A study of the relationship between age and performance on computer-assisted rehabilitation tasks for children

Sanford Paul Martin Jr.

College of William & Mary - School of Education

Follow this and additional works at: https://scholarworks.wm.edu/etd

Part of the Physical Therapy Commons

Recommended Citation


https://dx.doi.org/doi:10.25774/w4-87hv-k172
INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

Bell & Howell Information and Learning
300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA
800-521-0600

UMI®
A STUDY OF THE RELATIONSHIP BETWEEN
AGE AND PERFORMANCE ON
COMPUTER ASSISTED REHABILITATION TASKS
FOR CHILDREN

A Dissertation
Presented to
The Faculty of the School of Education
The College of William and Mary in Virginia

In Partial Fulfillment
Of the Requirements for the Degree
Doctor of Education

By
Sanford P. Martin, Jr.

May 2000
A STUDY OF THE RELATIONSHIP BETWEEN
AGE AND PERFORMANCE ON
COMMUTER ASSISTED REHABILITATION TASKS
FOR CHILDREN

BY

Sanford Paul Martin Jr.

Approved May 2000 by

Charles F. Gressard, Ph.D.
Chairperson of the Doctoral Committee

Victoria A. Foster, Ed.D.

Charles O. Matthews, Ph.D.
Dedication

This work is dedicated to my loving family. First, I dedicate it to my wife, Sheree. You are the best wife anyone could ever have. You have sacrificed yourself, done everything and more to see me through this, despite your own health, teaching full time and being there for Daniel in every way these past two years. Words alone cannot do justice to your honesty, integrity, and humble, loving unselfishness.

Sarah, I am so very proud of you. Your ability to think for yourself is beyond your years. God’s plans for your talents, abilities and future are all unlimited. Daniel, you are the perfect son every father wants. I know your birth and second chance at life are because God has something very special planned for you. You will be great at whatever you and God decide.
# Table of Contents

ACKNOWLEDGEMENTS ................................................................................................. vi

LIST OF TABLES ............................................................................................................... viii

ABSTRACT ........................................................................................................................... ix

CHAPTER ONE - Introduction ............................................................................................. 2
   Description of Problem ............................................................................................... 2
   Theoretical Rationale ................................................................................................. 4
   Definition of Terms ..................................................................................................... 8
   Research Hypotheses .................................................................................................. 9
   Sample and Data Gathering .............................................................................. 10
   Limitations ................................................................................................................... 11

CHAPTER TWO - Review of Literature .............................................................................. 12
   Historical and Theoretical Review ............................................................................. 13
   Attention/Concentration Related Skills ..................................................................... 17
   Visual/Perceptual Skills.............................................................................................. 22
   Visual/Iconic Memory ................................................................................................ 26
   Population .................................................................................................................... 30
   Critique ........................................................................................................................ 34

CHAPTER THREE - METHODOLOGY ............................................................................ 36
   Population .................................................................................................................... 37
   Standardization Sample and Descriptive Variables ................................................. 38
   Instrumentation ........................................................................................................... 40
      The Benton Visual Retention Test – 5th Revision ....................................... 42
      The Trail Making Test ................................................................................... 43
      REACT and Attention Reaction Conditioner .............................................. 44
      Visual Tracking – II ....................................................................................... 45
      SEARCH: Searching for Shapes ................................................................... 46
      Visual Discrimination Conditioner ............................................................... 47
   Research Design .......................................................................................................... 48
   Null Hypotheses .......................................................................................................... 49
   Ethical Considerations ............................................................................................... 49

CHAPTER FOUR - Results ................................................................................................... 51
   Sample .......................................................................................................................... 51
   Findings ....................................................................................................................... 57
   Summary ...................................................................................................................... 64
CHAPTER FIVE – Discussion and Conclusion ......................................................66
  Descriptive Results ........................................................................................67
  Examination by Hypothesis ..........................................................................68
  Limitations .....................................................................................................73
  Implications .....................................................................................................73
  Further Research ............................................................................................75

APPENDICES ............................................................................................................76

REFERENCES ...........................................................................................................83
ACKNOWLEDGEMENTS

I am first of all grateful to my family for their love and support. My wife, Sheree spent all those nights at home alone with a baby and a toddler almost ten years ago while I attended classes in Williamsburg, then took the kids out on Saturday mornings so I could get the class work completed. She has been my first line of computer support, and has never once complained about the time and money this work took away from her. When times were tough and I came home with my heart heavy, Sarah was 7 and Daniel 4, they had a “show” ready to perform where Daniel was Moses in a laundry basket and Sarah was Moses’ sister in a robe with a towel around her head. This reminded me He was still in control.

Kevin Geoffroy, my first advisor and committee chair, was a good and honorable man. He set a course for me to follow that has surpassed several traumas, tragedies and his own legacy.

Rick Gressard stepped in and has patiently waited, guided and directed. He came in with the bases loaded and saved a dissertation situation that had been hit hard by some of life’s biggest hitters. He is the consummate professional.

Chas Matthews kindly agreed to serve on my committee after we lost Kevin Geoffroy. He has been instrumental in shaping my view of counseling. He expanded my worldview to include a theoretical foundation for not just ‘what’, but ‘why’ in counseling. More than once over the years answering the question “What would Dr. Matthews say?” enabled me to make the right counseling decision.

Victoria Foster was so gracious to accept the challenge to join my committee. Her reputation as a valuable and knowledgeable editor for every dissertation is unanimous with every faculty member and student I know.
John Lavach has been my mentor since we first met in the spring of 1990. Without him I would not be completing this part of my life. He has pushed, pulled and coaxed me through more than space allows me to give him the honor he deserves. My hope is that the best is yet to be, that this research is just the first of bigger and better.

When we came down to last minute emergencies, my fellow student, deacon and brother and sister Bud and Charlene Livers stepped in and tackled problems bigger than I could handle. Charlene's phone calls in the middle of my computer catastrophes were more than just coincidence.

My church family deserves acknowledgement for more than I can describe. They have been praying and encouraging me in my doctoral work for years. They have loved and cared for my family through the worst of times. Only God was there the time I could find no literature I needed. When I stood there in the medical school copy room with no time or options left and asked You what I should do, then found my hand resting on a book cart with everything I needed, You affirmed all that I have been doing over these many years.
LIST OF TABLES

Table 1 Sample Demographics ............................................................................................52
Table 2 Simple Visual Reaction (SVR) Mean Scores ..........................................................53
Table 3 Visual Tracking – II (VT-II) Mean Scores .............................................................53
Table 4 Attention Reaction Conditioner (ARC) Mean Scores ..........................................54
Table 5 Visual Discrimination Conditioner (VDC) Mean Scores ....................................54
Table 6 REACT Mean Scores ...........................................................................................55
Table 7 SEARCH Mean Scores .........................................................................................55
Table 8 Trail Making Test (B) Mean Scores .....................................................................56
Table 9 Benton Visual Retention Test – Revised Mean Scores .........................................56
Table 10 Correlations of Age, CART Programs and Standardized Instruments ...............58
Table 11 Correlation Between Instruments and Age ..........................................................59
Table 12 Correlation Between BVRT-R and CART Programs .......................................60
Table 13 Correlation Between Trails (B) and CART Programs ......................................61
Table 14 Correlations Between CART Programs .........................................................62
RELATIONSHIPS BETWEEN AGE AND PERFORMANCE ON
COMPUTER ASSISTED REHABILITATION TASKS FOR CHILDREN

ABSTRACT

The purpose of this study was to investigate relationships between performance by children on computerized rehabilitation tasks, age and standardized assessment instruments. It was hypothesized that children's performance would differ by age on standardized assessment instruments and computer tasks developed for rehabilitation of attention, visual/perceptual and visual memory skills.

Two hundred five children from three schools in Chesapeake, Virginia, completed the Benton Visual Retention Test - Administration C, the Trail Making Test (B), and six computer tasks. Significant correlation was found between age, and both assessment instruments as well as five of the computer tasks. Standardized instruments correlated with one of each type of computer task for attention, visual/perceptual and visual memory skills. Additionally, correlation was found between one computer program and the Trail Making Test for visual/perceptual skills.

Further study is needed to develop standardization of these computer tasks for use rehabilitation of attention, visual/perceptual and memory skills dysfunction.

Sanford P. Martin, Jr.

School of Education Counseling Program

The College of William and Mary
RELATIONSHIPS BETWEEN AGE AND PERFORMANCE ON
COMPUTER ASSISTED REHABILITATION TASKS
FOR CHILDREN
CHAPTER ONE

Introduction

Description of the Problem

The purpose of this study was to investigate the relationship between age and computer assisted rehabilitation tasks of attention, visual/perceptual and visual memory skills in children. It appears from the literature that there is a demand for motivating forms of remedial intervention available to educators and medical rehabilitation professionals for addressing cognitive dysfunction in child survivors of traumatic brain injury (TBI). In authoring a primer for educators of TBI students, Dunse and Deboskey (1987), made the following statement. "As a part of evaluating these students, we were both closely involved in trying to fit square head injured children with round LD classes, triangular retarded classes, hexagonal emotionally disturbed classes, oval physically impaired classes, or even trapezoidal language impaired classes" (p. i). This dilemma continues to be faced by most educators in our country today.

The need for educational and rehabilitative alternatives specifically appropriate to this unique population is described and demanded throughout the literature. Etiological studies reported elsewhere in this manuscript describe a traumatic brain injury (TBI) incidence rate of 4.0 percent in boys and 2.5 percent in girls through age 15, about 1 million per year, (Harrington, 1990; Savage, 1991). "Students with brain injuries represent the single fastest-growing disabled population in the United States," (Cook, 1991, p. 71).
Several researchers have reported on the myriad difficulties associated with the education of TBI children and the need for services appropriate for cognitive and neurobehavioral dysfunction status/post TBI (DePompei and Blosser, 1991; Harrington, 1990; Telzrow, 1991). In a long term outcome study of 22 TBI children and adolescents in the Boston area, Filley, Cranberg, Alexander and Hart (1987), found that only 23% displayed a good educational or vocational outcome based on the Glasgow Outcome Scale. Social outcome of this population based on the Glasgow Outcome Scale indicated only 9% were found to have a good outcome.

The Education of All Handicapped Children Act, PL 94-142, does not include a specific category for brain related disorders. Although PL 94-142 has been recently amended to include traumatic brain injury under the identification of "other health impaired", children with acquired brain trauma other than from a head injury were excluded. In addition, many TBI students return to school and are placed in settings of educational and social demands without the benefit of adequate training or understanding on the part of their educators regarding cognitive and neurobehavioral remedial needs (Cohen, Joyce and Rhodes, 1985; Savage and Wolcott, 1988). Throughout the literature, the call for cognitive remedial services specific to the TBI student is loud and consistent (Blosser and DePompei, 1991; Cohen, 1991; Cans, Mann and Ylvisaker, 1990; Ylvisaker, et al., 1990).

Despite legislative amendments to PL 94-142, the capabilities of school personnel to identify and provide the necessary cognitive and neurobehavioral remedial services to the TBI student is limited and lacks the flexibility required from traditional special
education services (Ylvisaker, Hartwick, Stevens, 1991). Educators are unprepared for the student who can recall previously learned foreign languages or algebra, yet is now unable to process and integrate post TBI educational material and psychosocial experiences. Cooley and Singer (1991), suggest that categorical placement of these students given the present lack of appropriate services constitutes "reinventing a wheel that does not roll," (P. 47).

The description of the need and call for development of cognitive retraining related instruments and methodology for TB-I students is repeated throughout the literature (Cohen, 1986; Cans, Mann and Ylvisaker, 1990; Light, et al., 1987; Savage and Wolcott, 1988; Ylvisaker, Hartwick and Stevens, (1991). Despite the need, funding and political issues have retarded the advancement of these vitally needed services within the educational setting. Further research to obtain quantifiable answers to the questions related to intervention and availability of materials and resources is justifiably demanded in the literature. This research has attempted to seek answers that will bring us closer to arriving at solutions necessary to meet the unique needs of TBI students everywhere.

**Theoretical Rationale**

Cognitive rehabilitation has been defined by the American Congress of Rehabilitation Medicine as a systematic, functionally oriented service of therapeutic cognitive activities, based on an assessment and understanding of the person's brain behavioral deficits. The Congress of Rehabilitation Medicine has determined that cognitive rehabilitation, also referred to as cognitive remediation, is appropriate for
person's with acquired cognitive deficits from head injuries, strokes or other traumatic processes with neurological implications.

The scientific basis for cognitive rehabilitation as theorized by Ben-Yishay (1978, 1982), has developed from the pioneering hypotheses of restoration of brain function as put forth by Zangwill (Boake, 1989; Prigatano, 1986), Goldstein (Ben-Yishay, 1982; Boake, 1989; Prigatano, 1986), and especially Alexander Luria (Boake, 1989; Kolb and Whishaw, 1990; Prigatano, 1986). Luria's theoretical description of brain function has likely been the revolutionary force behind modern-day cognitive remedial therapy.

Luria stated that there are basically three brain areas called functional units involved in all complex cortical cerebral activity (Kolb and Whishaw, 1990). The first unit involves the reticular formation, brain stem and other subcortical areas in regulating the basic level of arousal.

