AWERProcedia
Information Technology
& Computer Science

Vol 04 (2013) 1046-1052

3rd World Conference on Innovation and Computer Sciences 2013

Brain Training by BrainWare® Safari: The Transfer Effects on the Visual Spatial Working Memory of Students with Reading Problems

Mohsen Shokoohi-Yekta *, Associate Professor, Faculty of Psychology and Educational Sciences, University of Tehran, Iran.

Salahadin Lotfi, Supervisor of Neurofeedback and Cognitive Training Section, Atieh Neuroscience-Baced Medical Center, Iran.

Reza Rostami, Chief Executive of Atieh Neuroscience-Baced Medical Center, Tehran, Iran.

Negin Motamed-Yeganeh, M.A. Student of Psychology, Faculty of Psychology and Educational Sciences, University of Tehran, Iran.

Yousef Khodabandeh-Lou, M.A. Student of Psychology, Faculty of Psychology and Educational Sciences, University of Tehran, Iran.

Mohammad Habibnezhad, M.Sc. in Cognitive Science, Institute for Cognitive Science Studies, Tehran, Iran.

Suggested Citation:

Shokoohi-Yekta, M., Lotfi, S., Rostami, R., Motamed-Yeganeh, N., Khodabandehlou, Y. & Habibnezhad M. Brain Training by BrainWare Safari: The Transfer Effects on the Visual Spatial Working Memory of Students with Reading Problems. *AWERProcedia Information Technology & Computer Science*. [Online]. 2013, 04, pp 1046-1052. Available from: www.awer-center.org/pitcs

Received November 24, 2012; revised January 20, 2013; accepted March 23, 2013.
Selection and peer review under responsibility of Prof. Dr. Fahrettin Sadıkoglu, Near East University.
©2013 Academic World Education & Research Center. All rights reserved.

Abstract

The authors evaluated the efficacy of a new computerized cognitive training program (BrainWare® Safari) on the working memory (WM) performance of students with reading problems. Fifteen students aged 7-12 with reading problems participated in the experimental group for five 50-minutes sessions per week (30 total sessions), whereas a 20 matched control group received no intervention. The experimental group training included Visual Spatial Working Memory, Visual Sustained Attention, Visual Selective Attention, Visual Figure Ground, Visual Processing Speed and Visual Motor Integration. A neuropsychological test battery on working memory functioning for children (WMTB-C), Computerized Raven's Colored Progressive Matries for children and a reading performance test (NAMA Scale) were administered both before and after the intervention.

*ADDRESSES FOR CORRESPONDANCE: **Mohsen Shokoohi-Yekta**, Associate Professor, Faculty of Psychology and Educational Sciences, University of Tehran, Iran, *E-mail Address:* ms-yekta@uiowa.edu.com

Statistically significant training effects were found on the forward visual spatial WM, the backward visual spatial WM and the mazes memory.
Finally, it's concluded that a 30-session systematic cognitive training developed by BrainWare Safari can significantly improve WM and its components in students with reading problems.

Keywords: Working Memory Training, BrainWare Safari Program, Dyslexic Children;

1. Introduction

Brain research has long confirmed that our brains change ceaselessly throughout our lifetime, and more interestingly, its changes are subject to what we do with it, a phenomen referred to as "the plasticity", which leads naturally to the idea of trying to promote our mental faculties: brain training. By controlling environmental factors and personal experiences, we can affect the development of our brain. Proper combination of activities may enable us to shape smarter, faster and even more creative minds (Moore & Stafford, 2010).

Broadly defined, brain training refers to the engagement in a specific program or activity that aims to enhance a cognitive skill or general cognitive ability as a result of repetition over a circumscribed timeframe. Such training can give rise to changes manifested at behavioral as well as the neuroanatomical and functional levels of the brain (Langer, von Bastian, Wirz, Oberauer, Jäncke, in press; Klingberg, 2010). Various forms and versions of brain training methods, particularly the programs that work on the attention and working memory (WM), appear to improve cognitive functioning and emotional control (Rueda, Posner, and Rothbart, 2005). By practicing games or tasks requiring choosing between two competing responses, attention training strengthens the neural networks underlying the control processes (Raz & Buhle, 2006). Similar to attention training (AT), many programs target WM, a system that mediates temporary information storage, modification, and protection from interference (Bledowski, Kaiser, & Rahm, 2010).

