Arrowsmith Research Initiatives Report

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INDEX

Introduction

The Arrowsmith Program is founded on neuroscience research and over 35 years of experience demonstrating that it is possible for students to strengthen the weak cognitive capacities underlying their specific learning difficulties through a program of targeted cognitive exercises. Beginning in 1997, Barbara Arrowsmith Young in collaboration with research colleagues, engaged in conducting research looking at the outcomes of the Arrowsmith Program and some of the theoretical constructs of the program. More information can be found at:

http://www.arrowsmithschool.org/arrowsmithprogram-background/research.html

Headed by Arrowsmith Program Director, Barbara Arrowsmith Young, and Research Director, Howard Eaton, Arrowsmith Program's Research Team is currently engaging with researchers to design and conduct studies in various disciplines, including education, psychology, and neuroscience, at universities around the world. These studies will show changes in the brain as well as academic, cognitive, emotional and social outcomes that occur for students engaged in the Arrowsmith Program.

This first *Research Initiatives Report* summarizes existing and ongoing studies of the Arrowsmith Program and its effects on the cognitive functions associated with specific learning difficulties. Arrowsmith Program will be releasing more reports as data becomes available.

A Case Study of the Learning Disabilities Association of Saskatchewan (LDAS) Arrowsmith Program

Kemp-Koo, D. (2013) PhD, University of Saskatchewan, Saskatoon.

Abstract: Case Study research was conducted to investigate how participation in the Learning Disabilities Association of Saskatchewan (LDAS) Arrowsmith program affected the cognitive, academic, emotional, and interpersonal functioning of five students who attended this program for two to three years. Learning disabilities involve consistent cognitive processing and academic difficulties that are present in individuals who have average or higher functioning in other cognitive processing areas. The average adult with a learning disability has less education, lower employment success, and higher rates of emotional and interpersonal difficulties. The Arrowsmith program is a cognitive training program based on neuroplasticity that claims to reduce or remove cognitive functioning deficits in persons with learning disabilities.

Semi-structured interviews were conducted with five students and one or both of their parents. Standardized test results and information from the school cumulative folders of the students were also reviewed.

Four of the five students experienced large and significant increases in cognitive, academic, emotional, and/or interpersonal functioning following their participation in the LDAS Arrowsmith program. One of the five students had much smaller gains in cognitive and academic functioning and experienced difficulties with emotional and interpersonal functioning following participation in the program.

Several themes related to participation in the LDAS Arrowsmith program are identified for the student, parent, school record perspectives and themes common to these perspectives are also identified. Possible reasons why the students had different outcomes following their participation in the LDAS Arrowsmith program are discussed. Recommendations for parents, school psychologists, teachers, schools/school divisions, the Arrowsmith program, and future research are given.

To read this full study, consult the following link:

http://ecommons.usask.ca/bitstream/handle/10388/ETD-2013-11-1268/KEMP-KOO-DISSERTATION.pdf?sequence=4

Effects of the Arrowsmith Program on Academic Performance: A Pilot Study - in process

University of Calgary - Brain Gain Lab

Principal Investigator:
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Alberta Children's Hospital Research Institute, Hotchkiss Brain Institute - http://www.educ.ucalgary.ca/braingain/hale

Kubas, H. A., Carmichael, J. A., Fitzer, K. R., & Hale, J. B. (2014).

Canadian Psychological Association Conference 2014 Vancouver, B.C., Poster session accepted

Introduction: The Arrowsmith Program (AP) is a cognitive-based intervention program designed to remediate processing weaknesses in children with specific learning disabilities (SLD) by providing a targeted intervention program that strengthens the specific underlying processing deficit presumably causing the SLD.

Methods: Woodcock-Johnson III (WJ-III) Achievement pilot data was collected on 15 students (11 males, 4 females; M age = 9.3 years; SD = 1.36 years) prior to AP entry, and again after intervention implementation (M time between testing = 28 months; SD = 8.36 months). Individual treatment response was assessed using a non-parametric randomization test (NPStat), which approximates multivariate analyses in the absence of normal data. Paired samples t-tests were used to compare pre-post group means.

