Statistical Analyses of Cognitive Change with LearningRx Training Procedures

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Overview, background, and procedure descriptions provided by LearningRx, Inc.

Purpose of Current Report

The current report documents preliminary statistical analyses of change in specific cognitive processes and learning for students who have completed the LearningRx cognitive training programs during the 2005 calendar year. Instruments utilized included pre- and post-test Woodcock Johnson Tests of Cognitive Abilities (WJ-III COG) and Achievement (WJ-III ACH) and the Comprehensive Test of Phonological Processing (CTOPP).

Overview and Background of LearningRx System

The LearningRx training system was developed to train and enhance cognitive learning skills. The LearningRx training procedures consist of tasks that emphasize auditory or visual processes and that require attention and reasoning throughout the training. The processing strategies are learned through inductive rather than deductive inference to ensure greater transfer. In other words, the subject is trained to develop the appropriate strategy to complete the task through the structured experience provided by the training procedures. The training consists of tasks that are organized in a progressively more challenging manner. Cognitive training uses a synergistic “drill for skill” and meta-cognitive approach to developing cognitive skills. The model is hierarchical and designed to specifically target one or more specific cognitive skills. The tasks repeatedly make demands on one's processing abilities and progressively increase those demands. These tasks are the means of developing cognitive functions. This training approach is based, in part, on the scientific and biological basis that the retraining of cognitive functions can help reorganize and improve higher cognitive functions. To do this, however, the targeted functions must be worked on repeatedly. Therefore, as soon as a student has mastered a task or group of tasks, higher-level tasks that target the same cognitive function must be available.

An important component of the training is the interactive nature of the sessions and feedback provided by the trainer to facilitate the learning of the student. The immediate reinforcement and feedback of both correct and incorrect responses is designed to enhance the student’s learning. This reinforcement is also important for the sequential nature of the cognitive procedures. As the procedures move from simple to more complex, the consistent feedback and reinforcement becomes increasingly important to allow the student to achieve mastery of the tasks and move forward to the more challenging levels of tasks. These intense, sequenced tasks and the accompanying feedback are the hallmarks of the LearningRx approach to processing skills training.

* For additional information about the history and development of the LearningRx cognitive training procedures, please visit http://www.learningrx.com.

Descriptions of the ThinkRx, ReadRx Partner, and ReadRx Pro Programs

THINKRX PARTNER TRAINING

The ThinkRx Partner training consists of 72 hours of the ThinkRx program for 12 weeks. Certified LearningRx trainers lead three, one-hour sessions each week with the student. Parents whose children are enrolled in the ThinkRx Partner program are also required to spend three hours per week helping their child practice those procedures that are most difficult for him or her. Parents observe and are trained by LearningRx trainers in procedures assigned for home training. The trainers provide constant feedback and sequence the levels worked on by the students. Each of the 24 procedures and over 1000 levels are graded according to difficulty, and tasks became progressively more complex. The pace is regulated by mastery, so the number of tasks completed during training sessions differ from student to student. However, the administration of the procedures is standardized across trainers. While all cognitive skills are addressed, programs are individualized to primarily address and strengthen deficient areas and enhance strengths.

Certain modifications may initially be allowed to assist a student with a procedure; however, mastery is quickly established through repetition and drill. Mental activities and distractions are implemented frequently in order to develop complex problem solving and concentration abilities.

An example of a procedure is described as follows:

Attention Arrows: Develops divided, sustained, and selective attention, processing speed, visual sequencing, saccadic fixation, and self-regulation.

