

Research Report: Arrowsmith Full-Time Program Outcomes

Arrowsmith Overview

In the human brain, networks of neurons are set up to perform particular cognitive functions such as: processing information; seeing relationships and making the connections necessary for insight and conceptualization; forming and retaining memories; navigating in space; recognizing familiar faces; parsing speech; learning motor plans for reading and writing; discriminating speech sounds; visually retaining symbol patterns necessary for reading, spelling and visual template learning; interpreting emotions; and thinking non-verbally.

Enhancement of these cognitive functions that underlie learning in school and throughout life is possible through the targeted application of cognitive programs utilizing the principles of neuroplasticity. This is the basis of the Arrowsmith Program.

The Arrowsmith Program has helped thousands of people over the last 40+ years by using the principles of neuroplasticity to strengthen cognitive functions related to regions and networks of regions of the brain.

The Arrowsmith Program is a suite of cognitive programs that utilize the principles of neuroplasticity to target and strengthen cognitive functions of the brain. The Arrowsmith Program is highly specialized. This neuroplastic approach uses the principles of targeted differential stimulation, active sustained engagement, novelty and complexity and effortful processing.

The Arrowsmith Full-Time Program

The Arrowsmith Full-Time Program involves participants working anywhere from a half to full day (four to eight 30-to-40-minute cognitive periods) five days per week on a series of specific cognitive programs designed to enhance each individual's cognitive profile. Each participant completes a cognitive assessment and the results of this assessment determine the cognitive programs they work on. Participants in this program have been identified as having learning disabilities or learning difficulties.

Arrowsmith's premise: change the brain, change cognitive functioning, change the acquisition of academic skills, and change social-emotional well-being.

Research Outcomes of the Arrowsmith Full-Time Program

The research reported in this document was conducted at schools implementing the Full-Time Arrowsmith Program. All participants were working in-person with their facilitator.

Research on the Full-Time Arrowsmith Program outcomes has demonstrated significant positive changes in:

- neural networks in the brain
- cognitive functioning
- acquisition of academic skills
- emotional intelligence and well-being

The research studies outlined in this Academic Outcomes report are by different investigators, in different schools and organizations implementing the Arrowsmith Program using different research frameworks. The research approach uses multiple designs and measures as recommended by the American Psychological Association in their paper [*More than one way to measure*](#). These research studies all show similar results – that the Arrowsmith Program is effective, resulting in significant improvements.

It is important to note that most participants in the Full-Time Arrowsmith Program complete one period of English and one period of mathematics curriculum per day with the rest of the day being engaged in cognitive programs. Many participants have no academic curriculum as part of their program. The gains in academic skills and in learning are not due to engagement in academic curriculum but due to changes in cognition as a result of the Arrowsmith Program.

For information on the research measures used, See Appendix A: Research Measures Used.

Research on the Full-Time Arrowsmith Program outcomes has demonstrated significant positive changes in:

- neural networks in the brain
- cognitive functioning
- acquisition of academic skills
- emotional intelligence and well-being

This research will be summarized in this document.

For information on additional research, see [Arrowsmith Research](#)

Brain Imaging Outcomes

Study 1: Brain Imaging – Efficiency of Processing

Group

This study was conducted in 2016 by Dr. Lara Boyd at the University of British Columbia on students in their first year of the Arrowsmith Program at three schools, one in the United States and two in Canada. All students were identified as having learning disabilities.

Measures

fMRI Imaging

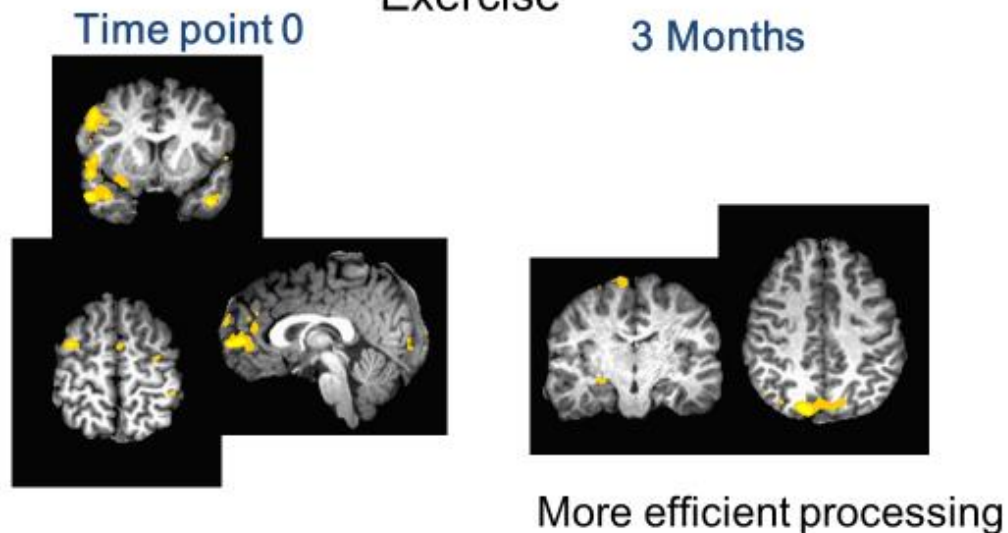
Functional magnetic resonance imaging (fMRI) measures brain activity by measuring changes in cerebral blood flow. Cerebral blood flow and neuronal activation are linked, so when an area of the brain is active, there is an increase in blood flow to that area.

fMRI images were taken prior to intervention, 3 months into the Arrowsmith Program and at the end of 1 year of the program. Students were asked to do a modified Symbol Relations (reasoning) task in the scanner. This research was presented at the 2016 Columbia University Cognitive Remediation in Psychiatry conference in New York City.

Results

Students at 3 months of the Arrowsmith Program required less regions to be activated when performing the reasoning task in the scanner. This change was also seen after 1 year.

fMRI during the Symbol Relations/Reasoning Exercise



Conclusion

Students with learning disabilities involved in the Arrowsmith Program cognitive exercises demonstrated more efficient brain processing when completing the reasoning task at both 3 months and 1 year of the program. Less brain real estate required to perform the task reflects more efficient processing.

Presentation (Peer Reviewed)

This research was presented at the 2016 Columbia University Cognitive Remediation in Psychiatry conference in New York City.

Dr. Lara Boyd. (2016, June). *Brain Plasticity in Children with Learning Disabilities* Cognitive Remediation in Psychiatry, New York City, New York, United States.

Study 1: Brain Imaging – Activation of the Prefrontal Cortex

Group

This study was conducted in 2016 by Dr. Lara Boyd at the University of British Columbia on students in their first year of the Arrowsmith Program at three schools, one in the United States and two in Canada. All students were identified as having learning disabilities.

Measures

Resting-state fMRI Imaging

Resting state fMRI is a method of brain imaging designed to investigate networks in the brain when no task is involved.

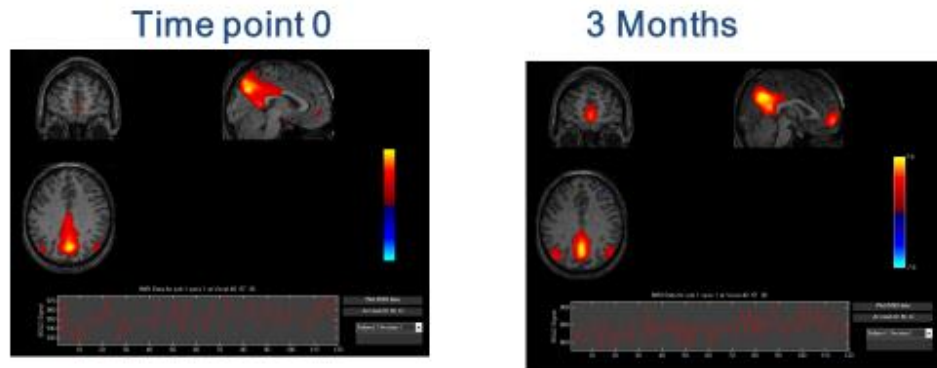
fMRI images were taken while students were in a 'resting state', prior to intervention, 3 months into the Arrowsmith Program and at the end of 1 year of the program. This research was presented at the 2016 Columbia University Cognitive Remediation in Psychiatry conference in New York City.

Results

Students at 3 months of the Arrowsmith Program showed an increase in activation in the prefrontal cortex. This change was also seen after 1 year.

The prefrontal cortex is critical for problem solving, strategy generation, working memory and mental initiative in all aspects of learning so increased activation indicates improvements in these cognitive functions.

Resting State Brain Activity



Increased Activation in the Prefrontal Cortex

Conclusion

Students with learning disabilities involved in the Arrowsmith Program cognitive exercises demonstrated increased activation in the prefrontal cortex both at three months and at one year of the program. This region is critical for executive functioning.

Presentation (Peer Reviewed)

This research was presented at the 2016 Columbia University Cognitive Remediation in Psychiatry conference in New York City.

Dr. Lara Boyd. (2016, June). *Brain Plasticity in Children with Learning Disabilities* Cognitive Remediation in Psychiatry, New York City, New York, United States.

