THE REAL-LIFE BENEFITS OF COGNITIVE TRAINING

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Abstract

This study purposes to determine if positive behavioral and academic effects are in evidence upon a student's completion of a cognitive skills training program, thereby showing that improvements in cognitive skills can translate into better performance in real- life, day-to-day activities. The Learning Skills Rating Scale (Gibson, 2007) served as the evaluation tool for this purpose. Areas of focus include attention skills, processing speed, auditory processing skills, memory skills, visual processing skills, logic and reasoning skills, sensory and motor skills, the presence of argumentative (oppositional) behavior, and school and/or work performance.

Based on information provided by parent surveys, student participants easily fit into one of three groups. The first group consisted of those involved in the ReadRx program, a sound-to-code reading training that teaches both reading and spelling concurrently. Students in the second group were participating in the ThinkRx program, which provides intense training to help students develop or hone skills involved in cognition. Finally, students who were not working with either program comprised the third group.

Two of the three variables yielded significant differences between pre and post surveys. Both cognition and academic success increased significantly in those students who had completed a cognitive skills training program. Behavior also improved with these students, though not significantly. Students who did not complete a cognitive skills training program showed no improvement in the three variables.

Limitations of this study include response bias, in which respondents may attempt to present images of their children or of themselves that may not be true. Additionally,

the sample is non-random (i.e., random assignment did not control the placement of students in groups). The study's third limitation is the possibility of examiner effect on scores, in which the examiner's expectancy can influence observations or results. The fourth limitation of this study is generalizability. Because there are a variety of different training programs available and this study focuses on two specific programs, methods of cognitive training in other programs may be different (i.e., online training, home-based programs, and other self-directed methods). This study focusses on the delivery method of one-on-one training to the exclusion of other delivery methods.

Direction for future study might seek someone other than the student or his or her parent(s) to complete the Learning Skills Rating Scale. Future research is necessary to determine additional factors that contribute to a student's inability to achieve at his or her highest level.

Dedication

This project is dedicated to my family. My wife Jody's unconditional love and daily support helped me to complete this project when time was crowded and energy depleted. Stefan, Olivia, and Sydney—my children—wholeheartedly acknowledged the importance of this study and tolerated the many occasions on which my involvement in this study took me away from them. For their unselfish, committed support, I will be forever grateful.

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CHAPTER 1. INTRODUCTION

Introduction to the Problem

Currently, many school districts are seeking research-based programs that can be used as interventions for academically challenged students, either within the classroom or on an individual basis (Fuchs, Compton, Fuchs et al., 2008). Traditionally, schools have provided academic help in the form of staff or peer tutoring during the school day, after school tutoring or homework assistance programs, summer school programs, and special education offerings. Response to intervention (RTI) is a newer initiative in which schools employ a holistic view of students in an effort to meet their individual needs. The RTI process uses pre and post testing to evaluate progress made in a given school year because of specific interventions students received (Fuchs et al., 2007). In addition to RTI and traditional academic intervention methods, current research suggests that cognitive skills' training is also an effective way to improve academic performance.

This chapter lays the groundwork for and establishes the importance of this study. A discussion of the theory of cognitive modifiability appears within the context of the background (Feuerstein, 1990). A clear statement of the objective and potential outcome of the study exists within the problem statement, the declaration of the study purpose, and the discussion of the project's significance. The research design together with related research questions and hypothesis follow. The chapter concludes with study assumptions and limitations, term definitions, and a description of expected research findings.

Background of the Study

Students today often feel tremendous pressure to excel academically, in large part because of the high admissions standards set by universities, colleges, and other postsecondary educational institutions. Often, struggling high school students who are not able to reach their potential long- and short-term academic goals can appear lazy or unmotivated. In truth, weak cognitive skills are often the culprit in poor academic performance, a problem commonly overlooked in many educational systems (Gibson, 2007). Several prominent twenty-first century researchers contend that cognitive skills are trainable or modifiable (Feuerstein & Rand, 1977; Feuerstein, Rand, Hoffman & Miller, 1980; Merzenich, 2001; McGrew & Flanagan, 1998). Further, they believe that by doing so, underachieving students can ultimately achieve academic success. One of the most validated and empirically supported models of cognitive abilities is that of Cattell-Horn-Carroll (CHC). This theory preserves the foundation for specifying and operationalizing cognitive abilities and processes. This model, an amalgamation of two previous theories, uses a mathematical technique to theorize about the content and structure of human cognitive abilities. Feuerstein's theory of cognitive modifiability (Feuerstein & Rand, 1977; Feuerstein, Rand, Hoffman & Miller, 1980) hinges on the premise that intelligence is malleable. To test this premise, the psychologist used a procedure called Instrumental Enrichment (IE), which consists of a series of cognitive exercises involving abstract reasoning, deduction, induction, and spatial tasks. Merzenich (2001), a leading researcher in brain plasticity, theorizes that perception and thinking ability can improve through memory, attention, processing, and sequencing skill trainings. Elementary students who used Merzenich's computer-based program displayed significant improvements in cognitive and early reading skills (Scientific Learning Corporation [SLC], 2004).

Currently, numerous types of cognitive skills training programs are available for struggling students. Based on the existing literature, this study will determine whether positive behavioral and academic changes are in evidence after a student completes a program of this nature.

Statement of the Problem

The goal of the study's research problem is to determine if behavior and academic performance improve upon students' completion of cognitive skills training programs. This study also endeavors to show that cognitive skill improvements can extend to better performance in real-life, day-to-day activities.

To date, the research on cognitive skills and their roles in academic success consists primarily of the Cattell-Horn-Carroll (CHC) theory of cognitive abilities (Flanagan & Ortiz, 2001; McGrew & Flanagan, 1998; Woodcock, McGrew & Mather, 2001). This theory outlines a three-level hierarchy of cognitive abilities: a general intelligence factor, 10 broad abilities, and more than 70 narrow abilities. Most research to this point, however, has focused on the broad abilities, which have been linked to a variety of achievement outcomes. This correlation adds significant explanatory power to overall IQ measures when predicting achievement (Flanagan, 2000).

Today, only minimal research studies exist on the trainability of a person's cognitive skills, an important oversight since cognitive skills are strongly associated with academic performance and student behaviors. A review of several scientifically-based studies and papers over the past 15 years as well as Gibson's own data indicates that weak cognitive skills are the source of more than 80% of learning problems (Gibson, 2007). Fiorello and Primerano (2005) state that underlying cognitive abilities, regardless of their determinants, are associated with academic achievement in school. These researchers also contend that the way a student processes, stores, retrieves, and analyzes information influences how that student will perform in school.

Some experts, however, contend that weak cognitive skills can be strengthened and that doing so can improve a student's ability to perform academically. Merzenich (2001) specializes in improving perception and thinking ability. His work to this point has focused on improving students' ability to think and perceive by training specific cognitive processing skills to increase their efficiency. In a study of adults, Merzenich concluded that brain plasticity-based training programs can significantly improve cognitive and memory function by retraining the brain through repetitious, challenging activities (Mahncke et al., 2006). This option is much less invasive than medication-based initiatives in which possible side effects can impact students negatively.

Several programs develop and strengthen cognitive skills, including Fast ForWord, Cogmed, Arrowsmith, and LearningRx. Each of these programs is unique in its approach to training individual cognitive skills. Fast ForWord builds cognitive skills in four areas: memory, attention, processing, and sequencing. This computer-based program targets specifically K-12 educational institutions, not individuals. On average, elementary students who used Fast ForWord products significantly improved their cognitive and early reading skills (SLC, 2004, p.1). Cogmed works to improve working memory, which in turn, improves each user's ability to focus and resist distractions. Creators of this program contend that improved working memory allows individuals to more easily acquire necessary skills. Klingberg, Westerberg, and Oleson (2003) recently completed a study of adults who used the program for five weeks. Brain scans administered before and after the training revealed improvement in the regions of the brain that control working memory. These brain scans show that the brain has the ability to change structurally and functionally as a result of input from the environment. The Arrowsmith program, on the other hand, focuses on 19 areas of the brain and provides exercises to strengthen the cognitive capacities of dysfunctional areas. These cognitive areas include motor symbol sequencing, symbol relations, memory for information/instructions, predicative speech, Broca's speech pronunciation, auditory speech discrimination, symbolic thinking, symbol recognition, lexical memory, kinesthetic perception, kinesthetic speech, artifactual thinking, narrow visual span, object recognition, spatial reasoning, mechanical reasoning, abstract reasoning, primary motor, and supplementary motor. Used in the study sample with 79 students in an academic setting over a period of two years, all identified deficit areas improved as a result of the application of Arrowsmith Program cognitive exercises (Lancee, 2005).

In a slightly different approach, LearningRx students work one-on-one with cognitive skills trainers who provide activities that stimulate skills necessary to make reading and learning easy and efficient. These skills include long- and short-term memory, processing speed, visual processing, auditory processing, and logic and reasoning. A recent dissertation study completed by Luckey (2009) revealed an average 14-point standard score difference between pre and post general intellectual ability scores for students completing the LearningRx program. Completion of the Woodcock-Johnson Psycho-Educational Battery 3rd edition determined participants' general intellectual ability scores.

Despite the current utilization of these programs, peer reviewed literature is insufficient to verify the effectiveness of these cognitive skills training approaches. Researchers and educators need additional study findings to feel confident that the outcomes each method promises are valid. This study focuses on the LearningRx program because it addresses a more global array of cognitive skills than Fast ForWord and CogMed and is more widely available than the Arrowsmith program.

The training provided by the LearningRx program helps students who have weaknesses in one or more critical cognitive skill areas, often causing them to struggle to learn and read. Learning and reading deficiencies ultimately can limit students' educational and vocational opportunities. While traditional tutoring programs often simply re-teach content students failed to learn in the classroom, new research has validated the effectiveness of the hierarchical CHC model as an organizing framework for making differential diagnoses and for guiding test selection (Fiorello & Primerano, 2005). Training of identified weak or absent skills can significantly reduce or eliminate learning difficulties. Rather than focusing on gains based on traditional academic testing, this research examines the possible gains from a behavioral perspective.

Luckey (2009) suggested that researchers analyze rating scales completed by parents and teachers before and after skills training to measure student attention and determine if a causal relationship exists between intensive cognitive training and improved student concentration and focus. Parents of children in the LearningRx program complete the Learning Skills Rating Scale (LSRS), a measurement of students' behavioral and academic tendencies, before their children begin the program. A post training study of the LearningRx program that was conducted by Roxana Marachi (2006) revealed significantly enhanced performance during cognitive skills testing.

While a post training LSRS is not part of the typical protocol, in this study the parents of student's between the ages of 5 and 18 who completed a ReadRx or ThinkRx cognitive skills training program will receive rating scale forms through electronic mail. The comparisons of each parent's post LSRS with his or her responses on the initial LSRS will help determine whether this type of skills training has positive behavioral and/or academic effects.

Purpose of the Study

This study purposes to determine whether positive behavioral and academic changes are in evidence after student's completion of a cognitive skills training program. Although previous research has documented general intelligence change, this study examines the real-life effects of cognitive skills training, which includes behaviors, academics, and cognition. The identification of a causal relationship between cognitive skills training programs and improved student behavior and academic performance may contribute to the scholarly work of other researchers and hopefully stimulate future studies of cognitive skills training.

Rationale

The limited nature of the body of research into cognitive skills training and its impact on successful student behavior and academic performance inspired this study. Currently, school options for students who struggle academically consist of tutoring, additional help in the classroom, and/or special education services, not remediation. None of these options addresses the root of the problem— in most cases, weak cognitive skills. Today, tests (e.g., the Woodcock-Johnson Psycho-Educational Battery third edition) are available to determine if a student is below grade level in academic areas. This Woodcock-Johnson test highlights areas of weak cognitive skills. Students with deficiencies in these areas could receive intervention through cognitive skills training. This study goes beyond the identification of weak cognitive skills in an effort to determine whether a student's behavior and academic performance indeed improves upon completion of this specialized training.

Significance of the Study

This study is significant in its contribution to the body of research on the viability of cognitive skills training as a method of enhancing an individual's ability to learn and sustain those improvements over time. According to Willis et al. (2006), research indicates that declined cognitive abilities lead to an increased risk of difficulty in performing instrumental activities of daily living. Their study evidenced that each of three cognitive interventions improved the cognitive ability it targeted and that individuals sustained these improvements throughout the two years of follow-up study. A statistical analysis completed by Marachi (2006) showed that students who received cognitive skills training increased their cognitive skills performance. These studies focused on the link between strengthened cognitive skills and improved opportunities for academic success.

In an earlier related study, Feuerstein's theory of structural cognitive modifiability (Feuerstein & Rand, 1977; Feuerstein, Rand, Hoffman, Hoffman, & Miller, 1980) maintained that intelligence is malleable. To test his theory, he utilized a series of 14 intense training workbooks that he labeled, in aggregate, Instrumental Enrichment (IE). His results indicated that those who had received Instrumental Enrichment experienced significantly higher academic success than those who had not. Both of these theories have strong connections to the CHC Theory, which has been validated based on its hierarchical model and organizational framework for making differential diagnoses and for guiding test selection (Fiorello & Primarano, 2005). Completed studies of the CHC theory examined the relationship between the theory-driven standardized measures of the CHC cognitive abilities and the standardized measures of achievement in reading, writing, and math. All concluded that certain specific abilities may be important to understanding the development of specific skills, above and beyond the understanding gained from general cognitive and achievement clusters (Fiorello & Primarano, 2005).

Research Design

This study employs a quasi-experimental design that considers those variables that can hinder a quality outcome in order to maintain internal validity. The rationale for this design choice comes from the research of Dimitrov and Rumrill (2003). According to these theorists, factors that can threaten internal validity are history, maturation, pretest effects, instruments, statistical regression towards the mean, differential selection of participants, mortality, and integration of factors. This design is more sensitive to internal validity problems due to factors such as selection and maturation, selection and history, and selection and pretesting (Dimitrov & Rumrill, 2003). By implementing a quasi-experimental design, the likelihood that the alternative hypothesis of the research questions at hand can be determined is greater.

According to Breakwell, Hammond, Fife-Schaw, and Smith (2009), the quasi-experimental approach is effective when participants cannot be allocated randomly or when it may be unethical to do so. The data collection method in this study makes quasi-experimental the best approach; since the data came from students who had already completed a cognitive skills training program, group assignments were automatic based on the cognitive skills training program they used.

In keeping with the design of this study, each participant belongs to one of three groups. Those who received cognitive training using the ReadRx program form group 1, students trained within the ThinkRx program belong to group 2, and those who received no cognitive training are members of group 3. The pre and post analysis used the same survey for all participants. Students in groups one and two completed identical cognitive pretests prior to starting a training program; they also completed identical cognitive posttests at least one year after they completed their cognitive training.

The study's nonequivalent group design allows an Analysis of Variance (ANOVA) approach for data analysis. Dimitrov and Rumrill (2003) stated that ANOVA is often used in research situations in which groups are compared with pretest and posttest data. At the outset of this study, It is assumed that a causal relationship between pre and post LSRS as well as for the identity of the cognitive skills program that made the largest improvement in behavioral and academic performance. It is assumed that the inclusion of a pre as well as a post test in this design will indicate a degree of similarity between the three groups prior to the intervention (Breakwell et al. 2009).

The sample, a smaller portion of the greater population (Warner, 2008) consists of students between the ages five through 18 who have completed a ReadRx or ThinkRx cognitive skills training program at an authorized training center in the United States; all participants must also have a completed pre Learning Skills Rating Scale. Since this researcher resides in northeast Wisconsin and is affiliated with the LearningRx training center there, excluded from this study were otherwise qualified participants from this area to avoid bias in this research. The G*power computer program (v.3.1.2) calculated the adequate sample size needed for this project.

Research Questions

The research question for this study is "What real-life effects do students experience as a result of completing a cognitive skills training program?"

Related questions include

- Does the completion of the ThinkRx or ReadRx cognitive skills training program have a positive effect on the cognition of a population of students?

- Does the completion of the ThinkRx or ReadRx cognitive skills training program have a positive effect on the behavior of a population of students?
- Does the completion of the ThinkRx or ReadRx cognitive skills training program have a positive effect on the academic achievement of a population of students?

