CLIENT OUTCOMES AND RESEARCH RESULTS

BrainRx®

2017 Edition

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Foreword

Executive processing is dependent upon the collective interplay of brain networks underlying fundamental cognitive skills. In ways, one's executive processing is only as strong as one's weakest cognitive skill. Cognitive training offers the most promising method for strengthening underlying cognitive networks, allowing one to increase overall executive processing ability!

However, not all cognitive training programs are alike! BrainRx is distinct in many ways from the variety of solely-digital training programs available today. Foremost, BrainRx programs are delivered by a clinician who gives dynamic feedback throughout every training session. Further, BrainRx programs are based on the Cattell-Horn-Carroll theory of intelligence, a widely-accepted view of cognition and the theoretical foundation of modern day cognitive assessment. BrainRx is comprehensive; targeting and training seven key cognitive skills and multiple sub-skills. It is also highly intensive, including an average of 60 to 120 hours of training over several months.

We are beginning to use MRI to visualize the underlying changes in brain structure and function after BrainRx training. In one research study, we looked at underlying changes related to gains in cognitive skills and found correlated changes in functional connectivity! The dynamic feedback, thoroughness, and intensity of BrainRx cognitive training are keys to producing lasting modifications of cognitive skill networks and the desired functional cognitive gains. It is certainly an exciting time to be in the field of cognitive training research.

Sincerely,

Christina Ledbetter, PhD
Neuroscientist and Research Fellow, LSU Health Sciences Center

Introduction

Since 1985, Dr. Ken Gibson and his colleagues have helped over 100,000 clients with a unique cognitive training methodology designed to remediate deficits in multiple underlying learning skills. Dr. Gibson devoted his entire career to helping children and adults with learning struggles, beginning first with a visual information processing intervention and later restructuring the program to include auditory processing, memory, attention, processing speed, and reasoning training procedures. With input from a team of psychologists, educators, speech and language pathologists, and occupational therapists, Dr. Gibson studied the results of learning and cognition research to develop an intensive reading intervention to complement the original training program. In 2009, an international model of cognitive training called BrainRx was developed to deliver the programs to children and adults around the world.

Later, the focus turned to building an empirical research base that supported the cognitive training procedures and assessments used by BrainRx and LearningRx brain training centers around the world, and to the continued development and testing of cognitive training program components. The Gibson Institute of Cognitive Research was established in April 2014 to accomplish those goals.

The mission of the Gibson Institute is to conduct research on the programs and assessments, to communicate the latest research findings to the education and cognitive science communities, to provide opportunities for outside researchers to participate in research projects that utilize our cognitive training and assessment instruments, and to inform the practices of cognitive trainers by translating research findings into real-world applications.

This report provides an overview of client outcomes from our United States brain training centers between 2010 and 2015, and summarizes the major research on our cognitive training programs.

Amy L. Moore, PhD
Educational Psychologist and Research Director, Gibson Institute of Cognitive Research

An Executive Summary

Introduction

This report presents an assessment of the training impacts on cognitive skills and reading achievement for nearly 18,000 clients of our brain training centers in the United States between 2010 and 2015, and presents a summary of research conducted to date on our training programs.

Background

Since 1985, our brain training methodology has been used with more than 100,000 clients at private clinical practices and in brain training centers around the world. The services are currently provided at BrainRx centers in over 40 countries and at 80 LearningRx Centers in the United States. Each center is independently owned and uses proprietary programs focused on improving cognitive skills, reading, and overall performance in work, school, and life.

Before and after completing a training program, clients complete a battery of tests that measure working memory, long-term memory, processing speed, logic & reasoning, visual processing, auditory processing, and English Word Attack skills. The client results presented in this report are based on pre-training and post-training test scores on the Woodcock-Johnson III Tests of Cognitive Abilities and Tests of Achievement. Additional measures, including magnetic resonance imaging and the Gibson Test of Cognitive Skills, are reported in the research section of the report.

Results from *Randomized Controlled Trials*

- **IQ.** Our training led to an average *IQ* gain of 21 points for children and teens.
- **Logic & Reasoning.** Our training led to average logic & reasoning gains of 38 percentile points and 5.3 years for children and teens.
- **Working Memory.** Our training led to average working memory gains of 25 percentile points and 4.8 years for children and teens.
- **Attention.** Our training led to an average attention gain of 18 percentile points for children and teens.
- **Neuronal Connections.** Our training led to significant changes in neuronal connections and global network efficiency measured by fMRI.

Results from *Quasi-experimental and Pilot Trials*

- **Cognitive Skills.** School-aged clients in the cognitive training group achieved significantly higher gains than the matched control group on working memory, associative memory, logic & reasoning, processing speed, auditory processing, and Word Attack scores.
- **Academic Difficulty.** Parent ratings of 226 school-aged clients showed that those who completed brain training experienced less academic difficulty afterwards, while academic difficulty in the same time period for children in a control group actually increased.
- **Traumatic Brain Injury (TBI).** Soldiers with TBI achieved clinically significant changes in working memory, IQ, auditory processing, long-term memory, auditory working memory, and logic & reasoning following our cognitive training.

Results from *Observational Studies*

- **Overall IQ.** Among the 17,998 clients between 2010 and 2015, the average gain in IQ was nearly 15 points following training.
- **Reading Skills.** Among the 6,460 reading program clients between 2010 and 2015, the average gains in reading skills ranged from 12 to 30 percentile points and 2.1 to 6.2 years following training. Based on an analysis of state reading achievement test scores from 65 clients, performance on the test jumped an average of 14 percentile points after brain training.
- **Classroom Improvements.** Among parents of 109 clients with dyslexia, nearly half reported classroom improvements, such as faster reading, better reading comprehension, and improved memory for details.
- **Retention.** Follow-up testing of 516 clients one year after training showed that retention rates ranged from 96% to 99% in all cognitive areas, including IQ, logic & reasoning, memory, and auditory processing.

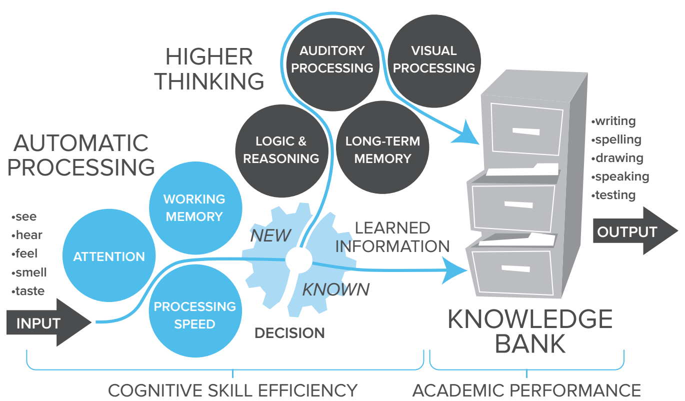
Conclusion

Our client outcomes are consistent across study designs and subgroups. To examine our client outcomes in detail, please see the client outcomes by program and diagnosis section of this report. To explore the individual research studies referenced in this summary, please see the research abstracts in the second half of this report.

The Science Behind Our One-on-One Brain Training

The Learning Model is grounded in the Cattell-Horn-Carroll (CHC) theory of intelligence, which describes thinking as a set of seven broad abilities: comprehension knowledge, long-term retrieval, visual-spatial thinking, auditory processing, fluid reasoning, processing speed, and short-term memory.

According to the Learning Model, an individual takes information in through the senses (input)



that must be recognized and analyzed by the active processing system (working memory, processing speed, attention). This executive control system determines which information is unimportant, easily handled, or requires thinking. Unimportant information is discarded from working memory. If the input contains important information about data that have already been stored in the knowledge bank, it is quickly retrieved and converted to output, such as speaking or writing.

If the information has not been previously stored, higher thinking processes must then occur. Reasoning, auditory processing, and visual processing must be used to solve the problem or complete the task. If the task is practiced often enough, however, the information is stored in the knowledge bank, which will decrease the time between input to output. This occurs because the higher thinking processes can then be bypassed.

SEVEN KEY COGNITIVE SKILLS

- **Attention:** Focus over time, despite distraction, or while multitasking
- **Processing Speed:** Think and perform tasks quickly and accurately
- **Working Memory:** Hold on to and use information during the learning process
- **Auditory Processing:** Distinguish, blend, and segment sounds accurately
- **Visual Processing:** Create and picture mental images while thinking or reading
- **Logic & Reasoning:** Reason, form ideas, and solve problems
- **Long-Term Memory:** Efficiently recall facts and stored information

Our Training Methodology

BrainRx cognitive training programs target and remediate seven primary cognitive skills and multiple sub-skills through repeated engagement in game-like mental tasks delivered one-on-one by a clinician or cognitive trainer, supplemented by computer-based training. The tasks emphasize visual or auditory processes that require attention and reasoning throughout each 60- to 90-minute training period. Using a synergistic "drill for skill" and metacognitive approach to developing cognitive skills, the program incorporates varying levels of intensity, hierarchical sequencing of tasks, multiple-task loading, and instant feedback from the clinician or trainer. Training sessions are focused, demanding, intense, and tightly controlled by the clinician or trainer to push students to just above their current cognitive skill levels. Deliberate distractions are built in to the sessions to tax the brain's capacity for sorting and evaluating the importance of incoming information. This ability to correctly handle distracting information and interruptions is the foundation for focus and attention skills.

THE SEVEN KEY INGREDIENTS OF EFFECTIVE BRAIN TRAINING

Brain training must be practiced. Because brain training builds skills, it can't be taught in the classroom. It must be practiced, like learning to play tennis or the piano.

Brain training that gets the best results is done one-on-one with a personal trainer. Teaming with an experienced trainer provides accountability, motivation, and—ultimately—life changing results.

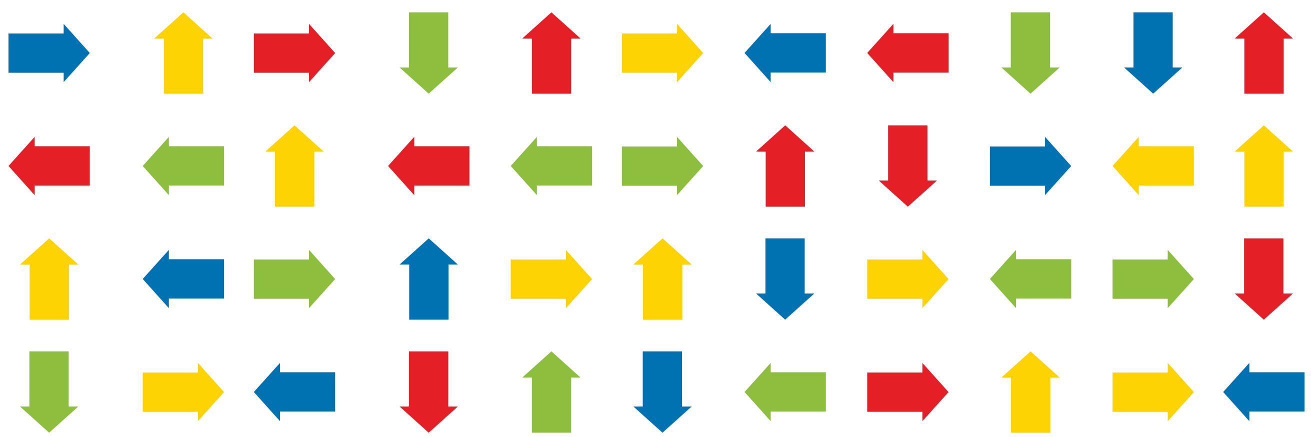
Brain training exercises need to be intense, requiring concentrated repetitions in order to train skills quickly.

Brain training exercises need to be targeted in order to address specific weak cognitive skills.

Brain training exercises need to be done in a particular sequence. Small challenging steps don't overwhelm the client, but allow the trainer to continually challenge the client incrementally and keep them engaged in the training.

Brain training exercises must be progressively loaded. Loading incorporates multitasking and is a fast-track way to take a new skill and make it a more automatic skill.

Brain training, to be effective, requires immediate, accurate feedback. Instant, effective reinforcement and adjustments keep training focused and intense.



