Promotion of Neuro-cognitive domains with working memory computerized test (WMCT) among healthy adult

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***Abstract*— Here, we examined whether working memory computerized test (WMCT) suggestibility would occur when participants were administered an immediate working memory by WMCT. This method is an investigative computerized technique that consistently elicits more correct details in memory reports than standard interviews. In this study, participants watched a monitor of a software program and then completed a various stages of computerized test with control condition by therapist. They then see information presented in a monitor. Participants produced more accurate memory details in the WMCT after several times. However, the WMCT also increased the later report of rehabilitation relative to the control condition by therapist. These results show that initial retrieval can increase subsequent suggestibility even when such retrieval occurs under relatively ideal conclusion: We thought that this method is suitable for assessing and rehabilitation of working memory.**

***Index Terms*— Promotion, Neuro-cognitive, domains, working memory, computerized test**

I. INTRODUCTION

Working memory is a part of cognitive processes which are sensitive to age, sex and education, these factors are associated with cognitive development of the individuals. In addition, neuroscience studies indicate the relationship between working memory and attention, memory and learning which are influenced by those mentioned factors [1]-[4]. Investigations have determined that the brain frontal cortex, parietal cortex, anterior cingulate and some parts of the basal ganglia are more critical than other domains of the brain. Neural basis of working memory is derived from animal experiments and human functional imaging. The cognitive neuroscience studies generally support multiple resource models of working memory such as Baddeley model [5]. Of course, memory models try to explain the details of function rather than structure. Recent studies show different functions of working memory performances in the brain. For example, the findings suggest that working, verbal, visual, spatial and executive memories are associated with different parts of the brain[6]. Also, other neurological evidences indicate the difference between verbal and visual-spatial sub-systems [7]. The first results on neural pathways and neurotransmitters of working memory have been obtained from animal studies [8]-[9]. For the first time, these studies showed that PFC lesions impair working memory performance in monkeys. Early models of Baddeley theory were the founder of computerized models of working memory which have been proposed by some researchers in different countries [10]. Determining the role of age, gender and education is of great importance on cognitive abilities of normal individuals in designing the neuro-cognitive computerized tests [11]. By comparing the obtained results of the mentioned computerized tests among different ages with different educations in both genders, the individual's cognitive strengths and weaknesses in the working memory sub-domain would be designated. Therefore, our purpose is to present a designed computerized evaluating model of working memory based on the three main variables of age, sex and education.

In the present study, the purpose of the application is the methodology, and of the research is descriptive and cross-sectional study, that the study of working memory on adult. The population in this study constitutes the normal adult, whose number is about 120 the sample size of healthy subjects in both genders was 18-80 years of age. Due to the possibility of loss in this pilot study, 60 individuals were considered for each gender group. Individuals of both sexes were examined initially by neurologists and psychiatrists. After the final diagnosis, the informed consent and demographic questionnaire were completed by the participants and then the computerized test of working memory was conducted. Sampling method is simple random type.

A. COMPUTRIZED WORKING MEMORY TEST (CWMT)

In this study, in addition to library of studies that were conducted in order to achieve theoretical background of the research, standardized computerized test were used for gathering information which is needed. The computerized test is as follows: via the changing novel memory model [5]-[12].This variable has six components and each component consists of six items that include: The number of Correct responses, The number of Error responses, Total time of Correct responses in milliseconds, Total time of Error responses in milliseconds, The last stage until which the user could proceed, Total time Record of the computerized test in milliseconds. In the present study, in order to access validity

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and reliability of this computerized test, it's used some scientists' comments in validity method of content and it confirmed by supervisor and consultant and for determining reliability of this test, they used Cronbach's Alpha Method. This method is used for computation inner harmony of calculators which calculate various features.

First in this computerized test, some information is given to the person regarding to the implementation method of the computerized test. Then, the participant should click on a specific part of the page or press the Space or Enter button for starting the computerized test.

In this computerized test, the user will see an 8*8 matrix at any stage. In each row and columns of this matrix, there is only one clear space (its color is different). After 5 seconds, the matrix is rotated 90 degrees clockwise and the user needs to recognize that the matrix is the same as before or a new matrix is shown to them. Then in case of same matrix, the left Shift key or left Arrow key should be pressed by the user. Otherwise, the user should press the right Shift key or right Arrow key. Correct statement would be displayed if the answer is true. He/she will then guide to the next step. If the answer is false, the incorrect statement will be shown.

This process continues till the user exit the test by clicking the Close button. The user can precede to the last step of this computerized test (step 50) where the test window will be closed automatically. This method use in the last study, it is the roles of working memory and intervening computerized test that repetition has benefit for improvement of memory [13].