This study hypothesizes that

- $H_{\theta 1}$: the ThinkRx or ReadRx cognitive skills training program will not have a positive effect on the cognition of a population of students.
- H_{A1}: the ThinkRx or ReadRx cognitive skills training program will have a positive effect on the cognition of a population of students.
- $H_{\theta 2}$: the ThinkRx or ReadRx cognitive skills training program will not have a positive effect on the behavior of a population of students.
- H_{A2}: the ThinkRx or ReadRx cognitive skills training program will have a positive effect on the behavior of a population of students.
- $H_{\theta 3}$: the ThinkRx or ReadRx cognitive skills training program will not have a positive effect on the academic achievement of a population of students.
- H_{A3}: the ThinkRx or ReadRx cognitive skills training program will have a positive effect on the academic achievement of a population of students.

The Learning Skills Rating Scale will be used to measure data.

The design of the questionnaire seeks to provide an understanding of how people view their own or their children's attention, processing speed, auditory processing skills, memory skills, visual processing skills, logic and reasoning skills, sensory and motor skills, argumentative (oppositional) behavior, and school and/or work performance. Its intended target population spans preschool through adulthood. The information provided by the questionnaire helps me determine the existence of academic and behavioral improvements in the nine skill areas from pre to post cognitive skills training. Because the LearningRx organization uses this field-tested scale regularly, it was determined by this researcher that it is the best and most valid measure of information obtained in this study.

Following are the data collection procedures for Hypotheses 1 and 2

- Prior to beginning: This researcher, develop a communication that LearningRx, Inc. sends electronically to prospective participants. The letter explains the nature of the research project and provides my background information.
- Initial phase: The communication to prospective participants is clear, concise, and thorough. The LearningRx home office sends me a practice electronic communication to verify that the transmission method is working properly.
- Implementation phase: With the message to prospective participants ready for transmission, the LearningRx home office enters all recipients' electronic mail addresses and completes the send process. There was no ablility to view any personal information about recipients, instead seeing only the identification numbers the LearningRx Company assigns to those being contacted. If a recipient is interested in participating in the study, he or she replies to me electronically. The electronic link was provided to the informed consent

statement and the Learning Skills Rating Scale form. After reviewing this information, interested parties decide whether they will participate in this study. Those who choose to participate complete the LSRS. Upon completion of the survey, participants view an electronic thank-you for completing the survey as well as my contact information (e-mail address) if questions or the need for further information should arise. It is assumed that assigned numbers will match the participant data received with the pre questionnaire.

Assumptions and Limitations

Cognitive change is the theoretical framework for this study. Although psychologists historically believed that the human brain was incapable of change, many current theorists acknowledge the existence of inherent, gene-driven constraints on, as well as experience-based modifications of, brain organization and cognitive functions (Geary & Huffman, 2002). Today, some believe that cognitive skills training can change a learner's daily functional ability, as suggested by theoretical framework provided by Vygotsky, Feuerstein, and Cattell-Horn-Carroll.

Piaget's human development model, which focuses more on human factors that affect learning than environmental factors (Vygotsky & Luria, 1993), provides the basis of Vygotsky's theory of cognitive development. The Russian researcher centered his theory on what he termed the "zone of proximal development" or ZPD. The ZPD is the area in which a learner's functions are in a state of development. Instruction and learning are responsible for the development of higher psychological functions that are absent in learners' natural cognitive endowments.

Feuerstein's theory of structural modifiability concentrates on the experience of mediated learning, which is a quality of interaction between a learner and his or her environment (Feuerstein & Feuerstein, 1991). Mediated learning experiences are very important to the development of the unique human conditions of modifiability, or the capacity to benefit from the exposure to stimuli in a more generalized way (Feuerstein, 1990).

Modern research also indicates that cognitive skills training can change cognitive functioning based on concepts of neural plasticity and environmental stimulation. Willis et al. (2006) cite evidence that sustained engagement in cognitively stimulating activities impacts neural structure and that, given appropriate practice, humans consequently improve on essentially every task performed.

Theoretical assumptions direct the work of researchers, often implicitly, by providing a conceptual basis for the development of theories and models, the formulation of research questions, the selection and use of methods, and the interpretation of data (Yanchar, Slife, & Warne, 2008). The first assumption of this study asserts that, given appropriate practice, humans improve on essentially every task, ranging from perceptual to motor to cognitive training (Green & Bavelier, 2008). Next, It is assumed that plasticity refers to cognitive modifiability through social interactions and training experiences (Mercado, 2008).

Additionally, it is assumed that underlying cognitive determinants are associated with academic achievement (Fiorello & Primerano, 2005). Finally, as a researcher, it is concurred with the belief that the ability to learn, acquire skills, and alter behavior as a result of experience is fundamentally important to the survival of man (Green & Bavelier, 2008).

This study also makes topical assumptions. The first of these is that training regimens can lead to the acquisition of new knowledge and strategies that can be used flexibly across a range of tasks and contexts (Green & Bevelier, 2008). Also assumed is the notion that cognitive revolution in learning theory and educational psychology has brought dramatic changes in current understanding of the process of cognitive development. This new direction for learning theory and cognitive education derives from a combination of work from Vygotsky's psychological tools paradigm and Feuerstein's mediated learning experience learning (Kozulin & Presseisen, 1995). The premise of these researchers is that cognitive education becomes a part of school curricula as well as of teacher development. Next, it is assumed that the way a student processes, stores, retrieves, and analyzes information influences how he or she will perform academically (Fiorello & Primerano, 2005). The study's final topical assumption asserts that cognitive plasticity, often termed by researchers as *cognitive development* during early childhood and *cognitive vitality* in old age, refers to the modifiability of cognition by social interactions and training experiences (Mercado, 2008).

Last, this study includes three methodological assumptions. First, in conjunction with most quantitative researchers, the assumption is that the two issues to consider when determining statistical analysis method are the types of variables involved and the distribution shapes of scores on quantitative variables (Warner, 2008). To this end, Warner (2008) states that research studies in which mean scores on a quantitative outcome variable are compared across groups often use ANOVA. With ANOVA, it is assumed that data can be gathered in a way that will support the validity and reliability of the LSRS. The third methodological assumption is a common one; Research helps people function in the world by letting them explain to others what they think is happening and why it is happening (Breakwell et al., 2009). With regard to the study, this assumption is significant since the possibility exists that collected data will reveal that the LSRS is not appropriate to measure the impact cognitive skills training has on cognition, academics, and behaviors. Last, it is assumed in this study that some areas of psychology often depend on the knowledge gained from research studies that rely on measurement tools (Kaplan & Saccuzzo, 2005). To that end, a measurement tool (the LSRS) will be used in this study.

This study has four limitations. The data collected for the research consists entirely of self-report responses to questionnaires. In this respect, while LSRS scores are a viable way to determine improvement in behavior, academics, and cognitive skills (Gibson, 2007), as with any self-report questionnaire, the typically abiding issue of response bias surfaces, in which respondents may attempt to present an untrue image of their children or of themselves (Breakwell, Hammond, and Fife-Schaw, 2002).

The study sample is non-random. When using the nonequivalent group design, the mechanism of random assignment does not control group assignment. As a result, the groups may be different prior to the study, which could make the study susceptible to the internal validity threat of selection (Warner, 2008).

Additionally, "examiner effect" is possible. Because participants will pay for their cognitive skills training (which usually motivates people to desire and expect positive results), the possibility exists that some participants will be happier with their training outcomes than others. For this reason, it is assumed that it may be difficult to predict whether a specific participating group or individual will complete the post survey.

Definition of Terms

Cognitive skills. These are the foundational skills or tools a student uses to learn (Gibson, 2007). After identifying problem areas, training can strengthen weak skills, thereby significantly reducing or eliminating learning difficulties. Skills such as memory, attention, auditory and visual processing, logic and reasoning, and processing speed are critical to learning and reading. An operational definition for cognitive skills involves asking parents survey questions that pertain to students' cognitive skills. Of the nine categories, five pertain to cognitive skills: processing speed, auditory processing skills, memory skills, visual processing skills, and logic and reasoning skills. A comparison of these responses to those to the pretest will reveal positive or negative changes.

Cognitive training. When cognitive training activities are practiced repetitively, neurons are recruited to assist in processing this information. The more practice or rehearsal, the more neurons are involved. Cognitive skills' training takes advantage of this neuronal activity by developing new connections in the brain which is established as soon as the training begins (Gibson, 2007). Cognitive training benefits from 7 key training foundations; specific targeting, a nonacademic format, one-on-one coaching, proper sequencing, immediate feedback, high intensity, and progressive loading.

Neuroplasticity. *Neuro* is for neurons which are the nerve cells in our brains and nervous systems. *Plastic* is for changeable, malleable, or modifiable (Doige, 2007). It is the lifelong ability of the brain to reorganize neural pathways based on new experiences. Neuroplasticity is then the ability of the brain to change with learning (Hoiland, 2012).

Expected Findings

At the end of this study, the expected findings is that the cognitive skills, behaviors, and academic skills of students who complete the ThinkRx or ReadRx cognitive skills training program will significantly improve. This expectation finds basis in the work of Feuerstein and Vygotsky who concluded that cognitive education should be an integrated part of everyday curriculum (Kozulin & Presseisen, 1995).

The available literature on cognitive skills training supports the idea that cognitive skills training positively correlate with improved cognitive skills. The research, however, lacks evidence of a positive correlation between cognitive skills training and behavior and academic success. Expected findings of this study include the rejection of the null hypothesis will occur as well as a correlation of the variables based on the literature presented in this paper.

CHAPTER 2. LITERATURE REVIEW

The literature review begins with a brief explanation of the theoretical framework of this study and an overview of cognitive skills critical to the learning process. The review then encompasses theories that have contributed to an understanding of cognitive development, its ability to change (cognitive modifiability), and agents of cognitive change (cognitive training). The final sections apply theory to learning and behavior, synthesize research findings, and critique previous research on the topic of cognitive skills training.

Theoretical Framework

The concept of cognitive change forms the theoretical framework of this study. For decades, educators and psychologists believed that the human mind was unable to change. For example, Perkins and Grotzer (1997) stated that people can learn to think more clearly and efficiently in some ways, but such effects would not have a broad generality or indicate a persistent elevation of IQ.

In early twentieth century, however, Binet asserted that intelligence is not fixed; he felt that those who contended otherwise had no basis for their beliefs (Plucker, 2003). Binet believed that intellectual development progresses at variable rates and responds to the influence of various aspects of the person's environment (Siegler, 1992). After working with Binet, Jean Piaget developed his theory of cognitive development: a child's cognition and abilities develop (or change) based on the influence of his or her environment (in particular, the human factors in that environment).

Today many theorists agree with this concept of neuroplasticity, or the brain's ability to change organizationally and functionally in response to the environment, although limited by inherent, gene-driven constraints and experience-based modifications (Geary & Huffman, 2002). Lev Vygotsky and Reuven Feuerstein are two such theorists. Their ideas about cognitive modifiability, instruction, and learning provide the basis of this study's theoretical framework.

Recently, Rabipour and Raz (2012) state that cognitive training can produce changes measured at the behavioral as well as the neuroanatomical and functional levels.

Vygotsky's concept of the "zone of proximal development", or ZPD, identifies the area in which a learner's functions are in a state of development (Vygotsky & Luria, 1993). This zone consists of the gap between areas in which a child can function independently and those in which a child needs assistance. Through instruction and learning, Vygotsky (1993) posits that a learner develops higher psychological functions absent in the person's natural cognitive endowment.

Similarly, Feuerstein incorporates the experience of mediated learning—a quality of interaction between learner and environment—in his theory of structural modifiability (Feuerstein & Feuerstein, 1991). Feuerstein contends that mediated learning experiences are critical to the development of the unique human condition of modifiability, or the capacity to benefit from exposure to stimuli in a more generalized way (Feuerstein, 1990).

Based on the premise of neuroplasticity and the presence of stimulation in the environment, this study contends that cognitive skills training can change cognitive functioning. Willis et al. (2002) found that sustained engagement in cognitively stimulating activities impacts neural structure. Further the researcher documented that, given appropriate practice, humans improve on essentially every task performed.

The research question under investigation is “What real-life effects do students experience as a result of completing a cognitive skills training program?” This research also addresses the following questions regarding a specific training program

- Does the completion of the LearningRx cognitive skills training program have a positive effect on the cognition of a population of students?
- Does the completion of the LearningRx cognitive skills training program have a positive effect on the behavior of a population of students?
- Does the completion of the LearningRx cognitive skills training program have a positive effect on the academic achievement of a population of students?

Cognitive Skills and Learning

Educators and parents often struggle to discern why children struggle scholastically. Although lack of effort or high rate of absence can contribute to academic non-performance, more often weak or absent cognitive skills are the root of the problem. Vygotsky and Feuerstein contend that the addition of cognitive education (i.e., cognitive skills training) to everyday school curricula can help students develop independent thinking and problem-solving strategies (as cited in Kozulin & Presseisen, 1995).

To learn, people use cognitive skills to classify information as either new or already known. This categorization process, known as automatic processing, involves three skills: working (short-term) memory, attention, and processing speed. If information is already known, the mind extracts it from the knowledge bank and output occurs. New information takes a different, higher-level thinking route: logic and reasoning, auditory processing, visual processing, and long-term memory. Students with weak higher-level thinking skills may have difficulty academically because they are unable to readily retrieve information.

Short-term, or working, memory enables an individual to store and recall small amounts of information about a current situation (Anderson, 2000). Students with deficient short-term memories may need to look at a picture, word, or passage several times before copying it. They may have problems following instructions or need information or directions repeated several times, a time-consuming process.

Academic success also hinges on attention: sustained (the ability to stay on task for a period), selective (the ability to focus on one task or item while ignoring distractions), and divided (multitasking, or the ability to attend to two or more tasks simultaneously) (Ward, 2004). To process information, a student needs to focus attention on it regardless of distractions. The learner then needs time to make connections, (i.e., to form neural networks that lead to long-term memory). Multisensory experiences increase the number of connections and provide excellent opportunities for successful attention (Sprenger, 1999). The inability to focus attention exclusive of distractions makes it difficult for students to complete tasks, such as homework, or focus on lessons presented in school.

The ability to (automatically or fluently) perform cognitive tasks quickly, known as processing speed, also is an important cognitive skill, particularly for complex or multi-step tasks. Slow processing speed can have a negative influence on thought formulation, reading comprehension, writing fluency and speed, math computations, and social interaction with other learners (Fletcher, Lyon, Fuchs, & Barnes, 2007).

Learning also requires logic and reasoning skills. Among logic skills are categorization, which enables the learner to generalize and go beyond information immediately given, and extrapolation in which the learner applies information found in one area to another area (Lea, Mulligan, & Walton, 2005). Through reasoning, individuals can detect similarities between different objects, people, and ideas and use knowledge about one set to understand another. They can also infer, or elaborate, from explicit information. Reasoning also helps learner's problem-solve and compose, or create new information, to express an idea. Also crucial to the learning process are auditory and visual processing skills. In auditory processing, learners receive and process (analyze, blend, segment, and synthesize) sounds. Those with auditory processing problems have difficulty organizing and using auditory information (Bellis, 2004). They hear but have a hard time listening, a critical skill in reading and spelling. In a similar fashion, visual processing is a person's ability to perceive, analyze, and think in visual images (Gibson, 2007). Students with visual processing deficiencies may reverse letters, have trouble reading maps, or find it difficult to decode math word problems. This cognitive skill area includes visualization—an individual's ability to create mental pictures, to make sense of what is seen. Since much of an environment's information is either visual or auditory, these cognitive skills are essential to learning.

Last, long-term memory enables individuals to recall previously stored information. Retrieving information from long-term memory involves transferring or, according to cognitive information processing theory, activating knowledge in memory networks (Yanchar et al., 2008). Transfer requires the cross-referencing of all information with propositions linked to memory. The greater the number of links between bits of information, the more likely it is that a piece of information will cue other information in memory (Yanchar et al., 2008). Transfer uses the same process with procedural knowledge and productions; that is, the mind links knowledge and productions with different content in long-term memory. Linking both the stored knowledge and its uses aids transfer (Yanchar et al., 2008). Academically successful learners need strong short-term (working) and long-term memories.

Learning Theories

Cognitive skills and their role in the learning process provide a connecting link between the theories of behaviorist B. F. Skinner, social learning psychologist Lev Vygotsky, and cognitive researchers Alfred Binet, Jean Piaget, Reuven Feuerstein, Robert Gagné, and CHC theory coauthors Raymond Catttell, John L. Horn, and John Bissell Carroll. Implicit in the theories of these researchers is the idea that learning involves the development of cognitive skills.