Results: Inspection of individual response curves and NPStat results revealed significant single subject treatment response across all WJ-III achievement variables (F range 24.83 to 128.96; $p < .001$). Paired samples t-tests (alpha set at .001 to guard against Type I error) revealed improvements in broad reading and writing areas, receptive language, and all math areas except applied problems, (t range 4.62 to 11.69; $p < .001$). Results suggest that the AP can lead to significant improvements in performance across a broad range of academic domains. Further research using a larger sample is required.

A Brain-Based Intervention Program that Changes Cognition - in process

University of Calgary - Brain Gain Lab

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Fitzer, K. R., Kubas, H. A., Carmichael, J. A., Holland, S. A., Eaton, G. H., & Hale, J. B. (2014).

American Psychological Association Conference 2014 Washington, D.C., Poster session accepted

Introduction: The Arrowsmith Program (AP) is a cognitive-based intervention program designed for remediating deficits experienced by children with specific learning disabilities (SLD). Built on an educational neuroscience foundation, and knowledge of brain plasticity, the purpose of the AP is to identify and strengthen deficit cognitive functions that underlie SLD. The premise of the AP is that the affected cognitive areas that contribute to SLD can be improved through targeted, systematic cognitive exercises.

Neuroimaging literature suggests systematic intervention targeting weak academic areas changes brain function and normalizes atypical patterns in children with SLD. However, it is unclear whether strengthening neuropsychological functions underlying academic achievement could further improve reading, writing, and mathematics by targeting the cause (e.g., cognitive deficits) rather than the symptoms (achievement deficits). In this respect, AP is a capacity-based program in that it targets the underlying cognitive cause of the SLD, and provides direct remediation for processing deficits rather than relying on indirect achievement intervention or providing compensatory strategies for learning deficits. Although similar efficacious rehabilitation efforts for individuals with traumatic brain injury are well known, AP methodology has been questioned and even maligned in special education circles. As a result, this study was undertaken to further examine the treatment validity of AP methods.

Methods: Pilot data was collected on 15 students (11 males; 4 females) with SLD enrolled in an AP program (M age = 9.3 years; SD = 1.36). Woodcock-Johnson III (WJ-III) Cognitive data were collected pre- and post- intervention (M duration = 28 months; SD = 8.36 months). NPStat non-parametric randomization tests, which approximate multivariate analyses in the absence of normal data, were used to judge changes in cognitive function for each participant. Paired sample t-tests (alpha level set at .001 to guard against Type I error) were used to compare pre-post group means.

Results: NPStat result revealed single-subject improvements across most cognitive domains with the exception of verbal ability (Gc) and long-term retrieval (Glr) using the WJ-III Cognitive (F range 8.92 to 114.05; $p < .001$). Paired samples t-tests results revealed improvements in short-term memory (Gsm), auditory processing (Ga), fluid reasoning (Gf), and processing speed (Gs) (t-range 4.40 to 12.92; $p < .001$).

A Brain-Based Intervention Program that Changes Cognition - in process

University of Calgary - Brain Gain Lab

Conclusion/Future Directions: Children with baseline cognitive difficulties showed significant overall improvement across cognitive domains including short-term memory, auditory processing, fluid reasoning, and processing speed. Given that these cognitive domains are associated with processing weaknesses that underlie SLD, their improvement should ameliorate achievement deficits in children with SLD. Future research with larger sample sizes and different SLD subtypes is needed. Research is also needed to determine if strengthening cognitive deficits impacts academic achievement across reading, writing, mathematics, and language domains, and/or has the potential to ameliorate SLD.

