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Effectiveness of Working Memory Training on Cognitive Flexibility

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***Abstract*—**The aim of this study was to investigate the effectiveness of memory training exercise on cognitive flexibility. The method of this study was experimental. The statistical population selected 40 students 14 years old, samples were chosen by available sampling method and then they were replaced in experimental (training program) group and control group randomly and answered to Wisconsin Card Sorting Test; covariance test results indicated that there were a significant in post-test scores of experimental group ($p<0.005$).

***Keywords*—**Cognitive flexibility, working memory exercises, problem solving, reaction time.

I. Introduction

WORKING memory has been defined as "a brain system that provides temporary storage and manipulation of the information necessary for complex cognitive tasks" [1]. The concept of working memory evolved from earlier concepts of short-term memory. Short-term memory was initially seen as a limited capacity memory store that was subject to rapid loss due to decay [2]. and human brain has an amazing ability to adapt mental capacities and abilities to process information very different strangely large and complex 'new experience' with relative ease the surprising ability of the brain to interactions ways ever-changing as in scientific communities, is known neuroplasticity [3]. Memory, is a complex process involving multiple structures in the brain as well as the use of key neurotransmitters. Using a time classification structure, memory can be divided into very short term, short term and Long-term memory. It can further be subdivided into explicit (conscious recollection), episodic (temporal recollection), semantic (conceptualized paradigms), and implicit (unconscious recollection), perceptual (symbolic imaging), procedural (habitual rules), associative (operative conditioning), non-associative (stimulus sensitization), and operational or working memory [4].

Working memory is one of the most influential theoretical constructs in cognitive psychology. This influence derives, at least in part, from links between measures of working memory capacity and a wide variety of real world skills. recently, excitement has been generated by claims that working memory capacity can be trained [5]. The basic mechanics of memory formation in the above domains involves the exposure to information or experiences and their subsequent transfer, storage and retrieval from memory. The part of the brain responsible for this function is comprised primarily of the hypothalamus and amygdala. There is also significant interplay of these limbic structures with the prefrontal cortex and the Para hippocampal cortexes of the medial temporal lobe. Added to this is the role of neurotransmitters (NT), particularly acetylcholine, and the muscarinic and nicotinic receptors that modulate NT pathways. With aging, it is postulated that a restricted loss of neurons occurs in key cortical areas involving memory [6]. Lifestyle choices, achievement of higher education, cognitive pursuits, physical activity, and social interaction, can reduce the slowing of mental speed, and age related decline in executive function. The effect of cognitive engagement and stimulation in preserving the brain has been an area that has received considerable attention. A systematic review of randomized clinical trials on the use of cognitive exercises in the prevention of dementia [7].

Hebb (1949) proposed a mechanism by which learning can occur at the neuronal level: If there is presynaptic and postsynaptic activity occurring at the same time, for whatever reason, the connection between these cells strengthens. This mechanism could allow for associative learning to occur between previously unrelated stimuli [8]. Cognitive skills are here defined as the abilities that an organism can improve through practice or observational learning and that involve judgment or processing beyond perceptual motor skills. The definition of cognitive plasticity usually involves a contrast between the individual's current average level of performance under normative conditions and latent potential. Several aspects of the definition of cognitive plasticity should be noted. First, cognitive plasticity deals with *intra individual* potential, the range of plasticity within an individual. Second, the *context* within which cognitive plasticity is studied needs to be specified. In most studies, cognitive plasticity has been examined within an experimental or intervention context. The individual's average level of cognitive functioning in normative, everyday experience is then contrasted with the range of plasticity exhibited under experimental or training conditions. Specification of the contextual conditions under which plasticity is studied is critical since the range of plasticity manifested will vary on the basis of such factors as the duration, intensity or instructional procedures used in the intervention. Third, cognitive plasticity has generally been studied within a short *time frame*. Most training studies range from one session to, at most, several months in length [9]. The mechanisms underlying cognitive flexibility have been

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explored extensively using various methods. Human studies using functional magnetic resonance imaging (fMRI) have revealed a variety of distinct regions of the brain that work in concert from which flexibility could be predicted reliably, including the prefrontal cortex (PFC), basal ganglia, anterior cingulate cortex (ACC), and posterior parietal cortex (PPC) [10].

Children can be strikingly inflexible when assessed using traditional tests of cognitive flexibility, but this does not come as a surprise considering the many cognitive processes involved in the mental flexibility, and the various developmental trajectories of such abilities. With age, children generally show increases in cognitive flexibility which is likely a product of the protracted development of the front parietal network evident in adults, with maturing synaptic connections, increased myelination and regional gray matter volume occurring from birth to mid-twenties [11].

Cognitive flexibility theory is a conceptual model for developing learning environments based on cognitive learning theory. Researchers have argued that cognitive flexibility is also a component of multiple classifications, as originally described by psychologist Jean Piaget. In multiple classification tasks, participants (primarily children, who have already developed or are in the process of developing this skill) must classify objects in several different ways at once, thereby thinking flexibly about them [13]. Training programs that are more focused on performance-based recognition, attention on details executive function, visual perception and memory storage space, and that cognitive training program is focused on the fact that attention, memory, executive function improved [14].