Given the task of finding a way to measure a child's intelligence, Alfred Binet and his associate Théodore Simon spent several years gathering data on the intellectual and moral development of children. They observed a correlation between children's measured intelligence and their program of study:

> Moreover, in trying to trace the lines of development of the child's intelligence, we naturally were led to cast a glance at the program of studies, and we have found that certain of these studies are premature, that is to say poorly adapted to the mental receptivity of young children. In other words, the relation between the child's intellectual development and the course of study constitutes a new problem, engrafted upon the first, the practical interest of which is very great. Therefore, before studying the intellectual aptitudes of children we shall be obliged to stop a while at these two stages; (a) special characteristics of the child mind, and (b) the relation between the intellectual development of children and the instruction which they receive (Binet & Simon, 1916, trans. 1973).

In other words, Binet and Simon acknowledged the importance of cognitive skill development in learning.

Interestingly, Skinner likewise made a startling discovery when observing students in a school. Like Binet and Simon, Skinner observed that the classroom instruction did not help children learn. While some students quickly completed a math worksheet because it represented no new material, others had no idea how to approach and solve the problems. In his words, "through no fault of her own the teacher was violating almost everything we knew about the learning process" (Skinner, 1983, p. 64).

In Skinner's view, shaping, in which the instructor adapts what he or she expects of the learner to the learner's current performance level (level of cognitive skill abilities), is essential to instruction (Dews, 1970). Like Binet and Simon, Skinner asserted that educational progress is graded by readiness; he also believed that teaching is empirically based, educational goals should emphasize both content and process, and natural consequences positively reinforce learning (Zimmerman & Schunk, 2003). Although Skinner regarded learning as a behavior—a correlation between classes of responses and stimuli (Zimmerman & Schunk, 2003)—rather than a mental or psychological process, with Binet and Simon he did affirm the importance of both content and instructional methods in the learning process.

Cognitive theorist Jean Piaget also recognized that the development of intelligence or cognition is a process of maturation. At certain of his identified stages of cognitive development, Piaget noted that children are capable of the cognitive skills of logic and reasoning, visual processing, and auditory processing. Piaget also addresses the influence of experiences on cognitive development: Intelligence is assimilation to the extent that it incorporates all the given data of experience within its framework… There can be no doubt either, that mental life is also accommodation to the environment. Assimilation can never be pure because by incorporating new elements into its earlier schemata the intelligence constantly modifies the latter in order to adjust them to new elements" (Piaget, 1963, pp. 6-7). According to this theorist, those experiences, or interactions, with a child's physical and social environments, help the child form schemas or organized patterns of thought.

The importance of experience in learning is also paramount in the cognitive development theories of Lev Vygotsky. Vygotsky's initial work was with the physically and mentally disabled. After observing the difficulty students with disabilities had in experiencing the cultural development non-disabled children were able to experience, he developed a cultural-historical theory (Zimmerman & Schunk, 2003) that asserted that culture and social interaction were integral to the development of complex thinking. In agreement with earliest theorists in this section, Vygotsky believed that a learner's developmental readiness is an important consideration. As such, he developed the idea of the zone of proximal development (ZPD), which represents the amount of learning a student can possibly achieve given the proper instructional conditions. This zone is mainly a test of a student's developmental readiness, or intellectual level in a specific domain, and shows how learning and development are related (Schunk, 2008). In practical terms, the ZPD is the distance between the child's independent problem-solving levels and his or her assisted levels. Vygotsky argued that, to understand the intellectual development of children, a person should inquire about two types of tasks: those the child can solve independently and those the child can solve with the help of a more capable member of the culture (as cited in Nilholm, 1999). The basic principle of ZPD is Vygotsky's contention that, unlike animals that only react to the environment, humans have the capacity to alter their environment for their own purposes.

This ability to alter is integral to Feuerstein's theory of structural cognitive modifiability, which maintains that intelligence is malleable (Feuerstein & Rand, 1977; Feuerstein et al., 1980). Feuerstein created an intervention strategy known as instrumental enrichment, with the intention of modifying students' cognitive functions. The theory can be applied in this situation because a) a two-year study was conducted of a sample population of 218 students; b) a series of intense training workbooks were created to test his theory; c) a series of tests of specific cognitive functions, scholastic achievement, and classroom interaction scales revealed a significant positive difference between the results of students that received Instrumental Enrichment and those who did not (Feuerstein et al., 1980).

Mediated learning plays a crucial role in Feuerstein's theory since it is anchored on the very distinct difference between the experiences of mediated and direct learning. Feuerstein et al. (1980) stated that the mediated learning experience is the quality of interaction between the student and the environment, which largely depends on the activity initiated by an adult who interjects between the student and the world. Accordingly, this experience is an important component in the development of the very unique human condition of cognitive modifiability (Feuerstein, 1990).

Feuerstein and Vygotsky developed an alternative theoretical approach based on shortcomings they identified in Piagetian theory (Kozulin & Presseisen, 1995). The first perceived shortcoming resides in the scope of Piaget's theory, which failed to include, for the most part, the sociocultural aspect of learning. In addition, the learning process Piaget proposed appeared as a direct interaction of the student with the environment, which omits human mediation in any exchange. According to Kozulin and Presseisen (1995), Vygotsky believed that the learning progression is a process in which the student appropriates methods of action in a given culture.

Feuerstein went on to suggest that a radical dichotomy exists between direct and mediated learning.

Together, their combined theory gives students the ability to restructure their cognitive processes and build their cognitive skills. Within this theory, students learn to respond to intrinsic motivation rather than require extrinsic rewards. In addition, students develop supportive characteristics that enable independent thinkers to apply the principles of this theory and transfer these cognitive strategies in a more global manner. Together, Vygotsky and Feuerstein feel cognitive education should be a part of all school curricula and teacher development (Kozulin & Presseisen, 1995). The development of a typology of higher mental processes that would reflect historical transition from one system of psychological tools to another is a major goal of Vygotsky's theory (Vygotsky & Luria, 1993). A major objective of Feuerstein's theory is the development of higher-order psychological tools that ensure students' academic success.

The concept of identifying existing cognitive skills and gradually adding new ones is also at the heart of Gagné's (1985) learning theory. This cognitive theorist introduced sequenced learning, a method of instruction that involves systematic movement toward higher-level skills while building on prerequisite skills. Gagné believed that learning is a process that can be facilitated by instructional intervention to ensure that the learner experiences the necessary instructional events (Zimmerman & Schunk, 2003). He was the first to propose a theory of cumulative learning, which postulated that new learning depends primarily on the combination of previously, acquired and recalled learned entities. Likewise, Gagné believed that transfer of learning is dependent on their probabilities. He explained that complex cognitive behaviors are invariably composed of simpler behaviors and that attainment of these subordinated tasks is necessary before the complex behavior can be effectively internalized and assimilated (Lawson, 1974). According to Gagné (1985), a learner must be able to recall the prerequisite capability before he or she can learn the new task. He further posited that prerequisite skills are hierarchical in nature and include discriminations, concrete concepts, defined concepts, rule using, and problem solving.

Three other theorists—Raymond Cattell, John L. Horn, and John Bissell Carroll—outlined a hierarchy of cognitive abilities in what came to be known as the CHC theory. Their three-level hierarchy included a general intelligence factor, 10 broad abilities, and greater than 70 narrow abilities. Research has linked the broad abilities to a variety of achievement outcomes; the researchers also added significant explanatory power to overall IQ measures when predicting achievement (Flanagan, 2000).

This hierarchical model made it possible to validate the theory by providing an organizational framework for making differential diagnoses and for guiding test selection (Fiorello & Primarano, 2005). Completed studies, which analyzed the relationship between theory-driven standardized measures of CHC-identified cognitive abilities and standardized measures of achievement in reading, writing, and math, concluded that certain specific abilities may be important for understanding the development of specific skills above and beyond the understanding gained from general cognitive and achievement clusters (Fiorello & Primarano, 2005).

Applying Learning Theories in the Classroom

To facilitate an understanding how the learning theories discussed in the previous section have real classroom applications, this section begins with an explanation of long-term memory and the process of information storage. Long-term memory has several related and overlapping memory components: episodic, procedural, semantic, and emotional. While these components overlap and are interrelated, scientists remain unclear about the exact nature of their interaction.

Episodic memory is location driven; that is, when students receive information in a specific location, they will more easily recall it if they are in that location. Specific instructional strategies and tools can encourage the storage and retrieval of information from episodic memory. The following trigger episodic memory: bulletin boards, changed seating arrangements or physical make-up of the classroom, transfer of class sessions to areas outside the regular classroom, the use of the same color of paper for handouts, instruction based in a specific area of the room, and the use of teaching accessories (Sprenger, 1999).

Procedural memory relies on the frequent repetition of processes or tasks. Because the brain stores oft-repeated steps in the cerebellum for easy retrieval, teachers can help students store information in procedural memory by having them perform specific steps in a task so often that the steps join to become a procedure. Established classroom procedures can create strong memories.

Semantic memories are pieces of stored information triggered by simple associations, such as multiplication tables, the alphabet, and word decoding rules. This information joins established schemata because it is meaningful. To stimulate semantic memory, teachers can use repetition with daily oral work, music, or flashcards.

As the cerebellum is involved in procedural memory, so experts believe the amygdala is associated with emotional memory—the retention of events that had strong emotional impact or significance. Emotional memories can be positive or negative. Both types cause the brain to release neurotransmitters that aid in retention. Although emotional memories are consciously available, they also elicit strong, involuntary physiological responses. Sensory information, such as music and other sounds, scents, and significant cultural symbols, can trigger emotional memories.

In general, teaching aids such as music, role-playing, and debate are powerful memory tools (Sprenger, 1999). The more memory lanes an instructor uses, the more successfully students will learn. Storytelling, for example, is an effective way of accessing multiple lanes. Placing semantic information into a story format gives students the main idea as well as the details. Conflict within the plot of a story stimulates emotional memory. The teacher's appearance—where the teacher stands or what he or she wears—triggers episodic memory. An essential part of any lesson plan details how the instructor will teach to the wide variety of memory types.

Skinner's stimulus-response theory of learning also has practical application in the classroom. When his own children were young, this behaviorist developed a machine that taught spelling and arithmetic. The machine, which consisted of separate devices or ancillary techniques for texts, lectures, and discussions (Skinner, 1958), required that the learner master each concept before proceeding to the next, a method later known as programmed instruction.

Programmed instruction relies on a three-term contingency: learning at the individual level, teaching at the interpersonal level, and education at the cultural level. As they learn, students must master current material before moving to new topics, receive new material only when ready, emit answers without error, and remain motivated through immediate and frequent reinforcement. On the interpersonal level, teaching compels programmers to define their current domain, arrange it sequentially, bring student responses under stimulus control, transfer and multiply those controls, integrate prior material with newer material to maintain behavior at strength, sustain interest and motivation, and assign no blame to the student. In the math classroom, for example, the teacher lectures for a period of time before allowing students to work on the same material on a computer. As students work, the teacher provides individual help to learners who have questions.

According to Skinner, education stipulates that knowledge is retained in a culture for future selection and is effectively analyzed (Zimmerman & Schunk, 2003). Although he believed these contingencies are interlocking, Skinner theorized that one metacontingency—cultural survival—ultimately maintains all three. In his view, cultures in which learning, teaching, and education are established practices are more likely to survive.

Like Skinner, Gagné and his co-researcher Robert M. Briggs believed that method of instruction is important and gained wide recognition for their instructional model, which identified a comprehensive set of capabilities that underlie educational goals (Jacka, 1985). Instructional objectives in this model address specific domains of learning: attitudes, knowledge, motor skills, cognitive strategies, and intellectual skills. Intellectual skills consist of a hierarchy of capabilities ranging from simple stimulus-response learning through the learning of discriminations, concrete concepts, defined concepts, rules, and higher-order thinking (Pietrofesa et al., 1984). According to these theorists, specific instructional conditions, both generalized and particular to each type of learning capability, must be present for learning to occur.

Internal conditions are the retained capabilities of the student established by previous learning (Zimmerman & Schunk, 2003). External conditions include both cognitive and behavioral components: gaining attention, informing the learner of the objective, stimulating recall of previous learning, presenting the stimulus, providing learner guidance, eliciting the performance, giving informative feedback, assessing performance, and enhancing retention and transfer. According to Zimmerman and Schunk (2003), Gagné felt instructors need to consider the phases of learning that students need to complete before they are able to learn efficiently. These phases consist of: (a) preparation of learning, which includes attending, expectancy, and retrieval; (b) acquisition and performance, or selective perception, semantic encoding, retrieval, and responding and reinforcement; and (c) transfer of learning that involves cueing, retrieval, and generalizability (Yanchar et al., 2008). To make lessons effective, the teacher must include each and every event.

Vygotsky, too, outlined the manner in which teachers could maximize their students' learning. Called instructional scaffolding, Vygotsky's method requires that classroom teachers control those task elements that are beyond learners' capabilities so students can focus on and master those parts of the task they can grasp easily. Scaffolding has five major aspects, or roles: to provide support, to function as a tool, to extend the range of the learner, to permit the attainment of tasks not otherwise possible, and to operate selectively only as needed (Schunk, 2008). These five aspects keep the learner in the ZPD. Cognition increases as the student develops capabilities. The student's challenge is to learn within the bounds of the ZPD. The instructor's role in instructional scaffolding is to model the task, provide support to the learner, and gradually reduce support as the learner develops the skill. In particular, the teacher must focus on each learner's zone of proximal development and ascertain what each child can do independently—his or her actual level of development—and what each can do with assistance of others—proximal level of development (Gonzalez, Andrade, Civil, & Moll, 2001). The instructor uses scaffolding to increase the chances that a learner will grasp a concept.

In practice, teachers who use Vygotsky's method discuss a new topic to gauge students' prior knowledge of the topic before building on that knowledge by explaining the latest and most effective research (Schunk, 2008). This theory strives to capture the relationship in learning between what Vygotsky termed "everyday" and “scientific” concepts. He explained that scientific, or learned, concepts are systematic (e.g., mammals and socialism) whereas everyday concepts (e.g., boats and cars) are not. Scientific concepts are part of and acquired through a system of formal instruction while everyday concepts provide the conceptual fabric for the development of scientific (learned) concepts. Through their connection to more systematic concepts, everyday concepts transform. Conversely, scientific concepts grow into the everyday, into the domain of personal experience, as they acquire meaning and significance while still inscribing a conscious awareness and control onto the everyday. These, Vygotsky believed, are essential characteristics of learning (as cited in Gonzalez et al., 2001).

Students gain awareness of these concepts in a variety of ways. With instructional scaffolding, the teacher initially works one-on-one with a student on a given topic but gradually withdraws as the learner demonstrates proficiency, which allows the learner to work more independently. Another approach, reciprocal teaching, involves an interactive dialogue between the instructor and a small group of students. The teacher begins by modeling the activity; learners then take turns being the instructor. This process allows social interaction as well as scaffolding so students gradually obtain the skills at hand.

Feuerstein’s instrumental enrichment (IE) program shares the systematic nature of scaffolding. The IE process concentrates on basic cognitive processes, problem-solving tactics, and motivational considerations necessary for student success in a traditional classroom (Feuerstein, Rand, Hoffman, Hoffman, & Miller, 1979). Instrumental enrichment carefully systematizes the necessary methods and manners by which academic success is best achieved. The intent of the process is to nurture proper learning sets and systematic data-gathering behavior at the input level. Results suggest that these skills in comparative analysis can improve students' relational insights and remove attitudinal inhibitions that often operate in lower functioning students. Students who are not ready for higher-level thinking activities also receive meta-learning activities together with IE. Meta-learning is the study of how one learns in a society oriented toward the scientific method (Feuerstein et al., 1979). Examples of meta-learning habits are the

- effort to determine the issue that needs resolution,
- effort to make preliminary estimates about constraints within which the result will be located and ahead of which there can be only peculiar or impossible solutions,
- assumption at the outset that single, precise, or multiple applicable solutions, rather than general estimates, are expected, and
- effort to reduce data to a manageable size by eliminating those that can delay solution of the problem at hand.

IE considers the cognitive and meta-learning weaknesses of students as well as the motivational deficits of those students whose higher thinking levels are inadequate (Feuerstein et al., 1979).

The six major goals of IE implementation (Kozulin & Presseisen, 1995) are to

- correct weaknesses and deficiencies in cognitive functions;

- help students learn and apply basic concepts, labels, vocabulary, and operations essential in effective thought;
- motivate learning through habit formation in students whose conditions and environment do not reinforce learning needs;
- develop task-intrinsic motivation;
- produce an insightful and reflective cognitive attitude; and
- transform poor learners from passive recipients and reproducers of information into active generators which, in turn, enhances each student's self-image as an active and independent learners.

