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Effect of Brain Training on Cognitive Performance in Elderly Women Diagnosed with Mild Cognitive Impairment

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ABSTRACT

Background: Cognitive impairment profoundly influences on older adults' activities and quality of life. Therefore, optimizing and remediating age-associated cognitive decline have great importance.
Objectives: To evaluate the effect of 8 weeks (3 day /week) computer based brain training on cognitive performance in old women with Mild Cognitive Impairment (MCI).
Materials and Methods: This randomized controlled study was performed in old women with MCI that was measured using the mini-mental state examination (MMSE). Twenty women diagnosed with MCI were divided into two groups of: exercised (trained with computerized brain program for 8 weeks (3 day /week, 30-60 min/day) and control group. Before and after training, reaction time, error number and data processing speed were measured using computer stroop task and digit symbol coding test, respectively. After checking the normal distribution of collected data by Kolmogorov-Smirnov test, the pre and post means difference and differences between groups were analyzed using paired T- test and independent t-test respectively.
Results: Brain training lead to a significant reduction in reaction time (p=0.001), error number (p=0.002) and increase in data processing speed (p=0.011) compared with pre-test values. Also, there were significant differences between experimental and control groups in reaction time (p=0.001), error number (p=0.007) and processing speed (p=0.013).
Conclusion: The findings indicate the efficacy of computer based brain training program on improving the reaction time, error number and processing speed in elderly women diagnosed with MCI and also reflects the plasticity of old brain for challenging to learn new tasks.

Keywords: Computerized Brain Exercise; Computer Stroop Task; Digit Symbol Coding Test; Mild Cognitive Impairment

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Introduction

As the individual ages, there are complaints about cognitive impairment [1], mostly due to neural death and brain atrophy [2,3]. Evidences show that the number of demented people in Iran in 2009 was two hundred thousand [4], and reached to five hundred thousand in 2011 [5] and doubled by 2016. In addition, the number of people with mild cognitive impairment is estimated to be more than diagnosed reported ones [5].

The term of mild cognitive impairment (MCI) is used to describe patients who are at the stage between normal ageing and dementia state [6]. A review study found that the reported rampancy of MCI varies widely across international studies, from around 3% to 42% [7]. Diagnostic criteria for MCI include: abnormal memory function for the person's age, normal general cognitive function and ordinary activities of daily living (ADL).

Since no medication has been clearly shown to delay or halt the progression of the disease [8], and also current pharmacological medications have different side effects, to find new strategies for preventing the progression of MCI to AD has great importance. For example, different brain games for targeting specific areas in the brain to boost mental activity are one of the newest therapies to prevent the progression of AD. It has been known that brain training causes an elevated attention and working memory ability [9]. In addition, there are evidences showing that the prefrontal cognitive system in the aged brain possesses plasticity, and therefore gives the one the ability to enhance cognition with games targeting these regions [9].

Growing body of technologies usage amongst elder, together with enthusiasms for programs like Lumosity and Brain Age, have led to enhanced interest in the effectiveness of these personalized cognitive training programs [10].

Despite some disputations about plasticity of old brains, cognitive training is relied on the idea that the brain, even in old age, has possibility to change. Brain is much similar to muscles; in a way that "uses it or loses it" and cognitive training resembles physical activity targets different aspects of brain functions. Cognitive training might be conducted computerized or on paper; individually or in groups. But it typically involves using repetitive exercises designed to improve single (*e.g.,* memory) or multiple (*e.g.,* memory and reasoning) cognitive abilities [11]. Considering the contradictions in the efficacy of brain training on cognitive performance in MCI [12-14], also lack of similar study in MCI elderly women with low level of education in the population of Iran, to our knowledge, the present study was designed to evaluate the effect of a special brain training program on reaction time, error number and processing speed in low educated elderly women with MCI.

Materials and Methods

This study was a randomized controlled trial. At the initial of the experiment 58 aged women voluntarily were recruited after announcing in the public places and Yas adult day center in Golestan province in the north of Iran in winter 2016. They were examined in terms of physical and psychological status and level of education as well. Then cognitive impairment and depression were measured using the mini-mental state examination (MMSE) cognitive test and Global Deterioration Scale-short form (GDS-SF) index, respectively [15,16].

Inclusion criteria for the study included: (1) age ranged from 60 to 85 years old (2) MMSE Score between 18 and 23 points (3) the level of GDS-SF score between 0 and 5 (4) normal visual and hearing functions (5) the ability of reading and writing and (6) lack of neurophysiological disorders.

After accurate examination of participants by physician, twenty individuals diagnosed as MCI randomly assigned to one of the following groups: Experimental group (EG=11) and control group (CG=9).The present study was approved by the Ethics and Research Committee of the Guilan University of Medical Sciences (IR.GUMS.REC.1394.447).

Subjects received information about the purpose and details of the study, then they were assured of the confidentiality of their responses and gave informed written consent prior to fulfilling the psychological questionnaires.

