# Testing the Effects of LearningRx: 2009 Control Group Study

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Background, program, procedure, and skill descriptions provided in part by LearningRx, Inc.

## Purpose of the Study

This study group consisted of problem readers between the ages of 6 and 16 years. The treatment group of 31 went through a 24-week ReadRx/ThinkRx program while the control group of 30 continued in their regular classroom activities.

## Overview and Background of the LearningRx Systems

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 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 LearningRx cognitive training programs, please visit http://www.learningrx.com.

## Descriptions of the ThinkRx/ReadRx Program

The ReadRx training consists of 5 hours of training per week for 24 weeks by a certified LearningRx trainer providing either all the training or 60 percent of the training (with the parent providing the balance after being instructed on procedures assigned for home).

The trainers provide constant feedback and sequence the levels worked on by the students. Each of the 32 procedures and over 1000 levels are structured according to difficulty, and tasks become progressively more complex. Eight of the 32 procedures focus on auditory processing, basic code, and complex code skills involved in reading rate, accuracy, fluency, comprehension, spelling, and writing. 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. Mastery is quickly established through repetition and drill. Mental activities and distractions are implemented frequently 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.
**Level 2** Student calls out the direction of the arrows without error in 3 rows within a set time.
**Level 3** Student calls out the color of the arrows in 4 rows on every other beat (in sync with the metronome set to between 85 beats per minutes (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.)

### An example of parts of an auditory processing procedure is described as follows:

Using a metronome, the trainer says a word (containing from 3 to 5 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,"…)

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.

## 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) and the Woodcock Johnson III Tests of Achievement (WJ-III ACH), 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 and Reasoning | WJ-III COG |
| Numbers Reversed | Short-Term Memory | WJ-III COG |
| Pair Cancellation | Processing Speed | WJ-III COG |
| Word Attack | Decoding | WJ-III ACH |
| Sound Awareness | Auditory Processing | WJ-III ACH |

**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:** 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).

**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

This study uses a pre-post control group design. Study participants included 61 students age 6 to 16 living in the Colorado Springs, CO area. Participants included all those who visited LearningRx centers in Colorado Springs seeking information about the program beginning August 2007. The treatment group (n = 31) included students whose parents or guardians elected to enroll them in the program. The control group (n = 30) included students whose parents or guardians chose not to enroll in the LearningRx program after pre-testing.

**Table 1** includes descriptive statistics for the sample. As indicated, most participants were white males; however, the distributions between groups within each category were basically equivalent. By disability diagnosis, the sample was also equally distributed both within groups and between groups. Average age and income also proved similar between groups.

**Table 1: Sample Descriptive Statistics (n = 61)**

| | Control (n = 30) | Treatment (n = 31) |
|---|---|---|
| Race/Ethnicity | | |
| White | 26 (42.6%) | 28 (45.9%) |
| Minority | 4 (6.5%) | 3 (4.9%) |
| Gender | | |
| Male | 21 (34.4%) | 20 (32.7%) |
| Female | 9 (14.7%) | 11 (18.0%) |
| Disability Diagnosis | | |
| No | 16 (26.2%) | 16 (26.2%) |
| Yes | 14 (22.9%) | 15 (10.6%) |
| Mean Income | $72,716 (SD = $18,234) | $70,194 (SD = $14,732) |
| Mean Age | 10.63 (SD = 2.78) | 11.58 (SD = 2.60) |

**Note:** Percentages represent frequencies of the entire sample for each variable.
SD = Standard Deviation

## Results

As the tables below illustrate, both the control group and the LearningRx treatment group showed growth on almost all tests, but the treatment group consistently showed greater growth on every test compared to the control group. The treatment group training focused on weak cognitive skills needed for reading (sound awareness, memory, word attack, and processing speed). As the detailed discussion of the statistical analyses below indicates, data were analyzed in their original raw score format, but for reporting purposes, results were transformed into the following tables and graphs.