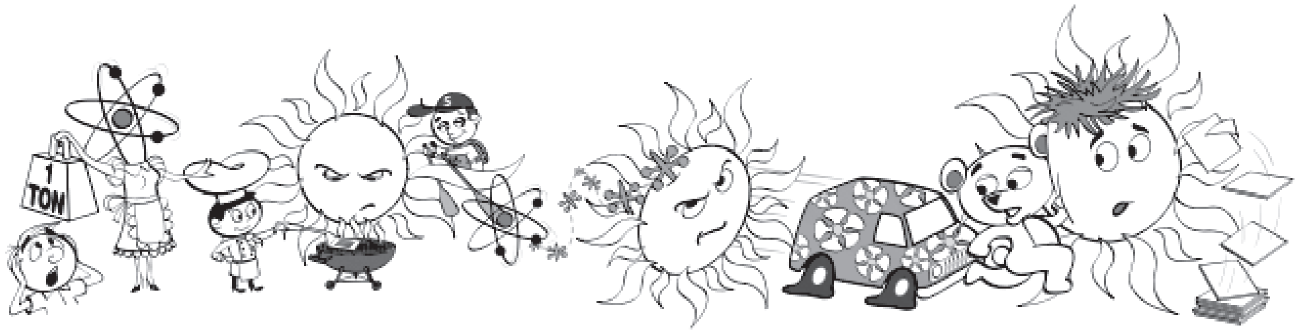
Feel Your Brain at Work:

Try a Procedure

Follow the directions below for a fun way to work on your attention, working memory, and visual processing skills. Each level increases the difficulty by adding a second mental challenge. Don't worry...your brain can adapt! Try it alone or try it with your child.

Directions

1. From the top row, moving left to right, call out the color of each of the arrows without a mistake.
2. Call out the direction of each arrow. Do it without error in 40 seconds. Keep practicing until you can do it in only 20 seconds.
3. Next, call out the direction of the arrows as if they were turned a ¼-turn clockwise. Get that time down to 20 seconds without error.
4. Now comes the fun part! Call out the color of the UP and DOWN arrows, and call out the direction of the LEFT and RIGHT arrows (this requires divided attention). Once mastered, increase the difficulty by saying red for yellow and blue for green. Try substituting different colors. Keep track of your time and stay with it until each exercise flows quickly and smoothly.
5. Finally, call out the direction of the arrow as if red and green arrows were turned a ¼-turn clockwise and yellow and blue were turned ¼-turn counterclockwise. You will find yourself not only doing the familiar ones more easily, but mastering each new variation faster as well.



Feel Your Brain at Work:

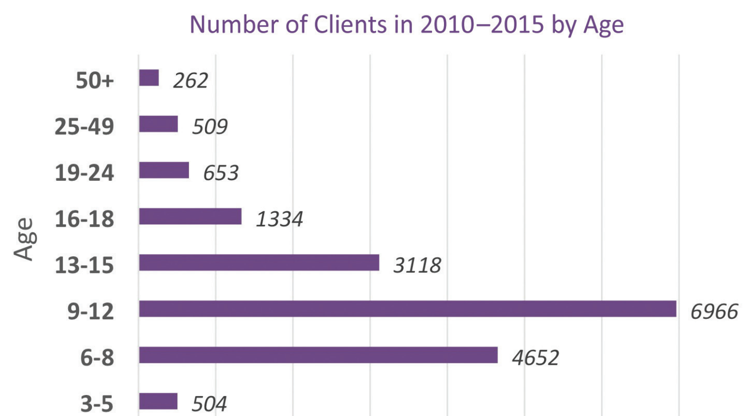
Try a Procedure

Our students learn the U.S. presidents forward and backward using a memory strategy called mnemonics. By using silly pictures and fun links, students can remember almost anything. Once they have completed the presidents, they learn how to visualize their own pictures and links, creating stronger memory and visualization skills. These skills are important for test-taking and reading comprehension. Have fun using this technique to learn the first 10 presidents.

Here is the script our trainers use to help students associate the linked images with the names they want to memorize:

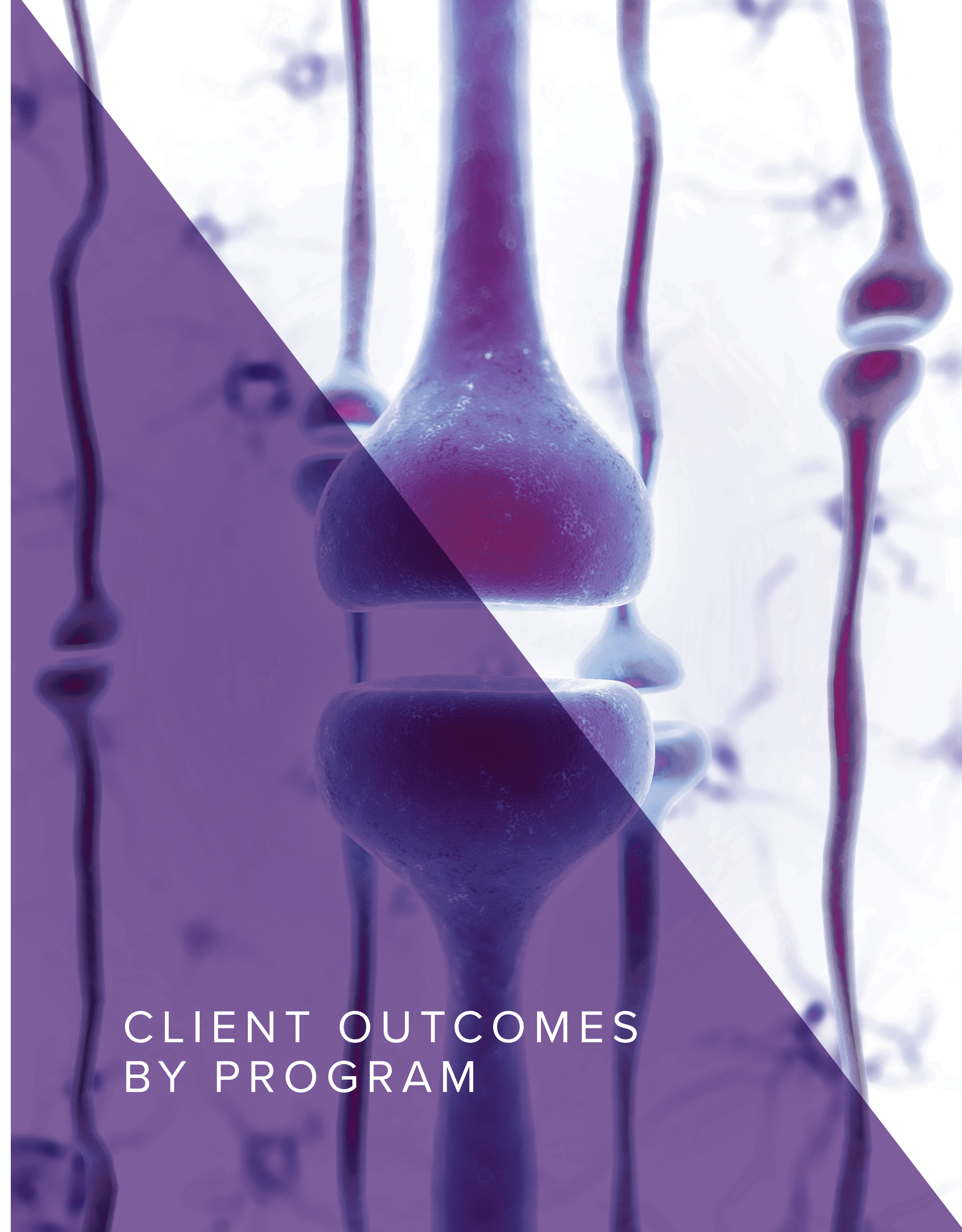
What is the man watching? (the man is WATCHING-a-TON). If a ton was hanging over my head, I'd be watching it too, wouldn't you? WATCHING-a-TON will remind you of WASHINGTON. (WATCHING-a-TON; WASHINGTON). What is funny about the lady who is holding the ton? (Her head). Her head is superpowered! Do you know where the superpowers are coming from? (ATOMS). ATOMS will remind you of ADAMS. (ATOMS; ADAMS). Who is the woman patting on the head? (a CHEF). The chef is HER-SON. CHEF-HER-SON will remind you of JEFFERSON. (CHEF-HER-SON; JEFFERSON). What is the chef grilling? (a SUN). Does the sun look happy or mad? (MAD). So, the sun is a...MAD-SUN. (MAD-SUN; MADISON). What do you see on one of the sunbeams? (a MAN-ROWing a boat). (MAN-ROW; MONROE). What superpowered thing do you see at the end of his oar? (ATOMS). (ATOMS; ADAMS). What little toys are flying out of the atoms? (JACKs). What did one of the jacks stab? (a SUN). (JACK-SUN; JACKSON). The sun is very hot and is melting the tires of what kind of vehicle? (a VAN). The van is about to run over what kind of animal? (a BEAR). If a van was trying to run you over, would you walk or run? (RUN). (VAN-BEAR-RUN; VAN BUREN). What does the bear run into? (a SUN). And what does the sun have a lot of on his head? (HAIR). So he is a...HAIRY-SUN. (HAIRY-SUN; HARRISON). What do you see the hairy sun stacking? (TILES; TYLER).

Profile of Clients



Percentage with a Prior Diagnosis	
Attention Deficit Hyperactivity Disorder (ADHD)	30
Dyslexia	12
Learning Disability	11
Speech/Language Delay	10
Autism Spectrum Disorder	5
Traumatic Brain Injury	2
Age-Related Memory Loss	<1

Gender	
Female	40
Male	60



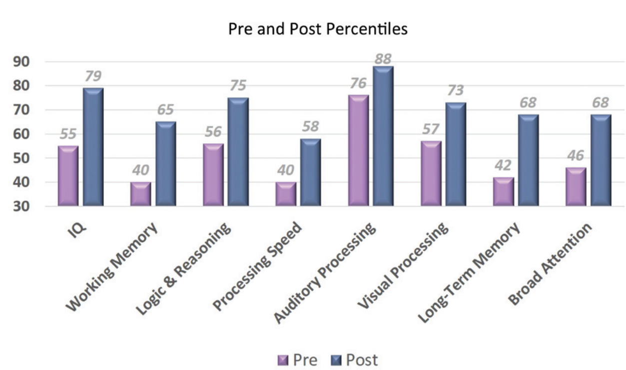
Cognitive Training Results: 2010–2015

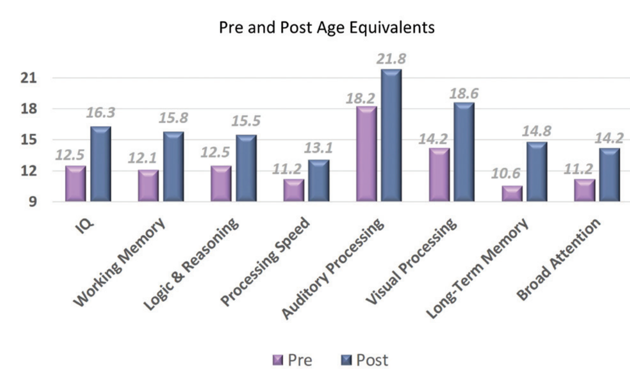
Program: Cognitive Training

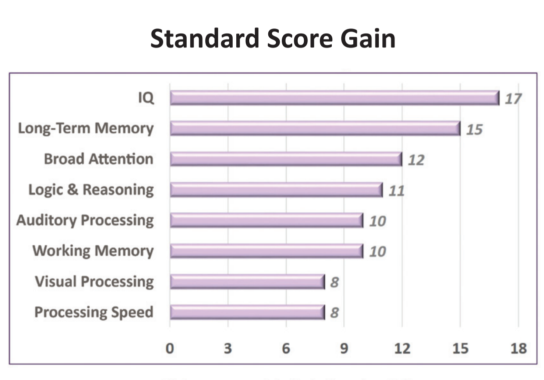
Number of Clients: 7,138

Mean Age: 13.7

Results: The changes in standard scores on the Woodcock-Johnson III – Tests of Cognitive Abilities were statistically significant for all skills ($p < .001$) assessed. Overall, the largest gains were seen in IQ and long-term memory, followed by broad attention, auditory processing, and logic & reasoning. The average pre-test IQ score was 100 and the average post-test IQ score was 117. In addition, post-training percentiles are well within the range of normal functioning, and the average age-equivalent gain in cognitive skill performance was 3.4 years.