Subjects in the experimental group practiced under the supervision of physiotherapist for 8 weeks (3 day/week, 30-60 min/day). It was an incremental protocol, starting from 30 minutes at the first day and prolonging till 60 minutes at the seventh and eighth week.

Brain training program consisted of special game entitled ‘‘My Better Mind’’; the program ran through an auto-download-enabled Flash Player software. The active program included of 4 games, each one designed to target a specific cognitive domain.

1. Photo flaw: the purpose of the game was to find teeny differences between similar identical pairs of photographs of views. This test engages visual attention, visual working memory, since player have to keep the reference image in mind as they search differences in the second image and visual-spatial relationships. It also underscores speeded processing of performing task.
2. Headline Clues focused on current events; participants solve captions with missing words and letters, about news of the day. It evaluates verbal memory and reasoning, and also speed of processing.
3. Sokoban is a logic puzzle game that tests strategic planning and uses both reasoning and visual-spatial skills. The aim of the game is to push lenses through a maze and onto targets in the minimum number of moves. This test assesses spatial executive processing and non-verbal reasoning.
4. Keep It in Mind is a brain task in which the aim is to remember a series of progressively longer lists of items.

Participants are first shown two items and then asked to choose those items from a complex of identical items. Each period progresses from remembering 2, then 3, then 4 on up to 7 items. Keep it in mind players pick out the item type they choose to work on (letters, numbers, words, objects, patterns as well as a difficulty setting). It was developed to engage working memory (both verbal and visuospatial) [17].

During the training sessions, the subjects were asked not to change their routines such as: the sleep-wake cycle, daily physical activity and diet. The control group had no mental training program except their routines.

To evaluate the effects of brain training on cognitive function, all indices were administered at baseline and also 8 weeks after intervention. Cognitive performances were assessed for both reaction time and error number on a computer stroop task [18]. Also, processing speed was assessed on computer digit symbol coding test [19].

Stroop task is a paradigm for studying aspects of cognitive performance that depends on executive functioning. This task assesses cognitive processes associated with selective attention to specific information during decision-making tasks and choosing appropriate responses [20]. Participants were presented color words (*e.g.*, RED) showing in either congruent (red) or incongruent (*e.g.*, green) colors. For control trials only one dimension of the stimulus was present (*i.e.*, illustrating all words in black colors, or color patches but without words [20].

The Digit symbol coding test (WAIS-R) was also used to evaluate processing speed. It consisted of (*e.g.* nine) digit symbol pairs (*e.g.* 1/β, 2/ Λ ... 7/ ⊥, 8/ =, 9/ X) pursued by a list of digits. Under each digit the subject had to write down the related symbol as quickly as possible in 90 seconds [21].

All data were analyzed for normal distribution by Kolmogorov-Smirnov test using SPSS version 23. Then paired t-test and independent t-test were used to compare pre and post, also between group differences. Significant level was set at $p \leq 0.05$.

Results

Baseline characteristics of subjects are shown in table 1.

Table 1. Baseline characteristics of subjects participating in the study

	Experimental group (N= 11) Mean± (SD)	Control group (N=9) Mean± (SD)
Age (year)	67.90±3.75	69.11±4.93
BMI (kg/m2)	28.40±6.35	3.22±1.20
Education (year)	3.54±1.29	3.22±1.20
MMSE	23.81±2.04	23.44±2.06
GDS-SF	1.72±1.42	2.00±1.58

There was no significant difference in baseline characteristics of subjects between the experimental and control groups. BMI: Body Mass Index, MMSE: Mini-Mental State Examination, GDS-SF: Global Deterioration-Scale-Short Form

Figures 1, 2 and 3 display Mean±SD for reaction time, error number and processing speed scores. The experimental group showed significant improvement in all neuropsychological tests after two months of brain training compared with pretest.

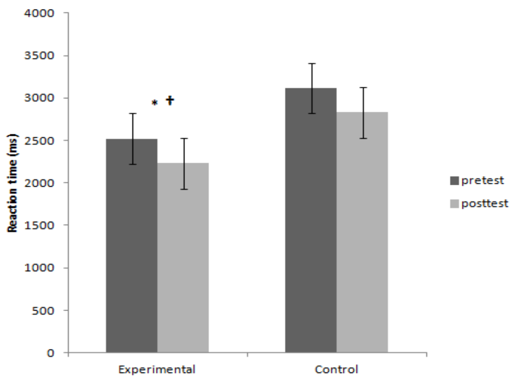

Fig 1. The mean ± SD of reaction time scores of experimental and control groups before and after intervention.
* p=0.001 Significant difference between pre and post exercise values
† p=0.001 Significant difference between experimental and control group