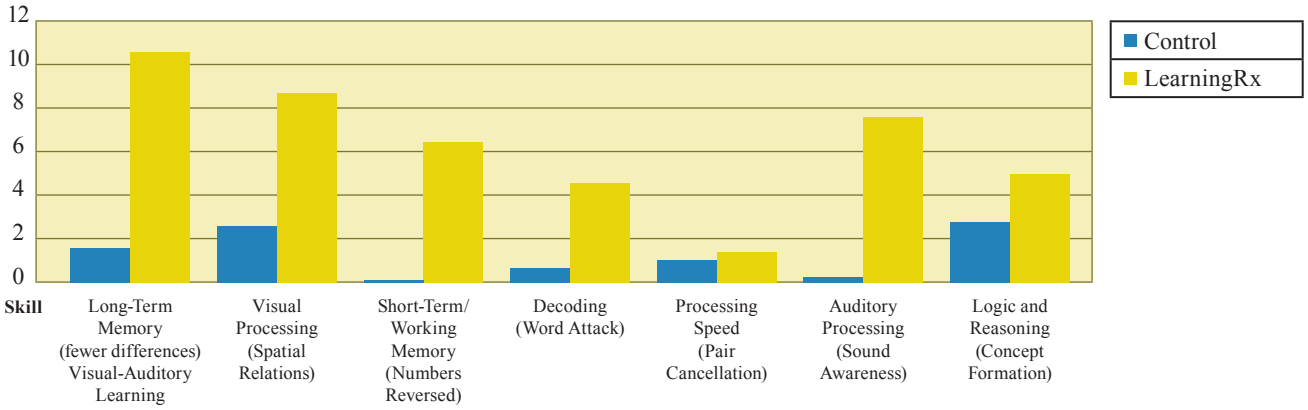
| | Treatment Pre-Test | Treatment Post-Test | Gain/ Change | Control Pre-Test | Control Post-Test | Gain/ Change |
|---|---|---|---|---|---|---|
| Long-Term Memory * (Visual Auditory Learning) | * Please note this test looks at the number of errors made.<br>** For Age Equivalent scores, yrs = years and mo/mos = month(s) | | | | | |
| Age Equivalent | 8 yrs 6 mos ** | > 19 yrs | 10 yrs 6 mos | 8 yrs 6 mos | 10 yrs 2 mos | 1 yr 8 mos |
| Percentile | 45th | 77th | 32 | 53rd | 54th | 1 |
| T Score | 54 | 44 | 10 | 54 | 49 | 5 |
| Visual Processing (Spatial Relations) | | | | | | |
| Age Equivalent | 11 yrs 3 mos | 20 yrs | 8 yrs 9 mos | 10 yrs 7 mos | 13 yrs | 2 yrs 5 mos |
| Percentile | 58.5th | 79nd | 20.5 | 59th | 67th | 8 |
| T Score | 47 | 54 | 7 | 47 | 51 | 4 |
| Short-Term Memory (Numbers Reversed) | | | | | | |
| Age Equivalent | 9 yrs 3 mos | 15 yrs 8 mos | 6 yrs 5 mos | 9 yrs 3 mos | 9 yrs 3 mos | 0 yrs |
| Percentile | 44th | 62nd | 18 | 45th | 42nd | 3 |
| T Score | 48 | 55 | 7 | 47 | 48 | 1 |
| Decoding (Word Attack) | | | | | | |
| Age Equivalent | 9 yrs 11 mos | 14 yrs 4 mos | 4 yrs 5 mos | 9 yrs 2 mos | 9 yrs 11 mos | 9 mos |
| Percentile | 58th | 67th | 9 | 57th | 58th | 1 |
| T Score | 49 | 54 | 5 | 47 | 49 | 2 |
| Processing Speed (Pair Cancellation) | | | | | | |
| Age Equivalent | 9 yrs 7 mos | 10 yrs 11 mos | 1 yr 4 mos | 9 yrs | 10 yrs | 1 yr |
| Percentile | 35th | 73rd | 38 | 39th | 56th | 17 |
| T Score | 48 | 54 | 6 | 46 | 51 | 5 |
| Auditory Processing (Sound Awareness) | | | | | | |
| Age Equivalent | 9 yrs 6 mos | 17 yrs | 7 yrs 6 mos | 9 yrs 1 mo | 9 yrs 6 mos | 5 mos |
| Percentile | 60th | 90th | 30 | 66th | 70th | 4 |
| T Score | 48 | 55 | 7 | 47 | 49 | 2 |
| Logic and Reasoning (Concept Formation) | | | | | | |
| Age Equivalent | 11 yrs 7 mos | 16 yrs 6 mos | 4 yrs 11 mos | 10 yrs 4 mos | 31 yrs 1 mo | 2 yrs 9 mos |
| Percentile | 75th | 92nd | 17 | 70th | 80th | 10 |
| T Score | 47 | 54 | 7 | 47 | 51 | 4 |