Using a metronome and a board with several rows of different colored arrows randomly pointing in the four primary directions, the subject would proceed through the following levels:

Level 1: Student calls out the color of the arrows without error in 3 rows within a set time (between 30 and 10 seconds).
Level 2: Student calls out the direction of the arrows without error for three rows within a set time.
Level 3: Student calls out the color of the arrows in four rows on every other beat (in sync with the metronome set to between 85 bpm and 160 bpm).
Level 4: Student calls out the direction of the arrows as if they were turned a quarter-turn clockwise on every other beat (in sync with the metronome set to between 85 bpm and 160 bpm).
Level 5: Student calls out the color of the "up" and "down" arrows and calls out the direction of the "right" and "left" arrows in 4 rows on every other beat (in sync with the metronome set to between 85 bpm and 160 bpm).
Level 6+: The levels continue to increase in difficulty. Throughout the procedures, the trainer includes a variety of distractions ranging from low level (walking around the student, coughing, etc.) to high-level distractions (clapping off beat, asking personal questions, etc.)

The procedures require focused attention and progression through the levels requires the attainment of increasing speed and complexity of processing. Also, as the levels of the task are achieved, the sequenced demands are increased, which makes the task increasingly intense and challenging.

READRX PRO AND READRX PARTNER

The ReadRx Pro training consists of five hours of training per week for 24 weeks by a certified LearningRx trainer with no parental home training involvement. The ReadRx Partner training consists of three one-hour sessions each week with a certified LearningRx trainer and three hours of practice at home each week with the parents. Parents observed and were trained by LearningRx trainers in procedures assigned for home. ReadRx includes the 24 procedures of the ThinkRx program plus an additional 24 lessons of approximately 8 procedures each, which focus on auditory processing, basic code, and complex code skills involved in reading rate, accuracy, fluency, comprehension, spelling, and writing. The training method is similar to ThinkRx. An example of parts of a ReadRx procedure is described as follows:

Using a metronome, the trainer says a word (three to five sounds) and the student recites the word, but without one of the sounds, as directed.

Level 4: Drop either the first or the last sound
Level 8: Drop out a sound as directed, varying which consonant sound to drop (Trainer: "cat," beat, "last," beat, Student: "ca," beat, beat, Trainer: "lut," beat, first, beat, Student: "ut,"…)

Cognitive Measures

Prior to and at the end of cognitive training, each student was assessed on up to 11 areas of cognitive processing according to scales on the Woodcock-Johnson III Tests of Cognitive Abilities (WJ-III COG), Woodcock-Johnson III Tests of Achievement (WJ-III ACH), and Comprehensive Test of Phonological Processing (CTOPP) depending on which program the student was enrolled in. These tests have been verified through extensive research as being reliable and valid measures. These measures are considered among school psychologists and mental health professionals as having the strongest psychometric properties in accurately assessing cognitive development. The measures used in the analyses are as follows:

Name of Test	Skill Tested	Test Used
Visual Auditory Learning	Long-Term Memory	WJ-III COG
Spatial Relations	Visual Processing	WJ-III COG
Concept Formation	Logic & Reasoning	WJ-III COG
Numbers Reversed	Short-Term/Working Memory	WJ-III COG
Pair Cancellation	Processing Speed	WJ-III COG
Broad Attention	Attention	WJ-III COG
Word Attack	Decoding	WJ-III ACH
Sound Awareness	Auditory Processing	WJ-III ACH
Segmenting Non-words	Auditory Processing	CTOPP
Blending Non-words	Auditory Processing	CTOPP
Auditory Analysis	Auditory Processing	CTOPP

Long-Term Memory: The ability to recall information that was stored in the past. Long-Term memory is important for spelling, recalling facts on tests, and comprehension.

Visual Processing: The ability to perceive, analyze, and think in visual images. This includes visualization, which is the ability to create a picture in your mind. Students who have problems with visual processing may reverse letters or have difficulty following instructions, reading maps, doing word math problems, and comprehending.

Logic and Reasoning: The ability to reason, form concepts, and solve problems using unfamiliar information or novel procedures.

Short-Term Memory/Working Memory: The ability to store and recall amounts of information about the current situation. Students with short-term memory problems may need to look several times at something before copying, have problems following instructions, or need to have information repeated often.

Processing Speed: The ability to perform cognitive tasks quickly; an important skill for complex tasks or tasks that have many steps (i.e. if we are dividing two numbers in our head but processing is slow, we might forget an earlier calculation before we are done and have to start over again. We took longer to do the problem than our ability to remember).