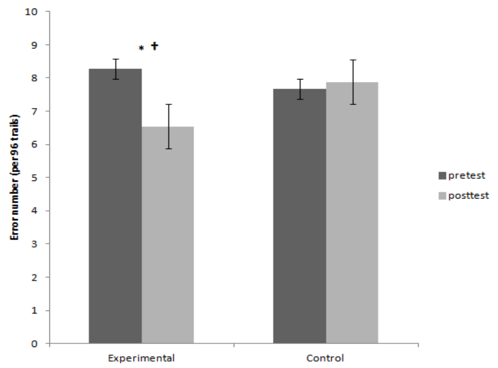

Fig 2. The mean ± SD of error number scores of experimental and control groups before and after intervention.
* p=0.001 Significant difference between pre and post exercise values
† p=0.001 Significant difference between experimental and control group

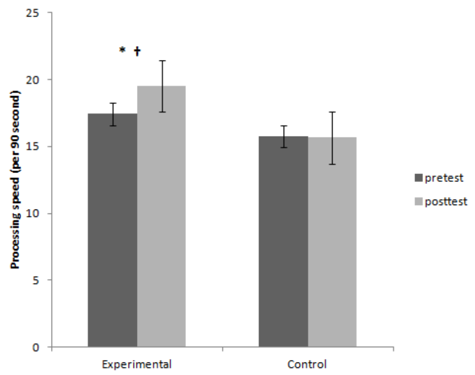

Fig 3. The mean ± SD of processing speed scores of experimental and control groups before and after intervention.
* p=0.001 Significant difference between pre and post exercise values
† p=0.001 Significant difference between experimental and control group

Reaction time (13%, t=4.54, p=0.001) and error number (26%, t=4.033, p=0.002) were decreased significantly compared with baseline. Also, processing speed improved significantly (12%, t=-3.136, *p*=0.011) compared with pre exercise value. There was no significant difference in neuropsycological values between pre-and post-practices in control untrained group.

Furthermore, there were significant differences between experimental and control groups in reaction time (t=-3.83, *p*=0.001), error number (t=-3.08, *p*=0.007) and processing speed (t=2.78, *p*=0.013).

Discussion

The present study investigated the effect of 8-week progressive computer-based brain training program on cognitive performance in patients with cognitive complaints. In line with Li *et al.* (2016), Jeong *et al.* (2016), Hwang *et al.* (2012), the present study found significant improvement in reaction time and error number in stroop test after 24 sessions of mental game [22-24]. However this is in contradictory with Bailey *et al.* study (2010) in which they evaluated the influence of video game experience on strop test, although they did not include control group [25].

Also, similar to the previous reports including Anguera *et al.*, 2013; Matthew *et al.*, 2009 [9,26], significant improvement in processing speed of digit symbol coding was found in our study after 24 sessions of mental game. In contradictory to our finding, Van Ravenzwaaij *et al.* (2014) declared that video games do not improve the speed of information processing [27]. One reason for discrepancies might be the duration of mental training which was 19 hours in our study, while their subjects experienced 10 hours.

Heeter (2008) reported in their study a natural tendency in subjects to choose modest challenges and to focus on one or a few brain domains that are easiest for them. They believe that a moderate level of challenge, not too easy but not impossibly hard, is likely to be an optimal prescription for cognitive gain [28]. Therefore, in the present study, the level of brain training was moderate and adequate to cause significant improvement on cognitive function in older adults' women with MCI.

Our findings confirm the maintenance of neural plasticity in elderly individuals as proposed by Kramer & Willis (2002) and Tarraga, *et al.* (2006) [29,30]. Neural plasticity, the mechanism that serves as the foundation for the "uses it or loses it" theory, suggests that cognitive interventions may promote neurogenesis. Humans (if not all animals) sustain the ability for brain change, or plasticity throughout their lives even though some deterioration in brain structure and/or function can be observed in nearly all elderly individuals [16]. Neural positive plasticity is one explanation that brain training augment cognition [31].

It is questionable finding some improvements -though no significant- were also seen in the control group (reaction time and processing speed). This might be due to learning effect of neuropsychological tests, since neither of our participants was familiar with computer based brain training, and they had to learn the new tasks which demand neural activities and further synaptic strengths required for boosting the cognitive performance. In general, sedentary life styles, such as control group tends to slow down their reaction time and curiosity compared with exercised group.

Although we didn't study the brain structures in the present study, we could add the possibility of increase in brain activity and grey matter volume [32], or reduced deposition of amyloid beta polypeptide, a protein hallmark of AD [33,34]. Engvig *et al.* (2014) found an increase in the overall increased grey matter volume, white matter integrity, and cortical thickness after mental training in older healthy and MCI participants [35]. Therefore the mechanisms by which brain training improves cognitive performance needs to be elucidate.

From clinical point of view, and considering high rate of MCI [5] and stroke [36] in Iran, the results of this study might be a good strategy to combat cognitive deficits induced by neurological disturbances.

To our knowledge this is the first study to examine the effect of computer brain training on cognitive function in low educated elderly female with MCI.

Conclusions

Taken together our results suggest that protocol of computer based brain training used in the present study is adequate to cause a significant improvement in reaction time, error number and processing speed in the subjects with mild cognitive impairment, even with no experience of such training.

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Conflict of Interest

The authors have no conflict of interest.

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