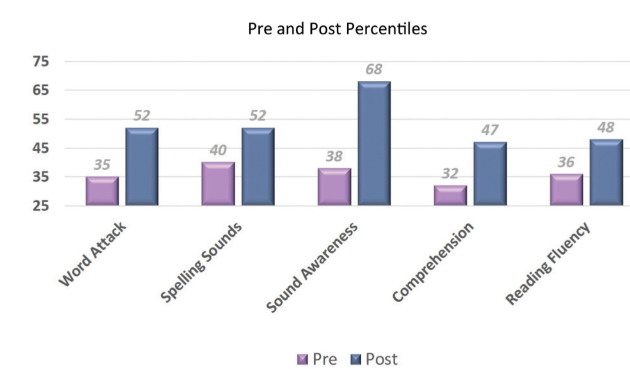
Reading Achievement Results: 2010–2015

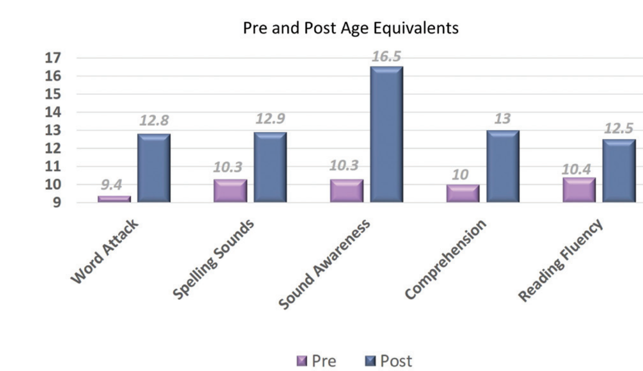
Program: Reading

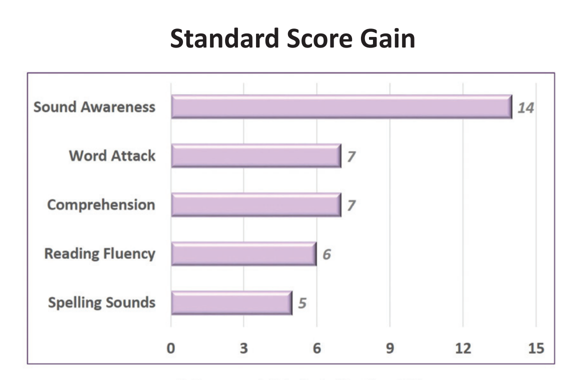
Number of Clients: 6,460

Mean Age: 11.4

Results: Clients who completed the 120-hour reading program achieved statistically significant standard score changes ($p < .001$) on all five reading subtests administered from Woodcock-Johnson III – Tests of Achievement. Overall, the largest gain was seen in sound awareness, the primary skill needed for reading. Post-training percentiles are all within the normal range, and the overall age-equivalent gain in reading achievement was 3.5 years.







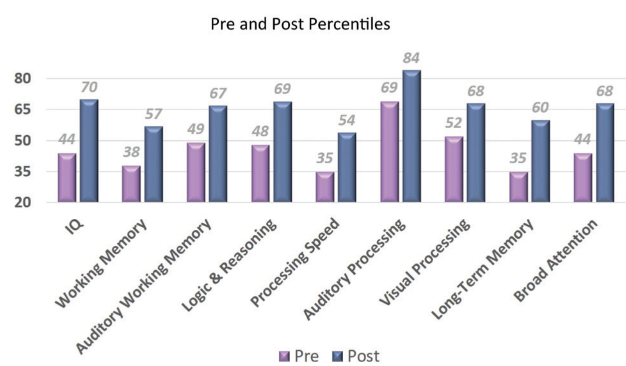
Overall Results: 2010–2015

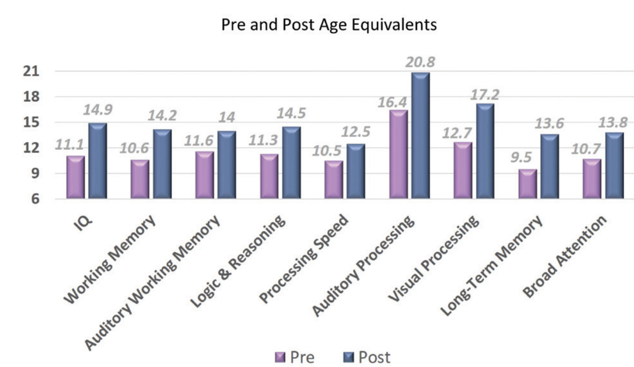
Program: All programs

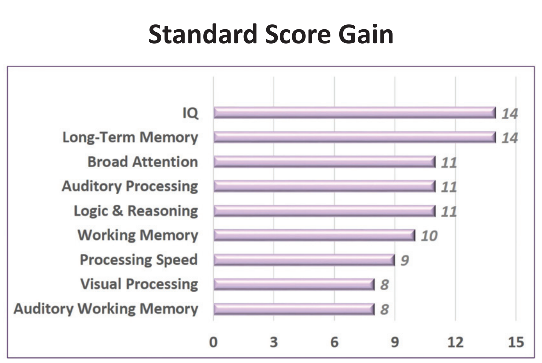
Number of Clients: 17,998

Mean Age: 12.3

Results: Clients were given pre- and post-assessments using the Woodcock-Johnson III – Tests of Cognitive Abilities. The changes in standard scores were statistically significant for all measures ($p < .001$). Overall, the largest gains were seen in IQ and long-term memory, followed by broad attention, auditory processing, and logic & reasoning. The average pre-test IQ score was 97 and the average post-test IQ score was 111. In addition, post-training percentiles are well within the range of normal functioning, and the average age-equivalent gain in cognitive skill performance was 3.4 years.







All changes are statistically significant ($p < .001$)

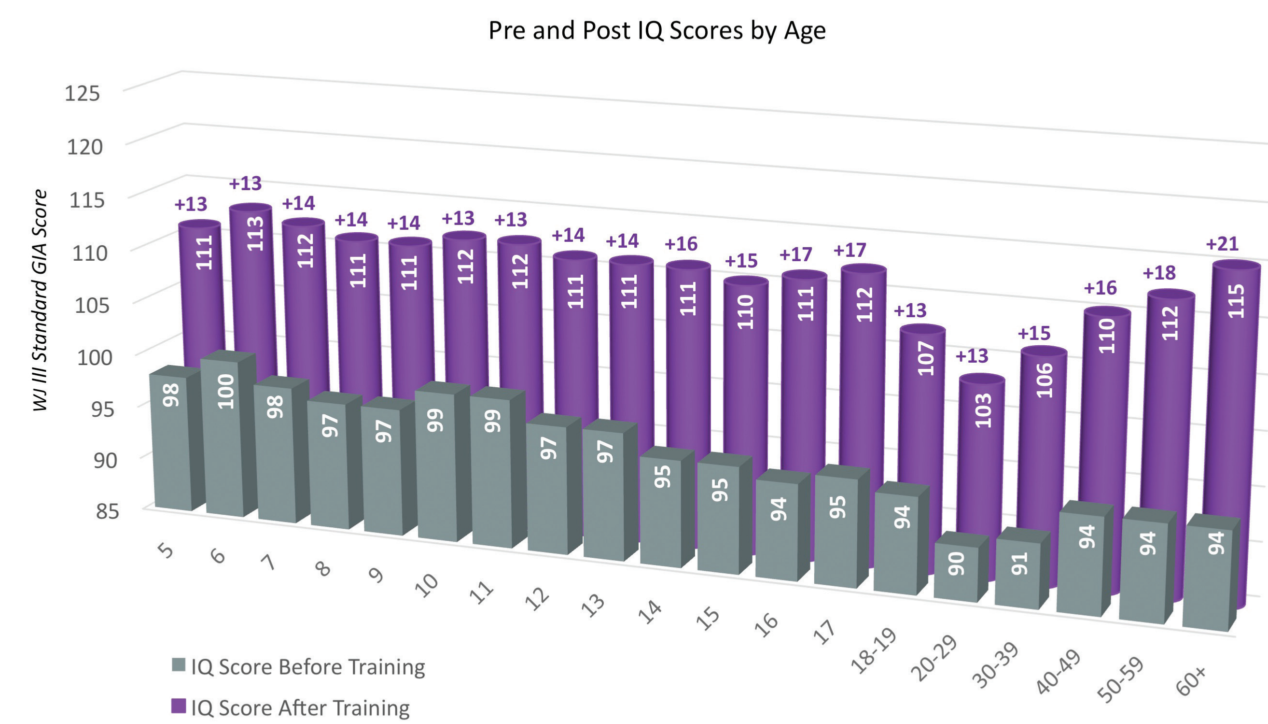
IQ Score Results: 2010–2015

Program: All programs

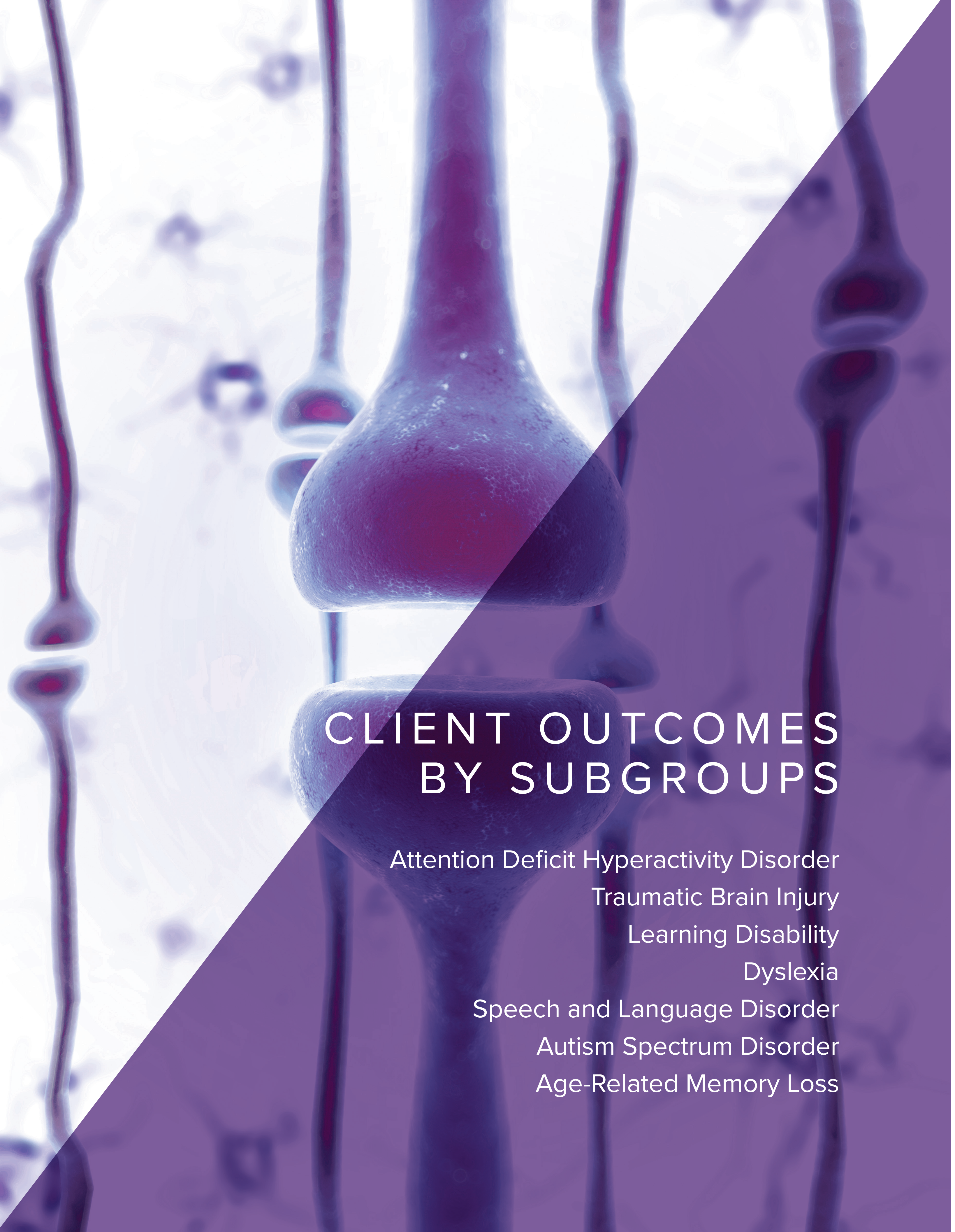
Number of Clients: 17,998

Mean Age: 12.3

Results: Clients were given pre- and post-assessments using the Woodcock-Johnson III – Tests of Cognitive Abilities. A majority of clients take the seven subtests required to calculate an IQ score, or General Intellectual Ability score. The changes in IQ scores were statistically significant for all measures ($p < .001$). The average pre-test IQ score was 97 and the average post-test IQ score was 111. Mean gains ranged from 13 points to 21 points across age groups.