Study 1: Brain Imaging – Connectivity Within and Between Brain Networks

Group

This study in 2016 investigated connectivity within brain networks and between brain networks in adolescents (ages 13 to 19) who did not have learning disabilities and those who did have learning disabilities. Dr. Gregory Rose and Dr. Audreyana Jagger-Rickels of the University of Southern Illinois conducted the research. which was presented in a peer-reviewed poster session at the 2019 Cognitive Neuroscience Society Annual Conference in San Francisco.

Measures

Resting-state fMRI Imaging

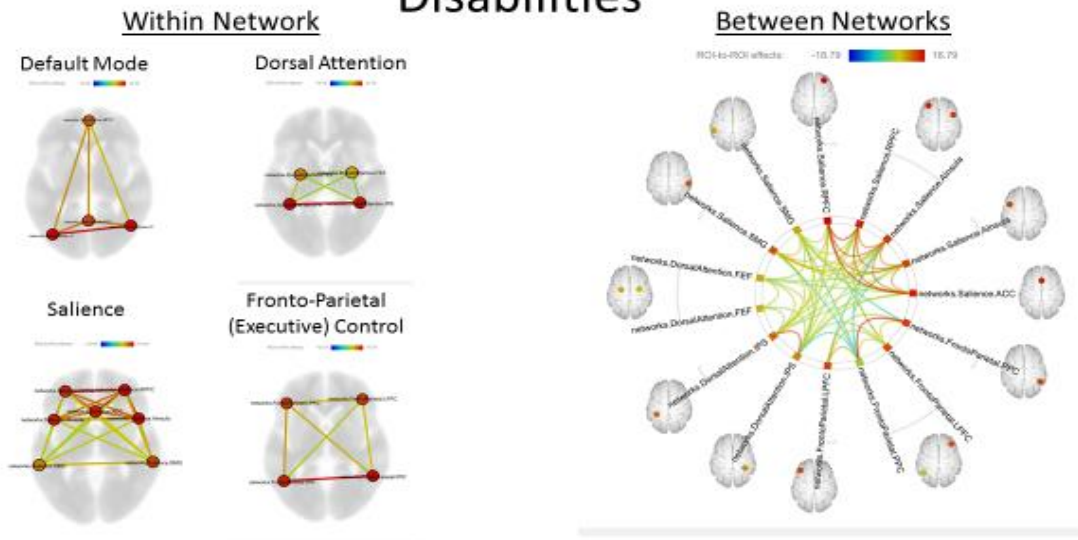
Results

When the brain networks of Arrowsmith Program students identified as having learning disabilities were compared to students not identified as having learning disabilities the following pattern was found for the students with learning disabilities:

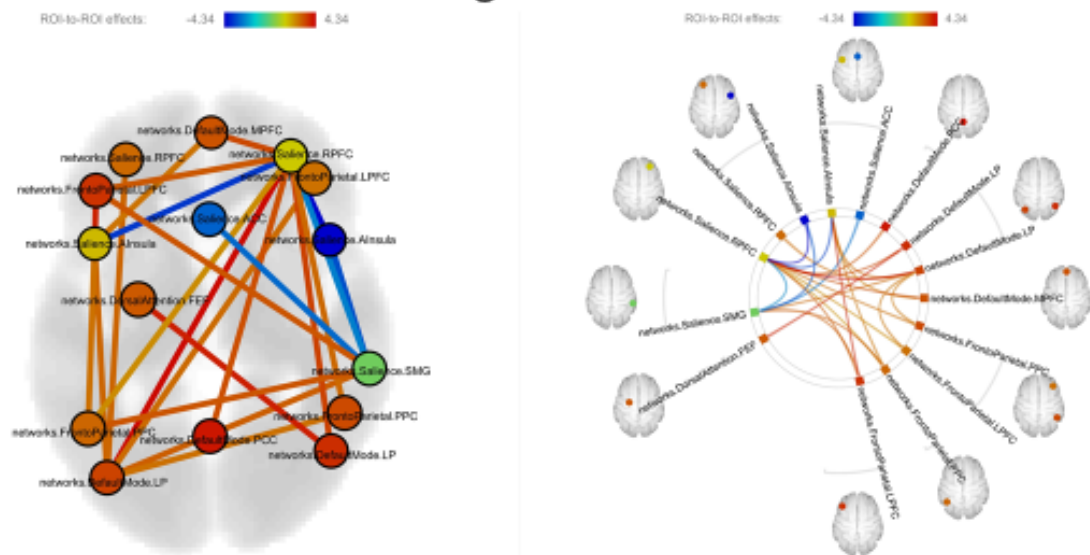
- A number of areas with less strong connections or under-connectivity
- A number of areas with much stronger connections or hyper-connectivity

This suggests that the brain networks of the students with learning disabilities are working harder and less efficiently than those of students without learning challenges. It is hypothesized that the hyper-connectivity is in response to the brain working harder to compensate for the areas that are under-connected and that this hyper-connectivity is a compensatory strategy to account for a loss of structural connectivity and that it comes at a cost of slowed processing speed and cognitive fatigue.

Connectivity in Students without Learning Disabilities



Network Connectivity is Altered in Arrowsmith Students with Learning Disabilities



Red lines indicate connections that are stronger, and blue lines weaker, in Arrowsmith students

Conclusion

The brain networks of Arrowsmith Program students identified as having learning disabilities show a pattern of both under-connectivity (areas with less strong connections) and hyper-connectivity (areas with much stronger connections) than those of individuals not identified as having learning disabilities. It is important to note these images of the Arrowsmith students were taken prior to their engaging in the Arrowsmith Program cognitive exercises.

Presentation (Peer Reviewed)

This research was presented in a peer-reviewed poster session at the 2019 Cognitive Neuroscience Society Annual Conference in San Francisco.

Audreyana C. Jagger-Rickels, Greg M. Rose and Michelle Y. Kibby. (2019, March). *Effect of comorbid learning and neurodevelopmental disorders in resting-state functional and effective connectivity in adolescents* [Presentation]. Cognitive Neuroscience Society Annual Conference, San Francisco, CA, United States.

[Effect of comorbid learning and neurodevelopmental disorders in resting-state functional and effective connectivity in adolescents](#)

Brain Imaging Outcomes

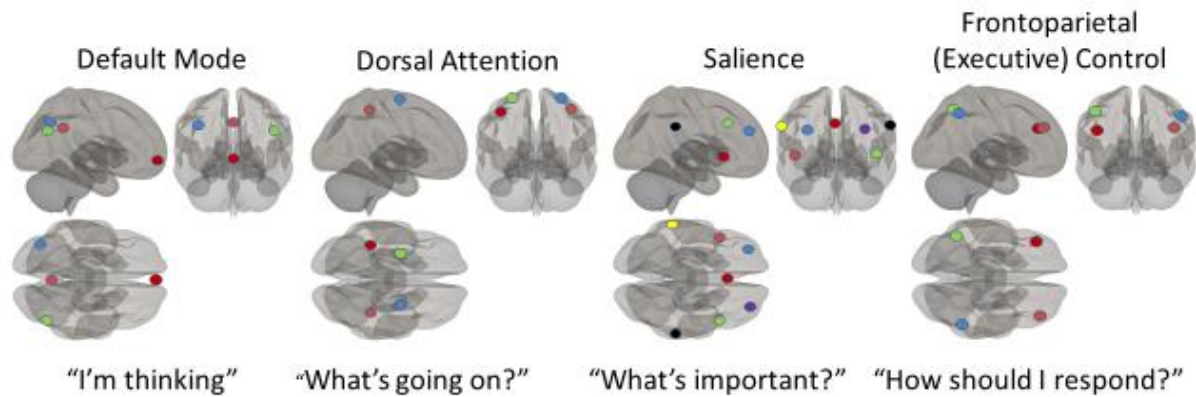
Study 1: Brain Imaging – Network Connectivity Changes

Group

This study in 2018 investigated the connectivity changes in the brain of students with learning disabilities participating in their first year of the Arrowsmith Program at two schools in Canada. This research was conducted by Dr. Gregory Rose and Dr. Audreyana Jagger-Rickels of the University of Southern Illinois. These students engaged in 6 periods of cognitive programs and one period each of English and mathematics each day over the course of the school year.

Neural Networks Being Investigated

For context, it is useful to understand that Dr. Gregory Rose of the University of Southern Illinois, in his ongoing research into the outcomes of the Arrowsmith Program, is focusing on the following four brain networks in the image below. These four networks are all part of what are called resting state networks (RSNs), of which there are least a dozen identified so far by neuroscientists. RSNs are networks comprised of groups of brain regions that coordinate their activity to perform specific functions, and this can be observed even when the brain is not actively engaged in a task but is in a ready state. This makes it relatively easy to study and the data acquisition method is easily standardized. The general function of each of these networks is identified by the statement or question noted under each image below.