Attention: The ability to stay on task even when distractions are present. Different kinds of attention include sustained attention (staying on task for a period of time), selective attention (focusing on one thing and ignoring distractions), and divided attention (attending to two things at once…often called "multi-tasking").

Decoding: The ability to accurately read written words.

Auditory Processing: The ability to analyze, blend, segment, and synthesize sounds. Auditory processing is a crucial underlying skill for reading and spelling.

Demographics

SAMPLE CHARACTERISTICS

The original dataset from which the analyses are drawn includes 1,265 students across 31 LearningRx Centers throughout the United States. Student data were compiled at the national headquarters for LearningRx in Colorado Springs, CO. Students' ages range from 4 to 22 with a mean of 11.5 years and standard deviation of 3 years. Ninety percent of the sample falls between the ages of 10 and 18 years of age. Overall, sixty-one percent of the sample is male.

The various programs and numbers of participants are as follows:

LearningRx Program	#	%
ThinkRx Partner	667	52.7
ReadRx Partner	453	35.8
ReadRx Pro	65	5.1
ReadRx Partner/Directed	25	2.0
ReadRx Directed	21	1.7
LiftOff (Pre-School Program)	15	1.2
ThinkRx Directed	11	.9
ThinkRx Pro	8	.6
Total	1265	100%

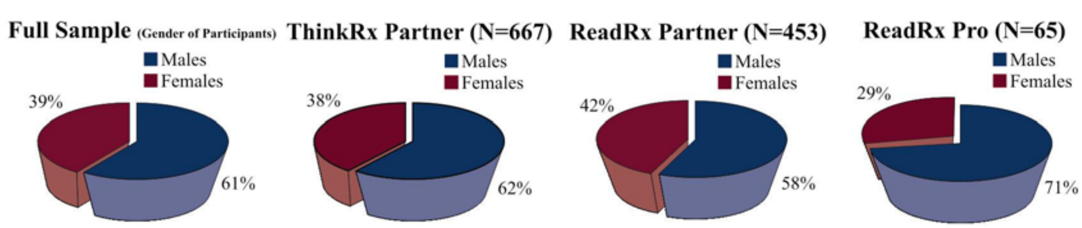
Approximately eighty-eight percent of the sample completed either the ThinkRx Partner or the ReadRx Partner programs, with an additional 5% having completed the ReadRx Pro program. In the interest of clarity of treatment results, data from the other program listed above are not included in the present analyses. The results below are for the three following groups: students who completed the ThinkRx Partner Program (N = 667), students who completed the ReadRx Partner Program (N = 453), and those who completed the ReadRx Pro Program (N = 65).

The mean age of students in each of these three groups is similar at 11.3 years (SD = 3.1) for the ThinkRx Partner program, 11.7 years (SD = 3) for the ReadRx Partner program, and 11.4 years (SD = 2.8) for the ReadRx Pro Program.

The ethnic compositions of the students across programs are similar and are indicated below for the full sample in the study.

Ethnicity	%
White	88%
Black	6%
Hispanic	2%
Other	4%

The gender distributions for each program are indicated below:



Combined Programs – all ThinkRx Partner, ReadRx Partner, ReadRx Pro
(t-test analyses of pre-/post- differences on cognitive measures)

In an initial analysis of t-tests of over 30 cognitive skills (measured pre- and post-treatment) every single measure indicated significant increases in test scores after LearningRx training. The following analyses represent the results of pre-/post- analysis differences among 9 core cognitive skills that are targeted in the LearningRx cognitive training programs.