Arrowsmith Program Brain Imaging Study - in process

University of British Columbia - Brain Behaviour Laboratory

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http://brain.rehab.med.ubc.ca/people/investigators/ | www.brain.rehab.med.ubc.ca

Main Aim: The main aim of this study is to gain insight into how the Arrowsmith Program alters the structure and function of the brain of children with learning disabilities. Given that this is the first time that advanced brain imaging has been used to assess the impact of the Arrowsmith Program the data collected will provide preliminary evidence of the impact of training on neuroplastic processes as well as enable power to be determined for a larger, longitudinal study. A longitudinal design will be employed to compare children with a learning disability who are enrolled in the Arrowsmith Program with children who have similar learning disabilities but are participating in other educational programs. These comparisons will take place over three time points across the school year (February and June 2014, and January 2015).

Population: In this preliminary study 20 right-handed individuals with a diagnosed learning disability who are enrolled in the Arrowsmith Program and 10 matched individuals who also have a diagnosed learning disability but are not participants in the Arrowsmith Program will be studied. These children will be between 9 and 17 years of age; both genders will be considered.

Experimental Overview: To begin to assess how the Arrowsmith Program may alter the brain a multiple time point design will be employed to capture neuroplastic change associated with training in children with a learning disability. Each child enrolled will already have a diagnosis of learning disability. An educational psychologist (Dr. Vanessa Lapointe) will confirm the diagnosis as well as administer a battery of educational and cognitive tests (see Education/Cognitive Testing section below). The learning disabilities may be in

Arrowsmith Program Brain Imaging Study - in process

University of British Columbia - Brain Behaviour Laboratory

one or more domains including reading, writing or mathematics. Multiple forms of imaging will take place including structural (T1 anatomy, myelin water imaging) and functional (resting and task based functional MRI).

Children enrolled in this study will be placed into three groups according to their participation and length of time in different educational programs for learning disabilities. The Early group (n=12) will just be entering into the Arrowsmith Program, the Ongoing group (n=12) will already be enrolled at Arrowsmith, and the Control group (n=12) will be receiving educational assistance for their learning disability through another program (e.g., Public School system, or another private education school in Vancouver). For each group, three brain imaging time points will take place. Brain imaging will take place before the school term is fully underway (early 2014), at the conclusion of the school year in June 2014, and then again next January 2015. Cognitive testing will take place at the beginning of the study (winter 2014) and again 1 year later (winter 2015) as a 1-year delay is required between many of the tests being employed.

Imaging Protocol: The pre-post brain imaging approach will enable consideration of the influence of the Arrowsmith Program on: 1) brain structure, specifically white matter (myelin water imaging); and 2) brain function (resting state functional connectivity and event related fMRI during the Clocks task).

Education/Cognitive Testing: Under the direction of the educational psychologist Dr. Lapointe, children will complete a battery of education and cognitive tests in the winter of 2014 (time point 1) and again in the winter of 2015 (time point 3). These data will not be collected at time point 2 as the tests require a 1-year interval before they may be repeated. Study participants will be given the option of completing testing in 1 full day with a lunch break, or over two half day sessions. Testing will take place at UBC in the quiet room within the Brain Behaviour Lab and consist of the following four assessments:

Woodcock-Johnson Test of Cognitive Abilities is a set of tests designed to provide information on cognitive abilities.

Otis-Lennon School Ability Test (OLSAT) assesses skills such as detecting likenesses and differences, recalling words and numbers, defining words, following directions, classifying, establishing sequence, solving arithmetic problems, and completing analogies.

Canadian Achievement Test (CAT) assesses the essential learning outcomes of the following basic skill areas: reading, language, spelling, and mathematics.

Wechsler Intelligence Scale for Children (WISC) or Wechsler Adults Intelligence Scale (WAIS) generates a Full Scale IQ (FSIQ) which represents overall cognitive ability.

Arrowsmith Program Brain Imaging Study - in process

University of British Columbia - Brain Behaviour Laboratory

Data from each test will be referenced to known norms. Change in test scores between time point 1 and 3 will be calculated. These change scores will be entered into statistical tests (below) to determine if there are relationships between change in brain and behavioural function.