The dots in each brain image represent regions of the brain that are active within that network

Measures

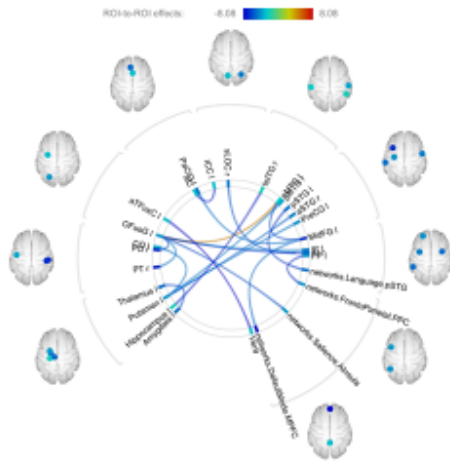
Resting-state fMRI Imaging

Results

After a 10-month academic year in the full time Arrowsmith Program, the imaging data shows that the under-connected areas in the brains of the students with learning disabilities have strengthened in connectivity and are approximating what is being seen in the brains of students without learning disabilities. As this occurs, the hyper-connected areas have toned down and don't have to work to compensate for the under connected regions.

Changes in connectivity within and between the four networks under investigation showed significant positive change.

Connectivity Changes After One Academic Year of Arrowsmith



Overall, the effect of Arrowsmith training is to:

- reduce the hyper-connectivity between brain regions seen before training
- increase strength of connections in areas of under-connectivity seen before training

It is reasonable to postulate that these brain changes underlie the changes reported later in this research report on standardized cognitive measures, academic measures, and measures of social-emotional well-being for students in the Full-Time Arrowsmith Program.

Conclusion

One year of participation in the full time Arrowsmith Program leads to changes in brain connectivity both within networks and between networks such that the brains of the individuals identified as having learning disabilities are now appearing more like the brains of students without learning disabilities.

Presentation

Greg Rose. (2019, July). *Research studies of the effects of Arrowsmith training on brain connectivity and neuropsychological measures*. [Presentation]. Toronto, Canada.

Effects of Arrowsmith Program on brain connectivity and neuropsychological measures

Cognitive Outcomes

Study 1: Cognitive Outcomes

Group

This study in 2014 examined the effects of Arrowsmith on cognitive outcomes over one school year for students identified as having learning disabilities enrolled at Arrowsmith School in Toronto. Dr. Brad Hale's research team in the Brain Gain Lab at the University of Calgary conducted the study. Each day, the students received one period of English and one period of mathematics and six periods of cognitive programs to strengthen the weak cognitive capacities underlying their learning disabilities.

Measures

Woodcock-Johnson III Tests of Cognitive Abilities

The Woodcock-Johnson III Tests of Cognitive Abilities is an individually administered, norm-referenced instrument that measures specific cognitive abilities in persons aged 2 to 90.

Results

The results of outcomes on cognitive measures on the Woodcock Johnson III Tests of Cognitive Abilities were presented in a peer-reviewed poster session at the 2014 American Psychological Association Conference in Washington, D.C.

For students engaged in the Arrowsmith cognitive exercise program statistically significant gains were found in the following cognitive measures:

- auditory processing
- fluid reasoning
- processing speed
- short-term memory
- phonemic awareness
- working memory

Effects of the Arrowsmith Program on Cognition

Pre-Post Mean Differences on WJ-III Cognitive Abilities

CHC Factors	Subtests		Mean (SS)	t	P
Auditory Processing	Sound Blending	Pre	102.00	2.01	< .001
		Post	115.87		
Fluid Reasoning	Concept Formation	Pre	105.73	5.61	< .001
		Post	114.27		
Processing Speed	Visual Matching	Pre	69.47	12.92	< .001
		Post	89.00		
	Decision Speed	Pre	79.87	5.85	< .001
		Post	95.47		
Short-Term Memory	Numbers Reversed	Pre	87.33	5.14	< .001
		Post	96.87		
	Memory for Words	Pre	94.20	7.27	< .001
		Post	111.67		
Phonemic Awareness	Incomplete Words	Pre	84.75	6.06	< .001
		Post	102.80		
Working Memory	Auditory Working Memory	Pre	96.20	4.40	< .001
		Post	101.80		

Significant Improvements in

- Auditory Processing
- Fluid Reasoning
- Processing Speed
- Short-Term Memory
- Phonemic Awareness
- Working Memory

Children showed significant improvement across cognitive domains

Conclusion

The researchers' conclusion: *"Targeted and individualized interventions designed to remediate cognitive deficits lead to improved academic performance across a broad range of domains [and that] brain plasticity allows for restructuring of cognitive processes, thereby enabling improved cognition and academic performance."*

Presentation (Peer Reviewed)

The results of outcomes on cognitive measures on the Woodcock-Johnson III Tests of Cognitive Abilities were presented in a peer-reviewed poster session at the 2014 American Psychological Association Conference in Washington, D.C.

Kim R. Fitzer, Hanna A. Kubas, Jessica A. Carmichael, Howard Eaton, James B. Hale. (2014, August). *A brain-based intervention program that changes cognition: implications for academic achievement*. [Presentation]. American Psychological Association Conference, Washington, D.C, United States.

[A brain-based intervention program that changes cognition: Implications for academic achievement](#)

Study 2: Cognitive Outcomes

Group

This study in 2016 was conducted by Dr. Lara Boyd and Dr. Rachel Weber at the University of British Columbia on students in their first year of the Arrowsmith Program at three schools, one in the United States and two in Canada. Each day these students received two academic periods (one of English and one of mathematics) and six periods of cognitive programs designed to address their learning disabilities.

Measures

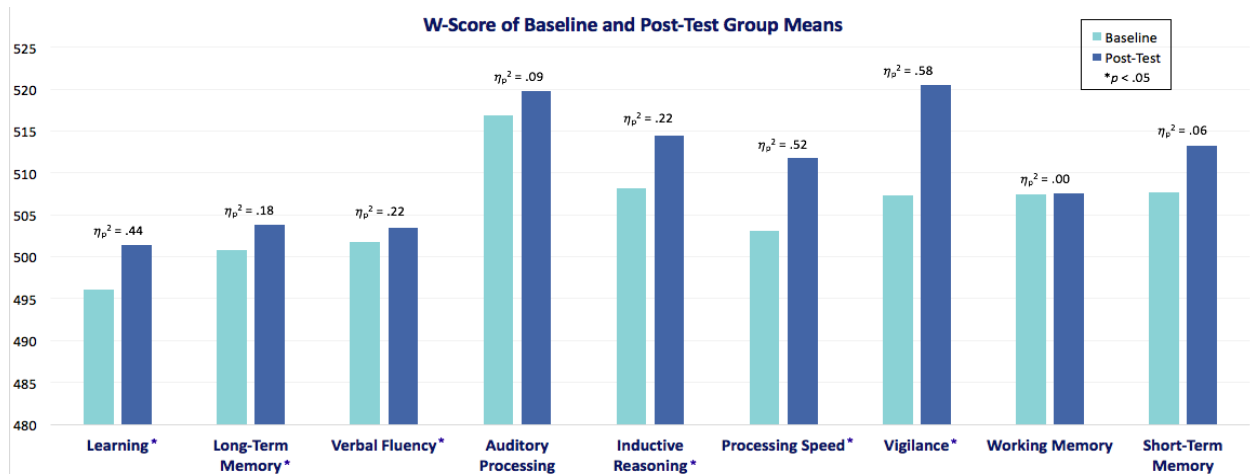
Woodcock Johnson III Tests of Cognitive Abilities

Results

Student performance in September was compared to performance in May (one academic year). Changes on all tests noted with an asterisk were at statistical significance. This research was presented in a peer-reviewed poster session at the 2019 International Neuropsychological Society conference in New York City and published in the peer-reviewed journal Learning: Research and Practice.

Significant positive cognitive ability gains were found on the following cognitive measures:

- Learning (Verbal-Auditory Learning)
- Long-term Memory (Verbal-Auditory Learning Delayed)
- Verbal Fluency (Retrieval Fluency)
- Inductive Reasoning (Concept Formation)
- Processing Speed (Decision Speed)
- Vigilance and Sustained Attention (Pair Cancellation)



Conclusion

Students with learning disabilities participating in the Arrowsmith cognitive programs over an academic year demonstrated significant gains in cognitive abilities on standardized measures.

Publication (Peer Reviewed)

Rachel C. Weber, Ronan Denyer, Negin Motamed Yeganeh, Rachel Maja, Meagan Murphy, Stephanie Martin, Larissa Chiu, Veronique Nguy, Katherine White & Lara Boyd (2019): Interpreting the preliminary outcomes of the Arrowsmith programme: a neuroimaging and behavioural study, *Learning: Research and Practice*, DOI: 10.1080/23735082.2019.1674908

[Outcomes of the Arrowsmith Program: A neuroimaging and behavioural study](#)

Negin Motamed Yeganeh, Rachel King, Lara A. Boyd, Gregory M. Rose & Rachel C. Weber (2021) Symbol relations training improves cognitive functioning in students with neurodevelopmental disorders, *Applied Neuropsychology: Child*, 11:4, 789–796, DOI: [10.1080/21622965.2021.1967154](https://doi.org/10.1080/21622965.2021.1967154)

[Symbol relations training improves cognitive functioning Applied Neuropsychology Child 2021](#)

Presentation

This research was presented in a peer-reviewed poster session at the 2019 International Neuropsychological Society conference in New York City and published in the peer-reviewed journal *Learning: Research and Practice*.