Ben-Yishay refers to the processes of arousal as "orientation" and suggests that this includes basic abilities of attention, concentration, task vigilance and impulse control. Luria suggested that injury to the reticular formation has widespread affects on performance of all brain areas especially in inhibiting and activating neuropsychological functioning.

The second unit as hypothesized by Luria includes the more surface areas of the temporal, parietal and occipital lobes. Luria believed the second unit is responsible for receiving, analyzing and retaining incoming stimulation. Each lobe within this unit has primary responsibility for processing sensory stimulation: temporal-auditory, parietal-tactile/kinesthetic, and occipital-visual. The second unit is comprised of three "zones"
within each sensory area. The primary zone receives the incoming information. The secondary zone assimilates and organizes the information. The tertiary zones serve a synthesizing function where information is combined and integrated from various areas of the brain. "It is in these zones, Luria believes, that sensory input is translated into symbolic processes, and concrete perception is translated into abstract thinking." (Kolb and Whishaw, 1990, p. 174). Ben-Yishay (1978), believes that a successful cognitive rehabilitation program includes as one component a systematic remediation of cognitive deficits secondary to lesions to areas within the second unit.

Luria suggested that the third unit is the frontal portion of the brain. He reported that the tertiary zone of this third unit plays a major role in the planning, regulating and monitoring of behaviors and actions of the individual. Through the combined and continuous interactions of all three brain units the complex operations resulting in conscious activity occurs. Luria conceptualized observable and measurable behavior as a product of basic processes integrating hierarchically into complex functional systems. As a result of this concept, dysfunctional behaviors or cortical-cerebral processes resulting from brain impairment can be hypothesized as consisting of hierarchical levels of function that can be organized into specific steps conducive to remediation by "cuing patients to reorganize their task performances" (Boake, 1989, p. 5).

Ben-Yishay and Diller (1983), refer to their process of systematic remediation of specific cognitive deficits as saturation cuing. When a survivor of brain trauma can be retrained in basic processes of attention, visual/perceptual and more complex cerebral
reasoning skills as part of a more comprehensive program of rehabilitation, then that
individual is more likely to demonstrate behaviors and abilities that can be generalized to
a variety of tasks and settings. This process is based on Luria's theory that restoration of
brain function can be facilitated through the direct retraining of cognitive processes (Ben-
Yishay and Diller, 1983; Prigatano, 1986).

Luria believed that when functional systems of the brain are reorganized through
the process of cognitive retraining, the brain permits the individual to perform old
behaviors utilizing new methods of cognitive functioning. Ben-Yishay and Diller
demonstrated remarkable results in rehabilitation of stroke victims in the 1970's using this
process of repetitive cognitive remedial tasks administered in a planned, systematic and
hierarchical approach.

Ben-Yishay (1982), proposed this program of cognitive remediation "as a task
hierarchy of remedial 'modules (P. 11). The major tenants of Ben-Yishay's model for
cognitive remediation can be conceptualized as representing a hierarchy along three
substantive dimensions. From the standpoint of attentional demand on the individual,
they range from those which involve primarily the more basic arousal attentional
functions to those involving the maximal demands for attention and concentration. From
the standpoint of locus of interaction and processing of the tasks, they range from those
which involve almost exclusively interaction with and the processing of external
stimulus-response cycles to those involving near total internal mental operations. From
the standpoint of generic functions involved in the execution of these tasks, they range
from those primarily simpler psychomotor functions to those involving ideation and reasoning.

Piaget proposed the terms assimilation and accommodation to describe the cognitive processes responsible for engaging one's environment successfully. This inherent ability of the brain to operationalize and organize one's experiences appears to be an ongoing part of cognitive development in both normal and impaired brain functioning. Unfortunately, when brain trauma has occurred, spontaneous cognitive development may be impaired. The focus on developing cognitive remediation programs has been in the adult population. This focus has resulted from political and economic motivation connected to a large available pool of adult TBI survivors, particularly through treatment for war survivors. Public law in the United States (i.e. p.l. 94-142), has left the burden of most efforts to assist pediatric survivors of head trauma on the public school system.

Research with this population has repeatedly focused on identifying and describing the problems encountered by these children. One objective of this study was to explore potential standardization of cognitive remedial tasks for children consistent with Luria's theory as developed by Ben-Yishay.

Definition of Terms

Cognition - to think; the processes involved in thinking/reasoning.

Cognitive Rehabilitation - the amelioration of deficits in problem-solving abilities in order to improve competence in everyday life.

Cognitive Remediation - see "cognitive rehabilitation".
Computer-Assisted Rehabilitation Tasks (CART) - activities utilizing computer programs designed specifically for cognitive remediation.

Cortical-Cerebral - brain function involving primarily the external "newer" layer of gray matter neurons and their synaptic connections; often related to more complex cognitive processes.

Reticular Formation - a combination of brain matter extending from the brain stem to the thalamus interconnected with a variety of brain functional systems.

Saturation Cuing - constant, extended signalization of the most explicit nature with the gradual fading of cues to the least explicit until the only cues are internalized selfcues.

Subcortical - lower, "older" brain matter below the outer four to six layers of gray matter.

Traumatic Brain Injury (TBI) - acquired damage to the brain resulting from an injury, stroke or other neurological trauma.

Research Hypotheses

Specific research questions investigated in this study included:

1. Does performance by children regarding attention, visual/perceptual and visual memory skills indicate a developmental trend as measured by computer assisted rehabilitation tasks and related standardized instruments?

2. Is there a positive relationship between computer assisted rehabilitation tasks for attention, visual/perceptual and visual memory skills and the Benton Visual Retention TestRevised?
3. Is there a positive relationship between computer assisted rehabilitation tasks for attention, visual/perceptual and visual memory skills and the Trail Making Test?

4. Is there a positive relationship between separate computer assisted rehabilitation task programs for attention, visual/perceptual and visual memory skills?

Sample Description and Data Gathering Procedures

The population studied was 205 nine through twelve year-old children in the Chesapeake Public Schools. One hundred girls and 105 boys were divided into four age groups chosen at random from among one elementary, one intermediate and one middle school. Children previously diagnosed with any educational handicap or challenge were excluded from the sample, in order to obtain normative performance means. The school system was selected for strong demographic similarities to the state regarding education, race and socioeconomic characteristics.

Upon satisfactory completion of all ethical safeguards for participating children, data collection was conducted. There was no treatment or related manipulation of the participants in this study. Data collection was conducted individually with each child. Each child was asked to complete six computer assisted rehabilitation tasks (CART), The Trail Making Test (children's version) and administration A of the Benton Visual Retention Test - Revised (BVRT-R), form C. administration C.

The CART, Trail Making and BVRT-R order of administration were randomized, as well as the order of the six tasks within the CART protocol, in order to reduce learning effect. Total administration time for all instruments was approximately 50
minutes. Administration was randomized by weekday and time of day throughout the school year to reduce external variables.

**Limitations of the Study**

The CART protocol utilized in this research has never received serious validation study, nor has it been applied to children. The applicability of this protocol to cognitive rehabilitation in children is therefore unclear.

The validity and generalizability of CART programs to the process of cognitive rehabilitation has become controversial. The extent to which this CART protocol might be productively applied to TBI children has not been demonstrated.

The sample population excludes any child previously diagnosed with an educational related dysfunction. As a result, the sample will not be representative of a "true" population of all public school children. The exclusion of private school, hospital and other populations reduces the generalizability to all children.
CHAPTER II

REVIEW OF LITERATURE
Historical and Theoretical Overview

Kurt Goldstein established the first twentieth century program to attempt rehabilitation for traumatic brain injured (TBI) soldiers in Frankfurt, Germany in 1917 (Prigatano, 1991). Goldstein's 1942 description of cognitive dysfunction and his emphasis on what might be today called cognitive rehabilitation were the first reported in the literature. Oliver Zangwill, a British psychologist, described the problems and related goals in cognitive retraining of TBI survivors in 1947 (Prigatano, et al., 1986). Zangwill proposed three potential methods of rehabilitation of TBI survivors. Zangwill postulated the remediation of cognitive- cerebral dysfunction by: 1) direct retraining of neurocognitive processes, 2) by what might now be considered substitution of an intact cerebral process for that normally conducted by cranial-cerebral tissue which has become impaired, and 3) by teaching what are now called compensation techniques to replace or supplement impaired function.

Research begun during World War II and continuing into the 1980's by Alexander Luria involving thousands of cases of TBI has led to his revolutionary theory of brain function and therapeutic intervention. As early as 1948, Luria proposed his theory of direct intervention in brain function in order to facilitate recovery (Prigatano, et al. 1986). Luria suggested that brain function could be restored or improved through system substitution or reorganization of a brain functional system or subsystem as a result of remediation through cuing specific cognitive tasks. Unfortunately, no major research on TBI rehabilitation appeared in English-speaking literature on a regular basis until the 1970's.
In 1978, Yehuda Ben-Yishay established a cognitive rehabilitation research and treatment center at the New York University Institute of Rehabilitative Medicine. This work followed his successful efforts in the early 1970's with Israeli war TBI survivors. Ben-Yishay has developed a "holistic" (BenYishay and Prigatano, 1990, p. 400), approach to cognitive rehabilitation. One component of his rehabilitation method has been that of intensive "saturation cuing" (p. 405), in the remediation of specific cognitive functions such as attention, visual/perceptual and visual information processing skills. The advent of the microcomputer for personal use at the same time as Ben-Yishay's development of the theory of cognitive remediation as proposed by Luria revolutionized TBI rehabilitation. Ben-Yishay has theorized that individual, systematic remedial training tasks presented on a cognitively hierarchical basis would result in: 1) amelioration of specific generic cognitive deficits; 2) generalizability to cognitively related skills (especially when combined with group and related holistic approaches); and 3) would result in an overall higher level of problem solving skills when combined with group cognitive rehabilitation psychosocial skills training and psychotherapeutic intervention.

The efficacy of cognitive rehabilitation involving the theoretical basis, role of computers and Ben-Yishay's approach in particular have been criticized in the literature by Gordon, Hibbard and Kreutzer, (1989). They submit that no theory exists to explain TBI-related dysfunction and that research has thus far lacked empirical credibility to support which methods do and do not work. Computers, additionally have been questioned as a primary means of cognitive remediation based on a lack of empirical research support. Ben-Yishay's research and approach to cognitive rehabilitation has also
been attacked on the basis that his work and theoretical approach has lacked empirically sufficient numbers of subjects and concurrent control groups.

A "retrospective prediction analysis" conducted by BenYishay and Prigatano (1990, pp. 407-408), of variables related to long-term vocational adjustment for subjects in Ben-Yishay's research yielded some equally disturbing results. Statistical analysis indicated that computer-assisted cognitive remedial training of visual information processing accounted for only 12 percent of the outcome, yet 46 percent were related to interpersonal and intrapersonal skills training. The authors go on to suggest that more research is necessary at this time.

While acknowledging the issues of concern regarding cognitive rehabilitation, empirical evidence has been reported in the literature supporting the theory. In a study involving both experimental and control groups, Prigatano, et al. (1986), demonstrated that cognitive remedial tasks resulted in improved interpersonal/problem-solving skills for those demonstrating increased speed of information processing compared to controls. Ruff, et al. (1989), described an experimental study utilizing computer-assisted cognitive rehabilitation tasks for one group and traditional rehabilitation for a second group. The former group demonstrated significant progress over the latter, especially in areas of attention, visual-spatial integration, memory and problem solving.

Ben-Yishay's holistic model of cognitive rehabilitation including computer-assisted cognitive remediation, psychosocial training and vocational readjustment was applied to a higher educational setting (Harrington, 1990). A program of "cognitive re-education" included hierarchically administered modules of attention/concentration, perceptual
(visual) processing, organizational processing and higher reasoning/problem solving. Students demonstrated statistically significant gains as measured by neuropsychological testing. The present study will contribute to this body of knowledge through application of the theory to children.

Critique

Luria's theories of brain function and rehabilitation of the injured brain have revolutionized the fields of neuropsychology and head trauma rehabilitation. Researchers and clinicians such as Harrington, Prigatano and Ben-Yishay have developed treatment models based on Luria's theories and the earlier work of Goldstein and Zangwill in demonstrating effective results toward remediation of dysfunction in this unique population.

Gordon, Hibbard and Kreutzer (1989), have stated that there is no theory of cognitive dysfunction secondary to TBI. Their work has completely ignored Luria, making no mention of his name. Their criticism of computer-assisted cognitive rehabilitation suggests that the techniques represent the sum total of cognitive remediation. Nowhere, however, does Ben-Yishay describe computer technology in cognitive rehabilitation as more than a tool used in conjunction with other significant components of his theoretical model of cognitive rehabilitation.

Harrington (1990), has described application of Ben-Yishay's model of cognitive rehabilitation including computer-assisted remedial techniques in successfully re-educating college students. This study will apply Ben-Yishay's theoretical model of cognitive rehabilitation to the childhood population.
Attention/Concentration Related Skills

Piaget recognized the processes that are inherently developed during infancy and early childhood that allow the individual to overcome conflicting demands of the environment. Piaget labeled these abilities assimilation and accommodation, suggesting that they are part of normal cognitive development. The disruption of the brain's ability to appropriately attend to the environment is frequently found among TBI survivors.

