Research Summary: BrainWare SAFARI and Low SES Students

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Background

BrainWare SAFARI is a cognitive training software program that addresses multiple areas of cognitive processing (attention, memory, visual and auditory processing, logic and reasoning and sensory integration) in a digital game-based format. It was derived from over 40 years of collaboration among clinicians in multiple disciplines, including speech pathology, vision development, psychology, and others. The therapeutic exercises developed and refined by these clinicians was then incorporated into a computer-based program designed according to key principles of cognitive training. Those principles are listed in Appendix A.

Over the last decade, BrainWare SAFARI has been used with a variety of populations, from low-performing to high-performing students of all economic backgrounds. While BrainWare SAFARI is not uniquely designed for low-SES students, the persistent national academic achievement gap related to poverty has prompted research and field studies in schools and districts around the U.S. examining the impact of cognitive training on cognitive functioning and academic achievement.

This document summarizes the studies of BrainWare SAFARI with students from low SES. Links to more detailed reports of each study as well as to other published research and field studies with BrainWare SAFARI is available at www.mybrainware.com/safari/research.

Following the study summaries is a discussion of the impact of poverty on cognitive development.

Study Summaries

BrainWare SAFARI Cognitive Skills Development in Before and After School Programs with Low Performing Readers (2015)

District: School City of Hammond, Hammond, IN
Subjects: 22 students in grades 3, 4 and 5, in 2 schools, economically disadvantaged, chosen because of poor reading performance
Usage: 4 sessions per week, 45 minutes per session, 10 weeks
Assessment: Cognitive Abilities Test (CogAT)

Summary of Findings: Students improved an average of 13 percentile points on the composite score on the CogAT, consistent with results from previous studies using the CogAT and the CCAT (Canadian Cognitive Abilities Test), including a previous study in one of the same schools with students with a range of abilities. The average pre-test score on the Verbal Reasoning subtest for these students was markedly low, at the 35th percentile, consistent with student selection criteria (low reading performance). On post-test, the average score on Verbal Reasoning increased to the 48th percentile.

Impact of Cognitive Skills Development in Grade 3 on Cognitive and Academic Measures (2014)

District: Huron-Superior Catholic District School Board, Sault Ste Marie, ON
Subjects: 169 students, all grade 3 classes (8) in 7 elementary schools, low SES, treatment and no-treatment conditions
Usage: 3 to 5 sessions per week, 30 minutes per session, 10 to 14 weeks
Assessment: Canadian Cognitive Abilities Test (CCAT), Canadian Test of Basic Skills (CTBS)

Summary of Findings: The Grade 3 students who used BrainWare SAFARI experienced significant cognitive growth compared to those who did not. After using BrainWare SAFARI, 50% of the students scored at the 70th percentile or above on the composite score of the CCAT, compared to 33% scoring at that level on the pre-test. For students who used BrainWare SAFARI in the fall, improvements were evident immediately following use and those gains were maintained or continued to increase at the end of the school year. Academic gains for these students were greater than expected, with Reading scores on the CTBS increasing by 1.4 Grade Equivalent (GE) and 1.6 GE respectively. Students with accommodations experienced significant increases in cognitive skills and also performed at Grade Level on academic tests at the end of the school year, despite starting the year below grade level expectations.

Improvement in California State Test Scores Following Cognitive Skills Training (2013)

District: Fillmore Unified School District, Fillmore, CA
Subjects: 257 students, all 3rd grade classes in all four district elementary schools, Low SES, predominantly Hispanic, treatment and no-treatment conditions
Usage: 3 sessions per week, 30 minutes per session, 11 weeks
Assessment: California State Test (ELA and Math)

Summary of Findings: The students who used BrainWare SAFARI performed better than a control group of students, looking at the difference in test scores from second grade in 2012 to third grade in 2013, for the same students. The change in English Language Arts was 17 scaled score units better for the BrainWare students, who also narrowed the gap between their scores and the median state score. Similar improvements were found for English Language Learners as for English-speaking students. In Math, the improvement for the BrainWare SAFARI students (19 scaled score units) also exceeded the state-wide growth in median score, while the control group's scores declined. While the trend was consistent for ELL and English-speaking students in Math, the difference for the English Language Learners was highly significant. The significant results for special education students was reported separately.

Evaluation of BrainWare SAFARI Using Academic Growth Measures in a Chicago Public School (2012)

District: Chicago Public Schools, Perez Elementary School, Chicago, IL
Subjects: 38 students in 2nd grade (22) and 3rd grade (16), Low SES, treatment and no-treatment conditions
Usage: 3 sessions per week, 30 minutes per session, 14 weeks
Assessment: NWEA MAP reading scores for 3rd grade, TRC reading levels for 2nd grade

Summary of Findings: There was significant improvement for the students in both grades on the academic measures. The 3rd grade students who used BrainWare SAFARI experienced twice as much growth on their MAP reading scores as their classmates who did not use BrainWare. The 2nd grade students made significant progress in reading comprehension as measured by their TRC levels.