Recent studies on the effects of systematic cognitive training of Working Memory (WM) and attention in children and adults (von Bastian & Oberauer, 2013; von Bastian et al., 2012; Loosli et al., 2011; Klingberg et al., 2010; 2005; 2002; Rueda et al., 2005) have raised interest among psychologists, teachers and the public at large. Researches suggest that a theory-based, carefully controlled and extensive training can impact cognitive abilities such as working memory and reasoning that were believed to be constant traits (von Bastian & Oberauer, 2013). Such a widespread attention could be due to the prevalence of problems concerning WM and attention at schools today and the possibility of transference of this effect to the other cognitive functions needed in school setting. Many children find it very difficult to accomplish the tasks at the expected level. Pinpointing different reasons and finding viable solutions for the performance related problems that some children encounter, is an aspiration in the interdisciplinary field of WM research. The processes underlying WM and its effects on human cognitive performance have been studied for years (Baddeley, 1992; Engle, Cantor & Carullo, 1992). However, it wasn't till recent years that studies reported the effects of training WM and explored the possibility of influencing working memory capacity (WMC).

Children's WMC improves gradually between the ages of 4 and 11 years (Alloway, 2006). The increase of WM ability among children occurs in parallel to the maturation of the frontal lobes (Toga, Thompson & Sowell, 2006). Numerous studies have demonstrated a close association between children's performance on indicators of scholastic attainments and their WM abilities (Gathercole, Pickering, Knight, & Stegmann, 2004; De Jong, 1998). Children with WM deficits have difficulties in handling simultaneous storage and processing. They also have greater difficulties in dealing with interfering stimuli (Unsworth & Engle, 2007). Recent studies, however, indicate that differences in WM ability and achievement are still present among children with learning disabilities when IQ has been statistically controlled (Alloway, 2006, Engle et al., 1999). Gathercole et al. (2004) showed that 7-years old children's academic success in Mathematics and English (reading and writing) was linked to the success on WM related tasks. However, at 14 years of age, this close connection was no longer seen; instead, only Mathematics and the science subjects correlated with WM. This indicates that the initial phases of learning to read are dependent on WMC (Gathercole et al., 2004). Another study describing reading and its connection to WM showed clearly those children with reading disability performed poorly on all WM tasks measured (De Jong, 1998).

Moreover, there is controversy over the existence of deficit in the visual spatial information storage and processing of dyslexics. Some studies have confirmed it (Helland & Asbjørnsen, 2003) while others have not. Data of the current study support the notion that a working memory deficit among dyslexics is not limited to verbal processing, but rather also encompasses the sub-system of working memory responsible for processing visual spatial information. Stein & Walsh (1997) have provided support for the notion that dyslexic readers exhibit a deficit in the visual system.

In the present study, we aimed at studying the efficacy of brain training (BrainWare® Safari, developed by Learning Enhancement Corporation, IL, USA) on the visual spatial working memory of children with reading problems.

2.Method

2.1. Design. After all participants were evaluated on reading, visual spatial working memory and IQ, they were randomly assigned to training or control group. Seven to eight weeks later, the participants were reassessed on the same tests. The period between pre- and post-test was tried to be kept almost the same for both the training and the control group.

2.2. Participants. Forty-one children of 7 to 12 years of age in grades 1–5 (*table.1*) with reading problems participated in the current study, all of whom were sampled from three official learning disability centers in Tehran. The parents were asked to sign a written consent for their children to participate in the study. All the students who attended the study were among those who completed the NAMA Scale (Kormi Nouri and Moradi, 2008) and scored two standard deviations below the mean in reading words and reading pseudoword subtests. Due to the diagnosed neurological, psychiatric, or developmental disorders or missing data in the post-test session, data for 6 children were excluded from data analyses. Fifteen of these students comprised the experimental and 20 the control groups. The two groups were matched according to their chronological age (experimental X = 8.26 ± 1.43 years, and control X = 8.15 ± 1.42 years) and they all were within normal range of non-verbal IQ as measured by the Raven Colored Progressive Matrices (Raven, 1977) [IQ = 94.06 ± 10.19 for the experimental group and IQ= 96 ± 11.97 for the control group]. All the participants were right-handed, native Persian speakers and had normal vision and hearing. There was no history of neurological or emotional disorders in any of the participants. Some rewards were used in the experimental group (i.e. 10-20 points every session to access to dolls, toys and games at the end of the experiment) for their attempts to keep them motivated during the treatment procedure. Those in the control group received their ordinary academic education in school, and no additional training. Those in the experimental group received training in working memory as explained below.