While the term "attention" is most frequently used, this general area of cognitive function actually denotes a variety of separate, but related brain processes. Van Zomeren and Deelman (1978), have conducted extensive studies in The Netherlands, differentiating the processes of alertness, selectivity and speed of processing. Prigatano, et al. (1986), suggested a differentiation between attention/concentration processes and speed of information processing. The process of attention was divided into the components of alertness, capacity and selection by Nissen, (1986). Mack, (1986), described attention as being comprised of the ability to register stimuli, divide attention, withstand distraction or maintain a vigil. The first modern description of attention, the various components of attention and a systematic strategy to ameliorate attentional disturbances after TBI were described by Ben-Yishay, Rattok and Diller (1979).

Level of attention-related ability has generally been accepted in the literature as measurable by speed of reaction time. Van Zomeren and Deelman (1978), reported that on a forced choice visual reaction time task TBI subjects displayed a significantly higher level of dysfunction. The authors attributed this to response interference related to speed of information processing, rather than level of attention. As seen with many TBI
survivors the increasing information demand overloads the damaged brain's capacity to process information.

The literature is consistent in describing alertness or basic levels of arousal as the most elementary component of attention/concentration related functioning. The ability to attend to a stimuli is observed in infants from shortly after birth. The ability to attend to stimulation involves what Luria described as the first functional unit. This component of attention is not selective (Nissen, 1986), and affects speed of stimulation response.

Most of the literature also agrees that attention involves the ability to selectively discriminate between sources of stimulation from the environment. Prigatano, et al. (1986), describe this dysfunction as an inability to shift from one source of stimulation to another, or to selectively ignore competing sources of environmental stimulation. Nissen (1986), asserts that the environmental stimulation can be either external or internal (e.g. ruminations, random thoughts, etc.). BenYishay, Rattok and Diller (1979), describe this attentional disturbance as an inability to combat distractions.

Van Zomeren and Deelman (1978), describe the attentional process of selectivity as including both the ability to ignore distraction and the ability to concentrate, which combined produce the ability to maintain focused arousal. Others, (Nissen, 1986; Mack, 1986; Prigatano, et al., 1986), view the ability to concentrate as a distinct process labeled capacity, concentration or sustained vigilance to task. Prigatano, et al. related this dysfunction to a commonly observed sequelae of easy fatigability reported by many TBI survivors.
Ben-Yishay described all these processes as attentional disturbances. Basically, all attention/concentration related functions can be grouped together on a continuum ranging from basic arousal and response to a single stimuli to the ability to discriminate and selectively filter out unnecessary stimulation while vigilant to task. Included in this continuum is the ability to combat distraction, the ability to rapidly shift attention from one stimuli to another and back again to the previous stimuli, and the ability to perform two tasks at the same time.

Locus of control and level of arousal are two dimensions of attention/concentration related functioning that are theorized by Ben-Yishay (1979, 1982), as ever present in the human being. Locus of control relates to attentional demands in terms of the need of the individual to receive external versus internal interaction and processing in order to produce the appropriate state of attention. Brooks (1990), described an example of this dimension in discussion of EEG data and level of drowsiness and attention discovered in TBI survivors and controls by Brouwer. Controls displayed an increasing number of drowsy episodes over TBI survivors. Without sufficient internal feedback, TBI survivors were unable to prevent maintaining an unnecessary higher level of arousal or to filter out unnecessary stimulation. Ben-Yishay described the attentional dimension as “that level of arousal ranging from ‘automatic’ to ‘intentional’” (p. 12, 1982).

Ben-Yishay recognized that in highly stimulating or frequently changing environments such as group social settings or most vocational settings attentional disturbances are more likely to become evident. The TBI survivor is often unaware of the
disturbance, so the behavioral response to this overwhelming stimulation or rapidly shifting demand for attention is often seen as impolite, weird or peculiar. Vocationally or educationally the survivor with a brain unable to maintain proper attention/concentration is frequently not tolerated by those in authority.

Ben-Yishay (1979), introduced a systematic, hierarchically based program or "module" of tasks designed to remediate disturbances of attention and concentration. The functional dimension of this module involved basic psychomotor functions rather than higher level ideation and reasoning. When the individual is challenged (externally) by the computer program and by the therapist when unable to perform the task (e.g. pushing a button when a light appears on the monitor), the process of internal awareness begins. When the therapist combines the individual computer assisted rehabilitation task (CART) with structured group/interpersonal skills tasks related to the same level of attentional disturbance the survivor can hopefully become more aware and thus more motivated to proceed with the therapeutic plan. Awareness and motivation are commonly found to jointly be absent in a high frequency of TBI survivors.

While level of attention can be assessed in a variety of ways, the objective computerized measure of reaction time as an indicator of level of attention continues to be well documented in the literature (Ben-Yishay, Rattok and Diller, 1982; Lavach, Gailey, Martin and Solomon, 1994). Improvement in speed of reaction time as an indicator of level of attention has also been shown to relate to increased levels of psychosocial functioning, level of independent living and level of vocational or productive living.
Critique

The literature has lacked a degree of agreement regarding a specific definition of attention related to neurocognitive functioning. Some researchers differentiate between speed of information processing and attention as separate functions (Prigatano, et al., 1986; Van Zomeren and Deelman, 1978). Other researchers differ regarding the number of different processes of attention. Some describe attention as comprised of three separate dimensions (e.g. alertness, discrimination and concentration), (Nissen, 1986), while others include the ability to combat distractions as an additional component of attention (Mack, 1986). Gordon (1989), describes the attentional process as the ability to inhibit impulsivity, task vigilance and the ability to combat distractions.

Ben-Yishay (1978), combined all these functions of attention under the term attentional disturbances and described these functions in a manner consistent with Luria's theory of functional units. In their writings Ben-Yishay and Prigatano frequently differentiate attention and concentration. Attention appears to be more frequently related to the more basic levels of arousal, ability to discriminate from among competing levels of environmental stimulation and ability to shift focus from one task to another. Concentration relates to a more conscious dimension of vigilance to task and inhibition of impulse.

The same inherent abilities described by Piaget in coping with attention/concentration related demands were engaged in this study.
**Visual/Perceptual Skills**

Visual/perceptual disturbances are among the most frequently observed sequelae of acquired brain trauma (Lavach, Gailey, Martin and Solomon, 1994; Zoltan, 1990). The high proportion of external stimulation to the brain involving visual function might be inferred from the complexity of the visual system found in the brain. Of the twelve cranial nerves, four serve only the visual system and two contribute to eye function (Kolb and Whishaw, 1990). Visual/perceptual skills involve the visual system, including the occipital lobe, as well as parietal and frontal lobe function.

Luria's second unit processes much of the visual/perceptual skills and requires appropriate function in the primary zones receiving information, secondary zones organizing and processing the information, and tertiary zones integrating the information. Visual/perceptual deficits are rarely seen in isolation (Zoltan, 1990). Dysfunction may include visual skill dysfunction such as field deficits and scanning/tracking impairments which may also involve the frontal cortex as in saccadic eye movements. Perceptual skill disturbances were initially described as cognitive-perceptual integration skills dysfunction by Ben-Yishay (1978). This deficit is frequently observed in the form of constructional apraxia and indicates an underlying occipitoparietal related lesion. Visual/perceptual disorders not specifically visual or perceptual are often described in terms of right/left discrimination or visual field neglect and have been described in detail by Luria as related to parietal lobe dysfunction.

Visual system dysfunction is often undiagnosed when the area of damage to the brain is not primarily the occipital lobe (Lavach, Gailey, Martin and Solomon, 1994).
Walker (1989), and Kolb and Whishaw (1990), describe the visual pathways as including the optic nerve and chiasm, as well as the visual geniculate striate system encompassing most regions of the brain. As a result, damage to any portion of the brain might result in visual/perceptual dysfunction.

The complexity of visual/perceptual dysfunction status post TBI may result in a combination of diagnoses or the necessity to differentiate between specific visual system deficits. For example, an individual displaying a scanning (quick localization), or tracking dysfunction (whether horizontally, vertically, obliquely or rotatory) might involve either deficit, both or be in combination with a visual field neglect (visual inattention) or visual hemianopsia.

Zoltan (1990), lists the use of computers in addition to functional and sensory motor approaches as appropriate treatment methods for visual scanning/tracking related disorders. King (1993), studied 21 poststroke adults involving treatment of unilateral visual field neglect using a computerized projection system up to 100 degrees of the visual field. Subsequent to a scanning/tracking training module subjects displayed significant improvement (p .005) regarding visual field neglect.

A lesion to the occipitoparietal region of either hemisphere may result in the visual/perceptual related deficit of constructional apraxia. Ben-Yishay, Diller, Gordon and Gerstman (1978), described this as a cognitive-perceptual integration or analytic constructional dysfunction. The deficit is manifested by inability or decreased ability to reproduce twoor three-dimensional designs. Ben-Yishay built on Luria's model of saturation cuing as a basic means of remediation. Beginning with simple two-
dimensional designs, the level of complexity would be increased until the individual could reproduce three-dimensional designs spontaneously with no external assistance.

Parietal lobe disturbance is primarily related to a variety of visual/perceptual deficits related to visuospatial dysfunction. Disorders related to figure-ground or form perception subsequent to parietal lobe lesion result in inability to distinguish differences in designs and/or distinguishing one item from among others in the environment.

Ben-Yishay, et al. (1982), conducted pretest and post-test studies of what he described as "integrative" (p. 168), functions training. These functions included a perceptual cognitive integration module and a visual information processing training hierarchy. Tasks included table-top and computerized tasks presented hierarchically with saturation cuing of skills necessary to master each task. Significant improvement was reported using the Benton Visual Retention Test (form c) and the block design and picture completion sub-tests of the WAIS from pretest to post-test (n=20).

Ben-Yishay and others rely on the computer as a major tool in cognitive remediation of visual, perceptual and cognitive dysfunction. Utilization of computers comprises what Zoltan (1990), describes as transfer of training approach. This approach is consistent with the work of Luria in which repetitive cuing of tasks in a hierarchical approach will generalize to daily functions. For example, the individual learning to scan a computer monitor to find an object will be asked to apply this redeveloping skill to finding an item on a grocery shelf. The efficacy of this approach has been questioned in some studies, although the limited total number of studies suggests the need for further research.
Critique

A conceptual basis for understanding the hierarchical interrelationships among vision/perceptual processing and higher cerebral cognitive skills is necessary for effective rehabilitation of neurocognitive disorders secondary to acquired damage to the brain. Luria's theory of rehabilitation of these cerebral brain functions is applied to the reorganization of the functional systems in operation for visual/perceptual processing to occur. The complexity of the visual/perceptual systems has resulted in a propensity of research describing the process (Kolb and Whishaw, 1990; Walker, 1989), and a scarcity of research documenting successful remedial techniques (Ben-Yishay, et al., 1982; King, 1993; Zoltan, 1990).

Visual/perceptual processing skills are necessary for the ability to visualize, conceptualize and create. Johan Pestalozzi, a fellow Swiss compatriot of Piaget, noted that "conceptual thinking is built on visual understanding; visual understanding is the basis of all knowledge" (Optometric Extension Program Foundation, 1993). When children or adults sustain TBI, they cannot on their own perceive the subtle gradations in daily task performance differentiating the processes of visual/perceptual functioning underlying cognitive dysfunction. This study has attempted to enhance the body of knowledge required by professionals in extending the programming of the restorative activity as proposed by Luria.
Visual/Iconic Memory

Memory involves those cognitive processes necessary for perceiving, encoding, storing and retrieving stimulation to the brain. Memory dysfunction secondary to TBI includes long term memory disorders (i.e. retrograde and anterograde amnesia, global and material-specific deficits), and short term working memory (i.e. immediate recognition or recall, short delay recognition or recall) (Nissen, 1986). While the quality or type of memory is often referred to by various distinctions such as verbal, non-verbal, visual and spatial, separate memory systems are not implied. Kolb and Whishaw (1990), emphasize that memory defects result from disorders in both the storage and retrieval portions of the sensory processes.

Most of present day literature agrees that direct retraining or restoration of memory function secondary to TBI is not feasible given the technology and scientific information available (Ben-Yishay and Prigatano, 1990). The vast majority of rehabilitation directed toward memory dysfunction involves compensation techniques delivered to the individual for complex verbal reasoning skills purposes. The complexity of memory processes and their interactions with other cognitive functions far surpasses the state of the art of clinical assessment of memory (Mack, 1986).

The storage portion of memory involves the processes of responding to sensory stimulation in interaction with attention, perception and executive skills. Parente and Anderson-Parente (1989), described the ability to quickly process visual information and retain an image of the information for a brief period of time after stimulation ends. Parente, Anderson-Parente and Shaw (1989), have explained that the fleeting visual
image that remains after visual stimulation is removed occurs on the cortical level. This brief period comprises the initial stage of the memory process for visual stimulation called iconic (visual) sensory memory.

After TBI, many individuals are unable to spontaneously engage this process which determines much of what is actually perceived and later processed into short term memory. Traditional visual or memory rehabilitation techniques have attempted to restore visual processing or compensate working memory systems. Iconic memory training involves those tasks and activities designed to improve the ability to process stimulation presented for only a short duration.