Cognitive Test (Skill)	(N)	Average Pre-Test Age Equivalency	Average Post-Test Age Equivalency	Average GAIN in Years	t-score	p-value <
Visual Auditory Learning (Long-Term Memory)	1013	10.24	13.97	3.73	30.77	.001
Spatial Relations (Visual Processing)	360	12.73	16.72	3.99	13.81	.001
Concept Formation (Logic & Reasoning)	363	11.19	14.66	3.47	20.66	.001
Numbers Reversed (Working Memory)	361	10.31	12.89	2.58	14.21	.001
Pair Cancellation (Processing Speed)	206	10.74	13.47	2.73	16.59	.001
Sound Awareness (Auditory Processing)	346	10.51	15.36	4.83	18.28	.001
Segmenting Non-words (Auditory Processing)	146	8.22	13.41	5.17	22.90	.001
Blending Non-words (Auditory Processing)	156	9.31	13.47	4.16	17.72	.001
Auditory Analysis (Auditory Processing)	820	6.40	11.88	5.48	40.62	.001

The above analyses indicate that for each of the cognitive skills measured, significant increases were attained at post-test, indicating a range of 2.58 to 5.48 average years of improvement across the skills. Each of these differences is significant at the .001 level of significance, meaning that such differences would be extremely unlikely (less than 1 in 1000) to have occurred as a “chance” increase. Thus, these results indicate there is strong evidence across all cognitive measures tested to suggest that there are statistically significant gains in cognitive skills following the LearningRx training programs. The extremely high t-scores are further indication that the differences between pre-and post-measures are pronounced. Typical t-values fall within the range of 0 to 1.96 if there are no significant differences between a pre- and post-test measure and above 1.96 if there are significant differences. In the analyses above, the t-scores range between 13.81 and 40.62 and provide further evidence for the strength of the differences between the pre-test and post-test scores.

Combined Programs
(students who pre-tested two or more years below age equivalency)

Cognitive Test (Skill)	(N)	Average Pre-Test Age Equivalency	Average Post-Test Age Equivalency	Average GAIN in Years	t-score	p-value <
Visual Auditory Learning (Long-Term Memory)	420	7.84	13.04	5.20	27.8	.001
Spatial Relations (Visual Processing)	95	8.46	14.68	6.22	10.89	.001
Concept Formation (Logic & Reasoning)	116	7.99	12.38	4.39	14.07	.001
Numbers Reversed (Working Memory)	131	8.30	11.56	3.26	11.52	.001
Pair Cancellation (Processing Speed)	44	10.37	14.59	4.22	11.29	.001
Sound Awareness (Auditory Processing)	115	8.80	15.11	6.31	13.69	.001
Segmenting Non-words (Auditory Processing)	95	7.5	13.55	6.05	24.24	.001
Blending Non-words (Auditory Processing)	73	8.38	13.80	5.42	19.71	.001
Auditory Analysis (Auditory Processing)	709	6.17	12.03	5.87	41.00	.001

When analyses are conducted on a sub-sample of students who pre-tested at two or more years below grade level, the findings are even more pronounced. The t-tests comparing the pre-/post- gains among these two subgroups also indicate significant differences in the gains achieved, with lower-performing students demonstrating the most marked gains in cognitive skills. Among this subset of students who pre-tested two or more years below age-equivalency, average years of gain in cognitive skills ranged from 3.26 to 6.31, depending on the cognitive measures tested. An example of one of the most important skill increases related to reading effectiveness is sound awareness. On average, a student who pre-tested at an age-equivalency of 8.80 years attained an age equivalency of 15.11 years after the 6 months of training. This illustrates an average 6-year gain in Sound Awareness. Other skills critical to reading, such as Segmenting Non-words, Blending Non-words, and Auditory Analysis, show similar marked gains of between 5 and 6 years of improvement after approximately 6 months of training.