Statistical Plan and Power Calculations:

The current study is designed as a pilot investigation with its main purpose being to generate preliminary data that can be used for power calculations in future studies.

A secondary exploratory analysis will be run to determine whether change in cognitive or educational function correlates with altered brain function. Though recognized that this study will be underpowered to consider all possible relationships, consideration will be given to whether any changes that may be noted between brain function are paralleled by similar changes in cognitive ability. It is the intent that by assessing these preliminary data, refinement of the data collection procedures and analyses in future work will be possible.

Significance: Findings from the proposed study will inform a larger study regarding the most sensitive measures as well as power necessary. The present study represents an essential first step in raising understanding of how neuroplastic change may be operationalized in children with learning disabilities as well as what types of change are stimulated by the Arrowsmith educational intervention. As such, they should help catalyze future work in this area, which may help the development of novel educational interventions that optimally stimulate learning in children.

Resting State MRI Measures of Brain Function in Children - in process

University of Southern Illinois - Center for Integrated Research in Cognitive & Neural Sciences

Investigators:
Gregory M. Rose, PhD, Professor of Anatomy
David Gilbert, PhD, Professor of Psychology

http://www.siumed.edu/circns/profiles/rose.html | http://www.siumed.edu/circns/profiles/gilbert.html

Purpose: The purpose of this study is to determine whether immersion in a specialized learning program will alter fMRI-assessed measures of brain function. Specifically, resting state networks and the strength of white matter pathways, assessed using diffusion tensor imaging (DTI), will be examined both within and across subjects who have been assigned to the specialized program or to a standard program. The expectation is that while both programs will result in a strengthening of resting state networks and white matter pathways, subjects enrolled in the specialized learning program will experience greater changes in these measures that will correlate with accelerated academic progress.

Subjects: Subjects (students) will be recruited from the Brehm Preparatory School located in Carbondale, Illinois since these are the individuals participating in the standardized and special learning program that will be compared. Inclusion criteria will be that the individuals be between 11 and 20 years of age. Potential subjects will receive medical history, neurological history, psychological history, drug history and metal screening questionnaires.

Location of Research: Questionnaires will be filled out and practice imaging sessions will take place at the Brehm School in Carbondale, IL. The fMRI and DTI sessions will take place at the Memorial Hospital Imaging Center in Carbondale, IL.

Methodology: While subjects are in the scanner, they will undergo brain scans while focusing on a fixation crosshair. The procedure begins with a structural MRI scan that will take approximately 10 minutes. Following this, the subject will receive an fMRI scan to evaluate their resting state network activity. MRI scans will be acquired using an echo-planar imaging sequence sensitive to Blood Oxygenation Level Dependant (BOLD) signal. Unlike the imaging sequence used in normal MRI (to produce a structural image), EPI-BOLD assesses brain activation by monitoring the regional changes in blood flow correlated with neuronal activity. This procedure will also take approximately 10 minutes. Finally, the subjects will be scanned using a different protocol (DTI) that will allow visualization of white matter pathways in the brain that connect brain regions. This procedure will also take approximately 10 minutes.

The current study is designed as a pilot investigation to gather preliminary data that can be used in further studies. Dr. Rose and Dr. Boyd of UBC are discussing ways to collaborate in order to use some of the same imaging protocols so that data can be compared between the study at USI and UBC.

Data collected from this study will be published in journal articles and presented at scientific conferences.

Research Studies Under Discussion

The Arrowsmith Program is in discussions to start research at the following locations over the next 12 to 24 months:

- Brain imaging study in Portland, Oregon, USA
- Brain imaging study in Seattle, Washington, USA
- Brain imaging study in Calgary, Alberta, Canada
- Research on the Arrowsmith Program with postsecondary students in Greenville, South Carolina, USA
- Research on the Arrowsmith Program and concussions at the University of British Columbia, Vancouver, British Columbia, Canada