Cognitive Gains in an Afterschool Program Using BrainWare SAFARI (2012)

District: School City of Hammond, Hammond, IN
Subjects: 30 students in 2nd through 5th grades, Low SES
Usage: 4 sessions per week, 45 minutes per session, 10 weeks
Assessment: Cognitive Abilities Test (CogAT)

Summary of Findings: Students experienced an average increase of 12 percentile points on the composite CogAT scores, with comparable increases on the Verbal (12 percentile points), Quantitative (10 percentile points), and Non-Verbal (13 percentile points) subtests, respectively. The overall increases and subtest increases were consistent with increases seen in previous research.

Broad-Based Improvement of Cognitive Ability (2010)

District: Horry County Schools, Conway, SC
Subjects: 257 students, all 2nd grade students in 3 schools, low SES
Usage: 2-3 sessions per week, 30 minutes per session, 17 weeks
Assessment: Cognitive Abilities Test (CogAT)

Summary of Findings: Overall student performance on the CogAT increased, with the average composite score rising 11 points, and with 75% of students improving their scores on at least 3 subtest areas. More students qualified for the gifted program following their use of BrainWare SAFARI. The distribution of percentile rankings shifted markedly between the two administrations of the tests, with significantly fewer students scoring in the lowest percentiles and many more performing at higher percentile rankings. The percentage of students scoring at the 91st percentile or higher increased from 3% to 10%.

Pilot of BrainWare SAFARI with Students in a Title I School (2010)

District: Topeka School District, Topeka, KS
Subjects: 150 students, all students in Grades 3, 4 and 5 at Ross Elementary, a Title I School
Usage: 4 sessions per week, 30-40 minutes per session, 11 weeks
Assessment: 3 Woodcock Johnson III Cognitive Battery subtests (administered to a sample of 20 students), Kansas State General Assessment

Summary of Findings: Student performance on the WCJIII subtests improved an average of 1 year 10 months, consistent with results from previous research on these three specific tests, following use of BrainWare SAFARI. On a second post-test, following 6 months of non-use of the program, the students cognitive development was maintained or continued to improve, yielding average total growth of 3 years and 2 months over the school year. The percentage of students meeting the state assessment standards improved for both reading (from 56% in 2009 to 65% in 2010) and math (from 26% in 2009 to 72% in 2010). The average reading score increase at each grade level, moving from below the standard to the meets or exceeds range. The average math score increased at each grade level, remaining in the meets or exceeds range.

Impact of BrainWare SAFARI Use on Cognitive and Academic Measures in Grades 2-8 (2009)

School: Glenwood Academy (formerly Glenwood School for Boys and Girls), Glenwood, IL
Subjects: 96 students, all students in Grades 2 through 8, mostly low SES
Usage: 5 sessions per week, 30 minutes per session, 10 weeks
Assessment: Woodcock Johnson III Cognitive Battery, Visual Motor Inventory

Summary of Findings: Average improvement from the pre-test to the post-test, following 10 weeks of BrainWare SAFARI use, ranged from 0.5 grade equivalents (GE) in 2nd grade to 2.9 GE in 8th grade. Average improvement on the cognitive tests ranged from 1.5 GE in 2nd grade to a high of 3.0 GE in 7th grade. The results showed a clear relationship between the improvement in underlying attention, memory and other cognitive processes and performance on academic tests.

Students Qualifying for a Gifted Program (2009)

District: Horry County Schools, Conway, SC, Conway Elementary
Subjects: 64 students, all 2nd grade students, low SES
Usage: 2 to 3 sessions per week, 30 minutes per session, 17 weeks
Assessment: Cognitive Abilities Test (CogAT)

Summary of Findings: In a school in which no students had qualified for the gifted program the prior year, 2 students qualified based on CogAT scores at the 98th percentile, 5 students qualified based on having at least one CogAT subtest score at the 93rd percentile or higher together iwith MAP test results and 3 students qualified for additional evaluation. 60 of 64 students improved their results on the CogAT, with the average composite score increasing by 11 points. Improvements were seen on all subtest areas.