II. Method

The aim of this study was to investigate effectiveness of memory training exercise on cognitive flexibility in children and method of this study was experimental. The statistical population selected girl (n=20) and boy (n=20) students 14 years old. Samples were chosen by available sampling method and they were replaced in experimental (training program) group and control group randomly and answered to Wisconsin Card Sorting Test (WCST), data were analyzed with MANCOVA TEST.

III. Tools

A. Wisconsin Card Sorting Test WCST

The Wisconsin Card Sorting Test (WCST) is a neuropsychological test of "set-shifting", i.e. the ability to display flexibility in the face of changing schedules of reinforcement. The WCST was written by David A. Grant and Esta A. Berg. The Professional Manual for the WCST was written by Robert K. Heaton, Gordon J. Chelune, Jack L. Talley, Gary G. Kay, and Glenn Curtiss [15], [16]. Although successful completion of the test relies upon a number of intact cognitive functions including attention, working memory, and visual processing, it is loosely termed a "frontal lobe" test on the basis that patients with any sort of frontal lobe lesion generally do poorly at the test. In particular, patients with lesions of the dorsolateral frontal lobe make a higher number of perseverative errors than control participants [17]. The test can be administered to those from 6.5 years to 89 years of age [18].

B. Working Memory Training Software

A brain game is a catch-all name for a variety of online or computer based games. In order to segment the brain game market, Brain Game Review uses the following definitions: A scientifically validated brain game is based on well-known neurocognitive tests, and the game is being/has been referenced in peer reviewed research journals. Several online brain game sites and software program brain games meet the definition of a scientifically validated brain game.

A brain training program is a methodology for using scientifically validated brain games to achieve optimal results – a personal trainer at your gym is a good analogy here – a program or person who keeps you on track and makes sure the optimal training schedule is being followed.

Casual brain games are for entertainment and general education purposes, and for the most part are not backed by any scientific validation. Sudoku, Nintendo Brain Age, and hundreds of other brain teasers, brain puzzles, and brain games fall in this category. Under certain circumstances, yes, scientifically validated brain games can improve cognitive abilities.

IV. Results

Means and standard deviations for cognitive flexibility control and experimental group are presented in Table I.

TABLE I
THE MEAN, STANDARD DEVIATION, FLEXIBILITY IN EXPERIMENTAL, AND CONTROL GROUP

Descriptive Statistics				
Control & Experimental		N	Mean	Std. Deviation
		Statistic	Statistic	Statistic
Control	Control & Experimental	20	1.0000	.000
	Pas Test P2 (Wcst)	20	3.6500	1.34
	Pas Test Ash2 (Wcst)	20	7.20	3.18
	Pas Test Tforfc2 (Wcst)	20	97.85	48.32
	Pas Test Nofc2 (Wcst)	20	4.00	.000
	Pas Test Nforfc2 (Wcst)	20	2.65	2.39
	Valid N (List wise)	20		
Experimental	Control & Experimental	20	2.00	.000
	Pas Test P2 (Wcst)	20	2.30	1.03
	Pas Test Ash2 (Wcst)	20	5.20	2.89
	Pas Test Tforfc2 (Wcst)	20	56.25	25.57
	Pas Test Nofc2 (Wcst)	20	4.0000	.000
	Pas Test Nforfc2 (Wcst)	20	1.60	1.84
	Valid N (List wise)	20		