Raven Standard Progressive Matrices (Raven, 1977) was employed to examine the analogous deduction and the ability to create perceptual connections independent of language and formal learning. The Reading Words and Reading Pseudoword subtests of NAMA Scale (Kormi Nouri and Moradi, 2008) were used to assess the children's reading problems. In the Visual-Spatial Working Memory during the Block Recall Test, the child views nine cubes located randomly on a board. The test administrator taps a sequence of blocks, and the child's task is to repeat the sequence in the same order. Testing begins with a single block tap, and increases by one additional block following the procedure outlined above. The mean test-retest reliability coefficient for this measure is 0.53. In the Mazes Memory Test, the child observes each trial of a two-dimensional line maze with a path drawn through the maze. The test administrator traces the line with her/his finger while the child is watching. The same maze is then shown to the child without the path, and the child is asked to recall the path by drawing it on the maze. Maze complexity increases by adding additional walls to the maze. The mean test-retest reliability coefficient for this measure is 0.62 (Pickering and Gathercole, 2004).

Table1. Subject characteristics

	Experimental	Control	Total
Boys	13	13	26
Girls	2	7	9
Age Mean (SD)	8.2 (1.4)	8.1 (1.4)	8.2 (1.4)
RCPM* Mean (SD)	94 (10.1)	96 (11.9)	95 (11.1)

* Raven Colored Progressive Matrices

3. Procedure

The evaluations included reading ability, visual spatial WM tasks, and non-verbal reasoning. All of the tests were administered before and after the training. Each participant was tested individually in a quiet area of the clinic for six 60-minutes sessions across eight weeks. The following tests were administered by the psychometrics in a different order to vary task demands across the testing sessions. Training was performed for approximately 50-60 minutes a day, 5 days a week for 6 weeks. Having 30 sessions of training was required for being included in the analyses. At each training session, the participants were trained on four (out of six) different versions of the VSWM exercises.

Training performance was monitored by the researchers across sessions in the clinic via an internet server for the experimental group. As mentioned above, feedback was provided to the experimental group individually according to the token economy system throughout the sessions.

3.1 Intervention software

Brain Training Program. The training included performing WM tasks using the computer program BrainWare® Safari (Learning Enhancement Corporation, IL, USA). Besides the software, a study booklet was provided to facilitate the training process. The difficulty level of the program is continuously and automatically adjusted with the performance of the participant to maximize the training effect. Each correct answer increased the number of presented stimulus objects, and in this way, increasing the difficulty level of the game. BrainWare Safari (BWS) is a computer-based cognitive skills development program in a video-game format for 6 years old and upper. It is designed to comprehensively develop 41 cognitive skills covering the major areas of cognition.

4.Results

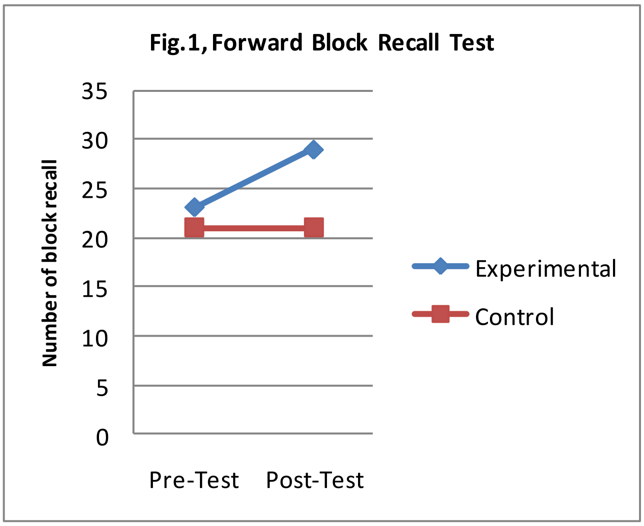
All tests were scored according to standardized procedures and the data were entered into an SPSS 18.0 file for analysis. *T*-tests revealed no significant differences in the baseline performance or age between the two groups (all p-values >0.1). Similarly, Chi Square tests showed no significant differences in the distribution for gender and the number of comorbid diagnoses between the two groups (both p-values >0.1). Statistical analysis shows that there is a significant difference between the means of the pre and post-test scores in all three subtypes of VSWM. The pre- and post-test performances of three VSWM tasks of experimental and control groups were showed in figures 1, 2 and 3 as well as in table 2.