Impact of BrainWare SAFARI on Progress in Reading (2008)

District: Indianapolis Public Schools, Indianapolis, IN, Coleman Academy
Subjects: 11 students, all 4th grade girls, low SES, at risk, with other classrooms (4th grade boys and 5th through 8th grade single-gender classrooms) as a comparison group
Usage: 3 to 5 sessions per week, 30 minutes per session, 12 weeks
Assessment: DIBELS Oral Reading Fluency, Teacher Observations

Summary of Findings: The 4th grade girls class was the only one in the school that exceeded their DIBELS benchmark score at the end of the school year. The rate of progress accelerated during the second half of the year when they were using BrainWare SAFARI, moving from 9 WPM above benchmark to 26 WPM above benchmark. The teacher observed behavioral improvements in the students, particularly in making fewer careless errors, memory, grasping new concepts and communication with parents, peers and teachers, following use of the program.

BrainWare SAFARI Benefits 4th and 5th Grade Boys At Risk (2006)

District: Indianapolis Public Schools, Indianapolis, IN, Edgar Evans Academy
Subjects: 24 males students, one 4th grade and one 5th grade, low SES, at risk, history of behavior problems
Usage: 2 to 3 hours per week, in 30-60 minute sessions, 11 weeks
Assessment: Woodcock Johnson III Cognitive Battery

Summary of Findings: The students had an average chronological age of 11 at the time of the pre-test but tested at an intellectual age of 8 years 2 months. The average post-test intellectual age was measured at 14 years 2 months, an improvement of 6 years. The classroom teachers and the principal noted markedly fewer behavioral issues.

The Cognitive Impact of Poverty

In the 1960s, Marian Diamond, Mark Rosenzweig, and their colleagues at the University of California, Berkeley, demonstrated that the brain's architecture can be influenced by an animal's environment (Diamond, 1988). Diamond's work was extended by William Greenough at the University of Illinois (Greenough). These researchers showed that the brains of rats in enriched environments had more branching of dendrites and somewhat increased cell weight. Moreover, these structural changes in the rats' brains resulted in their being better able to solve complex maze problems.

Recent research has shown that the human brain is affected by environment in much the same way. Jamie Hanson at the University of Wisconsin, Madison used MRIs to measure the amount of gray matter in the brains of children (Hanson, 2013). What the researchers found was more gray matter by volume in the brains of children from higher SES, and less in those from lower SES. Thus, higher SES is correlated with more neuronal connections and more efficient connections. Similar results have been shown by other scientists, including Joan Luby at Washington University in St. Louis, whose research documented significant differences in MRI scans of the hippocampus, a brain structure involved in short-term memory storage and retrieval and in the consolidation of long-term memory. In this study, differences were also noted in the frontal lobes, which play an important role in executive functions such as planning, impulse control and control of attention, and in the parietal lobes which play an important role in sensory integration, aspects of visual attention and may be especially important for connectivity among brain regions.

While the evidence has been building that poverty affects the brain's physical structure and development, the evidence has also been accumulating that poverty affects how the brain actually performs the functions associated with these brain areas. One of the earliest studies illuminating the gap in capacity for low-SES children was Hart and Risely's ground-breaking research on early family life and its effect on children's IQ (Hart & Risely, 1995). This research showed the profound effect or early childhood experiences on school readiness, including children's cognitive skills.

While the language disparity is widely known, the differences between children of different SES are not simply a function of how many words they have heard by age 3 and the extent of their vocabulary. More recently, research has shown a strong correlation between the degree of disadvantage and the magnitude of cognitive disparity. Moreover, these findings shed light on additional specific areas of cognition that are deficient which extend far beyond language acquisition (Noble, Norman & Farrah, 2005; Noble, McCandliss & Farrah, 2007).

The following chart, derived from the work of Noble and others presents some key areas of cognitive function where significant differences related to SES have been found and provides examples of the impact on educational performance.

Cognitive Skills and Their Relationship to Educational Performance

Cognitive System	Cognitive Skills	Examples of Educational Impact
Occipitotemporal/visual cognition system	The ability to perceive patterns and to visualize.	These skills impact a variety of non-verbal cognition tasks such as: • Visual-spatial organization (e.g., organization of physical and mental workspace) • Understanding non-verbal feedback in a social situation • Understanding math and science concepts • Visualization of information that has been read or heard
Parietal/spatial cognition system	The ability to perceive and mentally manipulate spatial relationships, including the ability to sequence.	These skills impact a variety of spatial learning tasks such as: • Mathematics, especially geometry, and following a set of procedures • Visual problem-solving and estimation • Physical coordination, acuity
Medial temporal/memory system	The ability to form new memories and to assemble information from distributed storage sites that represent a whole memory.	These skills are necessary for any learning to take place, including being able to remember multiple pieces of relevant information and to create relationships among similar concepts and ideas
Left perisylvian/ language system	The ability to learn and understand words, to distinguish sounds that distinguish similar sounding words.	These skills are essential for general linguistic competence and, specifically: • Vocabulary development • Phonological awareness (the ability to perceive sounds that distinguish similar sounding words) • Grammar, pronunciation • Communication, expression
Prefrontal/executive function system	The ability to control the focus of one's attention	These skills enable multiple functions including: • Deferring gratification • Creating plans • Making decisions
Anterior cingulated/cognitive control system	The ability to override competing attentional or behavioral responses.	These skills are essential for: • Choosing between alternatives in decision-making • Ignoring distractions and staying focused in the classroom • Being able to behave differently in different situations (e.g., classroom vs. home)
Lateral prefrontal/working memory system	The ability to retain and manipulate information over a short time span.	Working memory is essential for complex reasoning and problem solving, among other learning functions