## Results (continued)

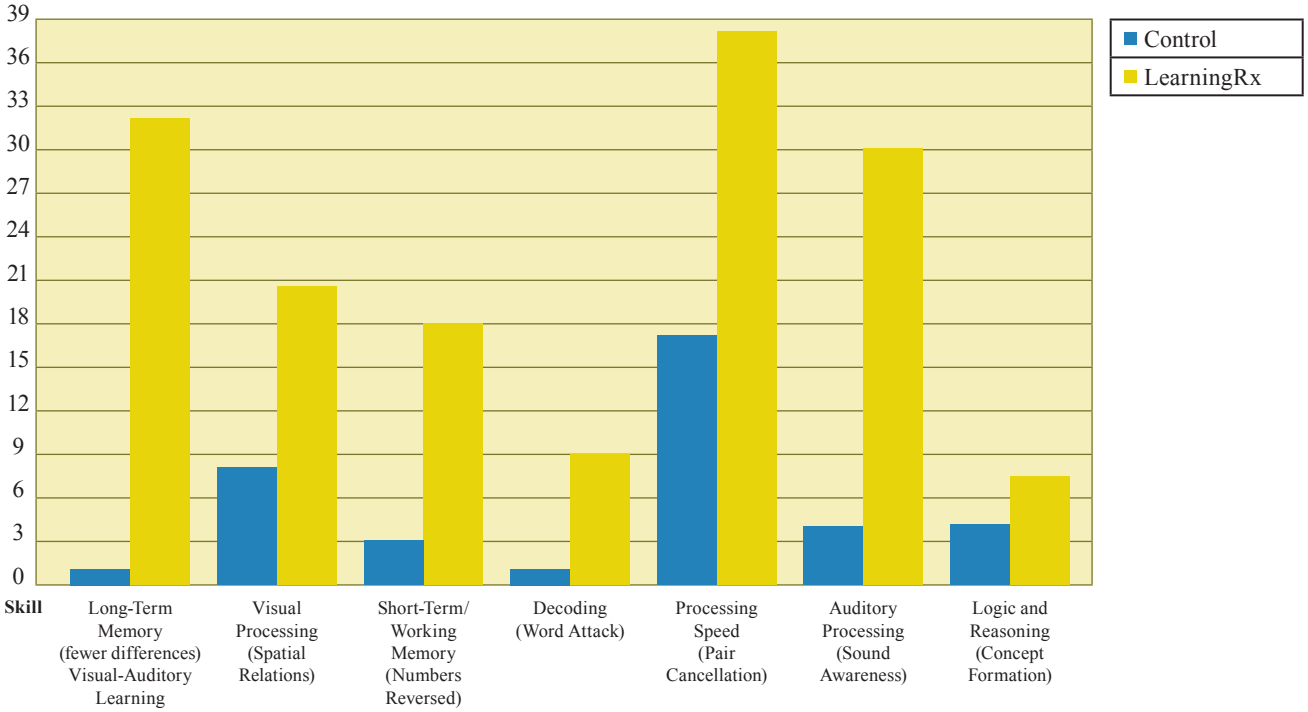
On 5 of the 7 skills, the difference in growth between the LearningRx group and the control group was statistically significant. **Those skills include:** Logic and Reasoning, Short-Term Memory, Word Attack, Phonemic Awareness, and Long-Term Memory. Moreover, these differences were significant after controlling for student race/ethnicity, gender, disability, age, and for family income.