All changes are statistically significant ($p < .001$)



CLIENT OUTCOMES BY SUBGROUPS

Attention Deficit Hyperactivity Disorder
Traumatic Brain Injury
Learning Disability
Dyslexia
Speech and Language Disorder
Autism Spectrum Disorder
Age-Related Memory Loss

Cognitive Assessment Results by Client-Reported Diagnosis

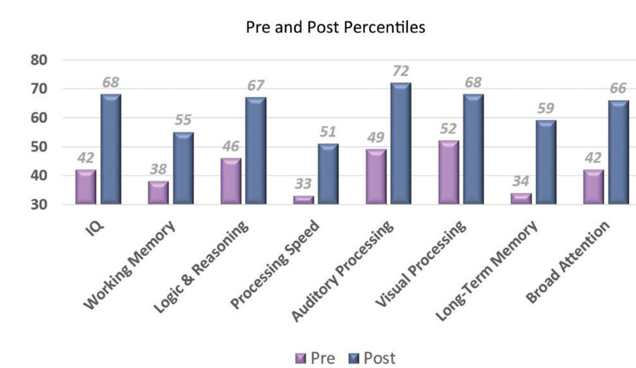
Attention Deficit Hyperactivity Disorder

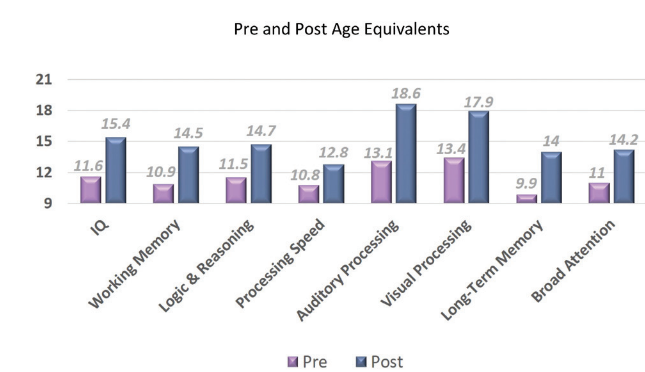
Program: All

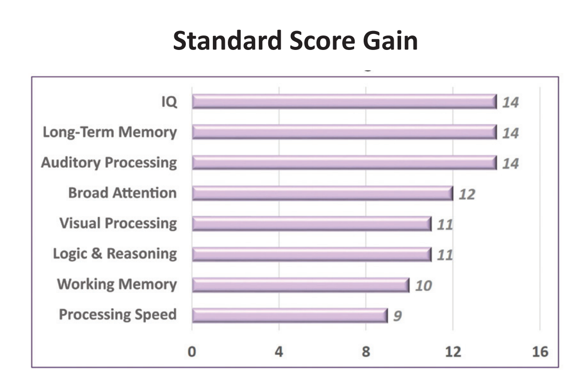
Number of Clients: 5,416

Mean Age: 12.3

Results: The following charts show the improvements in cognitive skills for clients who came with a diagnosis of ADHD between 2010 and 2015. The changes in standard scores on the Woodcock-Johnson III – Tests of Cognitive Abilities were statistically significant for all skills ($p < .001$) assessed. Overall, the largest gains were seen in IQ, auditory processing, and long-term memory, followed by broad attention and logic & reasoning. The average pre-test IQ score was 96 and the average post-test IQ score was 110. In addition, post-training percentiles are well within the range of normal functioning, and the average age-equivalent gain in cognitive skill performance was 3.7 years.







All changes are statistically significant ($p < .001$)

Cognitive Assessment Results by Client-Reported Diagnosis

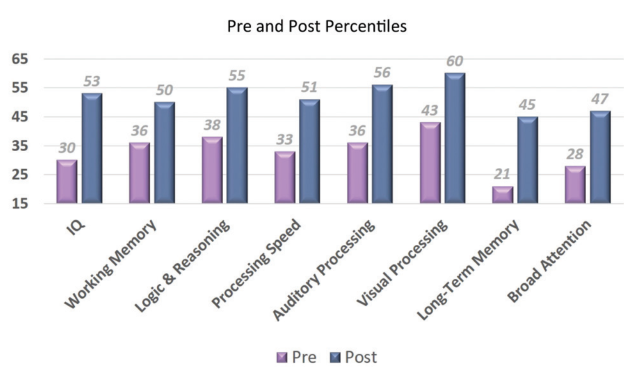
Traumatic Brain Injury

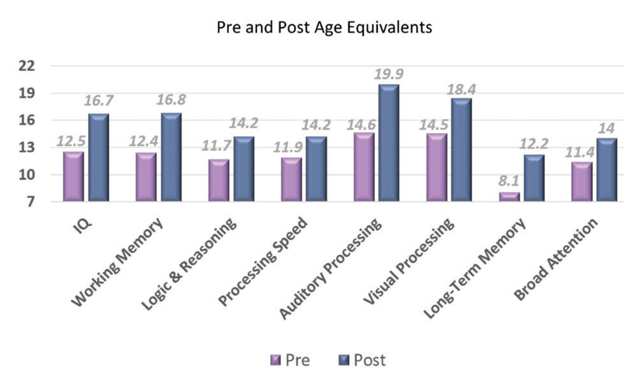
Program: All

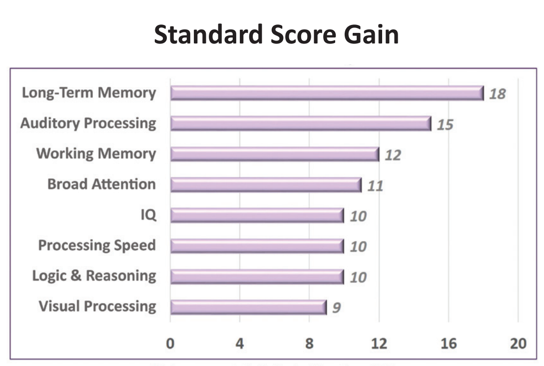
Number of Clients: 273

Mean Age: 25.6

Results: The following charts show the improvements in cognitive skills for clients who came with a diagnosis of traumatic brain injury (TBI) between 2010 and 2015. The changes in standard scores on the Woodcock-Johnson III – Tests of Cognitive Abilities were statistically significant for all skills (p< .001) assessed. Overall, the largest gains were seen in auditory processing and long-term memory, followed by working memory and broad attention. The average pre-test IQ score was 92 and the average post-test IQ score was 102. In addition, post-training percentiles are within the range of normal functioning, and the average age-equivalent gain in cognitive skill performance was 3.7 years.







Cognitive Assessment Results by Client-Reported Diagnosis

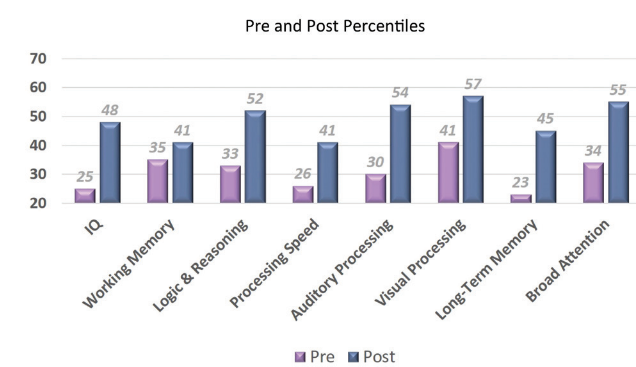
Learning Disability (LD)

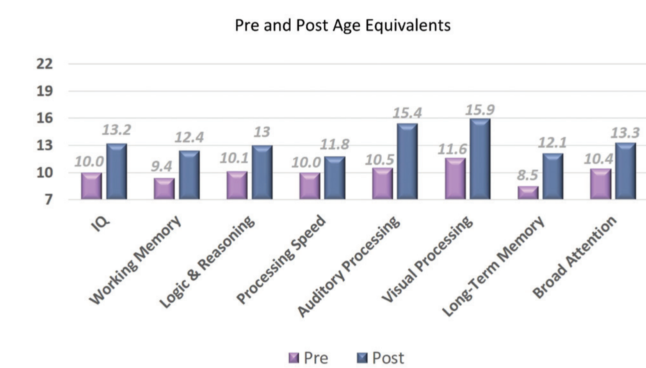
Program: All

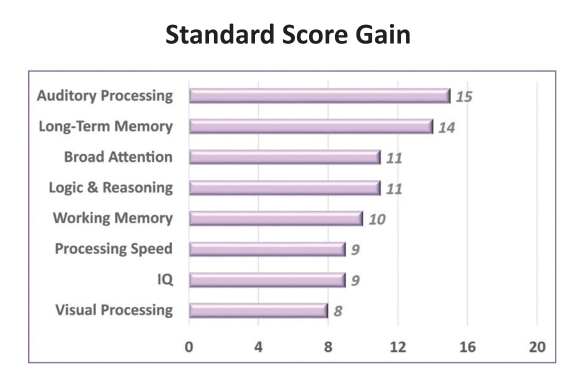
Number of Clients: 2,003

Mean Age: 13.1

Results: The following charts show the improvements in cognitive skills for clients who came with a diagnosis of Learning Disability (LD) between 2010 and 2015. The changes in standard scores on the Woodcock-Johnson III – Tests of Cognitive Abilities were statistically significant for all skills (p< .001) assessed. Overall, the largest gains were seen in auditory processing and long-term memory, followed by logic & reasoning and broad attention. The average pre-test IQ score was 90 and the average post-test IQ score was 99. In addition, post-training percentiles are within the range of normal functioning, and the average age-equivalent gain in cognitive skill performance was 3.3 years.







Cognitive Assessment Results by Client-Reported Diagnosis

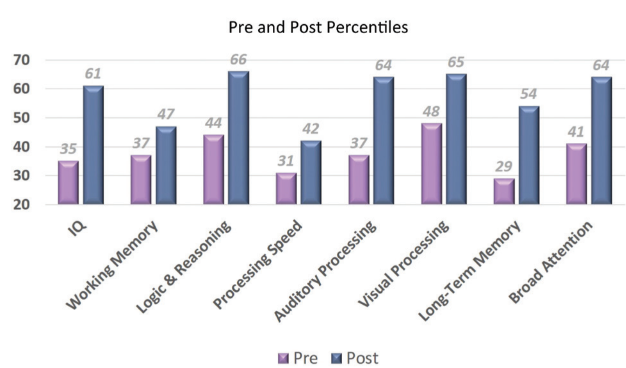
Dyslexia *(Cognitive Results)*

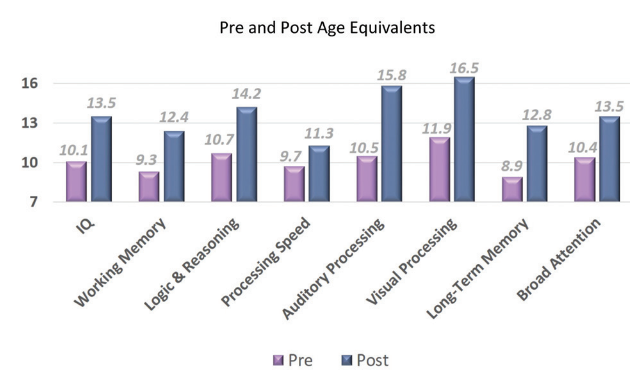
Program: All

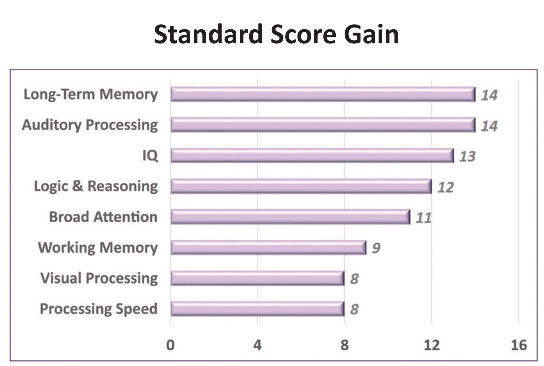
Number of Clients: 2,112

Mean Age: 11.9

Results: The following charts show the improvements in cognitive skills for clients who came with a diagnosis of dyslexia between 2010 and 2015. The changes in standard scores on the Woodcock-Johnson III – Tests of Cognitive Abilities were statistically significant for all skills (p< .001) assessed. Overall, the largest gains were seen in auditory processing and long-term memory, followed by logic & reasoning and broad attention. The average pre-test IQ score was 93 and the average post-test IQ score was 106. In addition, post-training percentiles are within the range of normal functioning, and the average age-equivalent gain in cognitive skill performance was 3.6 years.