Research regarding the exact nature of memory dysfunction has bewildered researchers for many years. Brooks (1990), surmises that the underlying memory components (encoding, storage and retrieval), may be individually dysfunctional and/or separate cognitive processes such as information processing may result in memory disorders. Luria espoused the principles of differential restoration of functional systems and of extended programming of the restorative activity. Ben-Yishay applied these principles in breaking down cognitive processes into cognitively hierarchical components and sub-components. Ben-Yishay and Prigatano (1990), distinguished memory functions from speed of information processing. Both agree on the lack of efficacy regarding direct remediation of memory function. Improved information processing, specifically sub-components of visual information processing (Ben-Yishay, 1981), has been hypothesized as a prerequisite to higher complex cerebral skills such as reasoning, learning and memory.
Ben-Yishay described a series of visual information processing tasks including certain "visual discrimination" and visuospatial memory activities. Certain tasks required the simultaneous processing of multiple visual stimulation (numbers, letters and colors, random dotted patterns, etc.), without visual scanning, necessitating immediate recall. The short duration of stimulation followed by the demand for immediate response incorporates the process of sensory registration Parente and Anderson-Parente (1989), described as visual iconic memory.

Parente and Anderson-Parente described a series of experiments designed to measure the effectiveness of iconic memory training. Using small groups of TBI survivors (n= 9, 6, respectively), the researchers found an improvement first in letter recall, then word identification, reading comprehension and reading rate after iconic memory training. Utilizing an A-B-C then A-C-B format Parente and Anderson-Parente reported significant improvement (p<.05), after iconic memory training relative to baseline or more traditional letter span type recall practice training methods.

Ben-Yishay and Parente and Anderson-Parente described the utilization of computer programs as ideal for the improvement of visual iconic memory function. Computers can present visual stimulation at speeds of such rapid duration as to reinforce iconic memory without scanning using eye movements. Manual presentation of totally randomized visual stimulation requiring high degrees of accuracy in recall response may not be possible. Computer programs can be adapted to the needs of the individual in order to increase or decrease the amount of eye muscle movement; target areas of visual neglect resulting from cortical dysfunction; and to provide more efficient objectivity.
process to the brain. Ben-Yishay's process of saturation cuing to provide external reinforcement and constantly challenge the recovering brain applies this Lurian principle to remediation of information processing of visual iconic memory. As the individual's performance improves the visual field range and the degree of difficulty can be easily adjusted when using computer programs. The individual's level of performance is challenged at the threshold of peak ability.

**Critique**

Research as summarized by Brooks (1990), has demonstrated considerable disharmony regarding the source(s) of memory dysfunction after TBI, as well as courses of remediation. Gliskey and Schacter (1986), report that there is little evidence to support attempts to directly restore lost memory function. Gliskey and Schacter failed, however, to differentiate the various memory processes in stating their position. Whyte, (1986), questioned the validity of the process of saturation cuing in memory remediation without ever examining the processes of memory or making any connection between memory and remediation. Saturation cuing as part of a computer-based remediation program for left-hemisphere brain dysfunction has, however, been found to be effective (Burns, 1999).

Ben-Yishay and Prigatano (1990), found that only in cases of very specific lesion sites would computer-based methods of cognitive remediation prove successful when not provided in the context of a more holistic rehabilitation program. As they have proposed on many occasions, any computer-based cognitive remediation must be considered as part of the tools utilized in a well-rounded treatment milieu.
on many occasions, any computer-based cognitive remediation must be considered as part of the tools utilized in a well-rounded treatment milieu.

Visual sensory iconic memory might be classified as a form of information processing skills. Parente, Anderson-Parente and Shaw (1989), have demonstrated that a deficit in this area is likely to undermine efficient processing of all other aspects of the memory process. These researchers, Ben-Yishay (1982), and others have demonstrated the effectiveness of remediation of visual sensory iconic memory and information processing.

Population

While injuries have consistently been reported in the literature to outnumber any form of disease as the leading cause of physician contacts for both children and adults, research among the adult TBI population has far outpaced research regarding childhood brain injuries. Significant levels of morbidity and mortality resulting from head trauma in children have been reported in the literature since 1980. Rivara and Mueller (1986), reviewed the literature and found three epidemiological studies utilizing standardized and uniformly applied criteria. This review found an average incidence rate of 270 males and 116 females per 100,000, each. The incidence was based on a definition of head trauma resulting in brain trauma and all diagnoses of skull fracture.

Similarly, Bruce, (1990), Jaffe, Brink, Hays, and Chorazy (1990), and Savage (1987), report hospitalization rates of 150,000 to 200,000 children annually, citing federal government documentation and other research. Most of the literature reports an incidence of approximately ten percent resulting in significant and usually life changing severe
brain trauma. Rates of TBI have been reported in most all studies to increase steadily from the first year of life to the late teens, and then declining until age 60.

Epidemiological studies regarding incidence rates and causes of TBI in children have become well accepted and recognized by the medical community. While epidemiology has been well established regarding childhood TBI, neurobehavioral sequelae have been much less reported in the literature. Jaffe, Brink, Hays and Chorazy (1990), reported on specific problems resulting from TBI in children utilizing a case study methodology, in addition to providing a thorough review of the literature. They found a variety of hypotheses regarding long term neurobehavioral consequences of TBI. This problem is more pronounced among survivors of mild brain injuries, especially when they occur among younger children. Aggressiveness, poor judgment, attention deficits, hyperactivity, increased stress, impulsivity combine with a variety of educationally challenging cognitive disorders to severely expose the TBI child to greater psychosocial risk in and out of the educational setting.

Severity of injury has been related to intellectual functioning as well as risk of psychiatric disorders in several correlational studies (Max et al., 1998). Regardless of the level of intellectual functioning as measured by standard tests of intelligence, specific problems related to educational reintegration and performance have been documented in the literature. Utilizing a case study method, Savage (1987), reported many of the same issues as Cohen (1986). She examined the need to remediate cognitive problem areas by the educational system, rather than assume they are automatic in TBI students. Cohen's comprehensive review and suggestions for intervention strategies demonstrated the
significant variety of cognitive related problems, although her position paper lacked supportive research by the author. Jaffe, Brink, Hays and Chorazy (1990), reported several well-controlled and statistically significant studies utilizing the correlational, comparative and descriptive research designs regarding the relationship between academic performance and neuropsychological sequelae in children after TBI. While intellectual recovery occurs in most children over a long period of time, memory related disorders continue to consistently impair scholastic abilities. Visual-spatial skills, visual-motor skills and speed of information processing combine with attention and behavioral related dysfunction to significantly impact educational and psychosocial functioning. Cognitive disorders are frequently manifested through impairments of age appropriate complex reasoning skills (e.g. abstract/logical reasoning), recall of information, organizational skills, reading comprehension, judgment and ability to generalize.

Ewing-Cobbs, Fletcher and Levin (1986), reviewed relevant research regarding neurobehavioral sequelae after TBI in children for purposes of drawing educational implications. The authors reported a number of descriptive studies showing the decline in intelligence test scores following TBI. Both comparative and descriptive studies have demonstrated differences between groups in speed of information processing, long term rates of change in memory, attention deficits and academic achievement.

Primary responsibility for assessment and restoration after TBI among children has traditionally been within the primary purview of the educational community. As a result, the purpose and methods of assessment and intervention have differed somewhat from the field of rehabilitation. Light, et al. (1987), attempted to integrate rehabilitation...
with education in comparative research regarding a neuropsychologically based reeducation study utilizing one-on-one tutoring. This research demonstrated gains in adaptive educational functioning based on parental interviews despite lack of statistically significant improvements measured by objective measures of neurocognitive function and methodological flaws such as small sample sizes.

Much of the literature proposes intervention strategies related to traditional educational approaches (Cohen, 1986; Savage, 1987). Others call for more neuropsychologically based intervention strategies (Ewing-Cobbs, Fletcher and Levin, 1986; Ylvisaker, et al., 1990). Most all the literature laments the lack of cognitive rehabilitation approaches applied to children. Gans, Mann and Ylvisaker (1990), differentiated between the traditional educational and cognitive rehabilitation approach through descriptive case studies. Content instruction can often only be successful when provided subsequent to or in conjunction with cognitive rehabilitation including environmental modifications, remedial exercises and training in compensatory strategies.

Long-term memory deficits in children with TBI's was studied utilizing a longitudinal comparative design by Eisenberg, Levin and Lilly (1993). In comparing 53 patients with 41 controls, the researchers found that children with severe brain injury performed significantly below that of controls, as well as mildly or moderately injured children as measured by consistent longterm retrieval of the Selective Reminding Test. The study provided further evidence of the wide range of sequelae in childhood TBI.
Children with severe brain injury improved rapidly until about the sixth month, then leveled off in performance. Mild or moderate impairment was represented by an improvement level that improved similar to that of the control group, yet remained slightly and consistently below that of controls.

Much of the literature regarding childhood TBI is dominated by position papers and calls for the introduction of intervention strategies regarding cognitive dysfunction (Cohen, 1986; Savage and Carter, 1984; Savage and Pollack, 1985). Gans, Mann and Ylvisaker (1990), emphasize the need for an understanding of the relationship between cognitive remediation and normal patterns of cognitive development in establishing a rehabilitation or reeducation program for children. The unique sequelae manifested in each individual after TBI requires the remediation of cognitive dysfunction before teaching academics.

Critique

The literature regarding childhood TBI is rich with epidemiological studies describing the causes and much of the sequelae (Bruce, 1990; Rivara and Mueller, 1986). Neuropsychological outcome studies began to appear in the 1980's (Jaffe, Brink, Hays and Chorazy, 1990; Max. et al., 1998). Researchers began to examine intellectual function, psychosocial function and academic performance. Cognitive functioning in children after TBI has been reported in the literature regarding visual-spatial and visual-motor skills, speed of information processing, memory and ability to learn (Crowley and Miles, 1991; Ewing-Cobbs, Fletcher and Levin. (1986).
While much of the services beyond the early to intermediate stages of recovery are provided through the educational system, most of the research has been conducted by the medical rehabilitation community. Coincidentally, many of the non-epidemiological studies have utilized small sample sizes while conducting correlational, comparative or descriptive studies (Light, et al., 1987; Eisenberg, Levin and Lilly, 1993). Other studies have relied on case study methods in reporting or describing the issues (Gans, Mann and Ylvisaker, 1990; Savage, 1987).

Literature regarding childhood TBI has demonstrated the efficacy of research with this unique clinical and educational population. Most all the literature agrees with the need for cognitive rehabilitation approaches applied to children.
CHAPTER III
METHODOLOGY
Population

The target population in this study is children with acquired brain trauma served in elementary and middle school settings. The sample selected for this study consisted of children who have not been diagnosed with any educationally related handicap or challenge (i.e. mental retardation, learning disabled, attention deficit disorder, etc.). The sample consisted of children from elementary, intermediate and middle schools in Chesapeake, Virginia.

Data from the U.S. Census Bureau (1990), provides a comparison of locality and Commonwealth of Virginia demographics indicating the selection of Chesapeake as an acceptable sitebase for serving as a sample pool population. Socioeconomically, household income in Virginia was reported as a median of $33,328, with a mean of $39,615. Chesapeake household income was reported as a median of $35,737, with a mean of $37,789. The racial composition of Virginia was reported as 22% African-American, 76% white and a total of 2% all other racial groups. Chesapeake racial demographics were reported as 28% African-American, 70% white and a total of 2% all other racial groups. High school graduates constitute 75.2% of the persons 25 years and over in Virginia and 77.1% in Chesapeake. Elementary or high school enrollment in Virginia is 7.1% private and 6.9% in Chesapeake. While place of residence differs significantly between Virginia and Chesapeake (69%-31% urban-rural vs. 96%-4%, respectively), the locality consists of a large enough population of rural residents to provide a comparative sample population.
The standardization sample consisted of 205 students and ranged in age from 9 through age 12. Each child's age was computed in one-year steps as described in other developmental related instruments for similar age groups (i.e. McCarthy Scale of Children's Abilities and the Piagetian scales by Laurendeau and Pinard, (Anastasi, 1988)). The standardization sample was stratified by race (African-American, white and other), and residence (urban-rural), consistent with the 1990 U.S. Census for the Commonwealth of Virginia.

Children from one elementary school, one intermediate and one middle school served as subjects for this study. The schools selected were based on those schools most ideally matching census bureau demographics of the state in terms of racial and residential proportions within each of the school settings. Public schools have been chosen as the sample population pool source, due to the fact that cognitive remedial services to children with acquired brain trauma are provided primarily within the public school setting. The attempt in this study was to describe specific areas of normal cognitive function for those not impacted by diagnosed educationally related handicaps or impairments in order to obtain normative data for possible use with TBI survivors.

**Standardization Sample and Descriptive Variables**

All students within each school selected for the study were considered eligible for the sample. Students were chosen at random, utilizing standard random sampling techniques (Borg and Gall, 1989). Students selected at random who did not meet selection criteria were not admitted into the study sample and random sampling continued until 32 children were chosen for each age/gender subject pool. The total number of children selected for
the original sample population equaled 256 students. This selection process allowed for student absences, scheduling difficulties, etc. The sample was divided equally between boys and girls with 50 children in each age group (9 to 12). Reasonable attempts were made to include the first 25 students selected for each sample pool, with the remaining 7 subjects considered as alternates in the order selected.