T scores represent a form of standard score that transforms raw score data into a more easily interpreted and understood metric, where the mean (or average) is 50 and the standard deviation is 10. This also facilitates a comparison of performance across different tests that use different scales of measurement. The LearningRx group consistently showed greater improvement on all tests compared to the control group. This trend is made even clearer in **Figures 1-3**, which display the pre-/post-test differences for each group on each test.

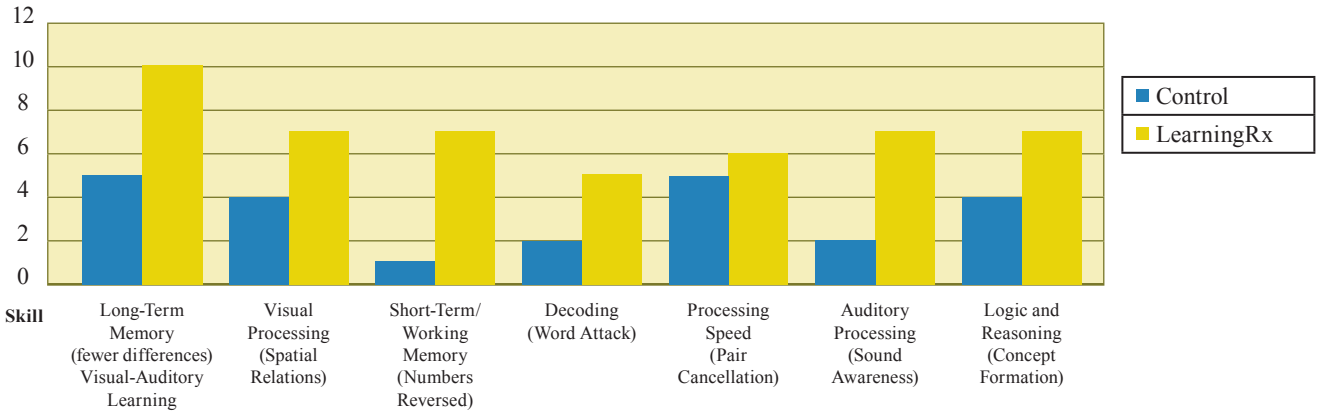
### Figure 1: Differences in Age Equivalency




### Figure 2: Differences in Percentile



## Figure 3: Differences in T Scores




## Data

In addition to the test data collection procedures reported above, the analyses reported below include covariates measuring race/ethnicity, income, sex, disability diagnosis, and age. All except income were gathered by LearningRx and provided to the researcher. Race/ethnicity originally included four categories, but was recoded into two (white and minority) due to small group sizes.

Disability diagnosis data was self-reported by parents/guardians as part of LearningRx's screening survey. A disability diagnosis reported in the survey would include any of the following: ADD, ADHD, Autism/Asperger's/Pervasive Developmental Disorder (PDD), Dyslexia/Reading Problem, Learning Disability, Mental Retardation, Speech/Language Disability, or other. This was coded as a dichotomous variable. The age variable was in continuous format.

The income variable was collected from the US Census data by the researcher using each participant's street address. The census database facilitates the identification of household income (among other related variables) down to the block group level using street addresses, zip codes, and other identifying information. This method represents an often used procedure in survey research, economics, and other disciplines for inferring incomes. This data is reported in continuous format in the census database and used as such in these analyses.

## Analyses

Pre- and post-test data was used to create difference scores for each student on each test. These difference scores represented the dependent measure in the analyses. The primary independent variable of interest was the LearningRx program. Other variables listed above acted as covariates.

The difference between treatment and control groups in the respective difference scores were analyzed using ordinary least squares (OLS) regression. Scores for each test were analyzed separately. All data was screened for normality prior to regression analyses, and all regressions included colinearity tests.

## Regression Results

**Table 3** includes the means and standard deviations for the pre- and post-test raw data for each group for each test. The bottom seven rows of the table include the means and standard deviations for the difference scores for each test.