All changes are statistically significant (*p* < .001)

Reading Assessment Results by Client-Reported Diagnosis

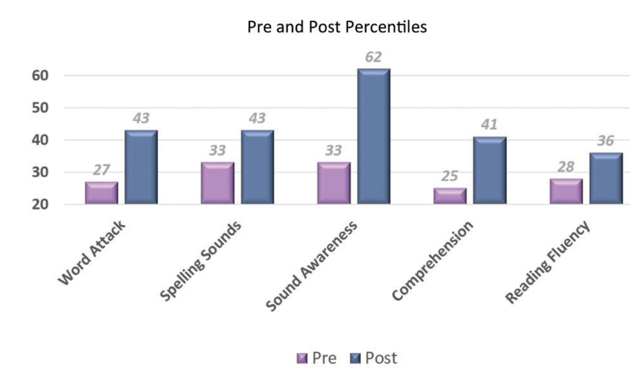
Dyslexia and Reading Skills *(Reading Results)*

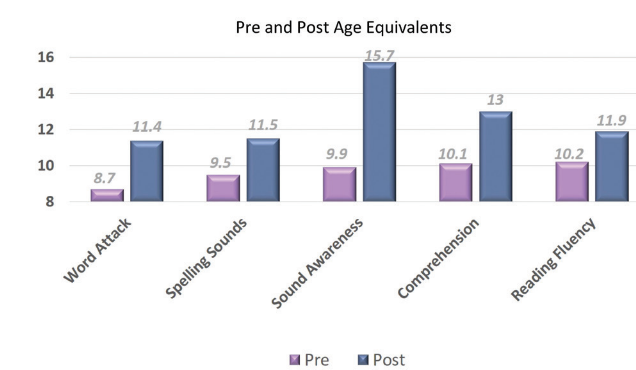
Program: Reading

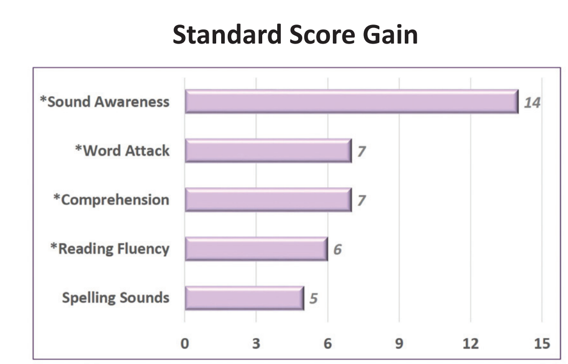
Number of Clients: 1,512

Mean Age: 11.8

Results: The following charts show the improvements in reading skills for clients who came with a diagnosis of dyslexia between 2010 and 2015, and completed the reading program. The changes in standard scores on the Woodcock-Johnson III – Tests of Achievement were statistically significant for four of five skills (p < .001) assessed. Overall, the largest gains were seen in sound awareness, Word Attack, and comprehension followed by reading fluency and spelling. In addition, the average age-equivalent gain in reading skill performance was three years. In sound awareness—the primary skill needed for reading—the average age-equivalent gain was nearly six years.







*Changes are statistically significant (*p* < .001)

Cognitive Assessment Results by Client-Reported Diagnosis

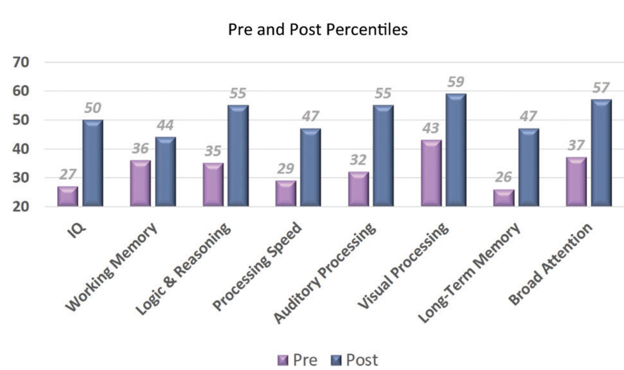
Speech and Language Disorder

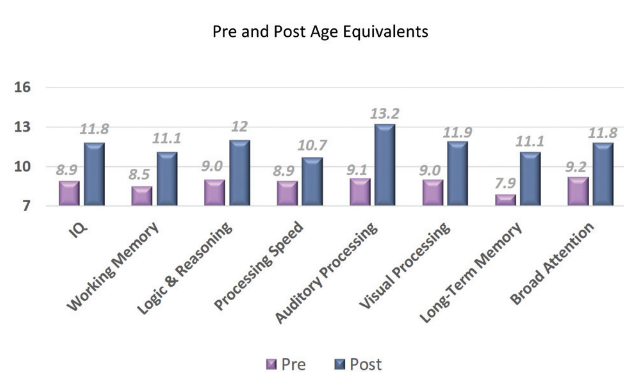
Program: All

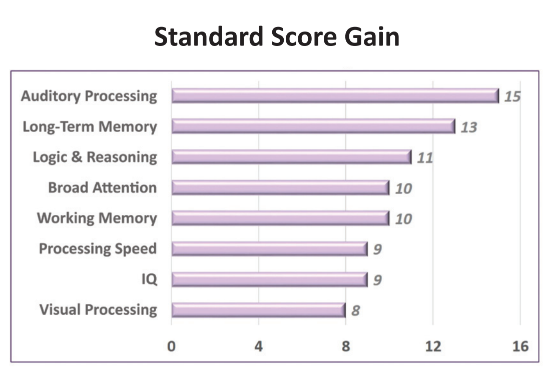
Number of Clients: 1,854

Mean Age: 10.7

Results: The following charts show the improvements in cognitive skills for clients who came with a diagnosis of speech and language disorder between 2010 and 2015. The changes in standard scores on the Woodcock-Johnson III – Tests of Cognitive Abilities were statistically significant for all skills (p< .001) assessed. Overall, the largest gains were seen in auditory processing and long-term memory, followed by logic & reasoning, working memory, and broad attention. The average pre-test IQ score was 91 and the average post-test IQ score was 100. In addition, post-training percentiles are within the range of normal functioning, and the average age-equivalent gain in cognitive skill performance was three years.







All changes are statistically significant (*p* < .001)

Cognitive Assessment Results by Client-Reported Diagnosis

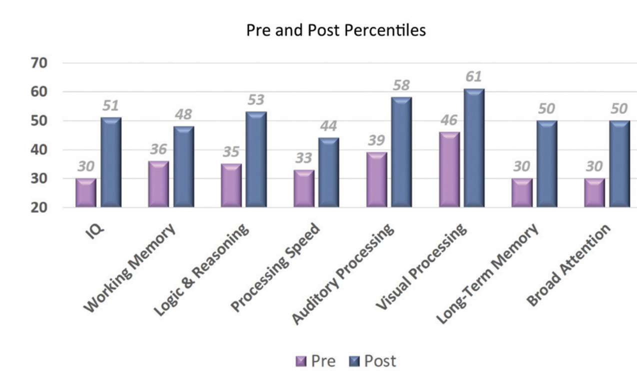
Autism Spectrum Disorder

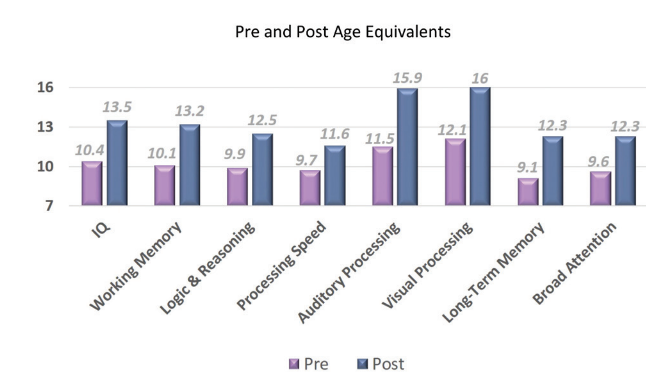
Program: All

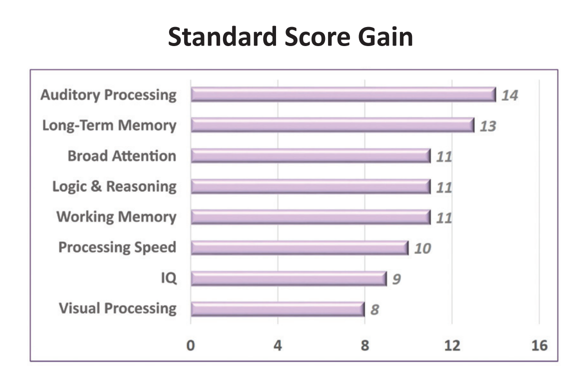
Number of Clients: 857

Mean Age: 11.9

Results: The following charts show the improvements in cognitive skills for clients who came with a diagnosis on the autism spectrum between 2010 and 2015. The changes in standard scores on the Woodcock-Johnson III – Tests of Cognitive Abilities were statistically significant for all skills (p< .001) assessed. Overall, the largest gains were seen in auditory processing and long-term memory, followed by logic & reasoning, working memory, and broad attention. The average pre-test IQ score was 92 and the average post-test IQ score was 101. In addition, post-training percentiles are within the range of normal functioning, and the average age-equivalent gain in cognitive skill performance was 3.1 years.







All changes are statistically significant (*p* < .001)

Cognitive Assessment Results by Client-Reported Diagnosis

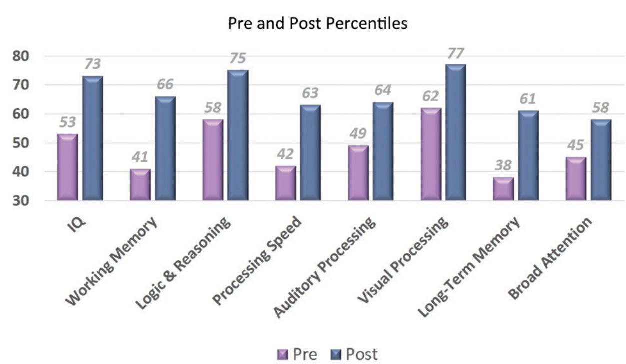
Senior Adults

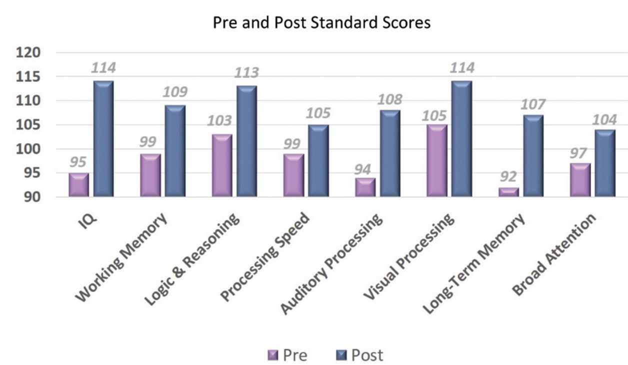
Program: All

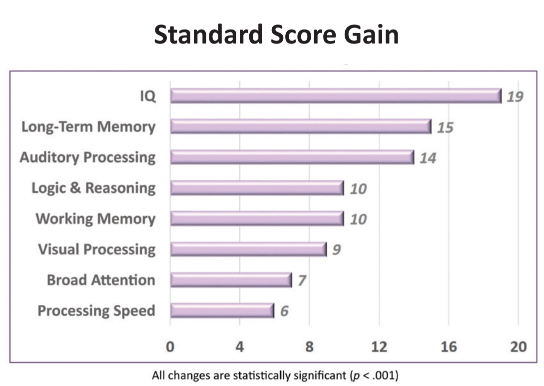
Number of Clients: 262

Mean Age: 60.1

Results: The following charts show the improvements in cognitive skills for clients over the age of 50 who came between 2010 and 2015. The changes in standard scores on the Woodcock-Johnson III – Tests of Cognitive Abilities were statistically significant for all skills (p< .001) assessed. Overall, the largest gains were seen in IQ, auditory processing, and long-term memory, followed by logic & reasoning, working memory, and visual processing. The average pre-test IQ score was 95 and the average post-test IQ score was 114. In addition, post-training percentiles are well within the range of normal functioning.







Cognitive Training Effects in Children Ages 8–14: A Randomized Controlled Trial

Abstract: In a randomized controlled study with students ages 8–14, we examined the effects of the (or of our)—either one will work cognitive training program on IQ, memory, visual and auditory processing, processing speed, and reasoning as measured by the Woodcock-Johnson III – Tests of Cognitive Abilities, and on attention as measured by the NIH Toolbox Cognitive Battery. Participants were randomly assigned to either an experimental group (n= 20) to complete 60 hours of cognitive training, or to a wait-list control group (n= 19). The purpose of the study was to examine changes in general intelligence and individual cognitive skills after completing our cognitive training program. Results showed statistically significant differences between groups on all outcome measures, except for attention. (R^2= .352), and Word Attack (R^2= .359). Completion of the cognitive training program was not a significant predictor of scores on visual processing.