The application of the CHC theory results from the validation of the theory through testing. As a result of research findings on this theory, many practicing school psychologists now place less emphasis on general ability and more on specific sub-scores because these professionals believe the sub-scores provide useful diagnostic and treatment validity (McGrew, Flanagan, Keith, & Underwood, 1997).

Learning Skills Rating Scale

Creators of this survey designed the questionnaire to show educators and researchers how parents assess their children's abilities in nine cognitive skill and behavioral areas: attention, processing speed, auditory processing, memory, visual processing, logic and reasoning, sensory and motor, argumentative (oppositional) behavior, and school/work performance. Its intended target population spans preschool through adulthood. The information from completed questionnaires, as well as the post testing scores, helped me measure academic gains and behavioral improvements that resulted from cognitive skills training in the nine pre-improved standardized test scores. While cognitive skills training has already shown improved standardized test scores, functional gains are important as well. A field test on this measurement scale took place prior to using it in the study. Because the LearningRx organization uses this scale on a regular basis, it was chosen as a baseline measure of each parent's perception of his or her child's abilities in these areas prior to skills training.

Synthesis of Research Findings

The research question for this study is "What real-life effects do students experience as a result of completing a cognitive skills training program?" Related questions include

- Does the completion of the ThinkRx or ReadRx cognitive skills training program have a positive effect on the cognition of a population of students?
- Does the completion of the ThinkRx or ReadRx cognitive skills training program have a positive effect on the behavior of a population of students?
- Does the completion of the ThinkRx or ReadRx cognitive skills training program have a positive effect on the academic achievement of a population of students?

These questions refer to students' learning abilities, which determine their success or failure in an academic setting. Each theorist cited in this study posited or concluded that cognitive skills are an important component of academic success and positive behavior.

Feuerstein's theory, for example, focuses on basic cognitive processes, problem-solving tactics, and motivational considerations necessary to student success in a traditional classroom. Fundamental to this theory is the belief that students can raise their cognition levels by working in the classroom to strengthen their weaker cognitive skills. The strengthening process Feuerstein outlined correlates with the cognitive skills training discussed in this study. The latter provides the activities necessary to improve those weak cognitive skills.

Vygotsky used a different approach to reach the same conclusion. His zone of proximal development analyzes the gap between what a child can do independently (his or her actual level of development) and what he or he can do with assistance from others (his or her proximal level of development). Scaffolding is an effective instructional tool teachers can use to help learners strengthen weak cognitive skills. The instructor begins by working one-on-one with a student on a given topic and gradually withdraws as the learner begins to work more independently. This process builds cognitive skills as well as student confidence in in his or her ability to complete assigned work and keep pace with the rest of the class. Students gain the ability to restructure their cognitive processes and build their cognitive skills.

Finally, the CHC theory provides perhaps the most specific information about the benefit of cognitive skills training. This theory contends that certain particular abilities may be important to understanding the development of specific skills. This understanding, according to the researchers, is above and beyond the understanding gained from general cognitive and achievement clusters. According to CHC theorists, students should seek out, or identify, their weak skills. Training helps strengthen identified weak skills, which then enables students to become academically successful.

Critique of Previous Research

Sizeable literature on the ability to change the makeup of the human brain has emerged over the last century; however, only limited research exists on cognitive skills training and other methods of altering brain makeup. Most of the existing studies compare the skills believed to be important to cognitive change. Fiorello and Primarano (2005) concluded that certain specific abilities may be important for understanding the development of particular skills above and beyond the understanding gained from general cognitive and achievement clusters. While these studies contain valuable information on cognitive change, they do not discuss the relationship of cognitive change to academic success or behavioral modifications. Fiorello and Primarano (2005) linked underlying cognitive abilities, regardless of their determinants, to academic achievement in school. They further state that the way a student processes, stores, retrieves, and analyzes information influences how that student will perform in school. According to cognitive theory, how people think provides meaning and organization to experiences and allows them to "go beyond the information given" (Bruner, 1990, p. 4).

The twentieth century also saw a change in perceptions of human intelligence. At the beginning of the century, most theorists believed intelligence was fixed. Others, most notably Binet, disagreed and set out to prove that intelligence, like the makeup of the human brain, is malleable (Plucker, 2003). Joining this school of thought were Vygotsky, Feuerstein, and the authors of the CHC theory. These researchers found strong evidence to support their hypotheses within their research of neuroplasticity. Binet's young daughters, whom he observed and queried about how they solved questions he had asked them, helped him refine his conception of intelligence, especially with regard to the importance of attention span and suggestibility in intellectual development. Vygotsky and Feuerstein's combined theory adds understanding of the malleability of intelligence as it recognizes that students have the ability to restructure their cognitive processes and build cognitive skills. The CHC theory lends even more credence since it outlines a three-level hierarchy of cognitive abilities: a general intelligence factor, 10 broad abilities, and more than 70 narrow abilities. The link between the road abilities and a variety of achievement outcomes adds significant explanatory power to the use of overall IQ measures when predicting achievement (Flanagan, 2000). All of these theorists make a strong case for the argument that students have the ability to make cognitive changes to achieve academic success.

Undoubtedly Piaget and Binet had their skeptics, especially at the beginning of their research. In the last 20 years or so, however, skepticism has dwindled due to technological advances and other corroborative research on neuroplasticity. Recently, Bindschaedler, Peter-Favre, Maeder, Hirsbrunner, and Clarke (2010) asserted that, while the brain is plastic, its plasticity has limits. These researchers reasoned that if the brain were infinitely plastic, brain damage would not be a serious issue. To illustrate their theory, they conducted a study of patients with brain damage. These individuals had trouble with tests of memory recall but experienced no problem with recognition. Other studies revealed that the hippocampus is necessary for recall while the nearby cortex is more important in recognition (Bindschaedler et al., 2010). They continued to track a particular patient who had sustained hippocampal damage, studying this patient from the ages of 8 to 17. This prolonged study revealed that the hippocampus has specialized circuitry that is not found in any other area of the brain. Further, the cortex is unable to compensate for the hippocampus. Based on these results, Bindschaedler et al. concluded that all areas of the brain, with the exception of the hippocampus, have the ability to rewrite themselves.

Summary

Cognitive skills play a major role in learning. Weak cognitive skills can affect reading ability and an individual's vocational options. In truth, the strength of a learner's cognitive skills can determine his or her level of success in school and in life.

An educator's knowledge and presentation of cognitive skills can transform learners who don't believe in their capabilities to ones who flourish in the classroom. Much of this transformation depends not only on how the teacher verbally instructs students but also on the classroom environment. Instructors must teach to each individual student, rather than to the entire class. When teachers fail to consider each individual, students with weak cognitive skills have insufficient time and receive insufficient instruction to master concepts. As a result, these students still struggle with concepts while other members of the class move on to new material.

Teachers must establish a classroom environment in which each student receives individual assistance and instruction as needed. Students should not proceed to the next lesson until they have mastered the current one. According to the theorists discussed in this article, this process gives learners positive self-feelings and promotes their academic success. Further, each theorist recommended that cognitive education become an integral part of school curriculum and teacher training.

CHAPTER 3. METHODOLOGY

Purpose of the Study

In this study, it is proposed to determine whether positive behavioral and academic benefits result from the completion of a cognitive skills training program. Previous research has evidenced change in general intelligence from this training; however, this researcher wishes to focus on the real-life effects of cognitive skills training. By testing my hypothesis (that cognitive skills training can improve student behavior and academic performance), this study contributes to the scholarly work completed previously by other researchers and will stimulate future work in the area of cognitive skills training.

Research Design

This study uses a quasi-experimental design with three groups. Members of one group received one cognitive skills training program, while members of the second group received another program. The third group did not receive a program but did participate in the testing process. Both pre and post analyses focused on the same survey. Participants completed the pretest prior to the start of a training program. They completed the posttest at least one year after they finished their training. A nonequivalent group design allows analysis of the data with an Analysis of Variance. Warner (2008) states that ANOVA is often useful in research situations in which mean scores on a quantitative outcome variable are compared across two or more groups.

Target Population

As stated in Chapter 1, the purpose of this study is to examine if cognitive skills training can improve students' cognition, academic performance, and positive behaviors. The research results of this study are expected to generalize to students who have received cognitive skills training. However, it is hard to reach this population and draw a sample from it. This is a target population, but not accessible. Since LearningRx is a cognitive skills training company who offers cognitive skills training and is available for drawing a sample from, the accessible population for this study consisted of students who had completed a LearningRx cognitive skills training program at any training center from the United States.

The sample is a smaller portion of members of the greater population (Warner, 2008). The sample for this study consisted of those students between the ages 5 and 18 who had completed a ReadRx or ThinkRx cognitive skills training program at one of the LearningRx training centers in the United States. Each participant's completed personal information sheet provided his or her age, gender, and the name of training program he or she completed. Only those participants who completed a ReadRx or ThinkRx program as well as a pre Learning Skills Rating Scale were eligible for this study. Since this researcher resides in northeast Wisconsin and is affiliated with the LearningRx training center there, excluded from this study are otherwise eligible participants from this area to avoid bias in the research. The G*power computer program (v. 3. 1. 2) provided the adequate sample size calculation for this research project.

Selection of Participants

To select participants, the President and CEO of LearningRx sent an electronic mail invitation to individuals who had completed a ReadRx or ThinkRx training program within the past two years. The invitation asked recipients to contact me by electronic mail if they were interested in participating in this study. When replying, the electronic mail included the following: a written invitation explaining the research study, informed consent information, and the questionnaire link.

All who agreed to complete the web-based survey, the agreement to participate form, and the online LSRS participated since considered were inclusionary and exclusionary factors prior to extending the invitation.

Completed survey information determined group assignments. Each participant was placed in one of the following groups: ReadRx program, ThinkRx program, or the control group.

Sample size and statistical power are important in planning and interpreting the results of research studies (Hedges & Pigott, 2004). According to Warner (2009), statistical power is the probability of obtaining a value of *z* or *t* that becomes large enough to reject the null hypothesis when the null hypothesis is actually false. Researchers typically want statistical power to be high, at least 0.80.

The G-Power program calculated sample size after the determination of effect size, alpha level, and power. The Pearson's rule of thumb guided effect size. Based on this rule, selected was Pearson's recommended 0.30 for a medium effect size, based on the projected difference between the means of both groups being considered (Howell, 2008). Measures of effect size include Cohen's d, eta squared (η^2), and omega squared (ω^2). Cohen's d helps assess the difference between two means. Eta squared examines the proportion of variance in the scores on the outcome variable that is predictable from group membership in an ANOVA. Omega squared is a measure of the strength of association between the independent and the dependent variable (Howell, 2008). The effect size considers the dependent variable—the academic and behavioral improvement that is dependent on those skills necessary to become academically successful. An effect size of 0.30 was appropriate for this study's research question since it considers both type of cognitive skills training program as well as its effect on students who completed the program. Pearson's set of conventions, which provides the research on cognitive skills training, is quite limited. Significance level by definition is the probability of obtaining a Type I error (Howell, 2008). It was assumed that the significance level for this study to be 0.05 to decrease the chance of making another type of error, such as a Type II. Power is the odds that a treatment effect will be observed when it occurs (Warner, 2008). It is also the probability of correctly rejecting a false null hypothesis (Howell, 2008). Power was set at 0.80, adhering to the growing trend to try to achieve a statistical power of at least that amount (Warner, 2008). After these variables were entered, the G*power program calculated a suggested total sample size of 352.

Variables

The independent variable is the training program. It is a categorical variable which includes three variables – two training programs, namely ThinkRx and ReadRx, and a non-training group. There are three dependent variables – behavior, cognition, and academics. They were measured using the LSRS and yielded ordinal values.

Extraneous variables under consideration included the "examiner effect." Because participants had to pay for their cognitive skills training, it was possible that some participants would be happier with the outcome of their training than others. Another extraneous variable is history. Changes that could affect cognition, behavior and academics such as aging, academic coursework, and the addition or alteration of medications, could have occurred over time. Finally, the LSRS itself could threaten internal validity. Since a parent became "knowledgeable" about the survey (completing it for both pre and posttest), the pretest could have had an effect on its later counterpart.

Instrument

The LSRS was developed by Gibson (2007) and used solely by the LearningRx franchise system. The construct of the LSRS is multi-dimensional as more than one construct is being addressed. This questionnaire sought to gain an understanding of parental assessments of children's academic performance and behaviors across nine skill or behavioral areas: attention, processing speed, auditory processing, memory, visual processing, logic and reasoning, sensory and motor, argumentative (oppositional) behavior, and overall school and/or work performance. The intended target population spanned preschool through adults. Parents completed this questionnaire before training commenced and after training was completed. The information on the pre and post questionnaires (the same questionnaire) helped me identify parent-perceived improvements in skill and behavioral areas. Because the LearningRx organization uses this instrument, it was selected as the means of obtaining the information needed for a worthy conclusion.

It is further assumed that a field test of the LSRS prior to implementing it as a measure for this study was imperative. The field test was completed prior to data collection. Following is a sample of questions taken from the LSRS. For the purpose of illustration, one question from each skill category was selected

1. The item “Student is distracted from the task” measured “attention.”
2. The item “Student is often one of the last to complete tasks” measured “Processing Speed.”
3. The item “Student has poor reading comprehension” measured Auditory Processing.”
4. The item “Student often asks to have things repeated” measured “Memory.”
5. The item “Student has poor sense of direction/map reading skills” measured “Visual Processing.”
6. The item “Student has poor math grades or test scores” measured “Logic & Reasoning.”
7. The item “Student has poor handwriting” measured “Sensory & Motor.”
8. The item “Student curses or uses obscene language” measured “Argumentative (Oppositional) Behavior.”
9. The item “Student takes a while to catch on to new things” measured “School and/or Work Performance.”

Data Collection

Data collection was solely my responsibility and did not involve assistance other than the transmission of the initial electronic correspondence to prospective participants. Data collection occurred in February 2012 and consisted of electronic correspondence to families of clients who had completed a LearningRx program (groups one and two) or had gone through initial testing but had not enrolled in a program (group three—the control group participants).

Data collected from participants included the completed post Learning Skills Rating Scale, facilitated by a survey company named Survey Monkey. It is believed that each participant viewed the informed consent form before completing the survey. By completing the survey, participants agreed that participation was voluntary and that they had the right to withdraw from the study at any time during the data collection period. As part of the informed consent form, all participants learned about the purpose of the study, which was to determine whether a cognitive skills training program positively affects academic performances and behavior.

To maintain confidentiality throughout the data collection process, identification numbers, not participant names, matched pre and post surveys. The data collection process for each participant consisted of completing an online post LSRS questionnaire, which took approximately five to ten minutes.

Procedures

Following are the data collection procedures for the study hypothesis.

- Prior to beginning: Developed was an electronic message that the LearningRx company sent to prospective participants. The message explained the research to be conducted and provided my background information. If recipients decided to participate, they replied electronically to this researcher; then responded with a hyper-link that supplied the informed consent statement as well as the Learning Skills Rating Scale. If recipients decided to continue, they completed the LSRS. After answering the last item on the scale, participants viewed a screen that thanks them for completing the survey. This screen also included my electronic mail address if further explanations or answers were necessary.
- Initial phase: It is believed that the message was clear, concise, and friendly. Before sending it to potential participants, the LearningRx home office transmitted a practice message to this researcher’s electronic mail address so it could be certain the communication system was working properly.
- Implementation phase: The message to prospective participants was ready to send at this stage. The LearningRx home office entered the electronic mail addresses of all prospective recipients and sent the message en masse. If a recipient decided to participate, he or she contacted me through electronic mail. Each interested recipient then received an electronic reply with a hyper-link to the informed consent statement and Learning Skills Rating Scale.

Research Questions and Hypothesis

It is assumed that the rationale for population and sampling procedures found basis on the study's research question: "What real-life effects do students experience as a result of completing a cognitive skills training program?" Sample size and recruitment process seemed suitable for accessing the information needed to either accept or reject the hypothesis of this research project. The thoughts of Jones and Sommerland (2007) verify this assessment. Statistical power increases when sampling error decreases. Since a small sample can increase the risk of sampling bias compared to that observed in larger samples. It is assumed that the sample size for this study is sufficient to increase the likelihood that the null hypothesis (i.e., that no positive behavioral or academic effects result from the completion of a cognitive skills training program) will be rejected.