As a reminder, the Visual-Auditory Learning test counts the number incorrect that a student makes. Therefore, from pre- to post-test, one hopes to see a decrease in the test result, indicating fewer mistakes from time 1 to time 2. That is why the visual-auditory learning difference score is a negative for both groups, although the treatment group showed a greater decrease in the number of incorrect responses.

**Table 3: Test Score Descriptive Statistics**

| | Control Group | | LearningRx Group | |
|---|---|---|---|---|
| | M | SD | M | SD |
| Visual-Auditory Learning Pre-Test | 17.87 | 11.01 | 17.61 | 7.03 |
| Visual-Auditory Learning Post-Test | 13.43 | 8.76 | 7.06 | 4.58 |
| Spatial Relations Pre-Test | 64.90 | 6.52 | 65.94 | 7.77 |
| Spatial Relations Post-Test | 68.00 | 7.13 | 71.29 | 5.38 |
| Concept Formation Pre-Test | 25.07 | 9.52 | 27.13 | 8.77 |
| Concept Formation Post-Test | 28.66 | 7.85 | 33.29 | 7.11 |
| Numbers Reversed Pre-Test | 10.73 | 3.18 | 11.23 | 4.58 |
| Numbers Reversed Post-Test | 11.13 | 3.29 | 14.90 | 4.69 |
| Word Attack Pre-Test | 19.40 | 7.57 | 20.87 | 8.25 |
| Word Attack Post-Test | 21.00 | 7.69 | 27.29 | 3.78 |
| Pair Cancellation Pre-Test | 47.70 | 15.31 | 51.69 | 12.55 |
| Pair Cancellation Post-Test | 55.37 | 13.06 | 61.24 | 5.33 |
| Sound Awareness Pre-Test | 34.80 | 8.78 | 36.39 | 7.94 |
| Sound Awareness Post-Test | 36.20 | 6.60 | 42.49 | 3.77 |
| Visual-Auditory Learning Difference Score | - 4.43 | 6.37 | - 10.55 | 4.38 |
| Spatial Relations Difference Score | 3.10 | 4.55 | 5.07 | 4.78 |
| Concept Formation Difference Score | 3.60 | 5.56 | 6.28 | 3.90 |
| Numbers Reversed Difference Score | 0.40 | 2.40 | 3.48 | 3.35 |
| Word Attack Difference Score | 1.60 | 3.03 | 5.69 | 4.66 |
| Pair Cancellation Difference Score | 7.67 | 7.91 | 9.55 | 9.40 |
| Sound Awareness Difference Score | 1.40 | 5.41 | 5.03 | 3.82 |

M = Mean
SD = Standard Deviation

## Regression Results (continued)

**Table 4** includes regression results for each test. Beginning with Visual-Auditory Learning skills, the treatment group made significantly fewer mistakes compared to the control group. As the unstandardized beta indicates, being in the treatment group decreased the number of errors by a little more than 6 points.

For Concept Formation, the treatment group realized significantly greater growth of almost 3 points. On this test, race/ethnicity also proved to be a significant variable, where white students reported growth scores of almost 5.5 points lower than minority students. The standardized beta indicates the race/ethnicity variable also appeared to have comparatively greater weight than the intervention variable.

For spatial relations, none of the variables proved to be significant. For Numbers Reversed, the treatment group showed significantly greater growth compared to the control group, and completing the intervention resulted in a growth score that was 3 points greater than in the control group. This pattern was also true for the Word Attack and Sound Awareness tests, where being in the treatment group resulted in a growth score that was around 5 points greater than the control group on both tests, differences that were both significant. On the Pair Cancellation test, the only significant variable was age. In this case, a 1-year increase in age resulted in a growth score that was about $1^{1}/_{2}$ points lower.