After fulfilling requirements of all necessary ethical safeguards and receiving documented parental permission, students in the research sample participated in the study by means of the procedure described as follows. The Benton Visual Retention Test - Revised (BVRT-R) and the Trail Making Test were administered to each child in addition to a series of computerized tasks reported to involve three areas of cognitive function including attention, visual/perceptual processing and visual sensory/iconic memory. The Attention protocol consists of the following computerized tasks. The "Attention Reaction Conditioner" computer program is produced by New York University Institute of Rehab Medicine (NYU-IRM). The "REACT" computer program is produced by Life Science Associates.

The visual/perceptual protocol consists of the following computerized tasks. The "Simple Visual Reaction" and "Visual Tracking - II" computer programs are produced by Psychological Software Services.

The visual sensory/iconic memory protocol consists of the following computerized tasks. The "Visual Discrimination Conditioner" computer program is produced by NYU-IRM. The "SEARCH" computer program is produced by Life Science Associates.
Borg and Gall (1989), describe the establishment and documentation of standard conditions of administration as essential in research related to instrument development in order to prevent the results of the research being rendered "worthless" (P. 276). In order to prevent any order effect (Borg and Gall, 1989), on task performance, a counterbalanced design was utilized in the administration of the six computer programs and two assessment instruments, with the 205 sets of administrations randomized by task order during the data collection process. Cognitive rehabilitation technicians were trained for data collection to reduce experimenter effect. The data collection procedure occurred over a period of eight months during the 1998-99 academic year.

**Instrumentation**

Unlike studies involving the assessment of cognitive abilities, this study seeks to describe performance on tasks developed for use in the remediation of cognitive dysfunction. As such, the authors of computer programs developed for cognitive rehabilitation of adults have focused primarily on individual performance, rather than attainment of standardized norms. Whyte (1986), suggests that the measurement of outcome in remediation of attention and memory deficits should be individualized to the specific questions regarding the particular patient. Gianutsos (1981), describes interpretation of subject performance on many of her cognitive remediation computer programs based on each therapist's comparison of patients considered to be at similar levels of cognitive functioning. Ben-Yishay (1981), describes some norms based on a small n (i.e. n=20) of brain damaged adults. In most descriptions of subject performance.
Ben-Yishay described the individual's performance via comparing pre-training/post-training task scores after a specified period of treatment time or plateau.

Nowhere in the literature are specific cognitive remediation tasks described in terms of standardized norms, reliability or validity. Gans, Mann and Ylvisaker (1990), however, describe the necessity of considering levels of cognitive, physical and neurologic development in the rehabilitation of children up to age 14.

Although not developed for purposes of assessment, the lack of documentation regarding validity and reliability of the remediation instruments presents an impediment to scientifically accepted standards of research. Borg and Call (1989), address this issue in describing the utilization of a brief standardized instrument administered along with the non-standardized task(s) as a means of determining concurrent validity of the criterion measure. The Benton Visual Retention Test - Revised (BVRT-R) (Benton, 1974), and the Trail Making Test (Reitan, 1971), require minimal time needed for administration, scoring and interpretation while combined they assess the cognitive functional areas of attention, visual/ perceptual skills and visual memory skills. Validity might also be analyzed by examining the developmental pattern of task performance on instruments by age of research subjects for both standardized and non-standardized instruments.

The combined administration time for the two standardized assessment instruments was an average of fifteen minutes. The combined administration time of the six computerized remediation tasks was an average of thirty-five minutes. The total administration time of fifty minutes insured that no child was removed from classroom
activities for a prolonged time period during the course of data collection. Data collection occurred during the school day (approximately 8:00 a.m. to 3:00 p.m.).

The Benton Visual Retention Test - Revised (BVRT-R)

The purpose of this instrument is to assess visual perceptual, visual memory and visuoconstructive capabilities (Benton, 1974). Attention dysfunction is also indicated by specific types of task errors (Lezak, 1983). The BVRT-R can be provided requiring memory recall reproduction (Administrations A,B,D), copying (Administration C) and visual recognition of multiple choice items (Administration M). Six primary error types on copying and reproduction involve distortions, misplacements, omissions, perseverations, rotations and size errors. Simplification, simple substitution and omissions indicate possible attention disorder.

Reliability: Benton (1974), reports high retest reliability (.85) for Administration A and good alternate form reliability between forms C,D, and E (.79 to .84). Swan, Morrison and Eslinger (1990), report excellent interrelater reliability (.95) for test scoring. The relationship between copying and memory is modest (.41 to .52) (Benton, 1974).

Validity: Overall construct-related validity as indicated by correlation with age and intelligence is .7 (Benton, 1974). While the instrument is sensitive to the presence of brain damage, concurrent validity is only modest (Benton, 1974). Larabee, et al., (1985), report the factorial validity is higher for a motor-perceptual-visual factor and lower for an attention-concentration-memory factor based on factorial analysis.
The Trail Making Test

The purpose of this instrument is the assessment of visual scanning, attention, mental flexibility and motor skills. The Intermediate or Children's Form for children ages 9 through 14 is similar to the adult form originated in 1944. The test consists of two parts (A and B) with part B the more complex. Part A involves connecting 15 encircled numbers by pencil lines in numerical order. Part B requires the connection of numbers and letters in alternating order.

Reliability: Lezak (1983), reported retest reliability coefficients of .98 for Part A and .67 for Part B. In a review of the research regarding the instrument Spreen and Strauss (1991), found many similar results including one-year retest coefficients mainly better than .6 for Part A and .7 for Part B. Alternate form reliability was found to be .80 and .81 (Parts A and B) (desRosiers and Kavanagh, 1987). The Part B portion appears to be more reliable as well as more sensitive to brain damage.

Validity: The instrument is sensitive to age and standard measures of intellectual function on instruments such as the Wechsler scales (Lezak, 1983). Factors such as visual search and visual sequencing are significant (desRosiers and Kavanagh, 1987). Spreen and Strauss (1991), report high correlations of construct validity for searching/scanning abilities found in several studies, but poor correlation with verbal tests.

Simple Visual Reaction

The purpose of this computer program is to enhance awareness of visual perceptual/scanning dysfunction and improve the processes of monitoring sensory input.
while selectively attending and maintaining attention for extended periods of time (Bracey, 1983). The computer-assisted rehabilitation task involves the presentation of a one-fourth inch yellow square at random locations on a blue screen after random delays (two to twelve seconds). The subject is instructed to react as quickly as possible to the presentation by pushing a joystick button. Feedback is provided by a high-pitched tone for correct responses and a low pitched tone for late responses. Average latency (norm = .25-.50 seconds), variance, and number of errors are presented after fifteen trials.

Gordon, Hibbard and Kreutzer (1989), question the value of this type instrument in teaching the specific skills stated above, although Bracy (1992) emphasizes the fact that it is a tool, not the entire cognitive rehabilitation program. Bracey (1983), emphasizes use of the program as part of a comprehensive or holistic program in remediation of the specific interrupted brain processes related to visual information processing and attention/concentration skills. The development of the software program specifically for head trauma rehabilitation, based on sound theoretical principles (Lurian), is endorsed by Lynch (1983).

**REACT and Attention Reaction Conditioner (ARC)**

The purpose of these computer programs is to improve awareness and function of alertness, attention/concentration on a task and speed of response to visual stimuli in the visual fields (Gianutsos. 1981). The REACT computer program presents numbers that appear in one spot and count up rapidly by ones from 1 to 400 within ten seconds unless a key is pressed. The individual is instructed to "stop the runaway numbers" (Gianutsos. 1981. p. 7), on the screen. The computer keeps track of response times for 5 trials in the
center of the screen and 8 each at random on the left and right halves of the screen. The ARC program requires a similar reaction on the computer space bar to a light that changes color in the center of the screen for fifteen trials (Ben-Yishay, 1980). Impulsivity is demonstrated by computer recorded frequencies of early or random responses not associated with a visual stimulation.

Deaton, et al., (1992), reviewed similar programs and found the requirement of sustained attention to task may be the instrument's most effective characteristic and they lament the lack of any normative data provided by most authors. Gianutsos (1981), suggests that the user establish appropriate performance goals based on the needs of the patient/client on an individualized basis. The fixed-eye version of use is similar to campimetry, because of the fixation requirement. Lynch (1986), described the program briefly without commentary, but has suggested elsewhere that the ability to measure improvements in attention as a function of reaction time is a significant contribution to cognitive rehabilitation.

**Visual Tracking-II**

This computer-assisted cognitive rehabilitation task was developed for the purpose of improving higher level areas of attention, vigilance and visuoperceptual skills involving recognition, localization and differentiation of stimuli (Bracey, 1983). A small red circle must be tracked visually as it moves randomly around the screen. Whenever the center of the square turns yellow in color the individual signals recognition of this by pressing the mouse button. The computer provides feedback for both correct and incorrect responses.
The value of this type instrument is questioned by Gordon, Hibbard and Kreutzer (1989), primarily on theoretical grounds rather than that of any specific software program task deficiency. Lynch (1986), however, finds the program beneficial for a variety of visuoperceptual related skills when administered as part of holistic rehabilitation. Spatial orientation is enhanced via the requirement of the individual to visually track the position of the stimuli. This component of the program also requires attention-related vigilance to task. Task performance also requires the ability to identify changes in visual stimuli as rapidly as possible. When the individual is unable to inhibit impulsive responses to non-stimuli, computer software feedback aids in improving self-awareness of inattention, impulsivity and problems in eye movement or visual field neglect.

SEARCH: Searching For Shapes

Developed as a task designed to improve visual/iconic memory and visuoperceptual skills, this computer program focuses specifically on hemi-inattention (visual field neglect without hemianopsia) (Gianutsos, 1981). An array of abstract shapes is displayed on the screen. The array is 8 rows by 8 columns, and in the center spot there is a box. When a shape disappears from the box the individual searches for the matching shape and utilizes the arrow keys to move the box the the matching shape. The computer indicates whether or not the response was correct and the speed of matching.

This computer assisted cognitive rehabilitation task has been shown to be effective in diagnosing visual information processing dysfunction in brain injured adults when standard neurological examination had failed to do so (Lavach, Gailey, Martin, and Solomon, (1994). The activity appears to be a computerized version of the visual search.
test developed originally by Poppelreuter in 1917. Teuber later adapted the test to demonstrate that it indicated frontal lobe damage impairing voluntary eye movement and reafferance from the frontal lobe to the parietal and temporal lobes. Lynch (1989), lauds this type program for providing computer-enhanced graphics and an unlimited variety, resulting in better patient motivation and positive response to the treatment that could not be duplicated in a noncomputerized environment.

**Visual Discrimination Conditioner**

Visual Discrimination Conditioner was developed for the purpose of improving ability to identify and retain information so that it can be recalled as the situation demands (Ben-Yishay, 1981). A single digit number is presented on the left side of the monitor screen, or one of four colors is presented on the right side at random until 12 items have been presented on each side. Then the items are presented simultaneously for an additional 12 presentations. The individual must recall which objects were displayed. Both involve the ability to recall visually (digits and colors) presented information. The simultaneous memory task adds the cognitive ability to retain and recall competing visual stimulation.

Deaton, et al. (1992), found that program performance was impacted by separate cognitive functions of attention and visual scanning. They rated the program easy to use regarding computer-generated documentation, exiting function, program installation and menu function. Clinical features were rated medium (average). The program provides a wide range of difficulty levels and reports performance quantitatively.

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
The fact that the software was specially written for cognitive rehabilitation and can be used language free has been commended by Lynch (1986b).

Research Design

This study was a causal-comparative design similar to a normative study examining the relationships between nonstandardized cognitive remedial computerized tasks, standardized assessment instruments and developmental (age-related) patterns of task performance. The data from this research will be analyzed to determine the efficacy of further national standardization and normative research regarding use of the computer assisted rehabilitation tasks for related neuropsychological sequelae in children who have educational challenges resulting from a traumatic brain injury.

Causal-comparative designs are often used in research development of norming studies where the intent is to determine a standard of task performance. Ylvisaker, et. al., (1990), described numerous TBI related assessment instruments used with children developed and/or validated with causal-comparative techniques. Ruff, et. al. (1989), conducted a correlational comparison of scores on neurobehavioral measures and demographic potential confounders in analyzing a cognitive rehabilitation program.

Validation of new or nonstandardized instruments often requires use of causal-comparative techniques. A primary purpose of the causal-comparative method described by Borg and Gall (1989). "is to discover relationships between variables" (p. 536).

Bivariate correlations were used to determine relationships between variables. Kiess (1989) suggests bivariate correlations as a statistical method appropriate for
analyzing the strength of relationship between variables (e.g. instrument with age, CART score with Trail Making Test or BVRT-R, and between CART scores). The examination of concurrent validity in this study involves statistical analysis of CART scores with standardized instrument scores, as well as the analysis of relationships among individual CART scores.

**Null Hypothesis**

Ho1: There will be no developmental trend in scores from the Computer Assisted Rehabilitation Tasks (CART), the BVRT-R or the Trail Making Test.

Ho2: There will be no significant relationship between scores on the CART protocol performance and scores on the BVRT-R.

Ho3: There will be no significant relationship between scores on the CART protocol performance and scores on the Trail Making Test.

Ho4: There will be no significant interrelationships among scores from the CART protocol.

**Ethical Considerations**

The purpose of this study was to examine the relationship between computer assisted rehabilitation task performance and age in 9 to 12 year-old children, and to study the concurrent validity of those tasks based on standardized test performance of related (attention/concentration, visual/perceptual and visual/iconic memory) cognitive skills.