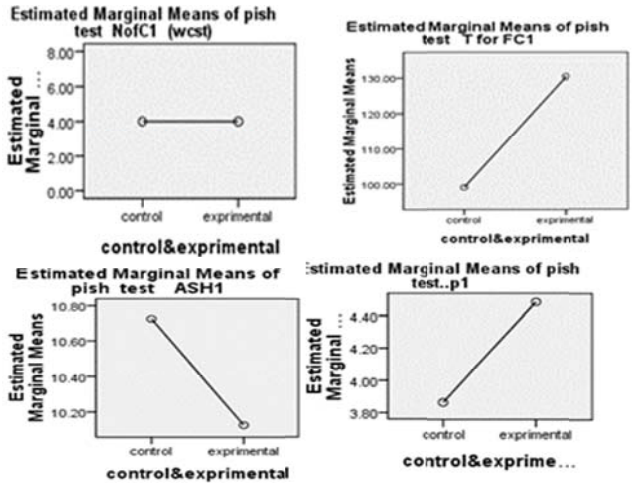

Fig. 1 Profile MEAN Adjusted for Flexibility in Testing Components WCST

TABLE II
MANCOVA ANALYSIS

Source	Dependent variable	Sum of Squares	df	Mean Square	F	Sig.
P2	Pretest. p1	6.884	1	6.884	1.239	0.273
	Pretest ASH1	15.345	1	15.34	0.649	0.426
	Pretest T for FC1	642.20	1	642.20	0.108	0.744
	pretest NofC1	0.000	1	0.000	.	.
	pretest NforFC1	7.790	1	7.790	0.298	0.589
ASH2	Pretest.p1	0.001	1	0.001	0.000	0.991
	pretest ASH1	25.068	1	25.068	1.061	0.310
	pretest T for FC1	1027.381	1	1027.3	0.173	0.680
	pretest NofC1	0.000	1	0.000	.	.
	pretest NforFC1	1.282	1	1.282	0.049	0.826
TforFC2	Pretest.p1	8.887	1	8.887	1.599	0.215
	pretest ASH1	144.81	1	144.81	6.126	0.018
	pretest T for FC1	20483.756	1	20483.75	3.445	0.072
	pretest NofC1	0.000	1	0.000	.	.
	pretest NforFC1	26.088	1	26.08	0.997	0.325
NforFC2	Pretest.p1	0.772	1	0.772	0.139	0.712
	pretest ASH1	9.316	1	9.316	0.394	0.534
	pretest T for FC1	108.23	1	108.23	0.018	0.893
	pretest NofC1	0.000	1	0.000	.	.
	pretest NforFC1	165.98	1	165.98	6.346	0.017

Component of Flexibility TEST Wisconsin Card Sorting Test WCST

- P= preservation
- Ash= Attention shift
- TforFC= Efforts time for First rule is to detect
- NofC= the number of discovered rules
- NforFC= the number of efforts to reach First rule

Since application of covariance analysis needs the existence of some conditions or assumptions, the following conditions about data are studied at first, and then data are analyzed if presumptions exist. Kolmogorow-Smirnov non parametric test (K-S) is used for being aware of pretest and post test data normality. According to K-S and Sig values about each of tests, data distribution is normal and data normality is confirmed (p> 0.05). Considering existence of essential presumptions to conduct covariance analysis using this test, effect of memory training exercise on cognitive flexibility are studied.

MANCOVA analysis (Table II) indicated that there were significant (p <0.05) between pretest and posttest scores of the experimental group and the control variable flexibility (P= preservation, Ash= Attention shift, TforFC= Efforts time for First rule is to detect, NofC= the number of discovered rules NforFC= the number of efforts to reach First rule).

Mean adjusted for flexibility in WCST (Fig. 1) indicated that there was significant difference in posttest flexibility scores. Therefore, training program memory has significantly increased cognitive flexibility.

V. DISCUSSION

The goal of this study was to evaluate the effect of exercise training on memory and cognitive flexibility. The results of analysis of covariance showed that the scores of boys and girls participating in cognitive flexibility Experimental group in the post-training memory training increased. Children who participated in training memory there was significant difference in posttest flexibility scores. Therefore, training exercise memory makes a difference significant in Flexibility (component WCST test). Information endurance as a form of synaptic flexibility including flexibility in synapse structure occurs in a specific set of neurons in long term memory [19]. Cognitive flexibility theory focuses on the nature of learning in complex and ill-structured domains. Spiro & Jehng state it as the ability to spontaneously restructure one's knowledge, in many ways, in adaptive response to radically changing situational demands. Cognitive flexibility is the ability to restructure knowledge in multiple ways depending on the changing situational demands [12]. Training programs focused Function based on the recognition attention to detail, executive function and memory, storage, visual perception spatial‹and cognitive training programs that are being used to improve executive function, attention, memory [21].

Video games for some reason they can be used effectively in schools:

1. They have a specific goal that children should try to arrive
2. The level of complexity that can be changed according to user needs.
3. They are faster than traditional handheld games.
4. In most games, kids reset instructions implicitly understand and do not need to read the instructions [22].

The vast majority of cognitive training intervention studies to improve memory skills, this is not surprising since research has shown that memory loss is one of the most extensive Complaints about aging. A number of studies have attempted to develop a wider range of Cognitive skills [23]. If there is a Hawthorne effect, performance improvements might be a consequence of some other factor—such as the intensive contact with study participants—rather than a consequence of the training itself [24]. A number of studies have reported that they provided pertaining sessions that consisted of training in imagery, semantic judgment, and relaxation training. Some studies have reported that such sessions are beneficial [25], [26].

The wide range of tests that has been utilized in cognitive-training studies has greatly complicated the task of interpreting the collective results. For example, it is possible that one study that reported no significant results might have produced different results if a different set of tests had been employed. Moreover, some studies have either not undertaken an evaluation of the effectiveness of their training program [27] or they have employed evaluation instruments which are not validated. For example, [28] developed an instrument called the Cusack-Thompson Mental Fitness Self-Assessment Scale. This tool was used to demonstrate the effectiveness of their training program, but no information was provided to establish the reliability and validity of the instrument. Human development has been shown to be modify able at all phases in the lifespan, although the range of modify ability may vary by chronological age and life experiences. Cognitive Plasticity is concerned with the individual's capacity to acquire cognitive skills and may be assessed in both brain structure and behavior. Cognitive Plasticity in cognitive aging research has most frequently been examined through short-term cognitive training studies, examining the range of modify ability of cognition through intervention procedures [29], [33].

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