Lara Boyd and Rachel C. Weber. (2019, March). *Neurocognitive and behavioral outcomes of the Arrowsmith program*. [Presentation]. University of British Columbia, Vancouver, B.C.

[Neurocognitive and behavioral outcomes of the Arrowsmith Program University of British Columbia Research Presentation March 2019](#)

Presentation (Peer Reviewed)

Rachel Maja, Negin Motamed-Yeganeh, Ronan Denyer, Larissa K. Chiu, Lara Boyd and Rachel C. Weber. (2019, February). *Cognitive outcomes of the Arrowsmith Program*. [Presentation]. International Neuropsychological Society Conference, New York City, N.Y., United States.

Study 3: Cognitive Outcomes

Group

This study investigated the cognitive outcomes over the 2017–2018 school year for students identified as having learning disabilities. These students were in their first year of the Arrowsmith Program at two schools in Canada. Each day these students received one period of English and one period of mathematics, and six periods of cognitive programs designed to strengthen the weak cognitive capacities underlying their learning disabilities. The study was conducted by Dr. Gregory Rose and Dr. Audreyana Jagger-Rickels of the University of Southern Illinois.

Measures

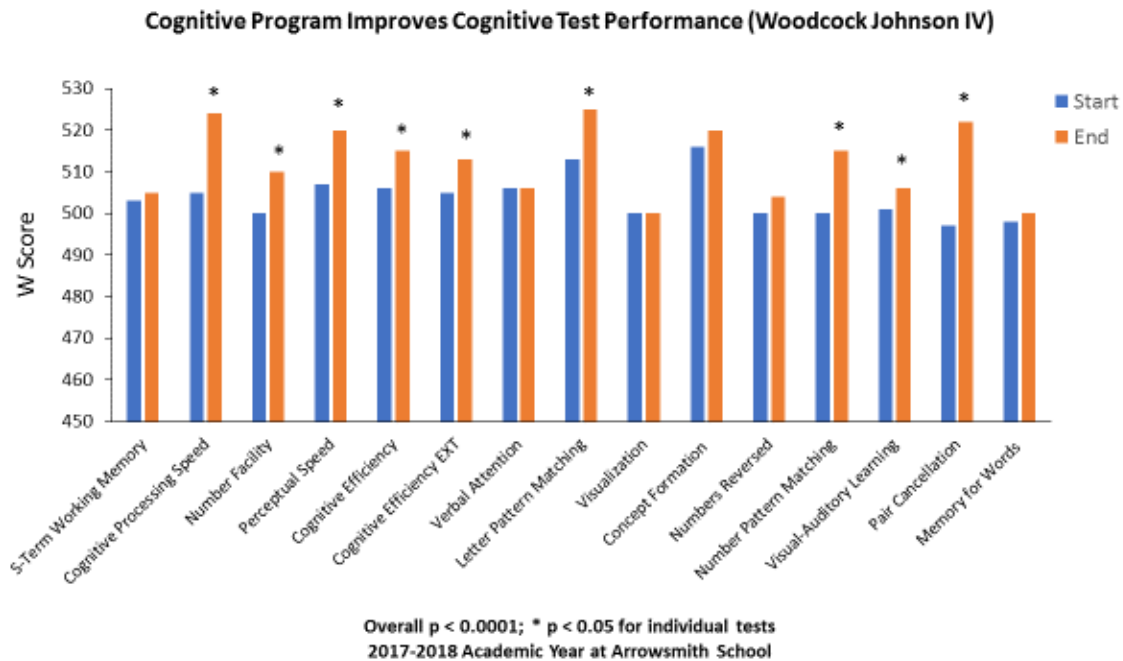
Woodcock Johnson IV Tests of Cognitive Abilities

Results

Student performance in September was compared to performance in May. Changes on all tests noted with an asterisk on the graph below were at statistical significance.

Significant positive cognitive ability gains were found on the following cognitive measures:

- Cognitive Processing Speed
- Cognitive Efficiency
- Perceptual Speed
- Visual Auditory Learning
- Pair Cancellation
- Number Facility
- Number Pattern Matching
- Letter Pattern Matching



Conclusion

Students with learning disabilities participating in the Arrowsmith cognitive programs over an academic year demonstrated significant gains in cognitive abilities on standardized measures.

Presentations

Greg Rose, Audreyana Jagger-Rickels, and Rich Collins. (2019, March). *Benefits of Arrowsmith training on brain connectivity and neuropsychological measures*. [Presentation]. University of British Columbia, Vancouver, B.C.

[Benefits of Arrowsmith training on brain connectivity and neuropsychological measures University of British Columbia Research Presentation March 2019](#)

Greg Rose. (2019, July). *Research studies of the effects of Arrowsmith training on brain connectivity and neuropsychological measures*. [Presentation]. Toronto, Canada.

[Effects of Arrowsmith program on brain connectivity and neuropsychological measures](#)

Academic Outcomes

Study 1: Academic Outcomes – Rate of Learning

Group

This study conducted in 2007, investigated the rate of acquisition of a series of academic skills for 60 learning disabled students in grade 3 to 9 in seven schools in the Toronto Catholic District School Board. The academic skills measured were:

- word recognition (the ability to read words accurately)
- reading speed
- reading comprehension
- arithmetic

Prior to the start of the study, all of these students were receiving a full day of academic classes with special education academic remedial support. Standardized measures, on average, showed that these students were acquiring academic skills at a rate of .5 to .6 of a grade per year.

These students then enrolled in the Arrowsmith Program and over the course of the year of the study, engaged in cognitive exercises designed to strengthen their weak learning capacities for 50% of their school day and academic curriculum for the other 50% of the day.

Data was also collected on 50 of the original 60 students after two years in the Arrowsmith Program, and these gains in rate of learning continued.

Measures

Wide Range Achievement Test – Word Recognition

An academic skills assessment which measures reading skills.

Wide Range Achievement Test – Arithmetic

An academic skills assessment which measures math skills.

Monroe-Sherman Achievement Test – Passage Comprehension

An academic skills test that measures reading comprehension.

Monroe-Sherman Achievement Test – Reading Speed

An academic skills test that measures reading speed.

Results

Data was collected at the end of one school year, on standardized measures. The students' rate of learning doubled and, in some cases, tripled. For students who were in their 2nd year in the program, these gains in rate of learning continued.

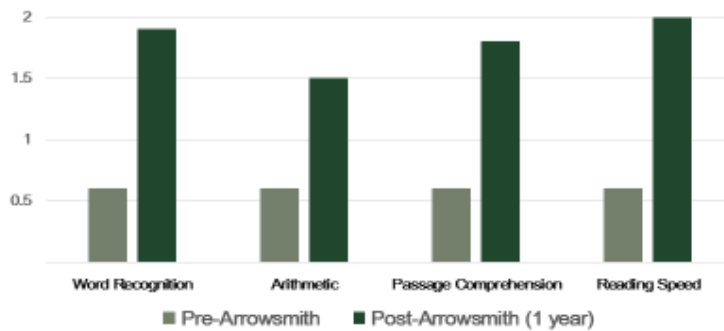
The average increase in the rate of acquisition of specific academic skills for students from prior to participation in the Arrowsmith Program compared to the results after one to two years in the program was as follows:

- Word Recognition – 3 times faster
- Arithmetic – 1.5 to 2 times faster
- Reading Comprehension – 2 to 3 times faster
- Reading Speed – 2 to 3 times faster

These gains on standardized academic tests were supported by student, teacher, and parent observations of improvement in these academic areas which appear in the extended report.

Cognitive Enhancement: Impact on Rate of Learning

Average grade gain per year prior to Arrowsmith and at the end of one year in the Arrowsmith Program at the Toronto Catholic District School Board (TCDSB)



Rate of learning accelerates after one year of Arrowsmith Program exercises
 60 students in grades 3 to 9 (majority of students in grades 4 to 8)
 Report on the Arrowsmith Program in the Toronto Catholic District School Board, 2007

Additional Data

These gains on standardized academic tests were supported by student, teacher, and parent observations of improvement in these academic areas which appear in the extended report.

Conclusion

An increased rate of learning of acquisition of academic skills was demonstrated for students with learning disabilities who participated in the Arrowsmith cognitive program over the course of one and two academic years, despite exposure to 50% less academic curriculum.

Research Report

[Report on the Arrowsmith Program in the Toronto Catholic District School Board](#)

Study 1: Academic Outcomes – Academic Achievement

Group

This study In August 2014, at Camperdown Academy in South Carolina, a school for students with dyslexia, had all students in grade 2 work on two cognitive programs, 40 minutes each per day five days per week over the academic year. These were the Motor Symbol Sequencing program, and the Symbol Relations program.