This research will further the body of knowledge regarding cognitive remedial tasks available for use with children diagnosed with acquired head trauma. Children and their parents were provided a brief written description of the research fully informing them,
including an option to terminate or refusal to participate at any time. A written statement of informed consent (Appendix A) was obtained for each participant. Each child’s performance was recorded by an age/gender identification number. The performance for each child was therefore anonymous. Children were again verbally informed at the time of participation of their right to terminate at any time upon request.

This research study was submitted and approved by the Committees for Research on Human Subjects at the College of William and Mary before the research was begun. Approval was also obtained by the Chesapeake Public Schools and by the individual schools involved in the study before data collection was undertaken.
CHAPTER 4

RESULTS

In this study four hypotheses were proposed which examined the relationships between cognitive remedial computer tasks, standardized assessment instruments and developmental (age-related) patterns of task performance. This chapter presents the findings of this study along three dimensions. The descriptive statistics report sample demographics and performance examined on the various instruments utilized evaluated in the study. Statistical analyses of four research hypotheses are reported. A qualitative description of the data examines the data in further detail.

Sample

Two hundred five students from one elementary, one intermediate and one middle school in Chesapeake, Virginia, Public Schools participated in this study. Students were divided into four age groups. The original plan was to work with students from two elementary and two middle schools. The age group span (9-12) in Chesapeake, however, required the involvement of students at the intermediate school level. Permission from the director of testing from the school system was first required, followed by permission of the schools located in areas that served both urban/suburban and rural localities within the city.

Data was collected individually during the school day on various days and time of day primarily during the students' physical education or computer class time in October 1998, to May 1999.
Table 1
Sample Demographics

<table>
<thead>
<tr>
<th>AGE</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>50</td>
<td>24.4</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>24.4</td>
</tr>
<tr>
<td>11</td>
<td>51</td>
<td>24.9</td>
</tr>
<tr>
<td>12</td>
<td>54</td>
<td>26.3</td>
</tr>
<tr>
<td>Total</td>
<td>205</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Sample Demographics

Alphabetical lists of students from each school were used to select 32 male and 32 female students in each age group were selected by random sampling. The first 25 in each group were intended for the data collection sample. As indicated in Table 1, data was collected from 50 nine year-old, 50 ten year-old, 51 eleven year-old, and 54 twelve year-old children. Due to changes in data collection dates and times five additional students were found to have been included when data analysis was initiated.

Data Analysis

Descriptive statistics of the participants' performance scores for the six computer-assisted rehabilitation tasks and two standardized tasks for each of the four age groups were calculated. Mean task performances for the "Simple Visual Reaction" (SVR), "Attention Reaction Conditioner" (ARC), "REACT", and "SEARCH" computer programs (Tables 2, 4, 6, 7) were measured in time to within thousandths of a second. Better performance scores were lower numbers. "Visual Tracking – II" (VT-II) performance means (Table 3) were measured by percent correct. "Visual Discrimination Conditioner" (VDC) performance means (Table 5) were reported by total number correct. Higher numbers therefore indicated better performances on the VT-II and VDC tasks.
Performance on the Trail Making Test - (B) was reported in seconds with the fewer number of seconds indicating a better performance. Benton Visual Retention Test – Revised scores were reported as total number correct with higher numbers indicating better scores. Correlation values with the two standardized instruments were utilized as an indication of validity of the constructs reported for each CART task.

Table 2

<table>
<thead>
<tr>
<th>AGE</th>
<th>N</th>
<th>MEAN (seconds)</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>50</td>
<td>.4467”</td>
<td>.1411</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>.3626</td>
<td>.1064</td>
</tr>
<tr>
<td>11</td>
<td>51</td>
<td>.3057</td>
<td>9.712E-02</td>
</tr>
<tr>
<td>12</td>
<td>54</td>
<td>.2461</td>
<td>9.408E-02</td>
</tr>
<tr>
<td>TOTAL</td>
<td>205</td>
<td>.3383</td>
<td>.1329</td>
</tr>
</tbody>
</table>

Table 3

<table>
<thead>
<tr>
<th>AGE</th>
<th>N</th>
<th>MEAN (% correct)</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>50</td>
<td>100.00</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>100.00</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>51</td>
<td>99.31</td>
<td>2.10</td>
</tr>
<tr>
<td>12</td>
<td>54</td>
<td>100.00</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>205</td>
<td>99.829</td>
<td>1.08</td>
</tr>
</tbody>
</table>
### Table 4

**Attention Reaction Conditioner (ARC) Mean Scores**

<table>
<thead>
<tr>
<th>AGE</th>
<th>N</th>
<th>MEAN (seconds)</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>50</td>
<td>.3430</td>
<td>5.744E-02</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>.3015</td>
<td>6.27E-02</td>
</tr>
<tr>
<td>11</td>
<td>51</td>
<td>.2841</td>
<td>6.943E-02</td>
</tr>
<tr>
<td>12</td>
<td>54</td>
<td>.2709</td>
<td>4.842E-02</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>205</strong></td>
<td><strong>.2992</strong></td>
<td><strong>6.532E-02</strong></td>
</tr>
</tbody>
</table>

### Table 5

**Visual Discrimination Conditioner (VDC) Mean Scores**

<table>
<thead>
<tr>
<th>AGE</th>
<th>N</th>
<th>MEAN (# correct)</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>50</td>
<td>11.82</td>
<td>.5956</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>11.84</td>
<td>.4647</td>
</tr>
<tr>
<td>11</td>
<td>51</td>
<td>11.9412</td>
<td>.2376</td>
</tr>
<tr>
<td>12</td>
<td>54</td>
<td>12.000</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>205</strong></td>
<td><strong>11.90</strong></td>
<td><strong>.3964</strong></td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
### Table 6
**REACT Mean Scores**

<table>
<thead>
<tr>
<th>AGE</th>
<th>N</th>
<th>MEAN (seconds)</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>50</td>
<td>.3382</td>
<td>5.086E-02</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>.3156</td>
<td>7.343E-02</td>
</tr>
<tr>
<td>11</td>
<td>51</td>
<td>3.084</td>
<td>7.066E-02</td>
</tr>
<tr>
<td>12</td>
<td>54</td>
<td>.2896</td>
<td>4.678E-02</td>
</tr>
<tr>
<td>TOTAL</td>
<td>205</td>
<td>.3125</td>
<td>6.337E-02</td>
</tr>
</tbody>
</table>

### Table 7
**SEARCH Mean Scores**

<table>
<thead>
<tr>
<th>AGE</th>
<th>N</th>
<th>MEAN (seconds)</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>50</td>
<td>12.9094</td>
<td>4.3415</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>11.2662</td>
<td>4.2106</td>
</tr>
<tr>
<td>11</td>
<td>51</td>
<td>11.1682</td>
<td>6.3008</td>
</tr>
<tr>
<td>12</td>
<td>54</td>
<td>9.1533</td>
<td>4.7454</td>
</tr>
<tr>
<td>TOTAL</td>
<td>205</td>
<td>11.0860</td>
<td>5.1166</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Table 8

Trail Making Test (B) Mean Scores

<table>
<thead>
<tr>
<th>AGE</th>
<th>N</th>
<th>MEAN (seconds)</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>50</td>
<td>52.6400</td>
<td>27.2926</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>39.4600</td>
<td>12.7571</td>
</tr>
<tr>
<td>11</td>
<td>51</td>
<td>43.9412</td>
<td>18.4558</td>
</tr>
<tr>
<td>12</td>
<td>54</td>
<td>41.0</td>
<td>12.6244</td>
</tr>
<tr>
<td>TOTAL</td>
<td>205</td>
<td>44.2098</td>
<td>19.1964</td>
</tr>
</tbody>
</table>

Table 9

Benton Visual Retention Test – Revised Mean Scores

<table>
<thead>
<tr>
<th>AGE</th>
<th>N</th>
<th>MEAN (# correct)</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>50</td>
<td>7.3200</td>
<td>2.2355</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
<td>9.0800</td>
<td>1.2591</td>
</tr>
<tr>
<td>11</td>
<td>51</td>
<td>8.7647</td>
<td>1.7040</td>
</tr>
<tr>
<td>12</td>
<td>54</td>
<td>9.2222</td>
<td>1.6445</td>
</tr>
<tr>
<td>TOTAL</td>
<td>205</td>
<td>8.6098</td>
<td>1.8875</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Statement of Hypotheses

Null Hypothesis 1: There will be no developmental trend in scores from the Computer Assisted Rehabilitation Tasks (CART), the BVRT-R or the Trail Making Test.

Null Hypothesis 2: There will be no significant relationship between scores on the CART protocol performance scores on the BVRT-R.

Null Hypothesis 3: There will be no significant relationship between scores on the CART protocol performance on the Trail Making Test.

Null Hypothesis 4: There will be no significant interrelationships among scores from the CART protocol.

Pearson two-tailed bivariate correlations were calculated to test for relationships across the six computer-assisted rehabilitation tasks and the two standardized instruments. Correlations were calculated for each dependent variable within each hypothesis. Alpha was set at .05 for significance.

Findings

Table 10 presents correlations and level of significance for each variable. Tables 11-14 present correlations for each research hypothesis. Every table presents three rows for each variable. The first row represents the Pearson correlation. Negative correlations are reported between decreased speeds on some tasks (indicative of a better performance) and increased age and/or tasks reported as higher scores (indicative of a better performance). The second row represents level of significance (two-tailed).
**TABLE 10**
Correlations of Age, CART Programs and Standardized Instruments

<table>
<thead>
<tr>
<th></th>
<th>AGE</th>
<th>SVR</th>
<th>VT2</th>
<th>ARC</th>
<th>VDC</th>
<th>REACT</th>
<th>SEARCH</th>
<th>TRAILB</th>
<th>BVRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.000</td>
<td>-.558**</td>
<td>-.066</td>
<td>-.401**</td>
<td>.183**</td>
<td>-.272**</td>
<td>-.251**</td>
<td>-.176*</td>
<td>.319**</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.000</td>
<td>.348</td>
<td>.000</td>
<td>.009</td>
<td>.000</td>
<td>.000</td>
<td>.012</td>
<td>.000</td>
</tr>
<tr>
<td>SVR</td>
<td>-.558**</td>
<td>1.000</td>
<td>.112</td>
<td>.399**</td>
<td>-.046</td>
<td>.325**</td>
<td>.295**</td>
<td>.140*</td>
<td>-.342**</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.000</td>
<td>.108</td>
<td>.000</td>
<td>.512</td>
<td>.000</td>
<td>.000</td>
<td>.045</td>
<td>.000</td>
</tr>
<tr>
<td>VT2</td>
<td>-.066</td>
<td>.112</td>
<td>1.000</td>
<td>.090</td>
<td>-.039</td>
<td>-.139*</td>
<td>.010</td>
<td>.033</td>
<td>-.050</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.348</td>
<td>.108</td>
<td>.198</td>
<td>.579</td>
<td>.047</td>
<td>.883</td>
<td>.637</td>
<td>.480</td>
</tr>
<tr>
<td>ARC</td>
<td>-.401**</td>
<td>.399**</td>
<td>.090</td>
<td>1.000</td>
<td>.037</td>
<td>.283**</td>
<td>.173*</td>
<td>.156*</td>
<td>-.186**</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.000</td>
<td>.000</td>
<td>.198</td>
<td>.599</td>
<td>.000</td>
<td>.013</td>
<td>.026</td>
<td>.007</td>
</tr>
<tr>
<td>VDC</td>
<td>.183**</td>
<td>-.046</td>
<td>-.039</td>
<td>.037</td>
<td>1.000</td>
<td>-.061</td>
<td>-.083</td>
<td>-.165*</td>
<td>-.025</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.009</td>
<td>.512</td>
<td>.579</td>
<td>.599</td>
<td>.388</td>
<td>.239</td>
<td>.018</td>
<td>.723</td>
</tr>
<tr>
<td>REACT</td>
<td>-.272**</td>
<td>.325**</td>
<td>-.139*</td>
<td>.283**</td>
<td>-.061</td>
<td>1.000</td>
<td>.116</td>
<td>.102</td>
<td>-.123</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.000</td>
<td>.000</td>
<td>.047</td>
<td>.000</td>
<td>.388</td>
<td>.099</td>
<td>.145</td>
<td>.078</td>
</tr>
<tr>
<td>SEARCH</td>
<td>-.251**</td>
<td>.295**</td>
<td>.010</td>
<td>.173*</td>
<td>-.083</td>
<td>.116</td>
<td>1.000</td>
<td>.248**</td>
<td>-.428**</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.000</td>
<td>.000</td>
<td>.883</td>
<td>.013</td>
<td>.239</td>
<td>.099</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>TRAILB</td>
<td>-.176*</td>
<td>.140*</td>
<td>.033</td>
<td>.156*</td>
<td>-.165*</td>
<td>.102</td>
<td>.248**</td>
<td>1.000</td>
<td>-.414**</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.012</td>
<td>.045</td>
<td>.637</td>
<td>.026</td>
<td>.018</td>
<td>.145</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>BVRT</td>
<td>.319**</td>
<td>-.342**</td>
<td>-.050</td>
<td>-.186**</td>
<td>-.025</td>
<td>-.123</td>
<td>-.428**</td>
<td>-.414**</td>
<td>1.000</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td>.000</td>
<td>.000</td>
<td>.480</td>
<td>.007</td>
<td>.723</td>
<td>.078</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
Research Hypothesis 1. Performance by children regarding attention, visual/perceptual and visual memory skills will indicate a developmental trend as measured by computer assisted rehabilitation tasks and related standardized instruments.