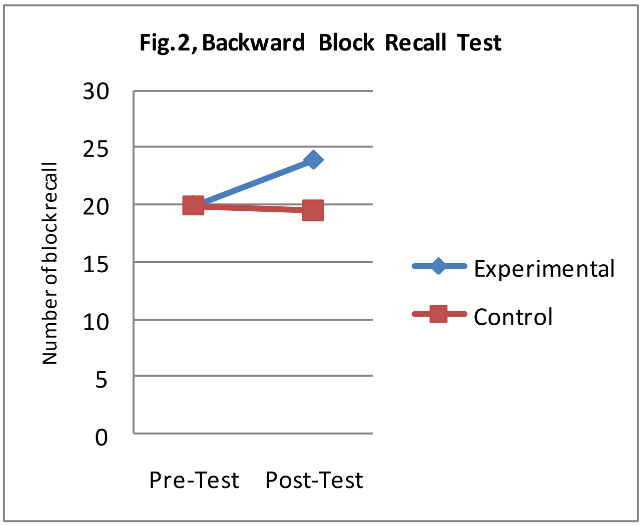
As one may conclude from table2 and Figures 1, 2 and 3, mean for post-testing compared to pre-testing, in the areas of Forward Block Recall, Backward Block Recall and Mazes Memory increased and the standard deviation showed the same trend.

Cohen's d score was calculated to evaluate the effect size between the pre-test and the post-test scores of the two groups. Effect size for Forward Block Recall test was $ES_{control}$ = .20, $ES_{experimental}$ = .90, for the Backward Block Recall test, $ES_{control}$ = .30, $ES_{experimental}$ = .85 and for Mazes Memory test, $ES_{control}$ = .35, $ES_{experimental}$ = .80.

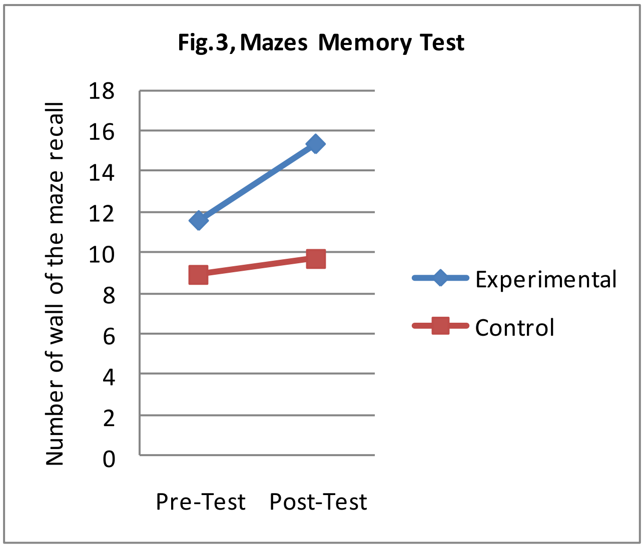
Table2. Means and Standard Deviations of Visual Spatial Working Memory test

Subtests		Experimental		Control	
		M	SD	M	SD
Forward Block Recall	Pre-Test	23.5	3.8	21.7	5.5
	Post-Test	29.2	2.9	21.3	4.7
Backward Block Recall	Pre-Test	19.9	3.8	19.9	5.2
	Post-Test	23.9	3.8	19.5	3.5
Mazes Memory	Pre-Test	11.6	6.3	8.9	4.7
	Post-Test	15.3	5.1	9.7	3.6





Figures 1, 2 and 3.
The pre- and post-test performances of the Forward Block Recall, Backward Block Recall and Mazes Memory tests



5.Discussion

In the present study, we aimed at studying the efficacy of brain training (BrainWare Safari, developed by Learning Enhancement Corporation, IL, USA) on the visual spatial working memory of children with reading problems.

According to the results of this study, it is clear that brain training conducted in an intensive, carefully controlled and extensive training has an impact on cognitive abilities such as working memory and its visual spatial component that were believed to be constant traits (von Bastian & Oberauer, 2013). Conclusions from this study are limited by the low number of participants. Furthermore, there was only a passive control group, and no follow-up. A larger study, including both a passive and an active control group, will be needed to confirm the effects of WM training.

Acknowledgment:

We would like to thank all the students and their parents participated in the study, staff of Atieh Neuroscience-Based Medical Center, Ostad Roozbeh Research Institute and the reviewers for valuable comments on the manuscript. Funding for this project was provided by Atieh Neuroscience-Based Medical Center, Iran (www.AtiehClinic.com). The software was provided by Learning Enhancement Corporation, IL, USA (www.MyBrainWare.com).