ThinkRx Program
(within 2 years below age equivalency and 2+ years below age equivalency at pre-test)

Cognitive Test (Skill)	Sample	(N)	Average Pre-Test Age Equivalency	Average Post-Test Age Equivalency	Average GAIN in Years	t-score	p-value <
Visual Auditory Learning (Long-Term Memory)	Within 2 Years Below AE	286	8.36	12.05	3.69	17.94	.001
	2 Years or more Below AE	459	7.80	12.96	5.16	28.59	.001
Spatial Relations (Visual Processing)	Within 2 Years Below AE	96	8.99	13.73	4.74	9.34	.001
	2 Years or more Below AE	106	8.35	14.37	6.02	11.27	.001
Concept Formation (Logic & Reasoning)	Within 2 Years Below AE	104	8.64	12.33	3.69	13.71	.001
	2 Years or more Below AE	131	7.87	12.17	4.30	14.01	.001
Numbers Reversed (Working Memory)	Within 2 Years Below AE	139	9.16	11.84	2.68	9.08	.001
	2 Years or more Below AE	147	8.22	11.44	3.22	11.78	.001
Pair Cancellation (Processing Speed)	Within 2 Years Below AE	90	9.50	12.08	2.58	12.12	.001
	2 Years or more Below AE	47	10.27	14.39	4.12	11.26	.001
Sound Awareness (Auditory Processing)	Within 2 Years Below AE	132	8.41	12.28	3.87	10.73	.001
	2 Years or more Below AE	128	8.80	15.05	6.25	14.34	.001

In examining the pre-test to post-test gains for the ThinkRx program, all the cognitive procedures tested yield significant increases in age-equivalency after the twelve weeks of training. As is evident in the table above, those students with the greatest cognitive disadvantages benefited the most from the training programs. The students who tested at 2 or more years below age equivalency at pre-test had an AVERAGE gain of between 3.22 and 6.25 age years of improvement depending on the cognitive test measured.

ReadRx Partner Program
(within 2 years below age equivalency at pre-test)

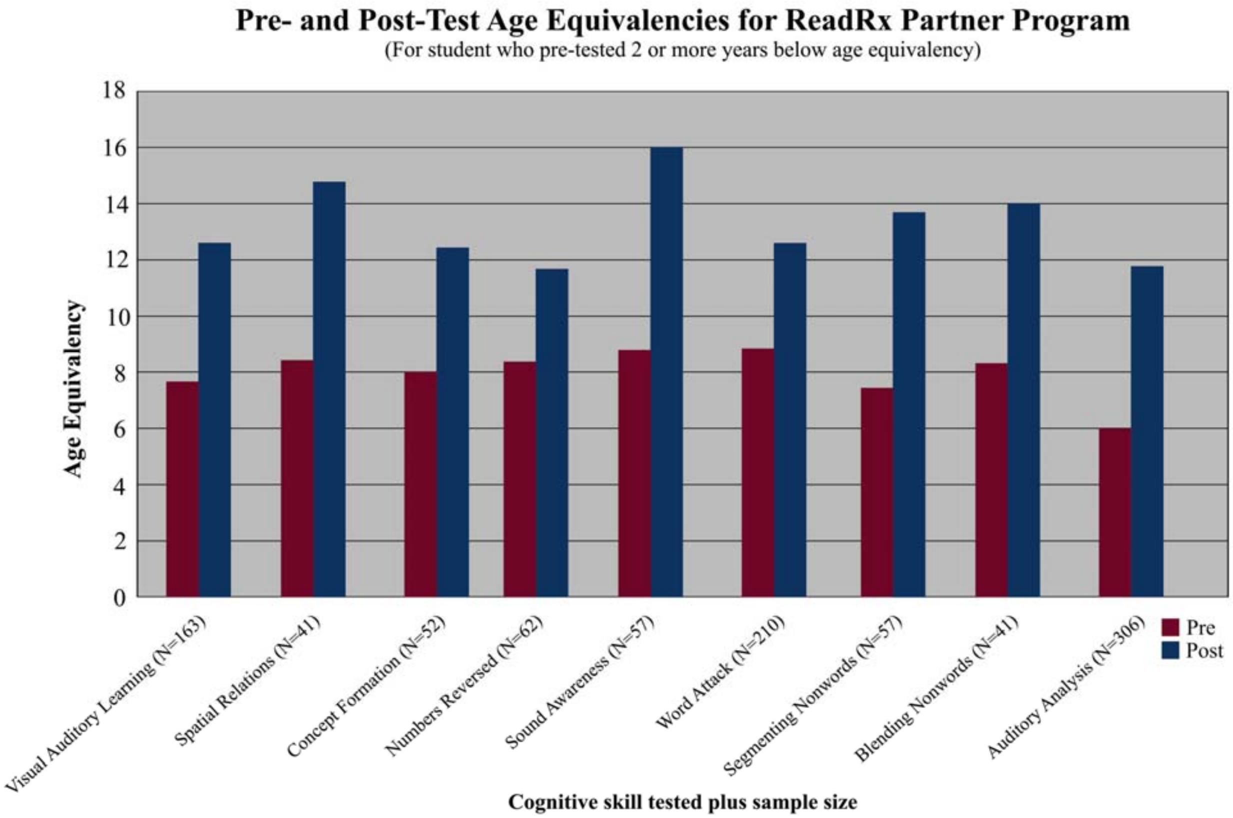
Note: Sample sizes for conducting analyses on the last three cognitive skills (Segmenting Non-words, Blending Non-words, and Auditory Analysis) were too small for meaningful analyses (n= 11, 20, and 16, respectively) so these procedures are not included in the table above.