**TABLE 11**

<table>
<thead>
<tr>
<th>Correlation Between Instruments and Age</th>
<th>SVR</th>
<th>VT2</th>
<th>ARC</th>
<th>VDC</th>
<th>REACT</th>
<th>SEARCH</th>
<th>TRAILB</th>
<th>BVRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearson</td>
<td>-.558**</td>
<td>-.066</td>
<td>-.401**</td>
<td>.183**</td>
<td>-.272**</td>
<td>-.251**</td>
<td>-.176*</td>
<td>.319**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.348</td>
<td>.000</td>
<td>.009</td>
<td>.000</td>
<td>.000</td>
<td>.012</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
</tr>
</tbody>
</table>

**Correlation is significant at the 0.01 level (2-tailed).**
*Correlation is significant at the 0.05 level (2-tailed).*

Pearson two-tailed bivariate correlations were calculated to test for relationships across the six computer-assisted rehabilitation tasks and the two standardized instruments. As shown in Table 11, there was a significant negative correlation (p< .01) of performance on the “Simple Visual Reaction”, “Attention Reaction Conditioner”, “REACT”, and “SEARCH” computer programs with age of the child. Significant positive correlations (p< .01) for performance on the “Visual Discrimination Conditioner” computer program and the Benton Visual Retention Test with age. A significant negative correlation (p< .05) was found on performance of the Trail Making Test (B) with age of the child. No significant correlation was found for performance on the “Visual Tracking – II” computer program with age.

The correlation with five of the CART computer programs and both of the standardized instruments with developmental trend was significant. The null hypothesis was therefore rejected. For one CART program (VT-II) no statistically significant
correlation with developmental trend was found ($r = -0.066$). The null hypothesis was therefore not rejected.

Research Hypothesis 2: There is a positive relationship between computer assisted rehabilitation tasks for attention, visual/perceptual and visual memory skills and the Benton Visual Retention Test – Revised.

TABLE 12

<table>
<thead>
<tr>
<th></th>
<th>SVR</th>
<th>VT2</th>
<th>ARC</th>
<th>VDC</th>
<th>REACT</th>
<th>SEARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>BVRT Pearson</td>
<td>-.342**</td>
<td>-.050</td>
<td>-.186**</td>
<td>-.025</td>
<td>-.123</td>
<td>-.428**</td>
</tr>
<tr>
<td>Correlation</td>
<td>.000</td>
<td>.480</td>
<td>.007</td>
<td>.723</td>
<td>.078</td>
<td>.000</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Pearson two-tailed bivariate correlations were calculated to test for relationships across the six computer-assisted rehabilitation tasks. As shown in Table 12, there was a significant negative correlation ($p < 0.01$) of performance on the “Simple Visual Reaction” (SVR), “Attention Reaction Conditioner” (ARC), and “SEARCH” computer programs with the Benton Visual Retention Test - Revised. For the SVR, ARC and SEARCH computer programs the null hypothesis was therefore rejected. No significant correlation was found for performance on the “Visual Tracking – II” (VT-II), “Visual Discrimination Conditioner” (VDC), and “React” computer programs with the Benton Visual Retention Test - Revised. For the VT-II, VDC and REACT computer programs the null hypothesis was therefore not rejected.
Research Hypothesis 3: There is a positive relationship between computer assisted rehabilitation tasks for attention, visual/perceptual and visual memory skills and the Trail Making Test.

TABLE 13

<table>
<thead>
<tr>
<th>TRAIL B Pearson Correlation with CART Programs</th>
<th>SVR</th>
<th>VT2</th>
<th>ARC</th>
<th>VDC</th>
<th>REACT</th>
<th>SEARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Correlation is significant at the 0.01 level (2-tailed).</strong></td>
<td>.140*</td>
<td>.033</td>
<td>.156*</td>
<td>-.165*</td>
<td>.102</td>
<td>.248**</td>
</tr>
<tr>
<td><strong>Correlation is significant at the 0.05 level (2-tailed).</strong></td>
<td>.045</td>
<td>.637</td>
<td>.026</td>
<td>.018</td>
<td>.145</td>
<td>.000</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
</tr>
</tbody>
</table>

Pearson two-tailed bivariate correlations were calculated to test for relationships across the six computer-assisted rehabilitation tasks. As shown in Table 13, there was a significant positive correlation (p< .01) of performance on the “SEARCH” computer program with the Trail Making Test (B). A significant positive correlation (p< .05) was also found for performance on the “Simple Visual Reaction”(SVR), and the “Attention Reaction Conditioner”(ARC), computer programs with the Trail Making Test (B). A significant negative correlation (p< .05) of performance on the “Visual Discrimination Conditioner” (VDC) computer program with the Trail Making Test (B) was found. For the SVR, ARC, VDC and SEARCH computer programs the null hypothesis was therefore rejected. No significant correlation was found for performance on the “Visual Tracking – II” (VT-II) or “REACT” computer program with the Trail Making Test (B). For the VT-II and REACT computer programs the null hypothesis was therefore not rejected.
Research Hypothesis 4: There is a positive relationship between separate computer assisted rehabilitation task programs for attention, visual/perceptual and visual memory skills.

**TABLE 14**

<table>
<thead>
<tr>
<th>Correlations Between CART Programs</th>
<th>SVR</th>
<th>VT2</th>
<th>ARC</th>
<th>VDC</th>
<th>REACT</th>
<th>SEARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>SVR Pearson Correlation</td>
<td>1.000</td>
<td>.112</td>
<td>.399**</td>
<td>-.046</td>
<td>.325**</td>
<td>.295**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.108</td>
<td>.000</td>
<td>.512</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
</tr>
<tr>
<td>VT2 Pearson Correlation</td>
<td>.112</td>
<td>1.000</td>
<td>.090</td>
<td>-.039</td>
<td>-.139*</td>
<td>.010</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.108</td>
<td>.198</td>
<td>.579</td>
<td>.047</td>
<td>.883</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
</tr>
<tr>
<td>ARC Pearson Correlation</td>
<td>.399**</td>
<td>.090</td>
<td>1.000</td>
<td>.037</td>
<td>.283**</td>
<td>.173*</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.198</td>
<td>.599</td>
<td>.000</td>
<td>.013</td>
<td>.239</td>
</tr>
<tr>
<td>N</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
</tr>
<tr>
<td>VDC Pearson Correlation</td>
<td>-.046</td>
<td>-.039</td>
<td>.037</td>
<td>1.000</td>
<td>-.061</td>
<td>-.083</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.512</td>
<td>.579</td>
<td>.599</td>
<td>.388</td>
<td>.239</td>
<td>.116</td>
</tr>
<tr>
<td>N</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
</tr>
<tr>
<td>REACT Pearson Correlation</td>
<td>.325**</td>
<td>-.139*</td>
<td>.283**</td>
<td>.061</td>
<td>1.000</td>
<td>.116</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.047</td>
<td>.000</td>
<td>.388</td>
<td>.099</td>
<td>.205</td>
</tr>
<tr>
<td>N</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
</tr>
<tr>
<td>SEARCH Pearson Correlation</td>
<td>.295**</td>
<td>.010</td>
<td>.173*</td>
<td>.083</td>
<td>.116</td>
<td>1.000</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.883</td>
<td>.013</td>
<td>.239</td>
<td>.099</td>
<td>.205</td>
</tr>
<tr>
<td>N</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
<td>205</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Pearson two-tailed bivariate correlations were calculated to test for relationships between the six computer-assisted rehabilitation tasks. As shown in Table 14, there was a significant positive correlation (p< .01) between the "Simple Visual Reaction" computer program and the "Attention Reaction Conditioner", "REACT", and"
"SEARCH" computer programs. There was a significant positive correlation (p< .01) between the "Attention Reaction Conditioner" computer program and the "Simple Visual Reaction" and "REACT" computer programs. There was a significant positive correlation (p< .01) between the "REACT" computer program and the "Simple Visual Reaction" and "Attention Reaction Conditioner" computer programs. There was a significant positive correlation (p< .01) between the "SEARCH" computer program and the "Simple Visual Reaction" computer program. For these computer program performance correlations the null hypothesis was therefore rejected.

There was a significant negative correlation (p< .05) of performance on the "Visual Tracking — II" computer program with the "REACT" computer program. There was a significant positive correlation (p< .05) of performance on the "Attention Reaction Conditioner" computer program with the "SEARCH" computer program. There was no significant correlation between the "Visual Tracking — II" computer program and any other computer program except the "REACT" computer program. For these computer program performance correlations the null hypothesis was therefore rejected.

There was no significant correlation between the "Simple Visual Reaction" computer program and the "Visual Tracking — II" or "Visual Discrimination Conditioner" computer programs. There was no significant correlation of performance on the "Attention Reaction Conditioner" computer program with the "Visual Tracking — II" or the "Visual Discrimination Conditioner" computer programs. There was no significant correlation of performance on the "Visual Discrimination Conditioner" computer program with any other program. There was no significant correlation of performance on the "REACT" computer program with the "Visual Discrimination Conditioner" or
“SEARCH” computer programs. There was no significant correlation of performance on the “SEARCH” computer program with the “Visual Tracking – II”, “Visual Discrimination Conditioner” and “REACT” computer programs. For these computer program performance correlations there was a failure to reject the null hypothesis.

**Summary**

Performance on five computer assisted rehabilitation tasks, the Trail Making Test (B) and the reproduction task on the Benton Visual Retention Test – Revised, was found to indicate a developmental trend among 9-12 year olds. This may suggest that developmental skills such as visual memory, visual perception and attention/concentration improve with chronological age in this population (Anastasi, 1988). One instrument (Visual Tracking – II) was found to lack significant correlation to developmental trend or standardized instruments utilized in identifying any form of validity.

One instrument, the Attention Reaction Conditioner, was found to correlate with developmental trend (- .401, p. < .01) Trails B (.156, p. < .05), and the BVRT-R (.186, p. < .01), as an indication of attention/concentration skills. The Simple Visual Reaction computer program correlated with developmental trend (- .558, p. < .01) and the standardized instruments (Trails B - .140, BVRT-R - .352) as an indication of visual/perceptual skills. The SEARCH program correlated with developmental trend (- .251, p. < .01) visual/perceptual and visual memory skills as indicated by correlation with the Trail-Making Test (part B) (.248, p. < .01), and the Benton Visual Retention Test – Revised (- .428, p. < .01).
The Visual Discrimination Conditioner computer program correlated with developmental trend (.183, p. < .01), and the Trails B test (- .165, p. < .05). The latter correlation was not hypothesized, but appears to indicate this instrument may likely be related more to visual/perceptual and scanning skills than to visual memory. There was no correlation, however between the VDC and any other CART. Correlation between computer assisted rehabilitation tasks and the BVRT-R were found to vary, but not in relation to the reported purpose of each program.

The null hypothesis for most computer assisted rehabilitation tasks was rejected, indicating that there was a developmental trend as well as validity for some CART tasks as measured by correlation with the BVRT-R and the Trail Making Test.
CHAPTER FIVE

DISCUSSION AND CONCLUSION

This research was undertaken to investigate the relationship between performance on computer programs developed for adults as rehabilitation tasks and the age of children performing these tasks. Specifically, the study sought to determine if there was any developmental trend in performance on these computer programs and validity for these tasks as indicated by correlation with standardized assessment instruments. Research cited in this study has demonstrated the demand for tasks specialized for remediation of specific areas of cognitive dysfunction in children with acquired brain trauma interfering with successful academic and lifelong outcomes.

During the past century, and especially the past twenty years the incidence of traumatic brain injury survival among children has grown (Max, et. al, 1998; Savage, 1991). Formal attempts at cognitive rehabilitation of traumatic brain injured (TBI) soldiers were first attempted in 1917, and first reported in the literature in by Kurt Goldstein in Germany in 1942 (Prigatano, 1991). The first, most comprehensive, and still least understood (in this country) attempts to develop a theoretical basis for remediation of TBI-related brain dysfunction have been developed over most of the 20th century by Alexander Luria in Russia (Prigatano, et al., 1986). Much of Luria’s work has only been translated into English over the past 10-20 years.

The growth in the number of students in the public schools has far surpassed the growth in available resources and techniques to adequately serve this rising population (Cook, 1991; Crowley and Miles, 1991: Max, et al., 1995). With so much change,
educators and treatment professionals are seeking appropriate intervention and remedial techniques to improve dysfunction of attention, visual/perceptual and visual memory skills that interfere with academic performance and social/behavioral success.

**Descriptive Results**

This study was conducted with 205 children from three public schools in Chesapeake, Virginia. Census data indicated that population demographics in Chesapeake are very consistent with demographics for the Commonwealth of Virginia. Children participating in the study were divided almost evenly by gender (100 female and 105 male) with at least 50 children in each of the four age groups (9-12).

This study was intended to provide an indication of which among six computer assisted rehabilitation tasks (CART) might be viable for further standardization and usage in addressing attention, visual/perceptual or visual memory dysfunction in children. Students completed six computer tasks that have been used successfully with adults for several years. In addition, each student completed the Benton Visual Retention Test - Revised, and the Trail Making Test (B).