Motor Symbol Sequencing is involved in motor planning necessary for writing and reading. Symbol Relations is involved in understanding, comprehension, reasoning, and speed of processing ideas.

Results

Over the course of the year, students showed improvement in a range of academic areas:

- Reading
- Spelling
- Writing
- comprehension

Students also demonstrated improvements in cognitive areas critical to learning:

- attention
- memory
- planning
- goal setting
- self-organization

Whole Cohort Program – Grade 2

Motor Symbol Sequencing and Symbol Relations Cognitive Programs

Students Engaged in two 40-minute cognitive periods per day five days per week

Significant improvements in

Reading
Spelling
Writing

Memory
Comprehension
Attention

Setting Goals
Self-Organization
Planning

Students receiving the cognitive program in grade 2, when tested in grade 3 on a math accuracy test, out-performed the grade 4 and 5 students and demonstrated a significantly greater willingness to tackle more difficult math problems

Additional Data

The teacher implementing this program at Camperdown Academy commented, “There’s something about Arrowsmith—it makes students excited to try something new.” This work, by building cognitive resources gives students the capacity to be successful when trying something new.

Students who had worked on the cognitive programs in grade 2, when they were in grade 3, they outperformed grade 4 and 5 students on a math accuracy test and demonstrated more willingness to attempt more difficult math problems.

Conclusion

Improved academic achievement and an increase in several cognitive skills necessary for learning were demonstrated over the course of one academic year for students with dyslexia who participated in the daily Arrowsmith Whole Cohort cognitive program.

Study 2: Academic Outcomes – Academic Achievement

Group

This study in 2014 examined the effects of Arrowsmith on academic performance over one school year for students identified as having learning disabilities enrolled at Arrowsmith School in Toronto. Dr. Brad Hale’s research team in the Brain Gain Lab at the University of Calgary conducted the study. Each day the students received one period of English and one period of mathematics and six periods of cognitive programs to strengthen the weak cognitive capacities underlying their learning disabilities.

Measures

Woodcock-Johnson III Achievement Test

Results

The results of outcomes on academic measures on the Woodcock Johnson III Tests of Achievement were presented in a peer-reviewed poster session at the 2014 Canadian Psychological Association Conference in Vancouver, Canada.

For students engaged in the Arrowsmith cognitive exercise program statistically significant gains were found in the following measures of academic achievement:

- word recognition
- reading fluency
- reading comprehension, word attack (blending sounds into words)
- math calculation
- math fluency
- quantitative concepts
- spelling
- writing fluency
- writing samples
- understanding directions

Effects of the Arrowsmith Program on Academic Performance

Pre-Post Mean Differences on WJ-III Achievement Tests

Cluster	Subtest		Mean (SS)	t	P
Reading	Letter Word Identification	Pre	87.80	5.57	< .001
		Post	98.53		
	Reading Fluency	Pre	81.50	8.48	< .001
		Post	90.14		
	Passage Comprehension	Pre	85.53	8.85	< .001
		Post	96.20		
Mathematics	Word Attack	Pre	88.53	5.21	< .001
		Post	101.95		
	Calculation	Pre	82.47	11.69	< .001
		Post	94.13		
	Math Fluency	Pre	72.47	6.61	< .001
		Post	84.07		
Writing	Quantitative Concepts	Pre	87.60	6.20	< .001
		Post	101.27		
	Spelling	Pre	81.93	5.40	< .001
		Post	91.00		
	Writing Fluency	Pre	74.85	8.15	< .001
		Post	94.69		
Receptive Language	Writing Samples	Pre	84.73	7.48	< .001
		Post	100.80		
	Understanding Directions	Pre	95.07	4.62	< .001
		Post	98.02		

Significant Improvements in

- **Broad Reading**
- **Mathematics**
- **Writing**
- **Receptive Language**

Strengthening cognitive/neuropsychological functions presumed to underlie academic achievement deficits improves reading, mathematics, and writing by targeting the cause (cognitive deficit) rather than the symptoms (achievement deficit).

Conclusion

The researchers' conclusion was: *"Strengthening cognitive/neuropsychological functions presumed to underlie academic achievement deficits improves reading, mathematics, and writing by targeting the cause (cognitive deficit) rather than the symptoms (achievement deficit)."*

Presentation (Peer Reviewed)

The results of outcomes on academic measures on the Woodcock Johnson III Tests of Achievement were presented in a peer-reviewed poster session at the 2014 Canadian Psychological Association Conference in Vancouver, Canada.

Hanna A. Kubas, Jessica A. Carmichael, Kim R. Fitzner, James B. Hale. (2014, June). *Effects of the Arrowsmith program on academic performance: a pilot study* [Presentation]. Canadian Psychological Association Conference, Vancouver, B.C., Canada.

[Effects of the Arrowsmith Program on academic performance](#)

Study 3: Academic Outcomes – Academic Achievement

Group

This study in 2016 investigated the academic outcomes for students in their first year of the Arrowsmith Program at three schools, one in the United States and two in Canada. Each day, these students were receiving two academic periods (one of English and one of mathematics) and six periods of cognitive programs designed to address their learning disabilities.

The research was conducted by Dr. Lara Boyd and Dr. Rachel Weber at the University of British Columbia.

Measures

Woodcock Johnson III Tests of Achievement

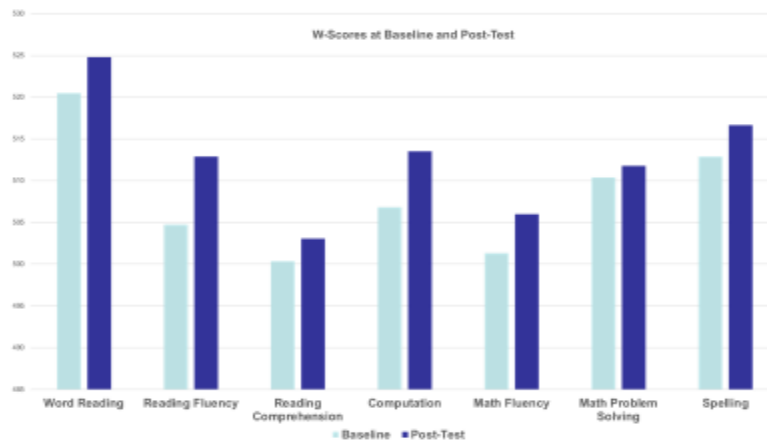
Student performance in September was compared to performance in May (one academic year).

Results

Significant positive academic achievement gains were found on the following measures of academic achievement:

- Word Reading
- Reading Fluency
- Computation
- Math Fluency
- Spelling

RESULTS –ACADEMIC ACHIEVEMENT IMPROVEMENT



Significant:
Word Reading; Reading Fluency; Computation; Math Fluency; Spelling

Conclusion

Significant gains in academic performance on a standardized measure was demonstrated for students with learning disabilities in three schools participating in the Full-Time Arrowsmith cognitive program over an academic year.

Publication (Peer Reviewed)

Rachel C. Weber, Ronan Denyer, Negin Motamed Yeganeh, Rachel Maja, Meagan Murphy, Stephanie Martin, Larissa Chiu, Veronique Nguy, Katherine White & Lara Boyd (2019): Interpreting the preliminary outcomes of the Arrowsmith programme: a neuroimaging and behavioural study, *Learning: Research and Practice*, DOI: 10.1080/23735082.2019.1674908

[Interpreting the preliminary outcomes of the Arrowsmith programme: a neuroimaging and behavioural study](#)

Presentation

This research was presented in a peer-reviewed poster session at the 2019 International Neuropsychological Society conference in New York City.

Lara Boyd and Rachel C. Weber. (2019, March). *Neurocognitive and behavioral outcomes of the Arrowsmith program*. [Presentation]. University of British Columbia, Vancouver, B.C.

[Neurocognitive and behavioral outcomes of the Arrowsmith Program University of British Columbia Research Presentation March 2019](#)

Greg Rose, Audreyana Jagger-Rickels, and Rich Collins. (2019, March). *Benefits of Arrowsmith training on brain connectivity and neuropsychological measures*. [Presentation]. University of British Columbia, Vancouver, B.C.

[Benefits of Arrowsmith training on brain connectivity and neuropsychological measures University of British Columbia Research Presentation March 2019](#)

Presentation (Peer Reviewed)

Megan Murphy, Ronan Denyer, Veronique Nguy, Lara Boyd and Rachel C. Weber. (2019, February). *Academic outcomes of the Arrowsmith program*. [Presentation]. International Neuropsychological Society Conference, New York City, N.Y., United States.

Study 4: Academic Outcomes – Academic Achievement

Group

This study investigated the academic outcomes over the 2017–2018 school year for students identified as having learning disabilities. These students were in their first year of the Arrowsmith Program at two schools in Canada. Each day these students received one period of English and one period of mathematics, and six periods of cognitive programs designed to strengthen the weak cognitive capacities underlying their learning disabilities.