Cognitive Test (Skill)	(N)	Average Pre-Test Age Equivalency	Average Post-Test Age Equivalency	Average GAIN in Years	t-score	p-value <
Visual Auditory Learning (Long-Term Memory)	104	8.54	12.62	4.08	11.56	.001
Spatial Relations (Visual Processing)	32	9.23	14.28	5.05	5.71	.001
Concept Formation (Logic & Reasoning)	31	9.47	13.44	3.97	7.89	.001
Numbers Reversed (Working Memory)	34	9.44	12.08	2.64	4.99	.001
Sound Awareness (Auditory Processing)	42	8.98	13.31	4.33	6.36	.001
Word Attack (Decoding)	157	8.92	11.36	2.38	13.34	.001

ReadRx Partner Program
(2+ years below age equivalency at pre-test)

Cognitive Test (Skill)	(N)	Average Pre-Test Age Equivalency	Average Post-Test Age Equivalency	Average GAIN in Years	t-score	p-value <
Visual Auditory Learning (Long-Term Memory)	163	7.66	12.65	4.99	15.87	.001
Spatial Relations (Visual Processing)	41	8.53	14.67	6.14	6.81	.001
Concept Formation (Logic & Reasoning)	52	7.92	12.48	4.56	8.62	.001
Numbers Reversed (Working Memory)	62	8.30	11.70	3.40	8.50	.001
Sound Awareness (Auditory Processing)	57	8.74	16.05	7.31	11.49	.001
Word Attack (Decoding)	210	8.85	12.40	3.55	19.82	.001
Segmenting Non-words (Auditory Processing)	57	7.20	13.82	6.62	21.77	.001
Blending Non-words (Auditory Processing)	41	8.17	14.10	5.93	20.95	.001
Auditory Analysis (Auditory Processing)	306	5.97	11.85	5.88	27.32	.001