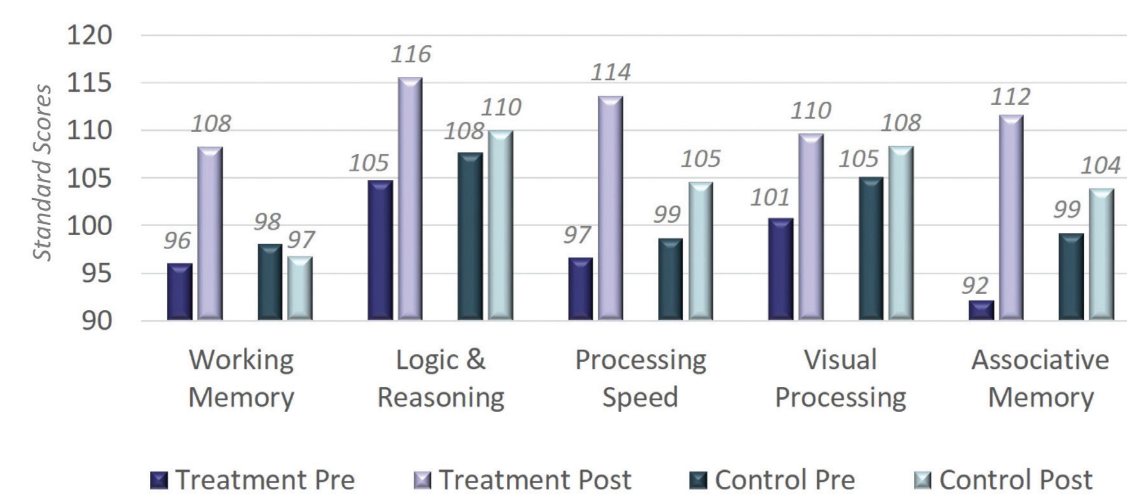
	CONTROL	TREATMENT	CAUSAL EFFECT
	Pre-Post Difference	Pre-Post Difference	Treatment-Control
Logic & Reasoning	-7	21	28
IQ	-5	21	26
Long-Term Memory	7	28	21
Working Memory	-8	13	21
Auditory Processing	-4	13	17
Associative Memory	8	23	15
Visual Processing	4	11	7
Processing Speed	7	13	6
Attention	3	5	2
Average Standard Score Gain	1	17	16

Carpenter, D., Ledbetter, C., & Moore, A.L. (2016). LearningRx cognitive training effects in children ages 8–14: A randomized controlled trial. *Applied Cognitive Psychology, 30*(5), 815-826. doi: 10.1002/acp.3257. Available at http://onlinelibrary.wiley.com/doi/10.1002/acp.3257/epdf

Training the Brain to Learn: Beyond Vision Therapy

Abstract: The purpose of this study was to investigate the effectiveness of our cognitive training program. Sixty-one children (ages 6–18) were given pre-test and post-test assessments using seven batteries from the Woodcock-Johnson III Tests of Cognitive Abilities and Tests of Achievement. Thirty-one of the students were enrolled in or had completed a 24-week cognitive training program. A propensity matched control group of 30 students was selected from a group who had pre-tested but chosen not to enroll in the cognitive training program. Students who completed our cognitive training program realized greater gains than the control group on all measures. Statistically significant differences between groups were noted in six of the seven sets of scores (ps < .001). There were no significant differences based on age, gender, or learning disability.

Multiple regression analyses indicated that treatment group membership was a statistically significant predictor of pre-test to post-test score differences in associative memory (R^2= .445), logic & reasoning (R^2= .233), working memory (R^2= .265), processing speed (R^2= .409), auditory processing (R^2= .352), and Word Attack (R^2= .359). Completion of the cognitive training program was not a significant predictor of scores on visual processing.



Reference: Gibson, K., Carpenter, D., Moore, A.L., & Mitchell, T. (2015). *Training the Brain to Learn: Beyond Vision Therapy. Vision Development and Rehabilitation*, 1(2), 119–128.

Analysis of Resting State Functional Connectivity in a Cognitive Training Study

Abstract: As part of a larger randomized controlled study by Hill, Serpell, and Faison (2016), 30 of the 225 participating high school students were randomly assigned to one of three conditions: Our cognitive training (n=11), our supplemental BrainSkills digital cognitive training (n=12), or Control (n=7). In addition to pre and post cognitive testing, these students underwent pre and post MRI imaging. Resting state functional MRI was used to assess: (1) training-induced changes in global efficiency, (2) training-induced changes in functional connectivity, and (3) correlation of changes in functional connectivity to changes in cognitive test scores.

Results: Training-induced changes in global efficiency, a measure of information exchange, occurred for areas associated with visual processing (left pITG, T=-3.34, p=0.002), auditory processing (left pSTG, T=-2.19, p=0.037; right pSTG, T=-2.08, p=0.047), contextual associations (left aPaHC, T=2.09, p=0.045), the default mode network (LLP, T=-2.18, p=0.038), and the cerebellum (left Cereb6, T=2.55, p=0.017; Ver12, T=2.29, p=0.030; Ver3, T=2.26, p=0.032).

Training-induced changes in functional connectivity, a measure of the relationship between anatomically distinct regions, occurred for areas associated with auditory processing (right HG & left putamen, T=-5.07, p-FRD=0.003; left PP & left putamen, T=-3.8, p-FDR=0.048), contextual associations (left aPaHC & vermis 9, T=4.08, p-FDR=0.028; left aPaHC & left pPaHC, T=4, p-FDR=0.028), and memory (left hippocampus & left Cereb8, T=4.09, p-FDR=0.045).

For all seven cognitive skills measured, changes in resting state functional connections correlated with changes in performance on the test (see Figure 3 on the following page).

Figure 1. Effect of Cognitive Training on Global Efficiency. Treatment vs Control, Pre to Post Changes.

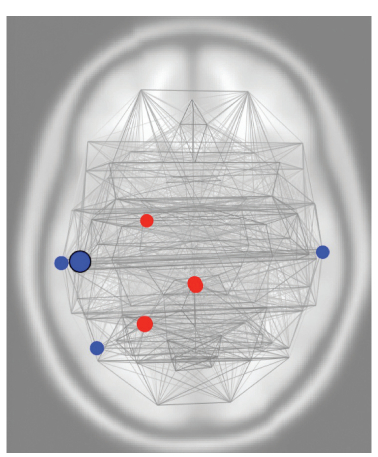
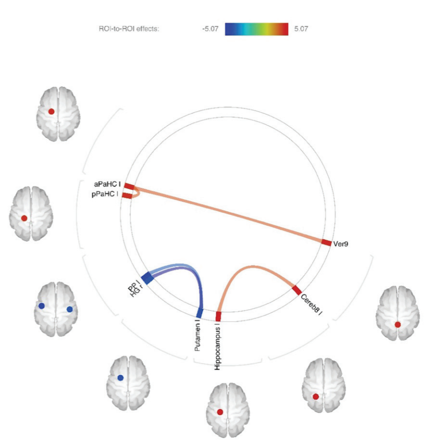
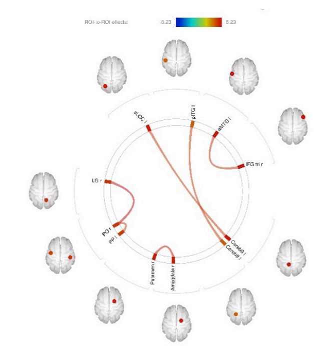


Figure 2. ROI-Level Analysis of Global Efficiency Cognitive Training > Controls Post Cognitive Training.

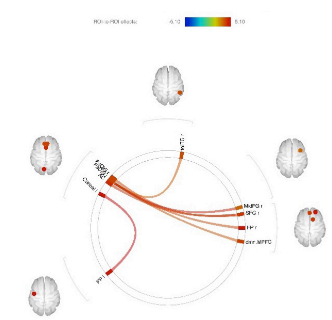


Correlation of Treatment Group Changes in Connectivity to Changes in Cognitive Test Scores

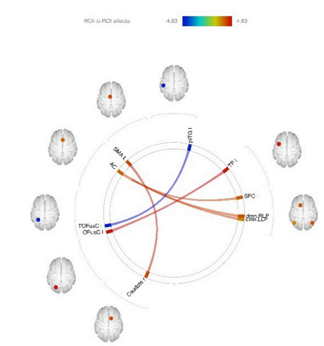
VISUAL PROCESSING



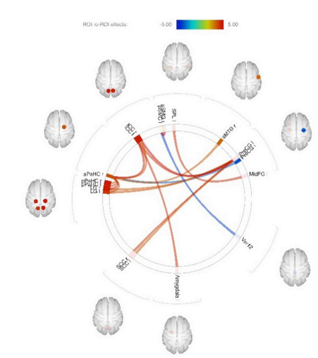
WORKING MEMORY



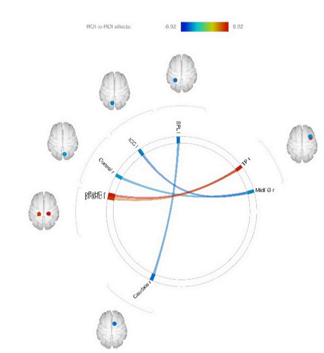
LONG-TERM MEMORY



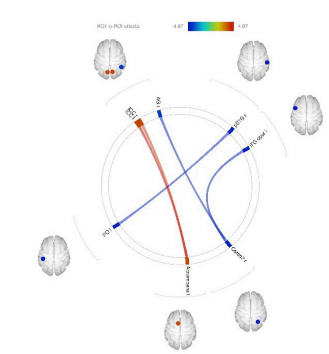
LOGIC & REASONING



AUDITORY DROPPING



AUDITORY SEGMENTING



PROCESSING SPEED

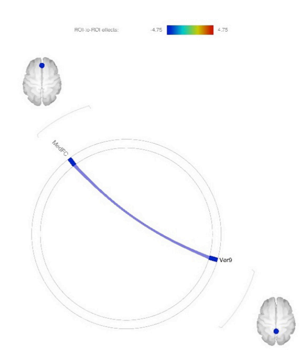


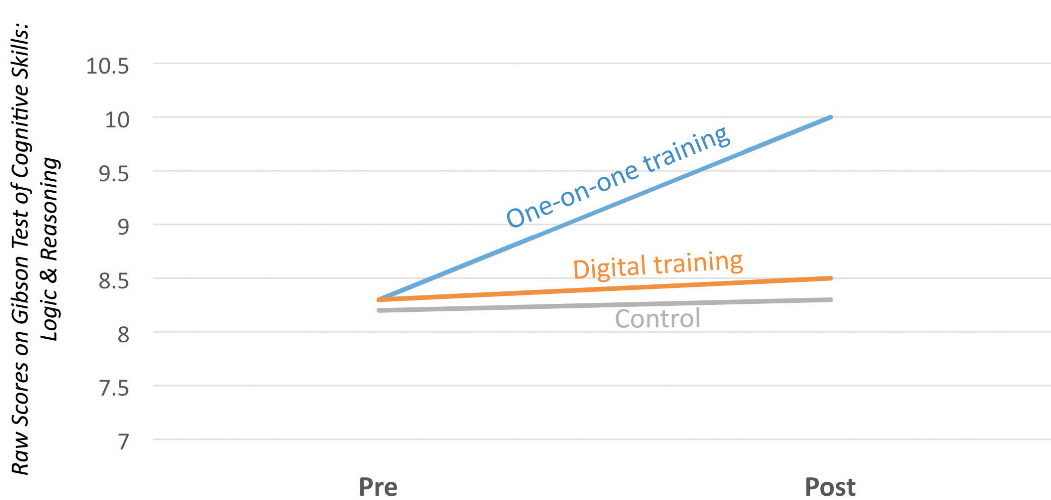
Figure 3. Changes in Connectivity that Correlated with Change in Cognitive Test Measures. All Connectivity Maps, p-FDR Corrected <0.05.

References: Ledbetter, C., Faison, M., Hill, O., & Patterson, J. (2016). Analysis of Resting State Functional Connectivity in a Cognitive Training Intervention Study. Poster presented at Center for Brain Health Annual Symposium: Reprogramming the Brain to Health: Computational Psychiatry and Neurology, University of Texas at Dallas, April 14, 2016.

Ledbetter, C., Faison, M., Hill, O., & Patterson, J. (2016). Correlation of Cognitive Training Gains and Resting State Functional Connectivity. Poster presented at Society for Neuroscience, San Diego, CA, November 12, 2016.

The Efficacy of Cognitive Training: Modality and Transfer Effects

Abstract: This study tested the efficacy of our one-on-one cognitive training program and a digital training program in laboratory and school settings. In a randomized controlled study, 225 high school students were randomly assigned to one of three conditions: Our cognitive training, digital training, or study hall (control) in a school setting for a 15-week training period. Univariate ANCOVAs revealed significantly higher scores for the treatment groups compared with controls on working memory, logic & reasoning, and three of four math attitude measures, but not for math performance. However, because the intervention did not include a math intervention, the results are as expected.