The study was conducted by Dr. Gregory Rose and Dr. Audreyana Jagger-Rickels of the University of Southern Illinois.

Measures

Woodcock Johnson IV Tests of Achievement

Student performance in September was compared to performance in May.

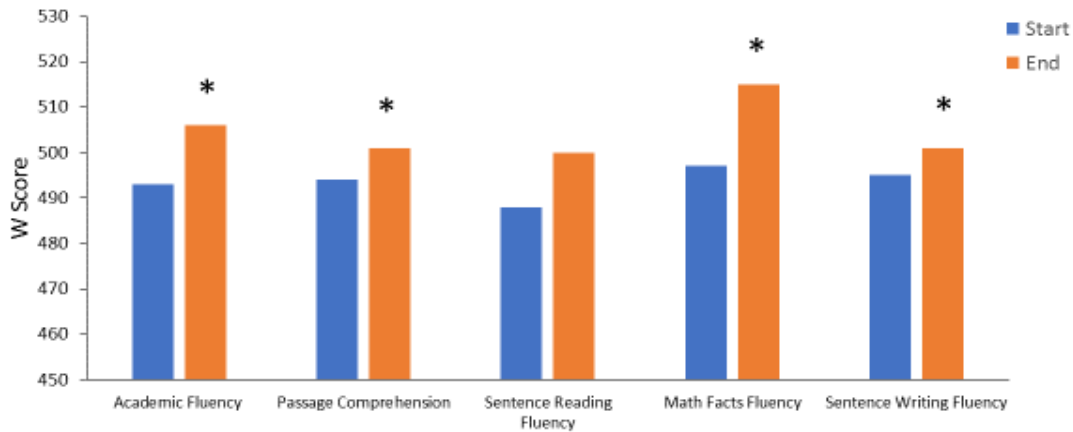
Results

Changes on all tests noted with an asterisk on the graph below were at statistical significance.

Significant positive academic achievement gains were found on the following measures of academic achievement:

- Passage Comprehension
- Academic Fluency
- Math Facts Fluency
- Sentence Writing Fluency

Cognitive Program Improves Academic Achievement Test Performance (Woodcock Johnson IV)



Overall $p < 0.0001$; * $p < 0.05$ for individual tests
2017-2018 Academic Year at Arrowsmith School

Conclusion

Significant gains in academic performance on a standardized measure was demonstrated for students with learning disabilities in two schools participating in the Full-Time Arrowsmith cognitive program over an academic year.

Presentation

Greg Rose. (2019, July). *Research studies of the effects of Arrowsmith training on brain connectivity and neuropsychological measures*. [Presentation]. Toronto, Canada.

[Effects of Arrowsmith training on brain connectivity and neuropsychological measures](#)

Study 1: Academic Outcomes – Average Academic Growth

Group

This study in 2015 investigated the average academic growth over a school year on academic measures for students in an Arrowsmith Program compared to those in mainstream academic curriculum.

Students at Holy Trinity Parish Schools in Australia each year undergo standardized testing on measures of Mathematics and Reading Comprehension. These measures, designed by the Australian Council for Education Research, are administered at the beginning and end of the school year for each grade. The average growth in academic skills is calculated for the students in each grade based on their performance over the course of one school year on these measures. The 'average academic growth' is the average gain these students make in each grade on these academic measures. The results over the course of the academic year for students in grade 3, grade 4 and grade 5 for students identified as having learning disabilities and enrolled in the Arrowsmith Program who received 50% less academic curriculum were compared to those of all students in the regular academic classes receiving full day academic curriculum.

Measures

PAT – Maths

An achievement test developed by the Australian Council for Educational Research to assess mathematical ability and measure growth from Years 1 to 10, It is mapped to the Australian, Victorian and New South Wales curriculum.

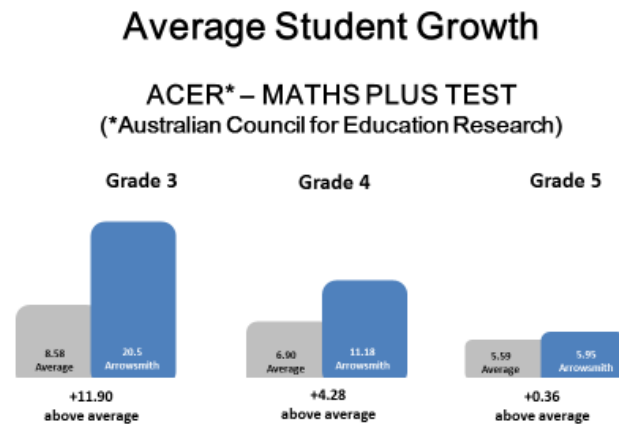
PAT – Reading

An achievement test developed by the Australian Council for Educational Research to assess reading comprehension and measure growth from Years 1 to 10, It is mapped to the Australian, Victorian and New South Wales curriculum.

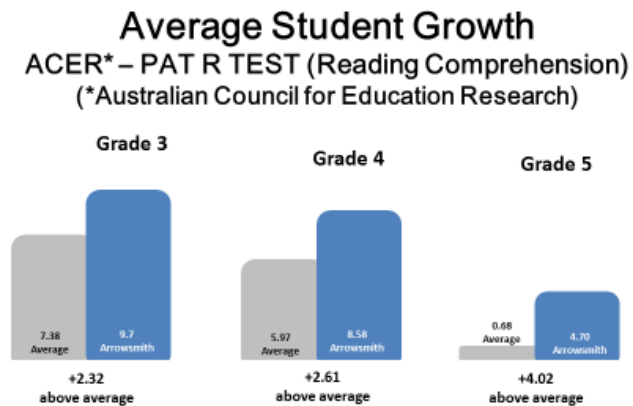
Results

In each grade the students receiving the Arrowsmith cognitive programs showed greater average academic growth on the standardized measures of Mathematics and Reading Comprehension than students in the mainstream curriculum classes.

PAT – Maths



PAT – Reading



Conclusion

Greater than average academic growth in Mathematics and Reading Comprehension on standardized academic measures were demonstrated for students with learning difficulties participating in the Arrowsmith cognitive program over the course of an academic year compared to students in regular mainstream academic classrooms. The Arrowsmith group made these gains while involved in 50% less academic curriculum.

Study 1: Academic Outcomes – Academic and Learning Behaviours

Group

A study in 2007 was conducted on students in the Arrowsmith Program in the Toronto Catholic District School Board (TCDSB). These students were in grades 3 to 9 in seven schools and all were identified by the school board as having learning disabilities.

Measures

TCDSB Survey Questionnaire

A survey questionnaire was developed in collaboration with TCDSB research and education staff to measure academic and learning behaviours.

As part of the study, students, parents and teachers rated change on a range of student behaviours over the course of a year in the program.

Results

The results on behaviours related to academic skills and general learning abilities appear in the following chart. The number of individuals rating each item appear beside each rater for that item.

Parents, students and teachers all reported noticeable change on:

Academic behaviours

- reading comprehension
- legibility of written work
- reads for pleasure
- understanding ideas
- remembering factual information
- willingness to attempt/complete homework
- understanding and following instructions
- telling time

General behaviours required for learning

- ability to focus
- listening skills
- organizational skills

IMPROVEMENT RATING				
		OF THOSE FOR WHOM THIS WAS A CONCERN		
	% Never A Concern	% No Change	% Noticeable Change	% Extremely Noticeable Change
Ability to Focus				
Student Rating n=42	12%	7%	65%	16%
Parent Rating n=62	5%	11%	60%	24%
Teacher Rating n=55	13%	7%	53%	27%
Understanding / Following Instructions				
Student Rating n=41	5%	10%	53%	32%
Parent Rating n=54	4%	9%	67%	20%
Teacher Rating n=55	7%	0%	62%	31%
Listening Skills				
Student Rating n=42	14%	10%	55%	21%
Parent Rating n=47	4%	17%	60%	19%
Teacher Rating n=54	18%	2%	54%	26%

Organizational Skills				
Student Rating n=42	14%	14%	51%	21%
Parent Rating n=45	2%	22%	56%	20%
Teacher Rating n=55	11%	4%	56%	29%
Willingness to Attempt/Complete Homework				
Student Rating n=42	10%	7%	50%	33%
Parent Rating n=58	1%	9%	43%	47%
Teacher Rating n=55	13%	7%	42%	38%
Remembering Factual Information				
Student Rating n=42	10%	10%	47%	33%
Parent Rating n=55	4%	12%	57%	27%
Teacher Rating n=55	4%	5%	60%	31%
Understanding Ideas				
Student Rating n=42	12%	7%	60%	21%
Parent Rating n=58	5%	10%	57%	28%
Teacher Rating n=55	7%	2%	56%	35%
Legibility of Written Work				
Student Rating n=42	5%	12%	50%	33%
Parent Rating n=53	2%	15%	49%	34%
Teacher Rating n=54	13%	4%	55%	28%

Reading Comprehension				
Student Rating n=42	12%	7%	44%	37%
Parent Rating n=57	14%	7%	58%	21%
Teacher Rating n=54	2%	7%	41%	50%
Reads for Pleasure				
Student Rating n=39	13%	28%	41%	18%
Parent Rating n=54	7%	39%	34%	20%
Teacher Rating n=54	7%	20%	43%	30%
Telling Time				
Student Rating n=41	17%	7%	17%	59%
Parent Rating n=51	14%	18%	31%	37%
Teacher Rating n=54	4%	7%	37%	52%

Conclusion

Noticeable change in academic and general behaviours required for learning were demonstrated for students with learning disabilities participating in the Arrowsmith cognitive program as reported by students, parents and teachers on a self-report measure over the course of an academic year.