- $H_{\theta 1}$: The ThinkRx and ReadRx cognitive skills training programs will not have a positive effect on the cognition of a population of students.
- H_{A1}: The ThinkRx and ReadRx cognitive skills training programs will have a positive effect on the cognition of a population of students.
- $H_{\theta 2}$: The ThinkRx and ReadRx cognitive skills training programs will not have a positive effect on the behavior of a population of students.
- H_{A2}: The ThinkRx and ReadRx cognitive skills training programs will have a positive effect on the behavior of a population of students.
- $H_{\theta 3}$: The ThinkRx and ReadRx cognitive skills training programs will not have a positive effect on the academic achievement of a population of students.

- H_{A3}: The ThinkRx and ReadRx cognitive skills training programs will have a positive effect on the academic achievement of a population of students.

Data Analysis

The descriptive statistics used in this study to interpret collected data included the mean and the standard deviation. Inferential statistics included the ANOVA. Study results focused on a comparison of scores of those who completed the ThinkRx and those who completed the ReadRx program. The SPSS software package was used to perform the statistical analysis, with a set level of confidence for the acceptance of the hypothesis of alpha < 0.95.

CHAPTER 4. DATA COLLECTION AND ANALYSIS

Introduction

This chapter presents the results of the data analyses, including the statistical procedures that were used to report the research question and the statistical findings for the hypotheses. The chapter includes explanations of the results of each statistical procedure as well as relevant information and tables. The hypothesis of this study proposes that the ThinkRx and ReadRx cognitive skills training program will positively impact cognition, behavior, and academic achievement of a population of students.

Description of the Sample

As stated in the previous chapter, the sample for this study consisted of those students between the ages 5 and 18 who had completed either a ReadRx or ThinkRx cognitive skills training program at one of the LearningRx training centers in the United States. Each participant's completed personal information sheet provided the participant's age, gender, and location, as well as the name of the program the participant had completed. Only those participants who had completed a ReadRx or ThinkRx program and/or a pre Learning Skills Rating Scale were eligible for this study.

Sample size and statistical power are important in planning and interpreting the results of research studies (Hedges & Pigott, 2004). According to Warner (2009), statistical power is the probability of obtaining a value of *z* or *t* that becomes large enough to reject the null hypothesis when the null hypothesis is actually false. Researchers typically want statistical power to be high, at least 0.80. The G*power program considered all variables and calculated a total sample size of 226. Power was set at 0.80, which adheres to the growing trend to try to achieve a statistical power of at least that amount (Warner, 2008).

The population, according to Breakwell et al. (2009), is the limitless objects in the real world in which a researcher is interested. Objects can be people, organizations, countries, or anything else that belongs to a taxonomic category. The population for this study consisted of any person who had completed a LearningRx cognitive skills training program at any training center in the United States. Participants were young men and young women between the ages of 5 and 18 who had completed the ThinkRx or the ReadRx training program and/or the LSRS.

To recruit participants, the President and CEO of LearningRx sent an electronic mail invitation to individuals who had completed a ReadRx or ThinkRx training program within the past two years. Approximately 6000 e-mails went to those who met the criteria of this study; 226 individual responded by completing the Learning Skills Rating Scale.

Summary of Results

The first hypothesis stated that the ThinkRx and ReadRx cognitive skills training programs would have a positive effect on the cognition of a population of students. The analysis concludes that the findings in this regard were significant. Assessment of each of the seven skills revealed similar results. The scores of students who had completed one of the training programs decreased while the scores of students who participated in neither program increased. In other words, the students who had completed a skills training program had greater overall improvement in their cognitive skills than that experienced by students who had not enrolled in one of the programs.

The second hypothesis stated that the ThinkRx and ReadRx cognitive skills training program would have a positive effect on the behavior of a population of students. The results evidenced no significant difference in the behavior of students who completed either the program nor did students who had not enrolled in a cognitive skills training program display significant behavioral change.

The third hypothesis stated that the ThinkRx or ReadRx cognitive skills training program would have a positive effect on the academic achievement of a population of students. The findings were again significant. Academic achievement scores students who had received skills training decreased and the scores of students who had completed neither program increased. In essence, students who had completed one of the cognitive skills training programs had greater academic success than did those who had not enrolled in either program.

Results in Detail

Descriptive Statistics

Table 1 presents frequencies and percentages for participant demographics.

Table 1. Frequencies and Percentages for Demographics

Demographics	*n*	%
Sex		
Female	108	47.8

Male	118	52.2
Program		
No program	80	35.4
ReadRx	69	30.5
ThinkRx	77	34.1
Region		
South	101	44.7
West	42	18.6
Midwest	36	15.9
East	47	20.8
Age	12.11*	3.47**

Note. * represents the mean. ** represents the standard deviation

Means and standard deviations for pretest and posttest scores are presented in Table 2

Table 2. Means and Standard Deviations for Scores (Pretest vs. Posttest)

	Pretest		Posttest	
	M	*SD*	*M*	*SD*
Attention skills	17.34	7.08	14.70	8.55
Processing speed	14.20	6.60	12.09	7.47
Auditory skills	13.87	8.02	11.64	8.45
Memory skills	14.27	6.58	12.21	7.58

Visual processing skills	10.79	6.12	10.06	7.66
Logic & reasoning	12.08	6.92	10.71	7.51
Sensory motor skills	8.84	5.34	7.79	5.79
Oppositional behavior	7.98	6.75	7.47	6.45
Work or academic performance	15.01	6.92	12.42	7.70

Hypothesis 1

The ThinkRx and ReadRx cognitive skills training programs will have a positive effect on the cognition of a population of students.

To assess Hypothesis 1, seven one-within one-between analysis of variances (ANOVAs) were conducted to assess if there were differences in the cognitive skills test scores (attention skills, processing speed, memory skills, visual processing skills, auditory processing skills, logic and reasoning, and sensory motor skills) and time (pretest vs. posttest) by program (no program, ThinkRx, and ReadRx).

In preliminary analysis of the first one-within one-between ANOVA, attention skills (pre vs. post) by program, two Kolmogorov Smirnov (KS) tests were conducted to assess for normality. The results for the both KS tests were significant, violating the assumption for normality. However, Pallant (2007) suggests that the analysis is robust against the assumption if there are at least 30 participants for the analysis (there are over

30 in each analysis). The assumption for equality of variance was assessed with two Levene's tests. The results of the tests were not significant, meeting the assumption.

The results of the first one-within one-between ANOVA, attention skills (pre vs. post) by program, were significant for the main effect of program, F (2, 223) = 5.30, p = .006, suggesting there was a significant difference in the test scores by just program. Pairwise comparisons were conducted to see where the differences lie. No program was significantly higher than ThinkRx (p = .005). No other significant differences existed between programs.

The results of the first ANOVA were significant for the main effect of time, F (1, 223) = 28.81, p < .001, suggesting that there was a significant difference in the test scores over time. Pairwise comparisons were conducted to assess where the differences lie. Pretest scores were significantly higher than posttest scores (p < .001).

The results of the ANOVA were also significant for the interaction effect of time and program, F (2, 223) = 12.18, p < .001, suggesting there were differences in the test scores by the interaction of program and time. Pairwise comparisons were conducted to assess where the differences lie. At pretest, there were no significant differences among the programs. At posttest, no program scored significantly higher than ReadRx (p < .001) and ThinkRx (p < .001). For no program, there was no significant difference between pretest and posttest scores. For ReadRx, pretest scores were significantly higher than posttest scores (p < .001). For ThinkRx, pretest scores were significantly higher than posttest scores (p < .001). Results of the first one-within one-between ANOVA are presented in Table 3. Means and standard deviations are presented in Table 4. Figure 1 shows the pretest and posttest scores over time.

Table 3. Results of One-Within One-Between ANOVA for Attention Skills Test Scores by Time and Program

Source	*SS*	*df*	*MS*	*F*	*p*	Partial η^2
			Between Subjects			
Program	921.48	2	460.74	5.30	.006	.05
Error	19390.85	223	86.96			
			Within Subjects			
Time	864.83	1	864.83	28.81	.001	.11
Time*Program	731.21	2	365.60	12.18	.001	.10
Error (Time)	6694.05	223	30.02			

Table 4. Means and Standard Deviations for Attention Skills (Pretest vs. Posttest) by Program

	Pretest		Posttest	
	M	*SD*	*M*	*SD*
No program	17.51	7.35	18.16	7.83
ReadRx	18.36	6.74	12.94	8.76
ThinkRx	16.23	7.04	12.69	8.03

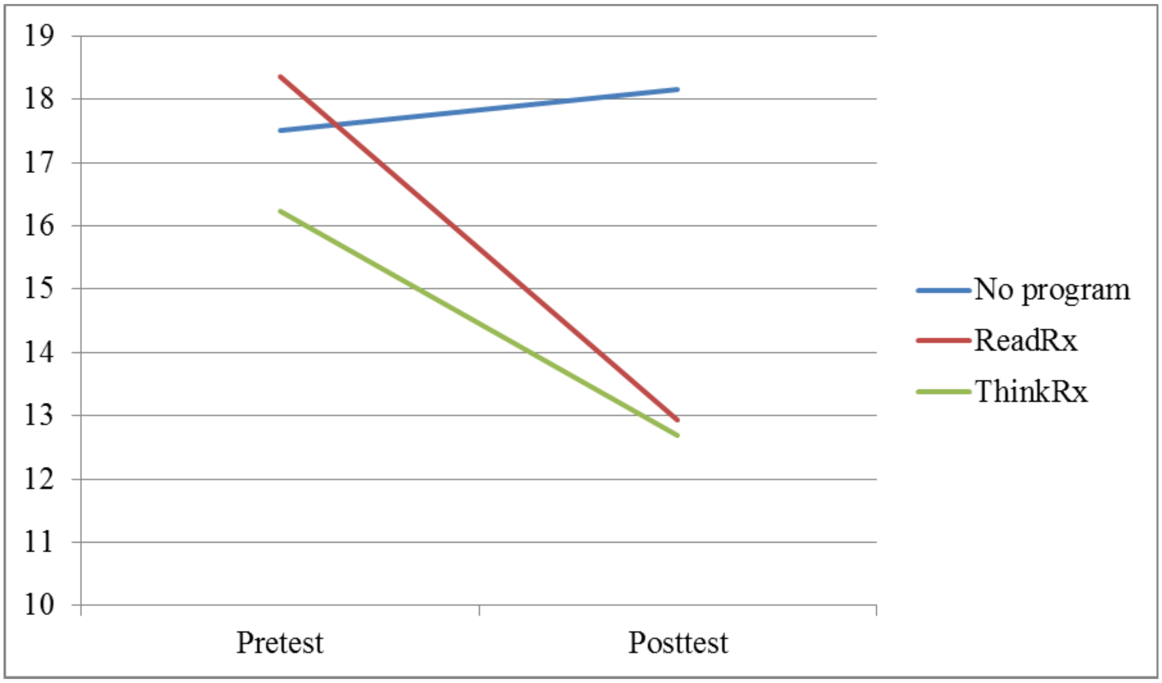

Figure 1. Attention skills pretest and posttest scores by program

In preliminary analysis of the second one-within one-between ANOVA, processing speed (pre vs. post) by program, two Kolmogorov Smirnov (KS) tests were conducted to assess for normality. The results for the both KS tests were significant, violating the assumption for normality. However, Pallant (2007) suggests that the analysis is robust against the assumption if there are at least 30 participants for the analysis (there are over 30 in each analysis). The assumption for equality of variance was assessed with two Levene's tests. The results of the tests were not significant, meeting the assumption.

The results of the second one-within one-between ANOVA, processing speed (pre vs. post) by program, were significant for the main effect of program (between-subjects effects), $F(2, 223) = 5.49$, $p = .005$, suggesting there was a significant difference in the processing speed test scores by just program. Pairwise comparisons were conducted to see where the differences lie. No program was significantly higher than ThinkRx (p = .004). No other significant differences existed between programs.

The results of the second ANOVA, processing speed (pre vs. post) by program, were significant for the main effect of time, F (1, 223) = 19.25, $p < .001$, suggesting that there was a significant difference in the processing speed test scores over time. Pairwise comparisons were conducted to assess where the differences lie. Pretest scores were significantly higher than posttest scores ($p < .001$).

The results of the second ANOVA, processing speed (pre vs. post) by program, were also significant for the interaction effect of time and program, F (2, 223) = 11.70, $p < .001$, suggesting there were differences in the processing speed test scores by the interaction of program and time. Pairwise comparisons were conducted to assess where the differences lie. At pretest, there were no significant differences among the programs. At posttest, no program scored significantly higher than ReadRx ($p < .001$) and ThinkRx ($p < .001$). For no program, there were no significant differences between pretest and posttest scores. For ReadRx, pretest scores were significantly higher than posttest scores ($p < .001$). For ThinkRx, pretest scores were significantly higher than posttest scores ($p < .001$). Results of the second one-within one-between ANOVA are presented in Table 5. Means and standard deviations are presented in Table 6. Figure 2 shows the processing speed pretest and posttest scores over time.

Table 5. Results of One-Within One-Between ANOVA for Processing Speed Test Scores by Time and Program

Source	*SS*	*df*	*MS*	*F*	*p*	Partial η^2
			Between Subjects			
Program	715.06	2	357.53	5.49	.005	.05
Error	14535.51	223	65.18			
			Within Subjects			
Time	556.68	1	556.68	19.25	.001	.08
Time*Program	676.89	2	338.45	11.70	.001	.10
Error (Time)	6450.23	223	28.93			

Table 6. Means and Standard Deviations for Processing Speed (Pretest vs. Posttest) by Program

	Pretest		Posttest	
	M	*SD*	*M*	*SD*
No program	14.19	7.41	15.38	7.31
ReadRx	14.78	6.35	10.64	7.40
ThinkRx	13.70	5.95	9.99	6.56

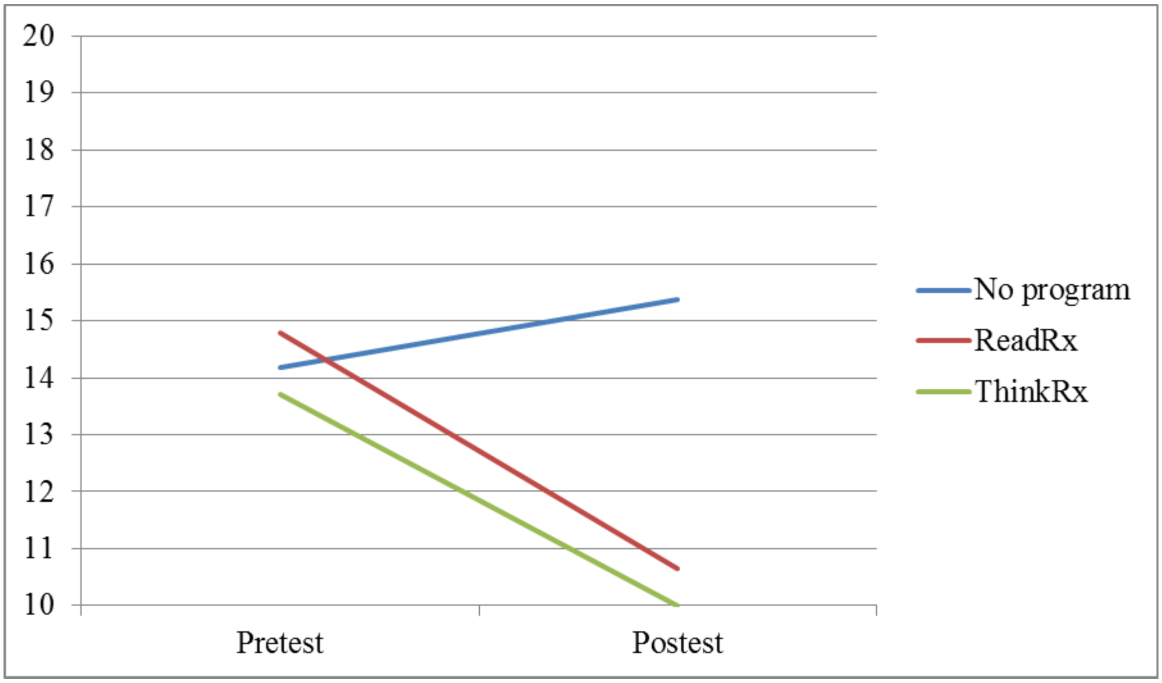

Figure 2. Processing speed pretest and posttest scores by program

In preliminary analysis of the third one-within one-between ANOVA, auditory processing skills (pre vs. post) by program, two Kolmogorov Smirnov (KS) tests were conducted to assess for normality. The results for the both KS tests were significant, violating the assumption for normality. However, Pallant (2007) suggests that the analysis is robust against the assumption if there are at least 30 participants for the analysis (there are over 30 in each analysis). The assumption for equality of variance was assessed with two Levene's tests. The results of the tests were significant, violating the assumption. However, the analysis is robust against violations of equality of variance as long as group sizes are relatively equal (Pallant, 2003).

