaired range. Separate scoring criteria is available for psychiatric populations. More than two elevated scores is considered indicative of brain impairment in the individual. Children in this age group who score within the normal range are considered to be functioning at stage four of neuropsychological development.

Initial norming used a sample of 100 children. Fifty were medically diagnosed as brain damaged and fifty were non-brain damaged controls. Results indicated significant differences between performance of the two groups on the LNNB-CR at the .05 level. Follow-up double blind studies indicate equivalent diagnostic validity to the adult battery ranging from 86% to 93% in correctly identifying brain damaged subjects. Test-retest reliability per sub-item ranges from .77 to .96 with mean reliability of .88.

D. Procedure

Subjects will be screened to eliminate any individual that has any medical history or current indicator of brain damage. All subjects will be medically examined including EEG results and neurological screening before inclusion. Each subject will be placed in one of three equal size groups dependent on performance as measured by the CAK-C. Each individual will then be assessed using the LNNB-CR.

E. Human Experimentation Considerations

Each subject will participate only voluntarily. Consent will be secured by the custodial authority, who will either be parents or the Oklahoma Mental Health Department representative. The research project will also comply with and be approved by the Phil Smalley Children's Center (PSCC) Research Committee. All procedures are non-intrusive. Any participant may withdraw from the study at his or her discretion. Each participant will be an inpatient psychiatric patient placed at PSCC by court order for evaluation and treatment. Results will be coded by subject and only code identification will be used to identify subjects on tests. The code will be kept in a secure location under control of the experimenter. Procedures for the study and rationale will be explained to the custodial authority and to the subject. Results will be made available to custodial authority upon request.

F. Experimental Design

An experimental design using three groups will be used, with equal numbers of subjects assigned to each according to developmental level, preoperational, transitional, or concrete operational.

An Anova will be used to compare the variance of the preoperational, transitional, and concrete operational groups.

Sample size was set at ten per group. Power was calculated to be .81 with an alpha level at .05 against the hypothesis of 1.5 standard deviation difference between any group.

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APPENDIX B

LURIA-NEBRASKA NEUROPSYCHOLOGICAL BATTERY-CHILDREN'S REVISION

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These consist of pages:

P. 71-94

P. 96-100

APPENDIX C

CONCEPT ASSESSMENT KIT-CONSERVATION

APPENDIX D

CONSENT FORM

OKLAHOMA YOUTH CENTER
1120 East Main
P.O. Box 1008
Norman, Oklahoma 73070
405-364-9004

CONSENT FORM

I, ______________________________, voluntarily grant permission for
(Parent or legal guardian)

______________________________ to participate in this study regarding
(subject)

neuropsychological performance and cognitive variables. The above named subject will be administered a Luria-Nebraska Neuropsychological Battery-Children (LNNB-C) and a Concept Assessment Kit - Conservation (CAK-C).

By signing this consent form we have not waived any of our legal rights or released investigators from liability or negligence. We may revoke our consent and withdraw from this study at any time.

The tests administered will be treated as confidential and will receive a code number so they will remain anonymous when filed. In no case will any use of these tests be made other than their application to experimental analysis.

____
(Parent or guardian) (date)

____
(Subject) (date)

Department of Mental Health

APPENDIX E

RESEARCH COMMITTEE CONSENT

OKLAHOMA YOUTH CENTER

Application for Human Subject Experimentation

1. Title Possible Misdiagnosis in Brain Impairment for Pre-operational Children

2. Short title (one word) Misdiagnosis

3. Principal Investigator(s) Michael Daves Phone number 364-9004 ext. 2717

4. Faculty Advisor (if student) Robert Ragland, Ph.D.

5. Number of subjects required thirty (30)

6. Description of subjects: X Below 14 yrs. ____ 14+ yrs. ____ Staff ____

7. Where will the study be performed? PSCC

8. How will subjects be debriefed? (Attach a copy of the information to be offered during debriefing.)
   Individually with researcher. Information conveyed will be overall research findings.