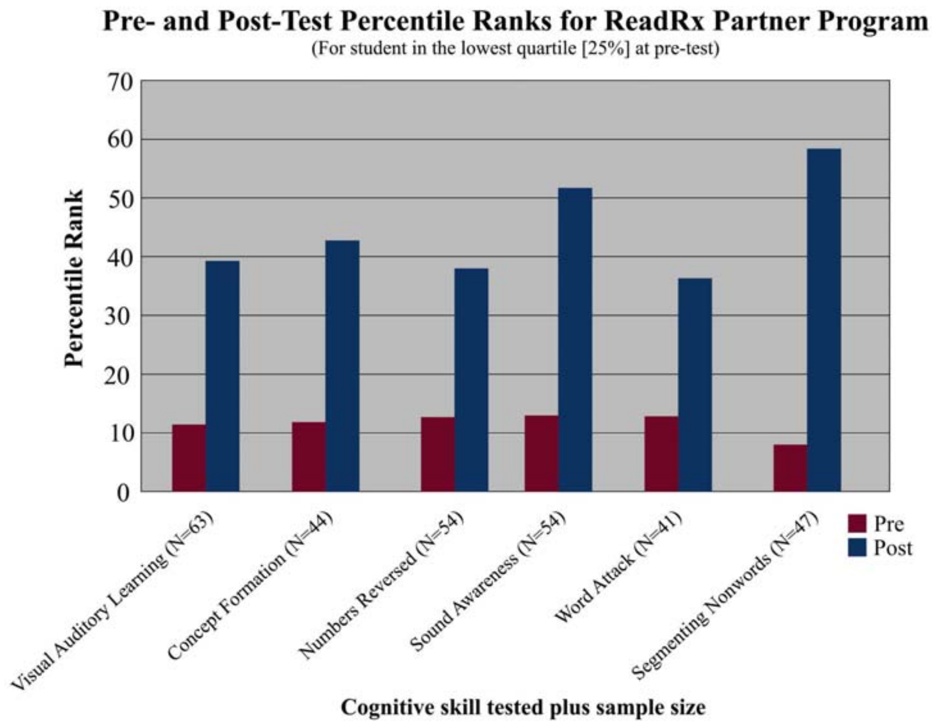
The two tables above represent t-test analyses for the ReadRx Partner Program and include the cognitive skills processes that are most relevant for reading effectiveness. Consistent with the results of the ThinkRx program, all the cognitive measures tested for ReadRx also resulted in strong significant gains in Age Equivalency from pre- to post-test. The students who tested at 2 or more years below age equivalency at pre-test had an AVERAGE gain of between 3.40 and 7.31 years of improvement depending on the cognitive test measured. To examine one of the measures in detail, we find that the 306 participants in the ReadRx Partner program (all of whom tested at 2+ years below age equivalency at pre-test) attained final post-test scores that indicated an average of 5.88 years improvement in their auditory analysis skills. Similar patterns are found for all the other cognitive measures that were assessed. The bar graph presented below illustrates the pre-test to post-test gains on the cognitive measures that were tested.



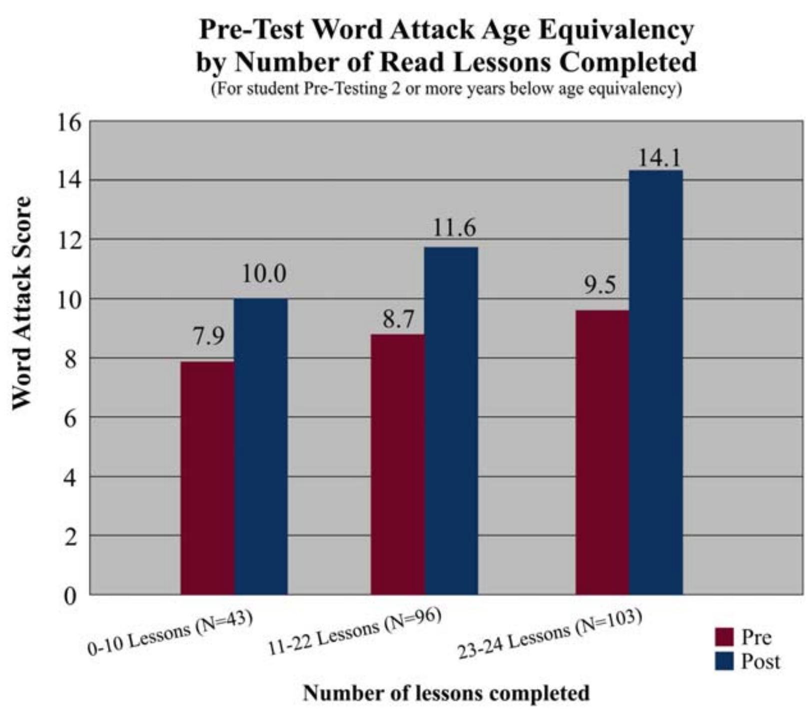
Age equivalency gains for the ReadRx Partner Program are included above. For each of the cognitive skills measures, there were statistically significant gains in age-equivalency that far exceeded what the developmental age equivalency would have been naturally (through 6 months of the child's development during the training). The table below also illustrates the percentile rank increases in the pre- and post-test measures for the various cognitive skills.