The results of the third one-within one-between ANOVA, auditory processing skills (pre vs. post) by program, were significant for the main effect of program (between-subjects effects), F (2, 223) = 10.20, $p < .001$, suggesting there was a significant difference in the auditory processing skills test scores by just program. Pairwise comparisons were conducted to see where the differences lie. No program was significantly higher than ThinkRx ($p < .001$). ReadRx was significantly higher than ThinkRx ($p = .003$). No other significant differences existed between programs.

The results of the third one-within one-between ANOVA, auditory processing skills (pre vs. post) by program, were significant for the main effect of time, F (1, 223) = 20.22, $p < .001$, suggesting that there was a significant difference in the auditory processing skills test scores over time. Pairwise comparisons were conducted to assess where the differences lie. Pretest scores were significantly higher than posttest scores ($p < .001$).

The results of the third one-within one-between ANOVA, auditory processing skills (pre vs. post) by program, were also significant for the interaction effect of time and program, F (2, 223) = 13.24, $p < .001$, suggesting there were differences in the auditory processing skills test scores by the interaction of program and time. Pairwise comparisons were conducted to assess where the differences lie. At pretest, ReadRx was significantly higher than ThinkRx ($p < .001$). At posttest, no program scored significantly higher than ThinkRx ($p < .001$) and ReadRx ($p = .006$). For no program, there were no significant differences between pretest and posttest scores. For ReadRx, pretest scores were significantly higher than posttest scores ($p < .001$). For ThinkRx, pretest scores were significantly higher than posttest scores ($p = .001$). Results of the third one-within one-between ANOVA are presented in Table 7. Means and standard deviations are presented in Table 8. Figure 3 shows the auditory processing skills pretest and posttest scores over time.

Table 7. Results of One-Within One- Between ANOVA for Auditory Processing Skills Test Scores by Time and Program

Source	*SS*	*df*	*MS*	*F*	*p*	Partial η^2
			Between Subjects			
Program	1895.89	2	947.95	10.20	.001	.08
Error	20728.36	223	92.95			
			Within Subjects			
Time	640.04	1	640.04	20.22	.001	.08
Time*Program	838.40	2	419.20	13.24	.001	.11
Error (Time)	7059.62	223	31.66			

Table 8. Means and Standard Deviations for Auditory Processing Skills (Pretest vs. Posttest) by Program

	Pretest		Posttest	
	M	*SD*	*M*	*SD*
No program	13.99	8.21	15.19	8.64
ReadRx	16.46	8.23	11.06	8.53
ThinkRx	11.42	6.88	8.47	6.71

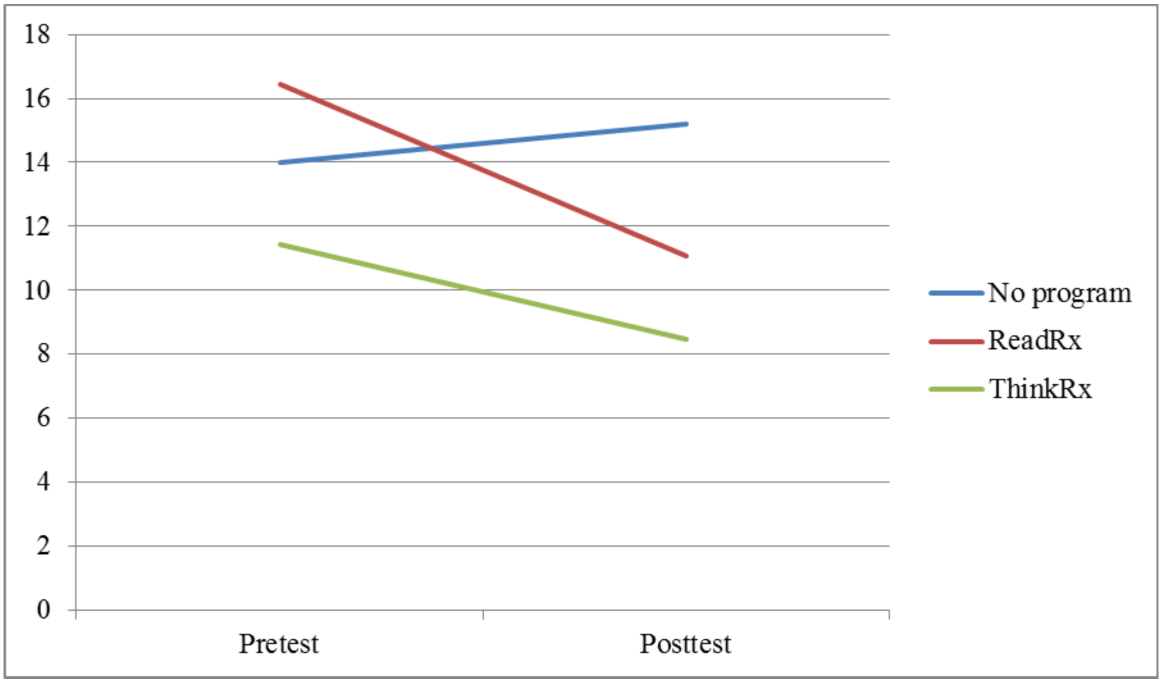

Figure 3. Auditory processing skills pretest and posttest scores by program

In preliminary analysis of the fourth one-within one-between ANOVA, memory skills (pre vs. post) by program, two Kolmogorov Smirnov (KS) tests were conducted to assess for normality. The results for the both KS tests were significant, violating the assumption for normality. However, Pallant (2007) suggests that the analysis is robust against the assumption if there are at least 30 participants for the analysis (there are over 30 in each analysis). The assumption for equality of variance was assessed with two Levene's tests. The results of the tests were significant, violating the assumption. However, the analysis is robust against violations of equality of variance as long as group sizes are relatively equal (Pallant, 2007).

The results of the fourth one-within one-between ANOVA, memory skills (pre vs. post) by program, were significant for the main effect of program (between-subjects effects), *F*

(2, 223) = 9.48, $p < .001$, suggesting there was a significant difference in the memory skills test scores by just program. Pairwise comparisons were conducted to see where the differences lie. No program was significantly higher than ThinkRx ($p < .001$). ReadRx was significantly higher than ThinkRx ($p = .014$). No other significant differences existed between programs.

The results of the fourth one-within one-between ANOVA, memory skills (pre vs. post) by program, were significant for the main effect of time, F (1, 223) = 16.91, $p < .001$, suggesting that there was a significant difference in the memory skills test scores over time. Pairwise comparisons were conducted to assess where the differences lie. Pretest scores were significantly higher than posttest scores ($p < .001$).

The results of the fourth one-within one-between ANOVA, memory skills (pre vs. post) by program, were also significant for the interaction effect of time and program, F (2, 223) = 9.79, $p < .001$, suggesting there were differences in the memory skills test scores by the interaction of program and time. Pairwise comparisons were conducted to assess where the differences lie. At pretest, ReadRx was significantly higher than ThinkRx ($p = .009$). At posttest, no program scored significantly higher than ThinkRx ($p < .001$) and ReadRx ($p = .004$). For no program, there were no significant differences between pretest and posttest scores. For ReadRx, pretest scores were significantly higher than posttest scores ($p < .001$). For ThinkRx, pretest scores were significantly higher than posttest scores ($p = .001$). Results of the fourth one-within one-between ANOVA are presented in Table 9. Means and standard deviations are presented in Table 10. Figure 4 shows the memory skills pretest and posttest scores over time.

Table 9. Results of One-Within One-Between ANOVA for Memory Skills Test Scores by Time and Program

Source	*SS*	*df*	*MS*	*F*	*p*	Partial η^2
			Between Subjects			
Program	1176.64	2	588.32	9.48	.001	.08
Error	13839.58	223	62.06			
			Within Subjects			
Time	533.95	1	533.95	16.91	.001	.07
Time*Program	618.54	2	309.27	9.79	.001	.08
Error (Time)	7043.58	223	31.59			

Table 10. Means and Standard Deviations for Memory Skills (Pretest vs. Posttest) by Program

	Pretest		Posttest	
	M	*SD*	*M*	*SD*
No program	14.36	6.83	15.40	7.54
ReadRx	15.93	6.56	11.55	7.88
ThinkRx	12.69	6.02	9.49	6.07

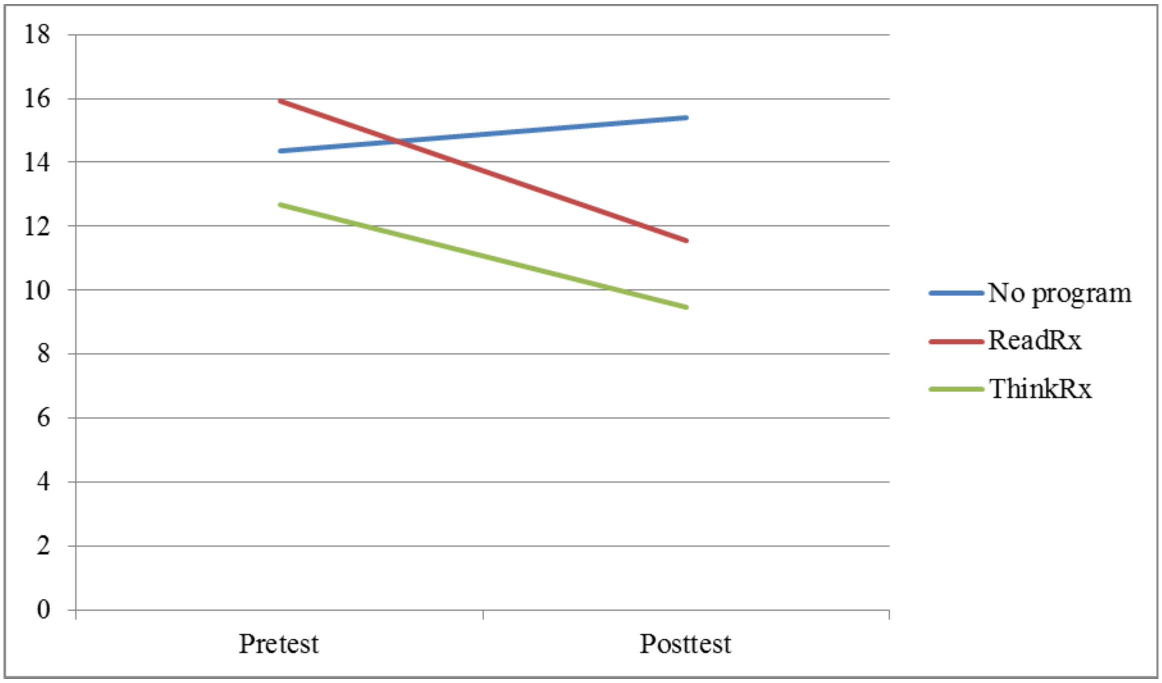

Figure 4. Memory skills (pre vs. post) scores by program

In preliminary analysis of the fifth one-within one-between ANOVA, visual processing skills (pre vs. post) by program, two Kolmogorov Smirnov (KS) tests were conducted to assess for normality. The results for the both KS tests were significant, violating the assumption for normality. However, Pallant (2007) suggests that the analysis is robust against the assumption if there are at least 30 participants for the analysis (there are over 30 in each analysis). The assumption for equality of variance was assessed with two Levene's tests. The results of the tests were significant, violating the assumption. However, the analysis is robust against violations of equality of variance as long as group sizes are relatively equal (Pallant, 2007).

The results of the fifth one-within one-between ANOVA, visual processing skills (pre vs. post) by program, were significant for the main effect of program (between-subjects effects), $F(2, 223) = 6.84$, $p = .001$, suggesting there was a significant difference in the visual processing skills test scores by just program. Pairwise comparisons were conducted to see where the differences lie. No program was significantly higher than ThinkRx ($p = .002$). ReadRx was significantly higher than ThinkRx ($p = .019$). No other significant differences existed between programs.

The results of the fifth one-within one-between ANOVA, visual processing skills (pre vs. post) by program were not significant for the main effect of time, $F(1, 223) = 2.49$, $p = .116$, suggesting that there was no significant difference in the visual processing skills test scores over time.

The results of the fifth one-within one-between ANOVA, visual processing skills (pre vs. post) by program, were significant for the interaction effect of time and program, $F(2, 223) = 4.76$, $p = .009$, suggesting there were differences in the visual processing skills test scores by the interaction of program and time. Pairwise comparisons were conducted to assess where the differences lie. At pretest, ReadRx was significantly higher than ThinkRx ($p = .016$). At posttest, no program scored significantly higher than ThinkRx ($p < .001$). For no program, there were no significant differences between pretest and posttest scores. For ReadRx, pretest scores were significantly higher than posttest scores ($p = .020$). For ThinkRx, there were no significant differences between pretest and posttest scores. Results of the fifth one-within one-between ANOVA are presented in Table 11. Means and standard deviations are presented in Table 12. Figure 5 shows the visual processing skills pretest and posttest scores over time.

Table 11. Results of One-Within One-Between ANOVA for Visual Processing Test Scores by Time and Program

Source	*SS*	*df*	*MS*	*F*	*p*	Partial η^2
			Between Subjects			
Program	848.39	2	424.20	6.84	.001	.06
Error	13834.05	223	62.04			
			Within Subjects			
Time	74.29	1	74.29	2.49	.116	.01
Time*Program	284.36	2	142.18	4.76	.009	.04
Error (Time)	6656.68	223	29.85			

Table 12. Means and Standard Deviations for Visual Processing (Pretest vs. Posttest) by Program

	Pretest		Posttest	
	M	*SD*	*M*	*SD*
No program	10.96	6.31	12.35	7.40
ReadRx	12.19	6.17	10.00	9.42
ThinkRx	9.36	5.63	7.73	5.17

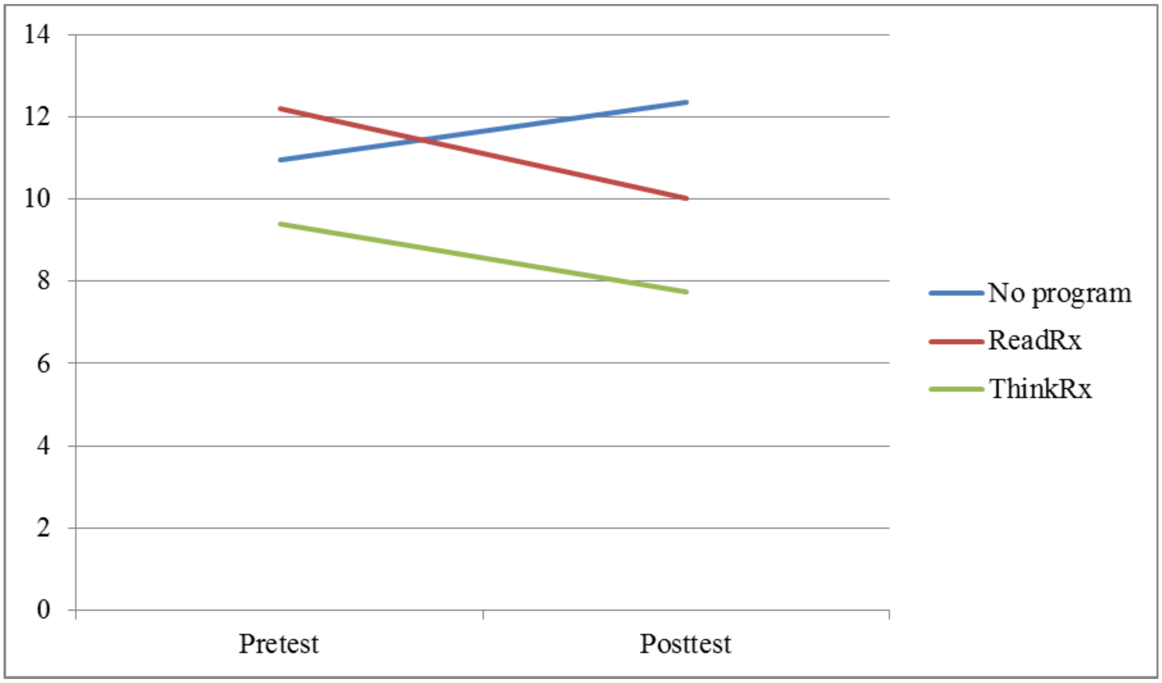

Figure 5. Visual processing skills (pre vs. post) scores by program

In preliminary analysis of the sixth one-within one-between ANOVA, logic & reasoning (pre vs. post) by program, two Kolmogorov Smirnov (KS) tests were conducted to assess for normality. The results for the both KS tests were significant, violating the assumption for normality. However, Pallant (2007) suggests that the analysis is robust against the assumption if there are at least 30 participants for the analysis (there are over 30 in each analysis). The assumption for equality of variance was assessed with two Levene's tests. The results of the tests were significant, violating the assumption. However, the analysis is robust against violations of equality of variance as long as group sizes are relatively equal (Pallant, 2007).