The normative nature of the study design necessitated rejection of children with any diagnosed academic dysfunction from the sample pool. Head injuries and the sequelae frequently associated with educationally related diagnoses are often undiagnosed or unreported (Max, et al., 1999; Savage, 1991). Further standardization of CART programs would serve as a control group in the development of performance norms for any TBI student attempting one of these tasks as part of rehabilitation or academic intervention.
Examination by Hypothesis

Hypothesis 1: Performance by children regarding attention, visual/perceptual and visual memory skills will indicate a developmental trend as measured by computer assisted rehabilitation tasks and related standardized instruments.

This hypothesis was included to assess the normative possibilities of the CART programs under consideration for use with children. Would children without any education-related diagnosis perform differently as they get older? Gans, Mann and Ylvisaker (1990), stressed the need to understand the relationship between cognitive remedial task performances and normal levels of cognitive development as described by Piaget. Performance normative data for TBI and other diagnostic populations often involves standardization with a controlled sample in order to establish appropriate levels of performance by the individual receiving the intervention or participating in an assessment (Burns, 1999; Gordon, 1989). Lack of funding and politics has severely limited this type research over the past decade, especially for children.

All but the Visual Tracking - II program were found to have performance means indicative of developmental trend. The Visual Tracking – II program was expected to have increasing levels of difficulty with decrease in age, because of the difficulty observed among head injured adults seen in treatment (Lavach, Gailey, Martin, and Solomon, 1994). Bracey (1983), suggested lowering the parameters from the manufacturer's default setting when TBI survivors experienced difficulty performing the task from the manufacturer's default setting used in this study. Surprisingly, there was no significant difference in performance (mean 99.82 % correct) across the four age groups for this computer task. This finding indicates the severity of visual information
processing that many TBI survivors may be experiencing when compared to the ease of performance by participants in this study. The lack of any developmental trend in this computer task does not preclude its use in intervention with TBI children. The level of performance implied by this result would be that children age 9-12 with acquired brain trauma should be able to perform this task.

The demand for the type of computer programs used in this study as part of cognitive remediation with children has been reported for more than ten years, but has been slow to be developed (Rizzo, Buckwalter, and Neumann, 1997; Solberg and Raskin, 1996). The challenge for researchers, software developers and manufacturers of this type program is to provide easy to use, valid instruments with demonstrated effectiveness. The programs used in this study proved problematic in terms of hardware/software difficulties. Some programs were written for Windows@ version application, others were not. Some programs required switching to DOS operations in order to be used. Some required use of a mouse, some the space bar, and some the arrow keys to operate. On separate occasions all programs were difficult to load, save or copy when used in more than one computer. Site-license agreements should have made this type operation free from any difficulty. The Scientific Learning Corporation recently produced the suggested type of software for use in remediation of verbal comprehension related reading disorders (Burns, 1999), but the price resulting from research and development costs makes the use of the software prohibitive for many schools and service providers.
Hypothesis 2: Computer assisted rehabilitation tasks (CART) for attention, visual/perceptual and visual memory skills will have a statistically significant relationship with the Benton Visual Retention Test – Revised (BVRT-R).

A significant correlation was found between three of the six computer programs (Simple Visual Reaction, Attention Reaction Conditioner and SEARCH) and the BVRT-R. Larabee, et al., (1985), had reported a higher validity for a motor-perceptual-visual factor than an attention-memory factor for the BVRT-R. Lezak, (1983), had reported indications of attentional dysfunction from the BVRT-R, which was developed to assess visual perceptive and memory capabilities (Benton, 1974).

Two computer programs (Visual Tracking – II and Visual Discrimination Conditioner) were expected to correlate with the BVRT-R, due to the visual/perceptual and visual memory attributes reported by their developers. There was less expectation for a correlation between the BVRT-R and Attention Reaction Conditioner (ARC) program. The ARC was developed only for remediation of attention/concentration dysfunction, while the BVRT-R was reported to be more related to visual/perceptual and visual memory skills. The capability of each CART program to be correlated with the BVRT-R appears unrelated to any particular developer. The three manufacturers' programs had one program each found to be correlated and not correlated with the BVRT-R.

One purpose of this hypothesis was to assist in establishing concurrent validity for the CART programs. One criticism of these rehabilitation tasks was the limited research involving validity and number of subjects (Gordon, Hibbard and Kreutzer, 1989). The nascent status of research in cognitive rehabilitation and differences in conceptual criteria...
by various researchers has resulted in controversy regarding the use and validity of these type instruments and techniques (Lynch, 1992; Parente and Herrmaann, 1996). The demand for intervention techniques has grown faster than time and resources have allowed for sufficient research. Development of normative and validity data regarding the CART programs used in this study should contribute to a basis for further research.

Hypothesis 3: Computer assisted rehabilitation tasks (CART) for attention, visual/perceptual and visual memory skills will have a statistically significant relationship with the Trail Making Test (B).

Four of the CART programs (Simple Visual Reaction, Attention Reaction Conditioner, Visual Discrimination Conditioner and SEARCH) were found to relate to the Trail Making Test. Trails B performance has long been used as an indicator of attention related function (Lezac, 1983). Spreen and Strauss (1991), reported high validity for visual searching/scanning. The attention related component of the Trail Making Test was the basis for expecting a significant relationship with the REACT program. REACT was reported to be an attentional process instrument by Gianutsos (1981). The similarity between the visual scanning component of the Trail Making Test and the Visual Tracking – II (VT-II) program was the basis for expecting a statistically significantly correlation between the two. Both involve a process of visually scanning randomly placed or moving objects, but there was no significant relationship. The lack of any developmental change in VT-II scores as discussed earlier may have contributed to the lack of relationship with the Trail Making Test.

There is no specific memory component to the Trail Making Test, but it correlated significantly to the SEARCH and Visual Discrimination Conditioner, which require more
of a visual memory component. This finding indicates the relationship between the other four CART programs and the complex interrelating neurocognitive processes of attention, visuoperception and visual memory.

Hypothesis 4: A positive relationship exists between the separate computer assisted rehabilitation tasks (CART) for attention, visual/perceptual and visual memory skills.

The purpose for this hypothesis is to assist in answering the question of concurrent validity for the CART instruments. The original development of these computer programs was based on the interrelationships between areas of brain function and rehabilitation as theorized by Luria (Ben-Yishay and Prigatano, 1990). Statistically significant relationships exist between four of the CART programs: Simple Visual Reaction, Attention Reaction Conditioner (ARC), SEARCH: Searching for Shapes, and REACT. Three of the four CART instruments also correlate with the BVRT-R and Trails B. The relationships strengthen the argument for concurrent validity based on the hierarchical interaction and function of the brain in attention, visual/perceptual and visual memory skills that have been described and hypothesized over the past half century (Boake, 1989; Kolb and Wishaw, 1990).

The three CART programs found to have a relationship with the BVRT-R and Trails B are Simple Visual Reaction, Attention Reaction Conditioner (ARC), and SEARCH: Searching for Shapes. The REACT program correlates with the other CART instruments, but not with the BVRT-R or Trails B. These four correlating computer programs are part of the various techniques of neurocognitive remediation developed over the past two decades (Parente and Herrmann, 1996; Sohlberg and Raskin, 1996).
Limitations of the Study

The first limitation is the lack of previous significant validation of the CART protocol used in this study. Small research samples and research design flaws have troubled the development of computer based rehabilitation tasks (Rizzo, Buckwalter and Neumann, 1997). The computer programs were originally developed for use in intervention, rather than assessment, which has limited their standardization and research of their validity. An attempt to determine concurrent validity was made as part of the study. The lack of sufficient previous validity of the instruments may have influenced the results of the study.

A second limitation is that the sampling in this study was purposefully exclusive of the target population (Gall, Borg and Gall, 1996). Students with known head injuries and other educational diagnoses, which may have included known or unknown head injured students, were excluded from the sample. The research sample was from schools in a locality where demographic criteria would closely match that of the entire state. The target population was excluded on the basis of attempting to obtain performance means from a non-head injured population. This exclusion likely influenced the results of the performance means and possibly the correlation results of the study.

Implications

The goal of this research was to obtain computer assisted rehabilitation task performance criteria that appear to have validity related to certain neurocognitive processes. This was attempted in order to identify computer tasks that may be further developed to meet the demand for resources necessitated by the growing number of children surviving acquired brain trauma. Further field trials on a national level will be
necessary before a fully standardized package of tasks can be developed and marketed for use by educators and rehabilitation professionals in interventions for related neurocognitive dysfunction in children.

One implication of this study is validation of the instruments related to the complex interrelationships between areas of brain function and methods of rehabilitation proposed by Luria (Bracey, 1992). One previous criticism for the use of these instruments has been the lack of validity due to research design and small number of subjects in previous research. The normative and validity data from this study should contribute to the development of additional instruments, techniques and further research in neurocognitive related interventions with children. We can now begin to have a reasonable expectation of performance standards for use of these instruments with children.

A second implication is that some rehabilitative tasks may not be addressing the area of brain function expected by the developers of the software tasks. For example, the Visual Discrimination Conditioner (VDC) program developed at the New York University Institute of Rehabilitative Medicine was not found to have a statistical relationship with any CART program or the BVRT-R. If the VDC is supposed to aid in rehabilitation of visual/perceptual and/or visual memory related skills there should have been some correlation between it and other research instruments.

A third implication is the lack of cohesive development by research-based institutions of rehabilitative techniques presently available to educators and service providers. Computer-based tasks used in this study were written for different operating systems (e.g. WINDOWS®, DOS, etc.) with varying degrees of complexity and
difficulty of use. Tasks require time consuming and possibly confusing switching from mouse to keyboard and back again. Timing mechanisms have to be calibrated when programs are copied from one computer to another. While these are issues of computer hardware and software as much as theoretical development, they hamper research efforts.

Further Research

One underlying significant area of further research is that of demonstrating reliable and meaningful outcomes with these instruments in educational intervention or rehabilitation of related neurocognitive dysfunction in children. Controlled studies should be conducted regarding performance differences between children with and without acquired brain trauma, as well as other academic related diagnoses. Another research question is whether these techniques work better or worse with children than with adults. Can these instruments be useful in remediation of attention, visual/perceptual or visual memory deficits related to other diagnoses such as Attention Deficit Disorder? The normative and validity data from the present study should contribute to a basis for further research into these questions.

Further research into the concurrent and criterion-related validity of the instruments evaluated in this study is called for. Do the CART program findings hold when correlated with other standardized instruments reported to measure similar neurocognitive processes? Do these instruments actually show a relationship or lack of relationship as found in this study? Significant relationships between the CART programs, different rehabilitation tasks and other related standardized instruments should be examined. Finally, this study could also be useful in contributing to the body of knowledge on Luria's theories of brain function and rehabilitation as applied to children.
APPENDIX A

Statement of Informed Consent
STATEMENT OF INFORMED CONSENT

NAME OF STUDENT: ______________________________________

PARENT(S) OR LEGAL GUARDIAN(S): _______________________

STATEMENT OF PARTICIPATION:
Your child has been selected for participation in a research project involving 200 students in the Chesapeake Public Schools.

PURPOSE OF THE RESEARCH:
The purpose of this research is to determine the relationship between age and performance on computer assisted tasks of attention, visual/perceptual and visual memory skills in children.

DESCRIPTION OF BENEFITS:
The data collected from this research will hopefully be useful in determining expected levels of performance in the rehabilitation treatment and education of children who have sustained traumatic brain injuries.

DESCRIPTION OF FORESEEABLE RISKS:
There are no anticipated risks or discomforts that might occur as a result of participating in the research and participation is voluntary.

RIGHT OF REFUSAL TO PARTICIPATE:
You or your child may refuse to participate at any time before or during the research. There will be no penalty for refusal to participate.

REQUESTS FOR FURTHER INFORMATION:
There will be no compensation for participation in the proposed research; however, a written description of the research findings will be forwarded to you if so indicated on this consent form.
Further information may be obtained from:

SANFORD P. MARTIN, ED.S.
1417 N. BATTLEFIELD BLVD., SUITE 115
CHESAPEAKE, VA 23320
757-497-6068

OR

CHARLES R. GRESSARD, Ed.D.
THE COLLEGE OF WILLIAM AND MARY
SCHOOL OF EDUCATION
POST OFFICE BOX 8795
WILLIAMSBURG, VA 23187-8795

STATEMENT OF CONFIDENTIALITY:
Your child's identity will be recorded only as a code number in order to insure confidentiality of your child's performance. Upon collection of all data, the list of identity code numbers will be destroyed and all results will be reported in terms related the performance of the entire group. This means there will be no way of identifying you child's individual performance on the research tasks.

I am the parent/legal guardian of ______________________, and having read the above, give my informed consent for participation in the research described.

__________________________________________
(your signature)

__________________________________________
Date

( ) I require more information before giving my consent and you may contact me at the following telephone number ________________________________

( ) Please send me information about the results of the research at the following address:

NAME: _______________________________

STREET: ____________________________

CHESAPEAKE, VA ____________________

(zip code)
APPENDIX B

Trail Making Test (B)
TRAIL MAKING

Part B

SAMPLE

Begin

1

C

End

D

4

A

2

B

3

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
REFERENCES


Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.


Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.