Pre-/Post- Percentile Ranks for ReadRx Partner Program
(students who pre-tested in the lowest quartile [25%])

Cognitive Test (Skill)	(N)	Average Pre-Test Percentile Rank	Average Post-Test Percentile Rank	Average GAIN in Percentile Rank	t-score	p-value <
Visual Auditory Learning (Long-Term Memory)	63	11.32	39.12	27.8%	9.90	.001
Concept Formation (Logic & Reasoning)	44	11.59	42.91	31.32%	9.41	.001
Numbers Reversed (Working Memory)	54	12.41	37.30	24.89%	8.59	.001
Sound Awareness (Auditory Processing)	54	12.43	51.35	38.92%	12.73	.001
Word Attack (Decoding)	41	12.53	36.24	23.72%	9.15	.001
Segmenting Non-words (Auditory Processing)	47	7.96	58.53	50.57%	17.66	.001



As illustrated in the table and graph above, the scores reflect steep gains in both age-equivalency and percentile rank scores of the students from pre-test to post-test assessments. For each of these cognitive skills, the gains demonstrated are far greater than what would be expected by chance. The gains demonstrated above are for students who scored in the lowest quartile (25%) at the initial assessment. These findings in addition to the ones presented throughout the report provide strong evidence to suggest that the LearningRx training is related to the gains that have been found.



This final graph on the previous page illustrates pre-test and post-test age equivalencies for students who were 2 years or more below grade level at the initial assessment. For those students who only completed 0-10 ReadRx Lessons, the average gain in Word Attack Skills was 2.03 years of improvement. For students who completed 11-22 ReadRx Lessons, the average gain in Word Attack Skills was 2.93 years of improvement. Finally, students who completed 23 or 24 ReadRx Lessons (24 indicates full completion of the program) demonstrated an average of 4.57 years of improvement in Word Attack Skills. This means that, on average, the students who were the lowest performing (2 years or more below age equivalency), who completed the vast majority of the program (95% of the required training), performed far above the average age expectancy following the training. The steep gains demonstrated by these students (with increasing strength related to the number of lessons completed) provide additional evidence for the effectiveness of ReadRx Training Programs.

Future Directions

The findings presented in the current report provide consistent and strong evidence for the increased cognitive performance of students who have received LearningRx training. Given the relatively large sample sizes of students in the present analyses, the highly reliable and valid measurement tools (the most widely used tests of cognitive skills among educators and psychologists), and the consistent results indicating cognitive gains following the LearningRx training, there are compelling reasons to continue research and development of these cognitive training procedures. With the strengths of the results, there are also some important limitations to note that should be kept in mind when interpreting the data and planning further analyses of the program. First, the current report examines data from students who have participated in the program and does not have an equivalent, matched control group for comparison. The present analyses also do not control for demographic variables or specific age groups. In addition, there are many procedures involved in LearningRx training; thus, these analyses do not isolate which particular procedures are the ones that could be attributed to the increase in scores. It is possible that the program as a package may provide the best training for students. It is also possible that separate components of the program are more or less effective than others. Further research on the separate procedures would allow more detailed interpretation of the effectiveness of the programs.

As an initial statistical inquiry, the present results provide strong evidence to support further research to be conducted in experimental controlled settings. It would also be valuable to include additional measures to assess the transfer of skills to academic achievement in the educational system. Future datasets should include data from students' test scores on state and national standardized tests, as well as grade point average data prior to and after the training to further strengthen the research base on the effectiveness of the LearningRx Program. Because of the strong theoretical background and research base that has been the foundation for the development of the LearningRx procedures, in addition to the consistent, pronounced cognitive skill increases that have emerged from this initial set of analyses, it is highly recommended that a full study be conducted and published in the scientific literature on cognitive development and learning.