9. Purpose of the investigation: X research ____ training
   Research: All investigative efforts that are intended or likely to be used as contributions to knowledge.
   Training: Other than research defined above, e.g. student class projects and exercises.

10. Describe the design to be used in the investigation, including the statistics which will be used to analyze the data.
    Dependent variable is LNNB-C results. Independent variable is cognitive level (3 groups, Preoperational, Transitional, and Concrete). Anova will be used to analyse difference in LNNB-C results.

For Committee Use Only

1. Experiment name Misdiagnosis

2. Are subjects judge at risk: X no ____ yes
   ____ psychological
   ____ physical
   ____ social

3. Are subjects anonymity-confidentiality protected? X yes ____ no

4. Human Experimentation Committee Approval

   Chairperson Gary W. Williams 6/11/85

   Member T. McClaskha PhD Member Jerry Witte MS

   Director M. Jeffer PhD

   Approved X Disapproved ____

   Comments:

APPENDIX F

SUMMARY STATISTICS

TABLE 16

LNNB-CR Results by Subject and Cognitive Group

	Subject	Motor	Rhythm	Tactile	Visual	Receptive	Expressive	Writing	Reading	Math	Memory	Intelligence
Preoperational	24	63	68	51	57	62	67	59	83	65	55	56
	03	45	48	46	62	76	94	96	93	100	62	78
	16	52	68	61	62	71	69	78	88	84	85	65
	08	57	44	90	78	67	59	66	52	95	65	61
	06	45	84	61	78	89	100	100	100	100	93	91
	20	62	72	72	67	76	73	84	79	76	58	55
	23	65	68	79	84	89	100	100	100	95	65	84
	25	53	72	51	57	76	79	78	79	84	54	74
	27	49	72	47	57	62	76	59	61	84	62	74
	28	55	76	72	57	71	76	72	65	61	78	61
	TOTAL	546	672	630	659	739	793	792	800	844	677	699
	MEAN	54.6	67.2	63.0	65.9	73.9	79.3	79.2	80.0	84.4	67.7	69.9

(CONTINUED)

TABLE 16 (Cont.)

	Subject	Motor	Rhythm	Tactile	Visual	Receptive	Expressive	Writing	Reading	Math	Memory	Intelligence
Transitional	05	63	73	86	41	84	61	100	83	100	65	64
	04	59	88	76	84	58	79	84	89	73	62	78
	07	57	56	47	57	44	35	47	41	57	46	64
	12	65	81	83	57	76	83	53	65	64	54	68
	22	63	40	58	57	40	46	59	56	49	58	61
	21	69	76	72	73	62	73	78	56	84	77	71
	10	50	60	61	67	43	56	66	56	57	50	61
	11	53	56	54	62	76	83	78	83	96	81	81
	26	49	44	44	46	58	74	66	56	54	58	61
	29	49	48	51	57	67	73	78	65	84	78	64
	TOTAL	577	622	632	601	608	663	709	650	718	629	673
	MEAN	57.7	62.2	63.2	60.1	60.8	66.3	70.9	65.0	71.8	62.9	67.3

(CONTINUED)

TABLE 16 (Cont.)

	Subject	Motor	Rhythm	Tactile	Visual	Recep- tive	Expres- sive	Writing	Reading	Math	Memory	Intelligence
Concrete	01	53	68	58	51	71	63	73	70	88	66	65
	02	50	44	44	51	40	46	41	41	42	42	36
	09	40	40	44	62	43	64	41	41	44	50	58
	15	47	48	51	46	49	46	66	52	41	46	55
	17	43	53	61	62	58	84	72	83	61	58	56
	18	57	48	44	62	58	84	72	83	61	58	56
	13	37	52	58	74	40	56	59	56	45	74	58
	14	49	44	60	78	61	76	79	53	73	69	71
	19	41	40	44	52	49	49	47	42	43	46	39
	30	40	40	58	40	53	59	72	56	57	46	61
	TOTAL	457	477	522	579	517	609	622	542	555	572	568
	MEAN	45.7	47.7	52.2	57.9	51.7	60.9	62.2	54.2	55.5	57.2	56.8