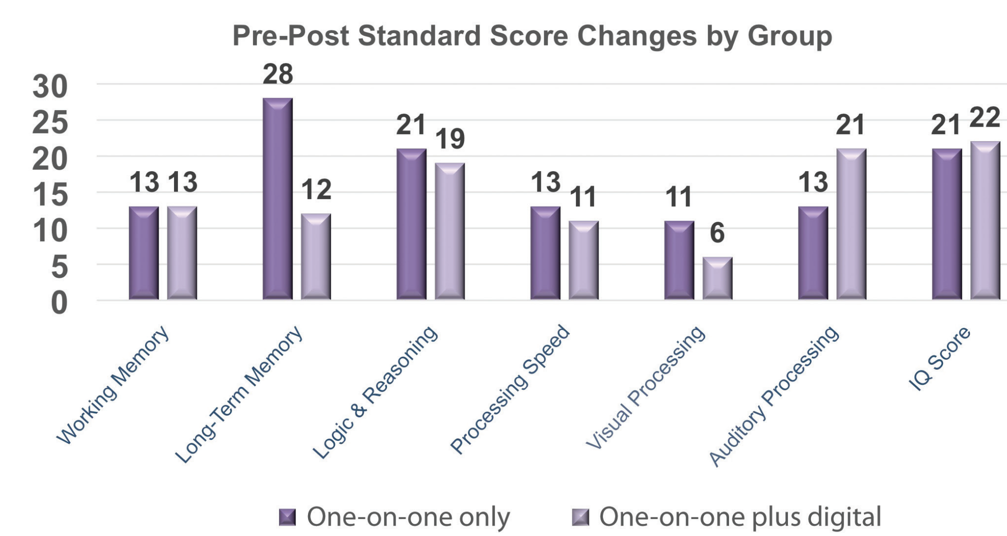
Hill, O.W., Serpell, Z., & Faison, O. (2016). The efficacy of the LearningRx cognitive training program: Modality and transfer effects. *Journal of Experimental Education: Learning, Instruction, and Cognition, 84*(3), 600-620. doi: 10.1080/00220973.2015.1065218. Available at http://dx.doi.org/10.1080/00220973.2015.1065218

Two Methods of Delivering Cognitive Training Improve Cognition in Children: A Randomized Controlled Trial

Abstract: In the second phase of a randomized controlled trial with students ages 8-14 (n = 38), we examined the effects of our cognitive training program on IQ, memory, visual and auditory processing, processing speed, and reasoning as measured by the Woodcock-Johnson III—Tests of Cognitive Abilities, and on attention as measured by the NIH Toolbox Cognitive Battery. In Phase 1, participants were randomly assigned to either an experimental group to complete 60 hours of cognitive training or to a wait-list control group (see Carpenter, Ledbetter, & Moore, 2016).

In Phase 2, the wait-list control group from Phase 1 completed 60 hours of the same cognitive training program, but with 30 hours delivered one-on-one by a cognitive trainer and 30 hours delivered through BrainSkills, our supplemental digital program. The purpose of the second phase was to determine if a combination of clinician-delivered and digitally-delivered training was as effective as clinician delivery alone at improving general intelligence and individual cognitive skills.

Results showed statistically significant differences between groups only on long-term memory outcomes. That is, both delivery methods enhanced IQ and cognition in children.

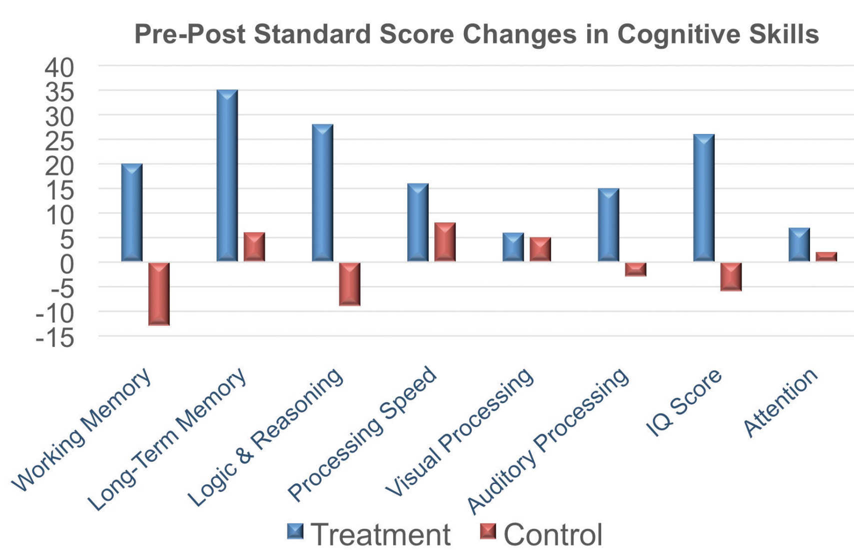


Reference: Moore, A.L., Ledbetter, C., & Carpenter, D.M. (2016, November). *Intensive Metronome-Based Cognitive Training Improves Cognition in Children: A Randomized Controlled Trial.* Presented at Society for Neuroscience Annual Meeting, San Diego, CA.

Cognitive Training for Children with ADHD: Cognitive and Behavioral Transfer Effects

Abstract: In a randomized controlled trial, we examined the effects of our cognitive training program on IQ, memory, visual and auditory processing, processing speed, and reasoning as measured by the Woodcock-Johnson III – Tests of Cognitive Abilities and attention as measured by the NIH Cognition Toolbox on children ages 8–14 with ADHD. Participants were randomly assigned to either an experimental group (n = 6) to complete 60 hours of cognitive training, or to a wait-list control group (n = 7).

Results showed statistically significant differences between treatment and control groups on five variables—auditory processing, logic & reasoning, working memory, long-term memory, and IQ score. The treatment group outperformed the control group on all measures. Qualitative thematic analysis of survey and interview data from participants, parents, and trainers revealed six themes of behavioral improvements in addition to the cognitive improvements reported by the treatment group.



Behavioral Improvements*

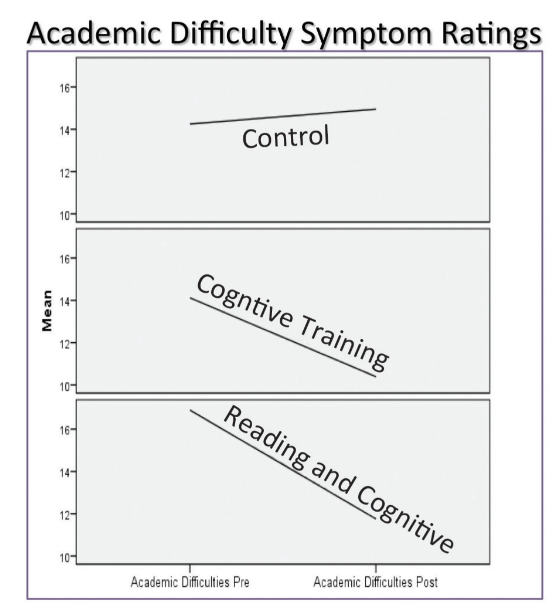
Academic performance	Confidence & self-esteem
Relationships with others	Self-discipline
Sports performance	Sleep habits

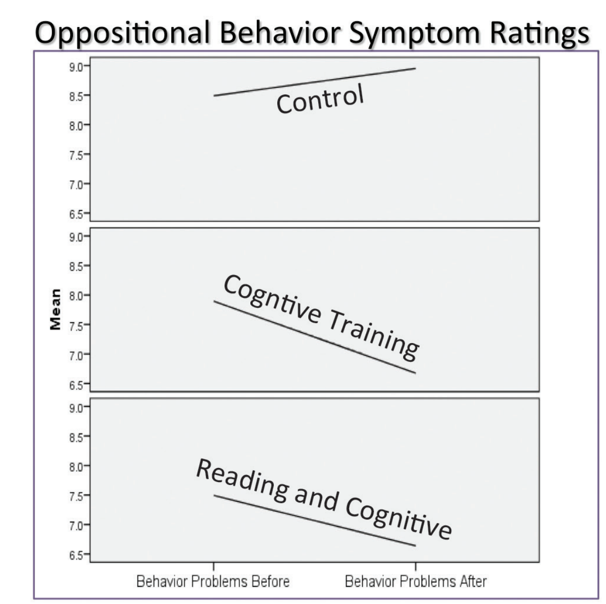
**Reported by the treatment group*

Reference: Carpenter, D.M., Ledbetter, C., Moore, A.L., & Miller, T. (2016). *Clinician-delivered cognitive training for children with ADHD: Cognitive and behavioral transfer effects from the ThinkRx randomized controlled trial.* Manuscript submitted for peer review.

Real Life Benefits of Cognitive Training: A Controlled Study

Abstract: This study investigated whether a one-on-one cognitive training program reduced academic difficulties and oppositional behavior for 226 school-age children. Using a standardized parent rating scale, Learning Skills Rating Scale (LSRS), three groups were surveyed: 77 students who had completed our 60-hour cognitive training program, 69 students who had completed our 120-hour reading plus cognitive training program, and 80 students who completed initial testing, but chose not to complete our training program. Results indicated there were statistically significant differences between the treatment groups and the control group on all measures of academic difficulties. Both treatment groups saw a reduction in academic difficulty ratings following training while the control group saw an increase in academic difficulty during a comparable time interval. Further, both treatment groups improved on ratings of oppositional behavior while the control group ratings worsened.



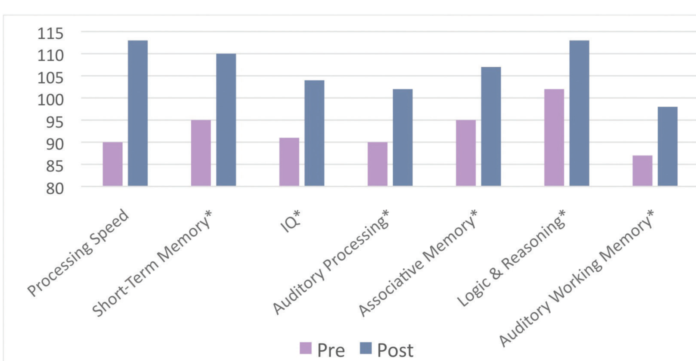


Reference: Jedlicka, E.J. (2015). *Real Life Benefits of LearningRx Cognitive Training: A Controlled Study*. Based on 2012 dissertation; manuscript submitted for publication.

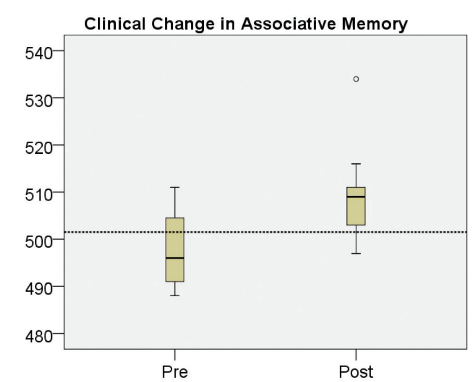
A Study of One-On-One Cognitive Training with Supplemental Digital Delivery for Soldiers with Traumatic Brain Injury

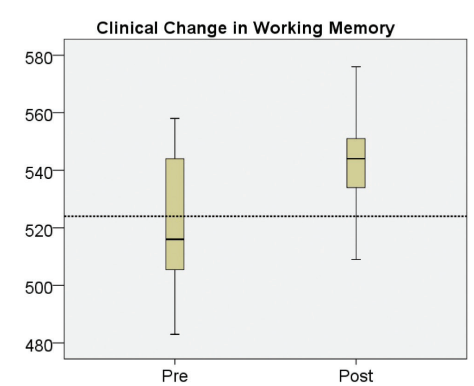
Abstract: In this quasi-experimental, pre-test-post-test feasibility study, 11 soldiers between 3 and 36 months post-traumatic-brain-injury completed half of our training through one-on-one cognitive training at an occupational therapy clinic, and half through computer-based cognitive training sessions at home. Participants achieved statistically significant gains in short-term memory, associative memory, executive processing, auditory processing, and fluid reasoning with very large effect sizes; and self-reported improvements in attention, memory, and organization. Further, they achieved significant clinical changes, restoring function to normal levels in nearly all cognitive skills. Examples of clinically significant changes in memory are shown in the box plots.

Pre and Post Standard Scores on Woodcock-Johnson III Tests of Cognitive Abilities



*change significant at $p < .005$





Reference: Ledbetter, C., Moore, A.L., & Mitchell, T. (2017). Cognitive effects of ThinkRx cognitive rehabilitation training for eleven soldiers with brain injury: A retrospective chart review. *Frontiers in Psychology, 8* (825). doi: 10.3389/fpsyg.2017.00825

A Study of One-on-One Cognitive Training with Supplemental Digital Delivery for Soldiers with Traumatic Brain Injury: Functional Results

Abstract: As part of the quasi-experimental, pre-test-post-test feasibility study with 11 soldiers between 3 and 36 months post-traumatic-brain-injury, researchers collected personal pre-intervention goals from each participant. At the completion of the study, researchers collected self-reported improvements from each participant. The results reveal a variety of improvements beyond the initial training goals.