The results of the sixth one-within one-between ANOVA, logic & reasoning (pre vs. post) by program, were significant for the main effect of program (between-subjects effects), F (2, 223) = 4.28, p = .015, suggesting there was a significant difference in the logic & reasoning test scores by just program. Pairwise comparisons were conducted to see where the differences lie. No program was significantly higher than ThinkRx (p = .020).

The results of the sixth one-within one-between ANOVA, logic & reasoning (pre vs. post) by program, were significant for the main effect of time, F (1, 223) = 8.34, p = .004, suggesting that there was a significant difference in the logic & reasoning test scores over time. Pairwise comparisons were conducted to assess where the differences lie. Pretest scores were significantly higher than posttest scores (p = .004).

The results of the sixth one-within one-between ANOVA, logic & reasoning (pre vs. post) by program, were also significant for the interaction effect of time and program, F (2, 223) = 8.90, $p < .001$, suggesting there were differences in the logic & reasoning test scores by the interaction of program and time. Pairwise comparisons were conducted to assess where the differences lie. At pretest, ReadRx was significantly higher than ThinkRx (p = .034). At posttest, no program scored significantly higher than ThinkRx (p = .001) and ReadRx (p = .046). For no program, there were no significant differences between pretest and posttest scores. For ReadRx, pretest scores were significantly higher than posttest scores ($p < .001$). For ThinkRx, pretest scores were significantly higher than posttest scores (p = .011). Results of the sixth one-within one-between ANOVA are presented in Table 13. Means and standard deviations are presented in Table 14. Figure 6 shows the logic & reasoning pretest and posttest scores over time.

Table 13. Results of One-Within One-Between ANOVA for Logic & Reasoning Test Scores by Time and Program

Source	*SS*	*df*	*MS*	*F*	*p*	Partial η^2
			Between Subjects			
Program	605.75	2	302.88	4.28	.015	.04
Error	15769.15	223	70.71			
			Within Subjects			
Time	245.93	1	245.93	8.34	.004	.04
Time*Program	525.10	2	262.55	8.90	.001	.07
Error (Time)	6580.03	223	29.51			

Table 14. Means and Standard Deviations for Logic & Reasoning (Pretest vs. Posttest) by Program

	Pretest		Posttest	
	M	*SD*	*M*	*SD*
No program	11.68	7.55	13.13	8.33
ReadRx	13.83	7.21	10.19	7.81
ThinkRx	10.92	5.64	8.68	5.46

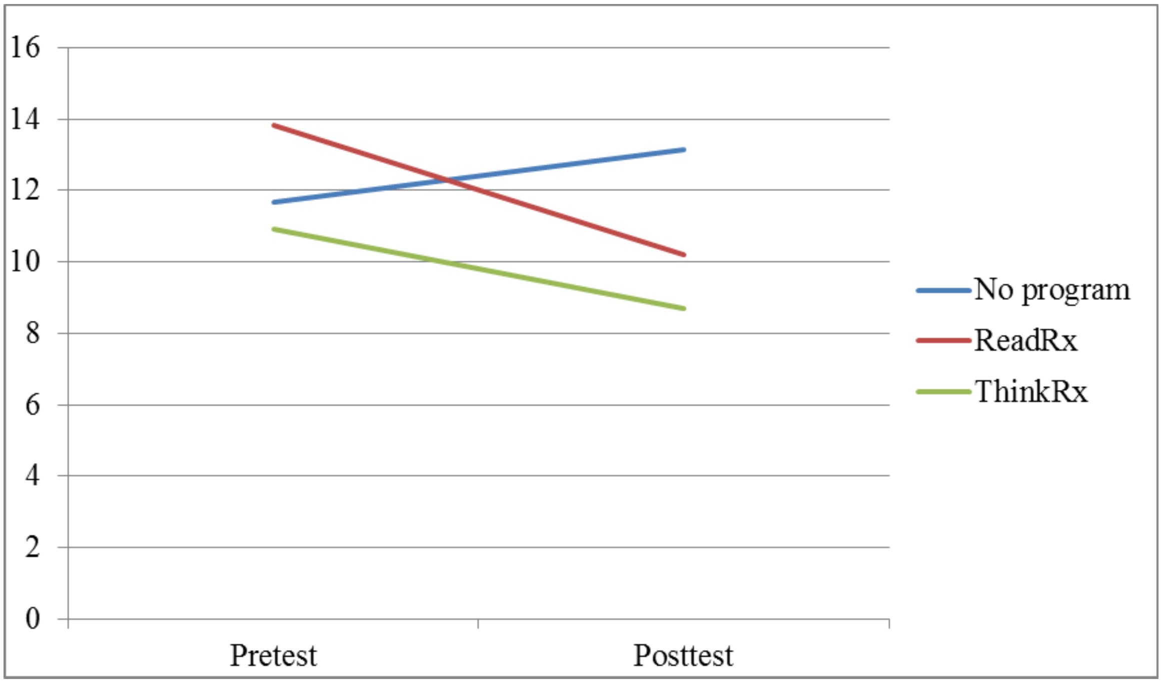

Figure 6. Logic & reasoning test scores (pretest vs. posttest) by program.

In preliminary analysis of the seventh one-within one-between ANOVA, sensory motor skills (pre vs. post) by program, two Kolmogorov Smirnov (KS) tests were conducted to assess for normality. The results for the both KS tests were significant, violating the assumption for normality. However, Pallant (2007) suggests that the analysis is robust against the assumption if there are at least 30 participants for the analysis (there are over 30 in each analysis). The assumption for equality of variance was assessed with two Levene's tests. The results of the tests were not significant, meeting the assumption.

The results of the seventh one-within one-between ANOVA, sensory motor skills (pre vs. post) by program, were significant for the main effect of program (between-subjects effects), F (2, 223) = 6.34, p = .002, suggesting there was a significant difference in the sensory motor skills test scores by just program. Pairwise comparisons were conducted to see where the differences lie. No program was significantly higher than ThinkRx (p = .001). No other significant comparisons existed.

The results of the seventh one-within one-between ANOVA, sensory motor skills (pre vs. post) by program, were significant for the main effect of time, F (1, 223) = 9.30, p = .003, suggesting that there was a significant difference in the sensory motor skills test scores over time. Pairwise comparisons were conducted to assess where the differences lie. Pretest scores were significantly higher than posttest scores (p = .003).

The results of the seventh one-within one-between ANOVA, sensory motor skills (pre vs. post) by program, were also significant for the interaction effect of time and program, F (2, 223) = 8.72, $p < .001$, suggesting there were differences in the sensory motor skills test scores by the interaction of program and time. Pairwise comparisons were conducted to assess where the differences lie. At pretest, no significant differences existed. At posttest, no program scored significantly higher than ThinkRx ($p < .001$) and ReadRx (p = .002). For no program, there were no significant differences between pretest and posttest scores. For ReadRx, pretest scores were significantly higher than posttest scores (p = .001). For ThinkRx, pretest scores were significantly higher than posttest scores (p = .001). Results of the seventh one-within one-between ANOVA are presented in Table 15. Means and standard deviations are presented in Table 16. Figure 7 shows the sensory motor skills pretest and posttest scores over time.

Table 15. Results of One-Within One-Between ANOVA for Sensory Motor Skills Test Scores by Time and Program

Source	*SS*	*df*	*MS*	*F*	*p*	Partial η^2
			Between Subjects			
Program	555.01	2	277.51	6.34	.002	.05
Error	9767.25	223	43.80			
			Within Subjects			
Time	140.67	1	140.67	9.30	.003	.04
Time*Program	263.67	2	131.84	8.72	.001	.07
Error (Time)	3371.56	223	15.12			

Table 16. Means and Standard Deviations for Sensory Motor Skills (Pretest vs. Posttest) by Program

	Pretest		Posttest	
	M	*SD*	*M*	*SD*
No program	9.18	5.28	10.19	6.05
ReadRx	9.30	5.70	7.03	5.45
ThinkRx	8.08	5.03	5.99	5.00

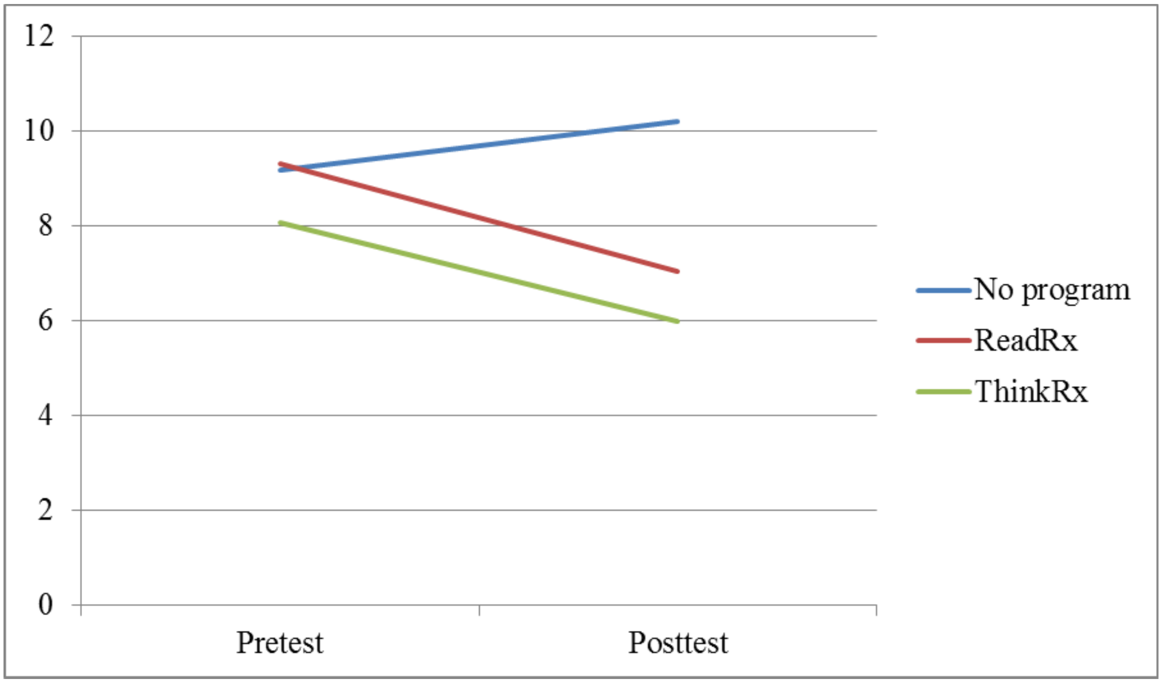

Figure 7. Sensory motor skills test scores (pre vs. post) by program

Hypothesis 2

The ThinkRx and ReadRx cognitive skills training programs will have a positive effect on the behavior of a population of students.

To assess Hypothesis 2, a one-within one-between analysis of variance (ANOVA) was conducted to assess if there were differences in the cognitive skills test scores (oppositional behavior) and time (pretest vs. posttest) by program (no program, ThinkRx, and ReadRx).

In preliminary analysis of the one-within one-between ANOVA, oppositional behavior (pre vs. post) by program, two Kolmogorov Smirnov (KS) tests were conducted to assess for normality.

The results for the both KS tests were significant, violating the assumption for normality. However, Pallant (2007) suggests that the analysis is robust against the assumption if there are at least 30 participants for the analysis (there are over 30 in each analysis). The assumption for equality of variance was assessed with two Levene's tests. The results of the tests were not significant, meeting the assumption.

The results of the one-within one-between ANOVA, oppositional behavior (pre vs. post) by program, were not significant for the main effect of program (between-subjects effects), F (2, 223) = 1.81, p = .167, suggesting there was not a significant difference in the test scores by just program.

The results of the ANOVA were not significant for the main effect of time, F (1, 223) = 1.81, p = .180, suggesting that there was not a significant difference in the test scores over time. The results of the ANOVA were also not significant for the interaction of time and program, F (2, 223) = 1.71, p = .184, suggesting there were no differences in oppositional behavior test scores by the interaction of time and program.

Due to this lack of significance, there can be no significant interaction effect of time and program. Results of the one-within one-between ANOVA are presented in Table 17. Means and standard deviations are presented in Table 18.

Table 17. Results of One-Within One-Between ANOVA for Oppositional Behavior Test Scores by Time and Program

Source	*SS*	*df*	*MS*	*F*	*p*	Partial η^2
			Between Subjects			
Program	247.80	2	123.90	1.81	.167	.02

Error	15290.19	223	68.57			
			Within Subjects			
Time	32.55	1	32.55	1.81	.180	.01
Time*Program	61.39	2	30.69	1.71	.184	.02
Error (Time)	4006.84	223	17.97			

Table 18. Means and Standard Deviations for Oppositional Behavior (Pretest vs. Posttest) by Program

	Pretest		Posttest	
	M	*SD*	*M*	*SD*
No program	8.49	7.69	8.95	7.15
ReadRx	7.49	6.10	6.64	5.90
ThinkRx	7.90	6.30	6.68	5.93

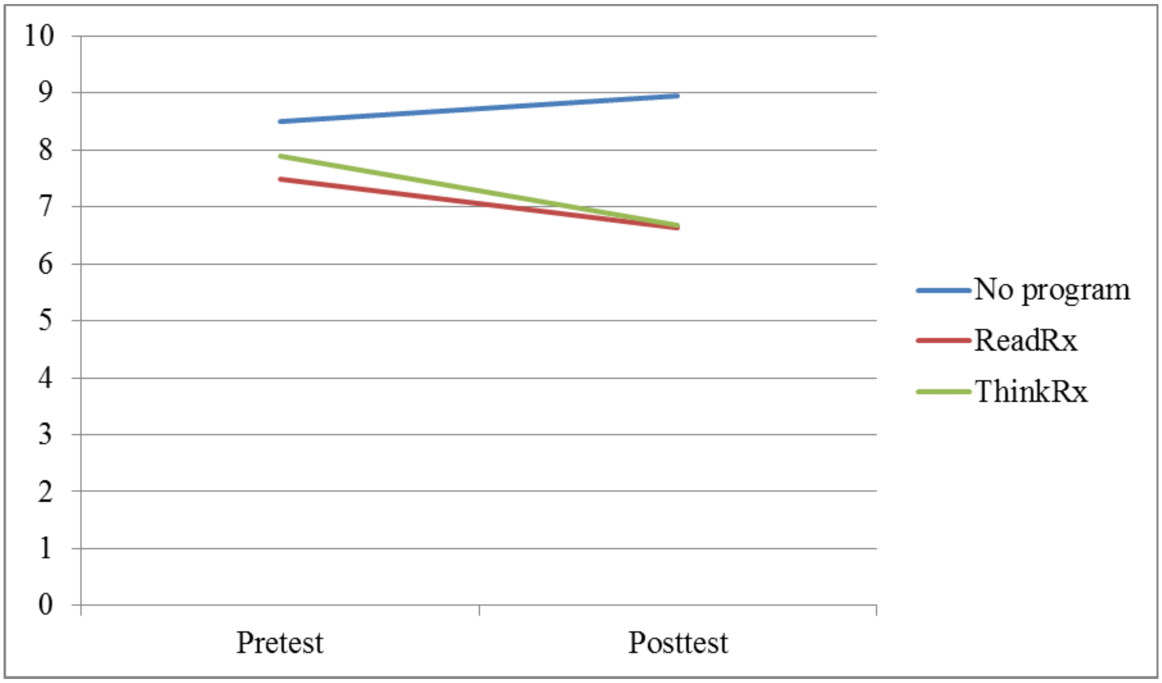

Figure 8. Oppositional behavior test scores (pre vs. post) by program.

Hypothesis 3

The ThinkRx and ReadRx cognitive skills training programs will have a positive effect on the academic achievement of a population of students.

To assess Hypothesis 3, a one-within one-between analysis of variance (ANOVA) was conducted to assess if there were differences in the cognitive skills test scores (work or academic performance) and time (pretest vs. posttest) by program (no program, ThinkRx, and ReadRx).