Research Report

[Report on the Arrowsmith Program in the Toronto Catholic District School Board](#)

Social, Emotional Well-Being Outcomes

Study 1: Social, Emotional Well-Being Outcomes

Group

This study in 2016 investigating social, emotional, and behavioural outcomes was conducted by Dr. Rachel Weber at the University of British Columbia on students in their first year of the Arrowsmith Program at three schools, one in the United States and two in Canada.

Measures:

The Behavior Assessment System for Children (BASC-2)

The Behavior Assessment System for Children is a comprehensive set of rating scales designed to inform understanding of the behaviors and emotions of children and adolescents ages 2 years through 21 years, 11 months.

Parent ratings on The Behavior Assessment System for Children (BASC-2) were collected at the beginning and end of the school year.

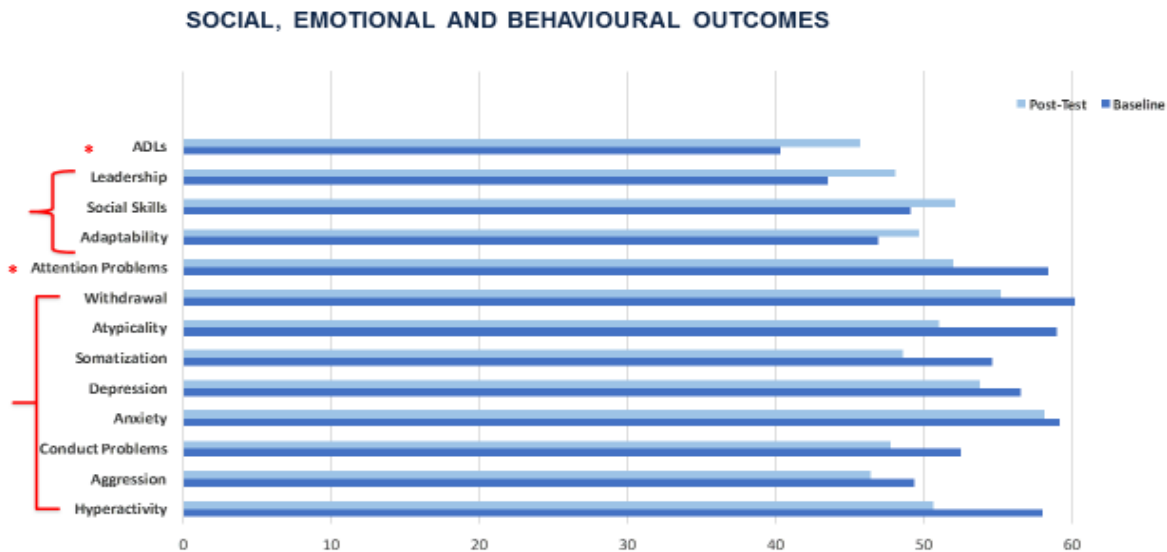
This research was presented in a peer-reviewed poster session at the 2019 International Neuropsychological Society conference in New York City.

Results

Changes were found on the following domains:

- Competence in Activities of Daily Living (ADL):
 - Personal Hygiene
 - Getting Dressed
 - Acts in Safe Manner
 - Organizes Chores
 - Following Routines – improved over the course of the year
- Adaptive scales:
 - Leadership
 - Social Skills
 - Adaptability – improved over the course of the year (higher scores are better)
- Maladaptive scales:
 - Withdrawal
 - Depression
 - Anxiety
 - Aggression
 - Hyperactivity
 - Conduct Problems – reduced over the year (lower scores are better)
- Attention, listening well, staying focused – improved

All of these ratings on the BASC improved over the course of the year and the ones noted with an asterisk were at a statistically significant level.



Conclusion:

Parents observed significant positive social, emotional, and behavioural changes in their children over the course of a year in the Arrowsmith Program.

Presentation

This research was presented in a peer-reviewed poster session at the 2019 International Neuropsychological Society conference in New York City.

Lara Boyd and Rachel C. Weber. (2019, March). *Neurocognitive and behavioral outcomes of the Arrowsmith program*. [Presentation]. University of British Columbia, Vancouver, B.C.

[Neurocognitive and behavioral outcomes of the Arrowsmith Program University of British Columbia Research Presentation March 2019](#)

Greg Rose, Audreyana Jagger-Rickels, and Rich Collins. (2019, March). *Benefits of Arrowsmith training on brain connectivity and neuropsychological measures*. [Presentation]. University of British Columbia, Vancouver, B.C.

[Benefits of Arrowsmith training on brain connectivity and neuropsychological measures University of British Columbia Research Presentation March 2019](#)

Study 2: Social, Emotional Well-Being Outcomes

Group

This study was conducted in 2017 by Dr. Kimberly Schonert-Reichl at the University of British Columbia on students in the Arrowsmith Program at three schools, one in the United States and two in Canada from November to May of one school year. This study examined the impact of Arrowsmith cognitive exercise on students' social and emotional health.

Results

Significant increases were found on:

- self-report measures of happiness and well-being. Typically, data for students without learning disabilities shows a decrease in these measures as students become more stressed over the academic year whereas Arrowsmith students are reporting they are happier and have a better sense of well-being over this time period.
- self-report measures of efficacy and incremental theory of belief (see self as agency of change and having locus of control)

A decrease was found in cortisol levels. Cortisol is a stress hormone.

Conclusion

Between November and May students in the Arrowsmith Program reported significant increases on measures of happiness and well-being as well as in sense of efficacy. They also had decreased levels of stress as measured by a reduction in cortisol production.

Study 3: Social, Emotional Well-Being Outcomes

Group

A study in 2007 was conducted on students in the Arrowsmith Program in the Toronto Catholic District School Board (TCDSB). These students were in grades 3 to 9 in seven schools and all were identified by the school board as having learning disabilities.

Measures

TCDSB Survey Questionnaire

A survey questionnaire was developed in collaboration with TCDSB research and education staff to measure academic and learning behaviours.

As part of the study, students, parents and teachers rated change on a range of student behaviours over the course of a year in the program.

Results

The results on behaviours related to social emotional well-being appear in the following chart. The number of individuals rating each item appear beside each rater for that item.

Parents, students and teachers all reported noticeable change on social emotional behaviours:

- growth of self-esteem
- growth of confidence and willingness to try new things
- frustration level
- anxiety level
- ability to self-advocate
- attitude towards school

IMPROVEMENT RATING				
		OF THOSE FOR WHOM THIS WAS A CONCERN		
	% Never A Concern	% No Change	% Noticeable Change	% Extremely Noticeable Change
Growth of Self Esteem				
Student Rating n=40	17%	10%	33%	40%
Parent Rating n=55	4%	9%	45%	42%
Teacher Rating n=54	4%	2%	33%	61%
Growth of Confidence (trying new things)				
Student Rating n=42	14%	7%	36%	43%
Parent Rating n=55	2%	13%	45%	40%
Teacher Rating n=55	5%	2%	35%	58%
Attitude toward School				
Student Rating n=42	24%	21%	31%	24%
Parent Rating n=53	17%	11%	38%	34%
Teacher Rating n=55	36%	5%	26%	33%
Frustration Level				
Student Rating n=42	20%	7%	41%	32%
Parent Rating n=54	7%	13%	65%	15%
Teacher Rating n=54	15%	0%	48%	37%

Anxiety Level				
Student Rating n=42	14%	19%	38%	29%
Parent Rating n=54	7%	13%	65%	15%
Teacher Rating n=54	17%	4%	46%	33%
Ability to Self Advocate				
Student Rating n=42	16%	14%	39%	31%
Parent Rating n=54	6%	26%	52%	16%
Teacher Rating n=44	6%	17%	46%	31%

Conclusion

Parents, students and teachers all reported noticeable change on social emotional behaviours over the course of a school year for students in the Arrowsmith Program.

Research Report

[Report on the Arrowsmith Program in the Toronto Catholic District School Board](#)

Study 4: Social, Emotional Well-Being Outcomes

Group

A study in 2018 was conducted on students in the Arrowsmith Program in a school in Australia, Plenty Valley Christian College (PVCC).