### Table 4: Difference Score Regression Results

| Visual-Auditory Learning | Unstandardized β | SE | Standardized β |
|---|---|---|---|
| Race | 2.34 | 2.42 | .118 |
| Treatment/Control | - 6.07 * | 1.50 | - .481 |
| Income | .000 | .000 | .092 |
| Gender | - 1.20 | 1.57 | - .089 |
| Disability | .939 | 1.55 | .074 |
| Age | .015 | .287 | .007 |
| | $F = 3.42, p = .006, R^2 = .195$ | | |
| **Concept Formation** | **Unstandardized β** | **SE** | **Standardized β** |
| Race | - 5.45 * | 1.83 | - .356 |
| Treatment/Control | 2.98 * | 1.13 | .306 |
| Income | .000 | .000 | - .010 |
| Gender | 1.62 | 1.19 | .156 |
| Disability | - 2.19 | 1.17 | - .225 |
| Age | - .301 | .217 | - .166 |
| | $F = 4.00, p = .002, R^2 = .231$ | | |
| **Spatial Relations** | **Unstandardized β** | **SE** | **Standardized β** |
| Race | 2.31 | 2.10 | .147 |
| Treatment/Control | 1.87 | 1.30 | .186 |
| Income | - .000 | .000 | - .004 |
| Gender | 1.73 | 1.36 | .162 |
| Disability | - 1.36 | 1.34 | - .136 |
| Age | .236 | .248 | .127 |
| | $F = 1.48, p = .201, R^2 = .046$ | | |

β = Beta F = F statistic $R^2$ = coefficient of determination
SE = Standard Error p = probability
*p < .05

| Numbers Reversed | Unstandardized β | SE | Standardized β |
|---|---|---|---|
| Race | .328 | 1.25 | .032 |
| Treatment/Control | 3.00 * | .776 | .455 |
| Income | - .000 | .000 | - .192 |
| Sex | .813 | .814 | .116 |
| Disability | .613 | .801 | .093 |
| Age | .119 | .148 | .097 |
| | $F = 3.72, p = .004, R^2 = .214$ | | |
| **Word Attack** | Unstandardized β | SE | Standardized β |
| Race | - 2.06 | 1.72 | - .134 |
| Treatment/Control | 5.28 * | 1.07 | .537 |
| Income | - .000 | .000 | - .038 |
| Gender | 1.41 | 1.12 | .135 |
| Disability | - 1.56 | 1.10 | - .159 |
| Age | - .497 * | .204 | - .272 |
| | $F = 5.92, p = .000, R^2 = .330$ | | |
| **Pair Cancellation** | Unstandardized β | SE | Standardized β |
| Race | - .725 | 3.37 | - .027 |
| Treatment/Control | 3.47 | 2.06 | .203 |
| Income | .000 | .000 | .027 |
| Gender | - .695 | 2.21 | - .038 |
| Disability | - 1.87 | 2.24 | - .109 |
| Age | - 1.58 * | .391 | - .506 |
| | $F = 3.31, p = .008, R^2 = .193$ | | |
| **Sound Awareness** | Unstandardized β | SE | Standardized β |
| Race | - 3.70 | 2.09 | - .211 |
| Treatment/Control | 4.90 * | 1.30 | .438 |
| Income | - .000 | .000 | - .169 |
| Gender | - .930 | 1.36 | - .078 |
| Disability | - .415 | 1.34 | - .037 |
| Age | - .371 | .248 | - .178 |
| | $F = 4.05, p = .002, R^2 = .234$ | | |

β = Beta
SE = Standard Error
F = F statistic
p = probability
$R^2$ = coefficient of determination
*p < .05

## Regression Results (continued)

In addition to the significant variables for each test, it is important to note the $R^2$ values for each. As indicated, none of the models explained more than 33 percent of the variance, with most around 20 percent. This means anywhere from 66 percent to more than 80 percent of the variance in scores remains unexplained by the variables included in these analyses. In some ways, this is not too surprising considering that any number of variables were not measured and included in this analysis, such as other types of instruction (in school or otherwise) students did or did not receive during the study period, health and nutrition variables, or home and school environment. Further research including such variables, randomization in the design, and a larger sample size would substantively contribute to a greater understanding of the effects of the LearningRx program. Nevertheless, these results suggest the LearningRx cognitive skills training can result in greater growth and that the program is worthy of further research.