In preliminary analysis of the one-within one-between ANOVA, work or academic performance (pre vs. post) by program, two Kolmogorov Smirnov (KS) tests were conducted to assess for normality. The results for the KS tests for post scores were significant, violating the assumption for normality. However, Pallant (2007) suggests that the analysis is robust against the assumption if there are at least 30 participants for the analysis (there are over 30 in each analysis). The assumption for equality of variance was assessed with two Levene's tests. The results of the tests were not significant, meeting the assumption.

The results of the one-within one-between ANOVA, work or academic performance (pre vs. post) by program, were significant for the main effect of program (between-subjects effects), F (2, 223) = 3.63, p = .028, suggesting there was a significant difference in the work or academic performance test scores by just program. Pairwise comparisons were conducted to see where the differences lie. No program was significantly higher than ThinkRx (p = .041). No other significant differences existed between programs.

The results of the ANOVA were significant for the main effect of time (within-subjects effects of time), F (1, 223) = 25.33, p < .001, suggesting that there was a significant difference in the work or academic performance test scores over time. Pairwise comparisons were conducted to assess where the differences lie. Pretest scores were significantly higher than posttest scores (p < .001).

The results of the ANOVA were also significant for the interaction effect of time and program, F (2, 223) = 10.73, p < .001, suggesting there were differences in the work or academic performance test scores by the interaction of program and time. Pairwise comparisons were conducted to assess where the differences lie. At pretest, ReadRx was significantly higher than ThinkRx (p = .044). At posttest, no program scored significantly higher than ReadRx (p = .030) and ThinkRx (p = .001). For no program, there was no significant difference between pretest and posttest scores. For ReadRx, pretest scores were significantly higher than posttest scores ($p < .001$). For ThinkRx, pretest scores were significantly higher than posttest scores ($p < .001$). Results of the one-within one-between ANOVA are presented in Table 19. Means and standard deviations are presented in Table 20. Figure 7 shows the pretest and posttest scores over time.

Table 19. Results of One-Within One-Between ANOVA for Work or Academic Performance Test Scores by Time and Program

Source	*SS*	*df*	*MS*	*F*	*p*	Partial η^2
			Between Subjects			
Program	505.90	2	252.95	3.63	.028	.03
Error	15543.85	223	69.70			
			Within Subjects			
Time	835.23	1	835.23	25.33	.001	.10
Time*Program	707.96	2	353.98	10.73	.001	.09
Error (Time)	7354.31	223	32.98			

Table 20. Means and Standard Deviations for Work or Academic Performance (Pretest vs. Posttest) by Program

	Pretest		Posttest	
	M	*SD*	*M*	*SD*
No program	14.25	7.51	14.95	7.44

ReadRx	16.90	6.61	11.75	8.33
ThinkRx	14.12	6.26	10.39	6.69

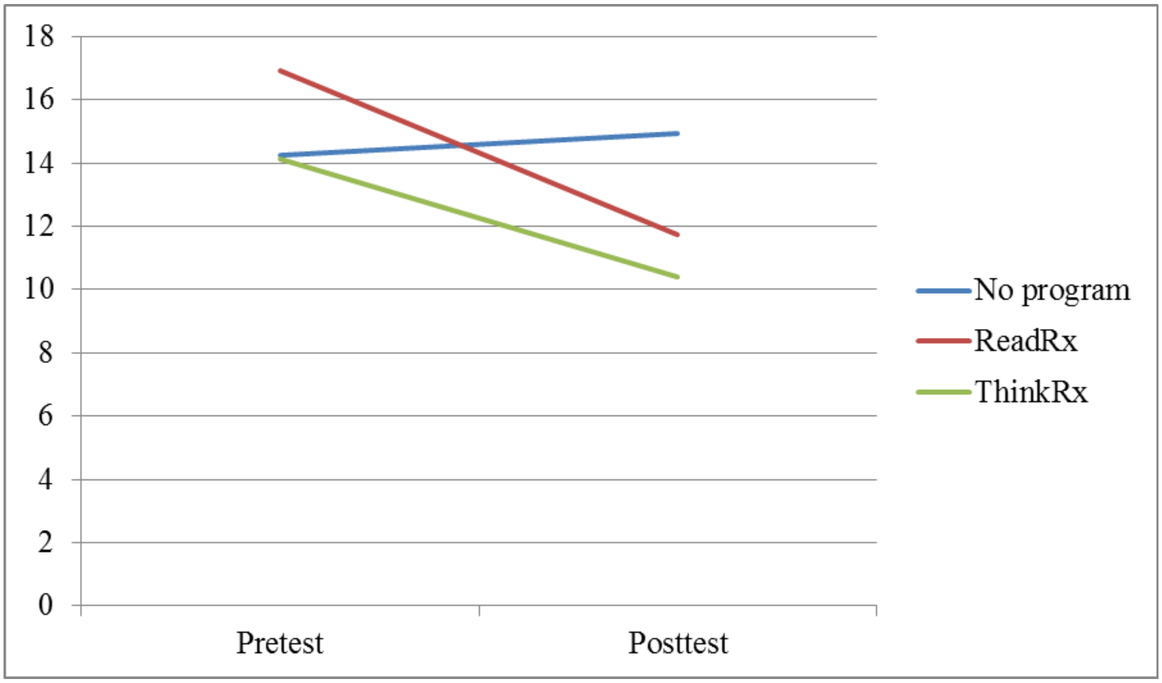

Figure 9. Work or academic performance test scores (pre vs. post) by program.

Conclusion

In summary study results, as evidenced by the data analyses employed in the study, indicated that those students who completed the ThinkRx or ReadRx cognitive skills training program showed both cognitive skills and academic improvement unlike those who had not completed either program. However, the results of this research also revealed that students from the entire sample showed no significant improvement in behavior.

CHAPTER 5. RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

This study was conducted to determine if positive behavioral and academic effects result from a student's completion of a cognitive skills training program. This research project proposed that improvements in cognitive skills could translate into better performance in real- life day-to-day activities. This chapter first presents the summary of the results, which includes the variability in the pre and post survey for each variable in the overall sample. The chapter also addresses differences between the types of program, as well as between diagnostic groups. Discussion also focuses on findings related to age, gender, and demographic variables. Finally, this chapter presents study limitations and future directions as well as study strengths and contributions and final thoughts.

Summary of Results

The objective of this research project was to determine if a specific cognitive training program aimed at improving cognitive skills, behavior, and academics had a positive impact on the participants. Measured were the effects of the program by evaluating differences between pre and post test scores across cognitive, behavioral, and academic domains. Addressed was the question of cognitive modifiability by examining the overall scores as well as changes in processing speed, auditory skills, memory skills, visual processing skills, logic and reasoning, sensory motor skills, oppositional behavior, and work or academic performance.

This study's significance lies in its contribution to the body of research on the viability of cognitive skills training as a method of enhancing an individual's ability to learn and sustaining those improvements over time. This study will also be beneficial to teachers in any curricular area as they adopt and implement effective learning strategies that contribute to student's cognition. By understanding the concepts of cognitive skills and the role those skills play in a student's education, students and teachers will experience an educational advantage. This study also will be helpful to parents as they seek to develop an understanding of cognitive skills and the role those skills play in their child's academic success.

The structural cognitive modifiability (SCM) model developed by Feuerstein (SCM; Feuerstein, 1974; Feuerstein & Rand, 1979) served as this study's foundation. Within his theory is Feuerstein's belief that cognitive skills have the potential to change as a result of intensive intervention. His theory incorporates aspects of learning theory from Binet, Gagné, Piaget, and Vygotsky. This study evaluated the SCM theory by assessing if cognitive abilities, behavior, and academic success could change through training. Cattell, Horn, and Carrol outlined a hierarchy of cognitive abilities in what came to be known as the CHC theory. Their three-level hierarchy included a general intelligence factor, 10 broad abilities, and more than 70 narrow abilities. Research has linked the broad abilities to a variety of achievement outcomes, which also adds significant explanatory power to overall IQ measures when predicting achievement (Flanagan, 2000).

The study methodology was of quasi-experimental design with three groups. Members of one group completed one cognitive skills training program while members of the second group completed a different training program. Participants in the third group did not complete a program but did participate in the testing process. Pre and post analysis focused on the same survey, the LSRS. Participants completed the pre LSRS before starting a training program; they completed the post LSRS at least one year after finishing their training. The population for this study consisted of any person who had completed a LearningRx cognitive skills training program and/or an LSRS questionnaire at any training center in the United States. The sample for this study consisted of those students' ages 5 to 18 who had completed either a ReadRx or ThinkRx cognitive skills training program and/or a LSRS at one of the LearningRx training centers in the United States.

Descriptive statistics that helped to interpret collected data in this study included the mean and the standard deviation. Inferential statistics in this project included the ANOVA. Study results focused on a comparison of scores of those who had completed the ThinkRx and those who had completed the ReadRx program.

This study's expectation is that those students who completed a cognitive skills training program will experience greater positive behavioral and academic effects than those who did not complete a training program. This study, therefore, can be valuable to parents, educators, and other researchers because it provides a roadmap for helping struggling students achieve a higher level of success.

The results of this study indicate that those students that completed the ThinkRx or ReadRx program showed improvement in both cognitive skills and academic performance more than did those students who did not complete one of the two programs. Behavior also improved but not enough to indicate a significant change. Rejecting the null hypotheses answered hypotheses one and three. Significant changes in scores from pre to posttest indicated that the completion of a cognitive skills training program improved students' cognitive skills and academics. Hypothesis two did not reject the null hypothesis because no significant change in behavior was observable.

Discussion of Results

Scores in attention skills, processing speed, memory skills, visual processing skills, auditory processing skills, logic and reasoning, sensory motor skills, and overall work or academic performance improved substantially as a result of intensive cognitive training. It was observed that no significant differences between pre to post scores for oppositional behavior.

Differences between the ReadRx and ThinkRx programs regarding improvements to cognition, behavior, and academics based on mean scores were minimal. ReadRx group scores showed an average improvement of 3.92 for cognition, .85 for behavior and 5.15 for academics. Scores of the ThinkRx group evidenced an average improvement of 2.76 for cognition, 1.22 for behavior, and 3.73 for academics. The no program group showed a consistent decrease of 1.13 in cognition, .46 in behavior, and .7 in academics. Students who had completed the ReadRx program had a higher mean difference of 1.16 over those who had completed the ThinkRx program for cognition and a 1.42 mean difference for academic improvement. Students in the ThinkRx group had a higher mean score for behavior by .37 over those in the ReadRx group.

The results of the analyses of the data collected for this study strongly supported the research question and hypotheses. The research question under investigation was

“What real-life effects do students experience as a result of completing a cognitive skills training program?” The hypotheses of the study fell under the umbrella of cognition, behavior, and academics.

The first hypothesis stated that the ThinkRx and ReadRx cognitive skills training programs would have a positive effect on the cognition of a population of students. The analysis concluded that the findings were significant. Each of the seven skills assessed had similar results: the scores decreased with the completion of the ThinkRx or ReadRx programs whereas the No Program participants’ scores increased. Those students who had completed a training program had increased overall improvement in cognitive skills over those who had not finished either program.

The second hypothesis stated that the ThinkRx and ReadRx cognitive skills training programs would have a positive effect on the behavior of a population of students. The results evidenced no significant difference in the behavior of students from pretest to posttest in any of the three groups.

The third hypothesis stated that the ThinkRx and ReadRx cognitive skills training programs would have a positive effect on the academic achievement of a population of students. Analysis results show significant findings in this area. Academic achievement scores decreased with the completion of the ThinkRx or ReadRx programs whereas the scores of participants in the no program group. Students who had completed either program evidenced greater academic success than those students who had not completed either cognitive skills training program.

Based on each hypothesis, the results indicate that parents of students who had completed a cognitive skills training program felt that their children had improved in cognition, academics, and behavior.

Discussion of the Conclusions

This study used vigorous statistical procedures and methods to assess changes reliably in scores from pre to post survey. The sample was gathered from a large national database, which represented the four major regions of the United States.

The foundation for this study was the structural cognitive modifiability model developed by Feuerstein (SCM; Feuerstein, 1974; Feuerstein & Rand, 1979). In his theory, Feuerstein believes that cognitive skills can change as the result of intensive intervention. His theory incorporates aspects of learning theory from Binet, Gagné, Piaget, and Vygotsky. This study evaluated the SCM theory by assessing if cognitive abilities, behavior, and academic success could change through training. Raymond Cattell, John L. Horn, and John Bissell Carroll outlined a hierarchy of cognitive abilities in what came to be known as the CHC theory. Their three-level hierarchy included a general intelligence factor, 10 broad abilities, and more than 70 narrow abilities. Research has linked the broad abilities to a variety of achievement outcomes, which also add significant explanatory power to overall IQ measures when predicting achievement (Flanagan, 2000).

Several prominent twenty-first century researchers contend that cognitive skills are trainable or modifiable (Feuerstein & Rand, 1977; Feuerstein, Rand, Hoffman & Miller, 1980; Merzenich, 2001; McGrew & Flanagan, 1998). This study evidences shown that a student's academic performance, cognition and behavior can change after completion of a cognitive training program.

Students who struggle academically now have an option that cannot only change their academic performance but can allow them to set goals they may not have previously considered. School districts currently seek research-based programs that can be used as interventions for academically challenged students, either within the classroom or on an individual basis. Response to intervention (RTI) is a newer initiative in which schools employ a holistic view of students in an effort to meet their individual needs. Schools that seek options for students now can access an intervention that is shown to develop the skills necessary for academic success.

Limitations

Perhaps the greatest limitation of this study is the fact that data collected for the research consisted entirely of self-report responses to questionnaires. While LSRS scores are a viable way to determine improvement in behavior, academics, and cognitive skills (Gibson, 2007), there is typically an abiding issue of response bias as with any self-report questionnaire in which respondents may attempt to present an inaccurate image of their children or of themselves (Breakwell, Hammond, and Fife-Schaw, 2002).

The second greatest limitation is the non-random nature of the study sample. When using the nonequivalent group design, the mechanism of random assignment does not govern group assignment. As a result, the groups potentially could be different prior to the study, which may make the study susceptible to the internal validity threat of selection.

The third greatest limitation to this study is the possibility of an examiner effect. Because participants pay for their cognitive skills training programs, some participants may have been happier with the outcome of their training than others. As a result, an expectancy or halo effect may have inflated scores on the posttest because of participants' expectations of positive outcomes of the programs. Future studies may benefit from having someone other than the family member who completed the pre LSRS complete the post LSRS. Finally, the fourth greatest limitation of this study is generalizability. Because there are a variety of different training programs available and this study focuses on two specific programs, methods of cognitive training in other programs may be different (i.e., online training, home-based programs, and other self-directed methods). This study focusses on the delivery method of one-on-one training to the exclusion of other delivery methods.

Recommendations for Future Research or Intervention

This study was the first to study cognitive and academic development from cognitive training programs based on using the Learning Skills Rating Scale. Study results indicate that interventions can help to improve cognitive skills, which leads to academic and behavioral improvement. Parents are seeking ways to improve their children's academic success, which makes cognitive training programs in high demand. Teachers are also demanding research- based programs that can be used in classrooms to generalize and expand their knowledge of cognitive based-interventions. Strategies to reduce practice effects include using two different versions of the same measure or ensuring that the length of time between surveys is long enough to reduce the possibility or impact of practice effects.

All LearningRx training centers around the United States use the Learning Skills Rating Scale on a daily basis. This study pursued participants who had completed an LSRS in the previous year with or without having completed a cognitive skills training program. Study participants were either students (depending on their ages) or their parents. Future researchers may need to ask someone other than a parent or the student to complete the LSRS to eliminate the issue of response bias, in which respondents attempt to present an inaccurate (often flattering) image of their child or themselves (Breakwell, Hammond, and Fife-Schaw, 2002).

Certain delimitations could have strengthened this study. Students have a variety of issues that may affect their academics. Issues related to students' environments, medical conditions, ADD/ADHD, or social/emotional issues are also important influences on academic performance. Future research is necessary to determine other factors that contribute to a student's inability to achieve at his or her highest level.

Conclusion

This study has implications regarding interventions parents, students and educators will pursue for students who are struggling academically. It also opens the door for future studies that focus closely on cognitive-based interventions whose goal is to improve academics. As stated earlier, many school districts are using the new initiative Response to Intervention (RTI). This study describes another option for districts and students. As demonstrated by this research, academics, cognitive skills, and behavior can improve with cognitive training. Additional research in the area of cognitive training is necessary to solidify these findings and find classroom-based interventions that will improve students' academic performance.

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