Pre-Intervention Goals	Post-Intervention Improvements
Improve memory	• Increased memory for daily tasks • Remembers appointments without reminders • Remembers conversations
Improve concentration, focus, and attention	• Increased attention span • Increased time on task • Organized and focused • Focused longer
Improve processing speed	• Finds information more quickly
Improve reading, writing, and communication	• Improved language skills • Can complete job applications
Improve math skills	• Increased confidence for math • Can manage bills
Learn and retain information	• Can return to school • Interested in learning
Multitask and work under pressure	• Works harder at challenging tasks • Makes and sticks to plans • Higher tolerance for frustration

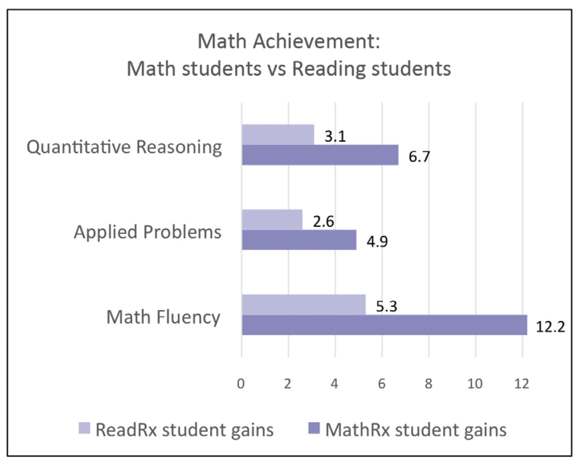
EXIT INTERVIEW COMMENTS FROM TWO PARTICIPANTS:

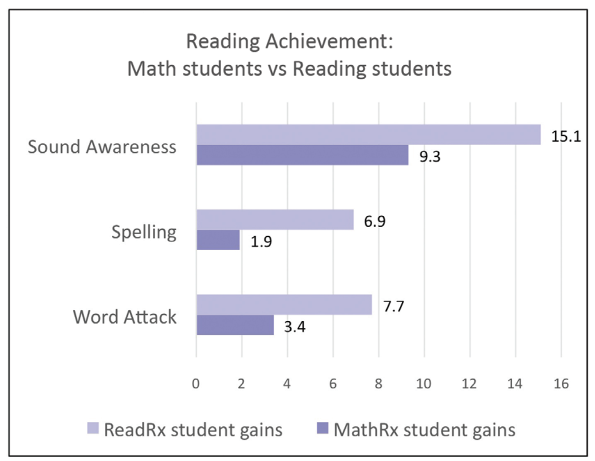
"This program was a bright light in a dark space."
"This was the most helpful thing I have experienced in my life."

Reference: Ledbetter, C., Moore, A.L., & Mitchell, T. (2017). Cognitive effects of ThinkRx cognitive rehabilitation training for eleven soldiers with brain injury: A retrospective chart review. *Frontiers in Psychology, 8* (825). doi: 10.3389/fpsyg.2017.00825

Achievement Outcomes for Cognitive Training Students: A Differential Effects Analysis of Math and Reading Achievement Before and After Cognitive Training

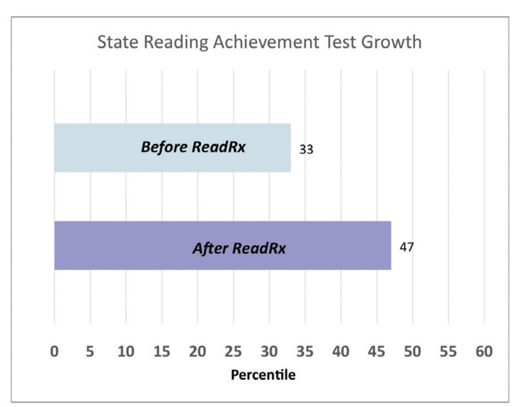
Abstract: To assess the outcomes of the programs for 2,096 students in 2008 to 2014, pre-intervention reading and math achievement scores were compared to post-intervention scores on the Woodcock-Johnson III Tests of Achievement. To add a measure of control, we conducted a differential effects analysis of performance on achievement tests measuring the opposite skills from which the students were trained. Math students made nearly twice the gains in math than the reading students, and reading students made nearly twice the gains in reading as the math students. The results indicate that the reading and math interventions are indeed targeting the skills they are intended to remediate.





State Achievement Test Results for Reading Clients

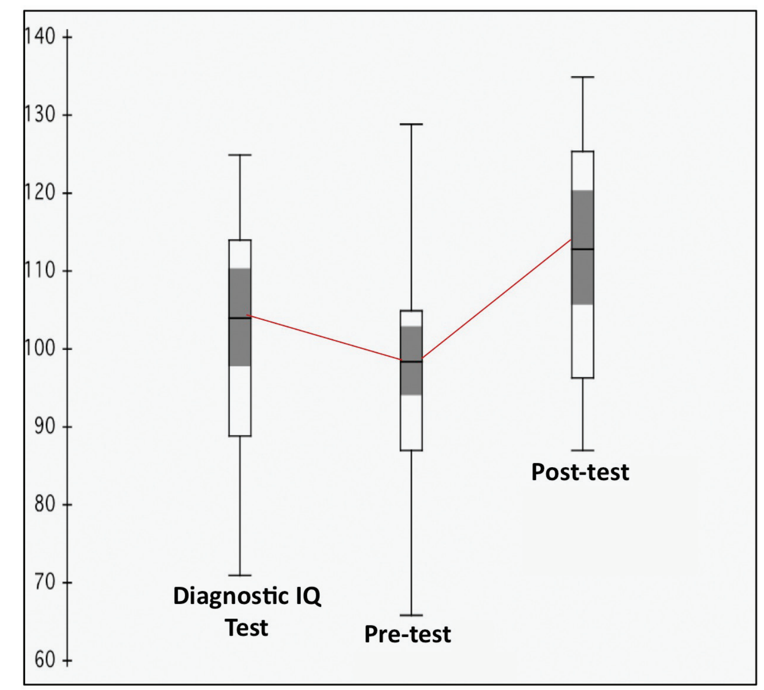
Abstract: In 2010, we collected state reading achievement test records from 65 of our reading program graduates. Prior to training, the mean percentile for this group was 33. After training, the group had jumped to the 47th percentile in reading—nearly average for their age. Further, 91% of students who completed the reading program (59 of 65) showed improvement on state reading achievement tests after the intervention.



Reference: Moore, A. (2015). *Achievement Outcomes for LearningRx Students: Math and Reading Achievement Before and After Cognitive Training*. Colorado Springs, CO: Gibson Institute of Cognitive Research.

Cognitive Training and IQ Gains: Multiple Baseline Study

Abstract: This study included multiple IQ baselines to allow students to serve as their own controls. We collected diagnostic test results of 40 students to establish their baseline IQ. These tests were given by independent psychologists within 18 months prior to initial contact with us. Comparing the diagnostic IQ score to the pre-test score, we saw a slight decline in IQ from an average of 102 to an average of 96 during the time students waited to begin training with us. Thus, it is apparent they were not spontaneously improving after their initial diagnosis; in fact, they were getting worse. However, this changed after treatment. From pre-test to post-test, they not only regained the ground they had lost previously, but had also made significant improvements. The average IQ after training had increased to 112—a gain of 16 points.



Reference: Moore, A.L. (2015). *LearningRx Training and IQ Gains*. Colorado Springs, CO: Gibson Institute of Cognitive Research.

Mixed Methods Study on Our Results for Students with Dyslexia

Abstract: To assess the real life changes following training, we surveyed parents of former clients who had been previously diagnosed with dyslexia and later completed our cognitive training program. The survey results from the 109 respondents indicated that a large percentage of clients saw classroom improvements such as faster reading, reading comprehension, and memory for details. Almost 50% reported achieving better grades after training, and more than 50% reported increased confidence in school. Clients also reported more positive relationships with others, more independence in completing homework, and increased participation and performance in sports.

SOCIAL/RECREATIONAL IMPROVEMENTS	
Answer Options	Response
More positive relationships with family	48%
More positive relationships with teachers	47%
More positive relationships with friends	43%
Increased confidence in extracurricular activities	34%
Increased participation in extracurricular activities	28%
Increased confidence about playing sports	26%
Increased participation in sports	18%
Better performance in extracurricular activities	16%
Better performance in sports	15%

SCHOOL-RELATED IMPROVEMENTS	
Answer Options	Response
Reads faster	59%
Completes homework more independently	56%
Is more confident about school	55%
Remembers details from reading	53%
Understands what is read	52%
Achieves better grades	46%
Completes homework faster	45%
Has a better memory	40%
Solves math problems more quickly	39%
Pays attention longer	38%
Is more organized	34%
Is eager to read	33%
Is more focused	33%
Achieves higher standardized test scores	30%
Finishes classwork on time	29%

Reference: Ledbetter, C., Moore, A.L., & Mitchell, T. (2016). *Mixed Methods Study on LearningRx Results for Students with Dyslexia*. Technical report in preparation.

One-Year Retention Results for Our Clients

Abstract: To assess retention of training gains for clients, we analyzed the results for 516 clients who opted to return for a one-year follow-up assessment on the Woodcock-Johnson III – Tests of Cognitive Abilities. The average age of clients who completed the follow-up testing was 10.8. Retention rates ranged from 96% to 99%, with the greatest retention of skills in visual processing, auditory processing, and logic & reasoning.

PRE, POST, AND FOLLOW-UP STANDARD SCORES				
Skill	Pre	Post	One Year Later	Retention
IQ	95	111	107	97%
Long-Term Memory	94	107	106	98%
Visual Processing	102	109	108	99%
Auditory Processing	111	122	121	99%
Logic & Reasoning	100	111	111	99%
Processing Speed	91	99	94	96%
Working Memory	94	104	101	98%

All scores are rounded to the nearest whole number

Client Satisfaction Ratings

Abstract: To assess client satisfaction with our training programs, parents and adult clients complete an exit survey at the end of training. From 2005-2015, over 19,000 of our 21,836 clients rated the training a 9 or a 10. 71% rated us a 10, and another 24% rated us an 8 or a 9. And in 2015, the average score across all locations was a 9.6 out of 10!

EXIT INTERVIEW RATINGS				
Question	10	9 or 8	7 or below	Average Rating
On a scale of 1 to 10, how likely would you be to refer a friend or family member to us?	71%	24%	5%	9.6

Reference: Cameron, K. & Moore, A.L. (2014). *2014 Report of LearningRx Training Results*. Colorado Springs, CO: LearningRx. Available at LearningRx.com

Completed Research

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Ishanpara, P. (2012). *Cognitive rehabilitation with LearningRx: Preliminary improvements in memory after traumatic brain injury.* Doctoral dissertation. Available at http://downloads.learningrx.com/official-dissertation.pdf

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Ledbetter, C., Faison, M., Hill, O., & Patterson, J. (2016). *Correlation of Cognitive Training Gains and Resting State Functional Connectivity.* Poster presented at Society for Neuroscience, San Diego, CA, November 12, 2016.

Ledbetter, C., Moore, A.L., & Mitchell, T. (2017). Cognitive effects of ThinkRx cognitive rehabilitation training for eleven soldiers with brain injury: A retrospective chart review. *Frontiers in Psychology*, 8 (825). doi: 10.3389/fpsyg.2017.00825 Available at http://journal.frontiersin.org/article/10.3389/fpsyg.2017.00825

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Moore, A.L., Ledbetter, C., & Carpenter, D.M. (2016, November). *Intensive Metronome-Based Cognitive Training Improves Cognition in Children: A Randomized Controlled Trial.* Presented at Society for Neuroscience Annual Meeting, San Diego, CA.

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Moore, A.L. (2015). *LearningRx Training and IQ Gains.* Presentation available at http://downloads.learningrx.com/Multiple-Baseline-IQ-Study.pdf

Moore, A.L. (2015). *Cognitive trainer characteristics that predict outcomes for students with and without ADHD.* Doctoral dissertation. (UMI No. 3687613). Available at http://downloads.learningrx.com/dissertation_amy-moore.pdf

Musick, S.A. (2015). *Cognitive training in a school curriculum: A qualitative single-instrument case study.* Doctoral dissertation. (UMI No. 3721288). Retrieved from ProQuest.

Pfister, B. (2012). *The effect of cognitive rehabilitation therapy on memory and processing speed in adolescents.* Doctoral dissertation. Available at http://downloads.learningrx.com/dissertation-2012-pfister-final-pdf.pdf

Research in Progress

Cognitive Training and Traumatic Brain Injury *(ClinicalTrials.gov NCT#02918994)*

Cognitive Training and ADHD *(ClinicalTrials.gov NCT# 02917109)*

Multidisciplinary Approach to Treating Mild Cognitive Impairment/Early Alzheimer's *(ClinicalTrials.gov NCT#02943187)*

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