Despite broad-based efforts such as increased funding for low-SES students under Title I, the achievement gap persists, and a growing body of research confirms the disparity in cognitive ability between children from different socio-economic backgrounds (Baydar, Brooks-Gunn & Furstenberg, 1993; Gottfied, Gottfried, Bathhurst, Guerin & Parramore, 2003; Liaw & Brooks-Gunn, 1994; Smith, Brooks-Gunn & Klebanov, 1997).

Deficits in cognitive capacity do not disappear immediately when children are exposed to good teaching and good curriculum. In fact, such deficits are important barriers to being able to learn and often constitute limitations to the amount and pace of learning. Before students with deficits can learn, they must develop the capacity to learn. The questions then become whether the capacity to learn can be developed, and, if so, how this kind of remediation can be accomplished.

There is strong scientific consensus that cognitive ability can, in fact, be developed. As Pat Wolfe said in the latest edition of *Brain Matters*, "Younger brains have greater malleability than older ones, but it has been shown that neuroplasticity exists from the cradle to the grave. Recognizing and understanding these changes will help us gain a better understanding of what we can do to help each child or young person reach his or her full potential" (Wolfe, 2010). Or as David Shenk expressed it in *The Genius in All of Us*, "It's not biology that establishes an individual's rank to begin with (social, academic, and academic factors are well-documented contributors). No individual is truly stuck in her original ranking. Every human being (even a whole society) can grow smarter if the environment demands it" (Shenk, 2010). And as Eric Jensen wrote in *Teaching with Poverty in Mind*, "We now know not only that students' brains can change but also that we can play a part in changing them" (Jensen, 2009).

Educators and researchers have suggested a variety of approaches. Most tend to be broad in scope and support the learning process in general, for all students. As a result, these approaches may take multiple years to have an impact and are unlikely to completely close the gaps of low SES students because they do not address students' underlying cognitive skills in a targeted, comprehensive and systematic way.

Training to overcome cognitive deficits has been known for decades as it is practiced by various therapeutic disciplines, such as vision therapy, speech/language pathology and educational therapy. However, the application of such techniques to the problem of cognitive deficits related to SES is fairly new, being raised by Noble and her colleagues: "An as-yet untested approach to maximizing the efficacy of interventions is to focus programs on those neurocognitive abilities that vary most steeply with SES" (Noble, 2007).

The concept of cognitive skill training to remediate cognitive deficits is no longer completely untested. Schools have begun to implement specific neurocognitive development programs addressing the very processes that have been determined to be most deficient in low-SES students with noteworthy results.

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Appendix – Principles of Effective Cognitive Training

Progressive challenge. One of the principles of good video games is that each level gets progressively more challenging and that's also critical for cognitive skill development. The concept is sometimes referred to as the "zone of proximal development." The user needs to be challenged but not too far above his or her current ability level.

Novelty and changing expectations. More than simple increases in difficulty, effective cognitive training involves novelty and changing expectations.

Cross-Training. If a program develops skills independently, then the brain doesn't get practice at using them together. An effective program needs to work cognitive skills in a comprehensive and integrated way so that the brain will know how to "put it all together."

Feedback. Good cognitive training programs provide instantaneous feedback. This enables us to learn from our mistakes, make immediate adjustments and try again.

Coaching. It is often helpful to have a coach working with the user, whether a parent at home, a teacher with students at school, or a clinician or therapist in their office.

Engagement. In order for the program to deliver significant cognitive growth, it will get hard for user – probably very hard – at some point. That is when engagement and motivation to persist are essential. Motivation to persist can be fostered by good coaching but the extrinsic and intrinsic rewards of the training and the degree to which the program delivers on the sense of developing mastery, builds the sense of autonomy and has an overall purpose are vital.

Protocols to achieve specific goals. A cognitive training program should have a regimen or protocol for usage to deliver the benefits that it claims, based on research. There may be different protocols for different goals or for different types of users, taking into consideration the frequency and intensity needed to result in changes in the strength of neural networks. Just like going to the gym once a week might make you feel less guilty, but doesn't do much for physical strength, flexibility or stamina, it will take multiple times a week for a number of weeks to make a noticeable difference with cognitive training.