References:

Alloway, T. B. (2006). How does working memory work in the classroom. *Educational Research and Reviews*, 1, 134-139.

Baddeley, A. D. (1992). Working memory. *Science,* 25, 556-559

Bledowski, C., Kaiser, J., & Rahm, B. (2010). Basic operations in working memory: Contributions from functional imaging studies. *Behavioural Brain Research*, 214(2), 172–179.

Daneman, M. & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior, 19*, 450–466.

De Jong, P. F. (1998). Working memory deficits of reading disabled children. *Journal of Experimental Child Psychology*, 70, 75–96.

Engle, R. W., Tuholski, S. W., Laughlin, J. E. & Conway, A. R. (1999). Working Memory, Short-term Memory, and Fluid Intelligence: A Latent Variable Approach. *Journal of Experimental Psychology: General, 128*, 309-331.

Engle, R. W., Cantor, J. & Carullo, J. J. (1992). Individual differences in working memory for comprehension: A test of four hypotheses. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *18*, 927-992.

Gathercole, S. E., Pickering, S. J., Knight, C. & Stegmann, Z. (2004). Working memory skills and educational attainments: evidence from national curriculum assessments at 7 and 14 years of age. *Applied Cognitive Psychology, 18, 1-16.*

Helland, T., & Asbjørnsen, A. (2003). Digit span in dyslexia: Variations according to language comprehension and mathematics skills. *Journal of Clinical and Experimental Neuropsychology*, *26* (1), 31–42.

Klingberg, T. (2010). Training and plasticity of working memory. *Trends in Cognitive Sciences*, 14(7), 317–324.

Klingberg, T., Fernell, E., Olesen, P. J., Johnson, M., Gustafsson, P., Dahlstro¨m, K., et al. (2005). Computerized training of working memory in children with ADHD-A randomized controlled trial. *Journal of the American Academy of Child and Adolescent Psychiatry, 44*(2), 177–186.

Klingberg, T., Forssberg, H., & Westerberg, H. (2002). Training of working memory in children with ADHD. *Journal of Clinical and Intervention Neuropsychology, 24*(6), 781–791.

Langer, N., von Bastian, C., Wirz, H., Oberauer, K., Jäncke, L. (In press). The Effects of Working Memory Training on Functional Brain Network Efficiency, *CORTEX.* doi: 10.1016/j.cortex.2013.01.008.

Loosli, Sandra V. , Buschkuehl, Martin , Perrig, Walter J. and Jaeggi, Susanne M.(2011) Working memory training improves reading processes in typically developing children*, Child Neuropsychology,26.*

Moore, G., & Stafford, T. (2010). *The Rough Guide Book of Brain Training*, Rough Guides: Landon, Uk.

Raz, A., & Buhle, J. (2006). Typologies of attentional networks*. Nature Reviews Neuroscience*, *7*(5), 367–379.

Rueda, M. R., Posner, M. I., & Rothbart, M. K. (2005). The development of executive attention: Contributions to the emergence of self-regulation. *Developmental Neuropsychology*, 28(2), 573–594.

Rueda, M. R., Rothbart, M. K., McCandliss, B. D., Saccomanno, L., & Posner, M. I. (2005). Training, maturation, and genetic influences on the development of executive attention. *Proceedings of the National Academy of Sciences of the United States of America, 102*(41), 14931–14936.

Stein, J., &Walsh, V. (1997). To see but not to read; the magnocellular theory of dyslexia. *Trends in Neurosciences*, *20 (4)*, 147–152.

oga, A. W., Thompson, P.M., Sowell, E.R. (2006). Mapping brain maturation. *Trends in Neurosciences*, *29*, 148-159.

Unsworth, N. & Engle, R.W. (2007). The Nature of Individual Differences in Working Memory Capacity: Active Maintenance in Primary Memory and Controlled Search from Secondary Memory. *Psychological Review, 114*, 104-132.

von Bastian, C. C., & Oberauer, K. (2013). Distinct transfer effects of training different facets of working memory capacity. *Journal of Memory and Language. , 69*, 36-58.

von Bastian, C. C., Langer, N., Jäncke, L., & Oberauer, K. (2012). Effects of working memory training in young and old adults. *Memory & Cognition, 41*(4), 611-624.