Measures

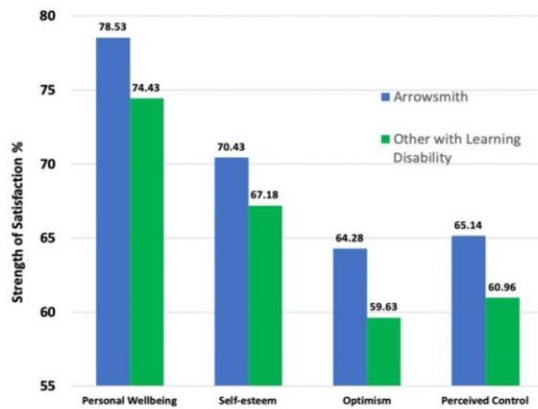
Personal Wellbeing (PWI) measure

Results

- The Personal Wellbeing (PWI) of Arrowsmith students is above the Australian adult normal range, other Victorian young people and the averaged level of personal wellbeing derived from the total PVCC student cohort.
- Arrowsmith students have higher levels of satisfaction regarding two important interpersonal domains. Their satisfaction with connectedness to their community and personal relationships are above all comparison groups.
- Levels of satisfaction with the school are significantly higher than the averaged score derived from the total PVCC student cohort.
- Arrowsmith students returned higher mean scores on Personal Wellbeing, Self-esteem, Optimism and Perceived Control, compared to mainstream students with a diagnosed learning disability. These differences are as follows: Personal Wellbeing=4.1%. Self-esteem=3.25%. Optimism=4.65%. Perceived Control=4.18%.
- Arrowsmith students recorded lower levels of satisfaction with what they were achieving in life compared to the PVCC total student cohort.

Student Wellbeing*

Plenty Valley Christian College, Australia



At the end of the school year, Arrowsmith Program students had significantly higher mean scores on:

- Personal Wellbeing
- Self-Esteem
- Optimism
- Perceived Control

compared to mainstream students with a diagnosed learning disability

*All students in both groups had a diagnosed learning disability.

Conclusion

Arrowsmith students had higher mean scores on Personal Wellbeing, Self-esteem, Optimism and Perceived Control, compared to mainstream students with a diagnosed learning disability. Arrowsmith students had higher levels of satisfaction with their personal relationships than the Australian adult normative range (a cohort of external adolescents) and the averaged PVCC student population.

Brain Imaging, Cognitive and Emotional Combined Outcomes – Study with Individuals with Acquired Brain Injury

Group

This study was conducted in 2016 at the University of British Columbia under the direction of Dr. Naznin Virji-Babul on individuals with Traumatic Brain Injury. These individuals were engaged in the Arrowsmith Program cognitive exercises daily for four of the higher order cognitive functions (Symbol Relations/Reasoning; Predicative Speech/Sequential Logic; Symbolic Thinking/Executive Functioning; Non-Verbal Thinking) at the Watson Centre Society for Brain Health in Canada. Participants completed between 3 to 4 hours per week on each of the four cognitive programs over a 3-month period.

Measures

Generalized Anxiety Disorder Scale (GAD)

This is a self-report measure to assess symptoms of generalized anxiety.

NIH Toolbox Cognitive Battery

This is a series of measures to assess cognitive, emotional, motor and sensory functions.

PHQ-9 Depression Scale (PHQ-9)

This is a self-report measure to assess symptoms of depression.

Resting state EEG

This involves an EEG to measure neural activity without a specific task or stimulus.

Resting State fMRI Imaging

Rey Auditory Verbal Learning Test (RAVLT)

This is a measure of a person's ability to encode, store and recover verbal information.

Trail Making Test Parts A and B

The Trails A test measures visual attention and processing speed, and Trails B assesses complex attentional shifting.

Verbal Fluency

This is a measure of executive functioning problems. Subjects are asked to generate as many words beginning with specified letters.

Results

The following significant improvements were found following the three-month program:

- an increase in cognitive performance, most notably fluid cognition, verbal learning, and memory
- changes in functional network connectivity in frontal regions
- a decrease in anxiety and depression

Fluid cognition is the ability to analyze and solve problems as they arise, to identify patterns and relationships underlying problems, and to reason.

Conclusion

The researchers concluded: [After intervention] “Our results provide preliminary evidence that participating in an intensive cognitive intervention program was associated with neuroplastic changes in adults with chronic TBI that occurred in parallel with improvements in cognition. Overall, we observed a shift from a baseline pattern of network organization that may be characterized by neural inefficiency and decreased cognition to a reorganization that reflected improved efficiency with possible improvements in fluid cognition. Importantly this data suggests that brain network organization is capable of reorganization even in chronic patients with intense intervention. Further work with a larger sample is clearly needed to understand the nuances of how brain organization impacts on cognitive ability and performance.”

Publication (Peer-Reviewed)

S. Porter, I.J. Torres, W. Panenka, Z. Rajwani, D. Fawcett, A. Hyder and N. Virji-Babul (2017) Changes in brain-behavior relationships following a 3-month cognitive intervention program for adults with traumatic brain injury. *Heliyon*, 3, doi: 10.1016/j.heliyon.2017. e00373

[Changes in brain-behavior relationships following a 3-month cognitive intervention program for adults with traumatic brain injury](#)

Presentations (Peer-Reviewed)

Jessica M. Sevvick, Naznin Virji-Babul and William J. Panenka. (2020, October). *Alterations in resting state functional connectivity in patients with traumatic brain injury following a 3-month pilot cognitive intervention program* [Presentation]. Psychiatry Research Day, University of British Columbia, Vancouver, British Columbia.

[Alterations in resting state functional connectivity in patients with traumatic brain injury following a 3-month pilot cognitive intervention program](#)

Leyla Brucar, Ivan Torres, Will Panenka, Angela Muller, Rebecca Kenny and Naznin Virji-Babul. (2019, March). *Changes in brain network organization and brain-behaviour relationships following a 3-month intervention program for individuals with chronic TBI* [Presentation]. 13th World Congress on Brain Injury, Toronto, Canada.

[Changes in brain network organization and brain-behaviour relationships following a 3-month intervention program for individuals with chronic TBI](#)

Summary of the Full-Time Program Research

The Arrowsmith Program is a suite of cognitive programs that utilize the principles of neuroplasticity to target and strengthen neural regions and networks of the brain set up to perform particular cognitive functions such as: processing information; seeing relationships and making the connections necessary for insight and conceptualization; forming and retaining memories; navigating in space; recognizing familiar faces; parsing speech; learning motor plans for reading and writing; discriminating speech sounds; visually retaining symbol patterns necessary for reading, spelling and visual template learning; interpreting emotions; and thinking non-verbally.

Enhancement of these cognitive functions that underlie learning in school and throughout life is possible through the targeted application of cognitive programs utilizing the principles of neuroplasticity. This is the basis of the Arrowsmith Program.

Research on students identified with learning disabilities or learning difficulties in the Full-Time Arrowsmith Program has demonstrated significant improvements in:

- Brain Activation
- Efficiency of Brain Processing
- Neural Connectivity (within and between networks)
- Cognitive Abilities
- Rate of Acquisition of Academic Skills
- Academic Achievement
- Learning Behaviours
- Social Emotional Well-Being

As one of the researchers said at a research presentation in New York City in February 2019, “the capacity to learn new things appears to be changing in the Arrowsmith students.”

The Arrowsmith Program is an effective program to address learning disabilities and learning difficulties.

This research has been conducted by different researchers, using different research designs and different measures – academic, cognitive, social emotional and imaging – and studying students in different schools implementing the Arrowsmith Program. For updates on the research being conducted on the Arrowsmith Program, please visit the [Arrowsmith Research](#)

Full Time Arrowsmith Program – Ongoing Research

Ongoing research is investigating outcomes for students in the Full Time Arrowsmith Program. Further data is being gathered on the following domains:

- Brain Connectivity and Activation
- Cognitive Abilities
- Academic Achievement and Learning
- Social Emotional Well-Being

Global Research Initiative

In February 2019, a research collaborative was formed comprised of researchers from the University of British Columbia, Southern Illinois University, and Universidad Camilo José Cela. The researchers are meeting on a regular basis to collaborate on further research investigations into the outcomes of students in the Arrowsmith Program. Arrowsmith's vision is to create a research institute to further these investigations in the fields of learning disabilities, cognitive enhancement, education and acquired brain injury.

Appendix A: Research Measures Used

[BASC-3 Behaviour Assessment System for Children 3rd Edition](#)

[fMRI Imaging](#)

[fMRI Imaging – Resting State](#)

[Generalized Anxiety Disorder Scale \(GAD\)](#)

[Monroe-Sherman Achievement Test – Passage Comprehension and Reading Speed](#)

[NIH Toolbox Cognitive Battery](#)

[PAT – Maths and PAT – Reading](#)

Personal Wellbeing (PWI) measure

[PHQ-9 Depression Scale \(PHQ-9\)](#)

[Resting state EEG](#)

[Rey Auditory Verbal Learning Test \(RAVLT\)](#)

TCDSB Survey Questionnaire

[Trail Making Test A and B](#)

[Verbal Fluency Test](#)

[Wide Range Achievement Test – Word Recognition and Arithmetic](#)

[Woodcock-Johnson IV Tests of Cognitive Abilities and Achievement](#)