B. Time

1. Display time duration of the Ready phrase at the beginning of the task: 2000 milliseconds
2. Display time duration of each stage: 5000 milliseconds
3. Display time duration of the Correct and Incorrect phrases: 2000 milliseconds
4. Time duration of the user's reply in each stage: 10000 milliseconds
5. The entire time duration of the computerized test is considered 15 minutes. The user has the opportunity to finish the computerized test in this time, otherwise; it will be closed automatically after 15 minutes.

C. Variables

1. The number of Correct responses
2. The number of Error responses
3. Total time of Correct responses in milliseconds
4. Total time of Error responses in milliseconds
5. The last stage until which the user could proceed
6. Total time Record of the task in milliseconds

II. RESULTS & ANALYSIS

By performing the tasks, the collected data are entered the $SPSS_{18}$ software and are analyzed through descriptive statistics, Pearson's correlation coefficient and t-test.

Table 1- The frequency of age, sex and education variables among healthy individuals

Variable	Number	Average	Standard Deviation	Average of Standard Error
Correct Response	120	15.68	15.19	1.38
Error Response	120	12.78	10.80	0.98
Correct Time	120	4.01	39900.85	3642.43
Error Time	120	5.94	81502.81	7440.15
Last Level	120	27.12	20.40	1.86
Time Record	120	2.97	2.20	20156.69
Memory Span Percent	120	54.21	40.85	3.72

According to the table, the mean responses for all computerized test variables are considered.

Table 2- The comparison of correlation and age of healthy individuals with working memory computerized test variables

Working Memory Test Variables	Age	Sex	Education
Correct Response	R=0.280 P-value=0.002	R=-0.036 P-value=0.001	R=0.018 P-value=0.842
Error Response	R=0.447 P-value=0.000	R=0.101 P-value=0.271	R=-0.122 P-value=0.186
Correct Time	R=0.510 P-value=0.000	R=0.035 P-value=0.003	R=-0.180 P-value=0.049
Error Time	R=0.361 P-value=0.000	R=0.121 P-value=0.186	R=-160 P-value=0.080
Last Level	R=0.448 P-value=0.000	R=0.049 P-value=0.595	R=-0.063 P-value=0.491
Time Record	R=0.463 P-value=0.000	R=0.075 P-value=0.003	R=-0.184 P-value=0.045
Memory Span Percent	R=0.447 P-value=0.000	R=0.049 P-value=0.002	R=-0.063 P-value=0.491

According to the table, the column of age showed a significant positive correlation with the whole working computerized test variables among healthy individuals (P<0.05). In the sex column, a significant positive correlation was seen with Correct Response, Correct Time, Time Record and Memory Span Percent variables of the working computerized test (P<0.05). The Correct Time and Time Record variables of the test displayed a significant negative correlation with education (P<0.05).

Table 3- Comparison of frequency, mean, standard deviation, standard error of the mean variables to computerized test working memory in healthy individuals before and after rehabilitation

Variable	Group	Number	Mean	Standard deviation	Standard error of the mean
Correct response	After rehabilitation	120	15.68	15.19	1.38
	Before rehabilitation	120	4.28	12.77	1.16
Error response	After rehabilitation	120	4.17	10.80	0.98
	Before rehabilitation	120	12.78	2.16	0.19
Correct time	After rehabilitation	120	1.59	39900.85	3642.43
	Before rehabilitation	120	4.01	40862.98	373030.26
Error time	After rehabilitation	120	2.72	81502.81	7440.15
	Before rehabilitation	120	5.94	25270.31	2306.85
Last level	After rehabilitation	120	6.43	20.40	1.86
	Before rehabilitation	120	27.12	2.96	27084
Time record	After rehabilitation	120	2.97	2.20	20156.69
	Before rehabilitation	120	9.63	49467.52	4515.74
Memory span percent	After rehabilitation	120	54.21	40.85	3.72
	Before rehabilitation	120	16.45	10.59	0.96

Memory span percent has been increased after rehabilitation.

Table 4-Evaluation of the significance value t, the variables tested working memory in healthy individuals before and after rehabilitation

Variable	F	Sig	T	Df
Correct response	61.63	0.000	6.40	231.17
Error response	123.22	0.000	8.56	128.50
Correct time	24.32	0.000	4.65	237.86
Error time	24.89	0.000	4.12	141.67
Last level	862.06	0.000	10.99	124.02
Time record	352.14	0.000	9.74	130.91
Memory span percent	576.73	0.000	9.80	134.93

Significant differences were observed in all variables testing working memory in healthy individuals before and after rehabilitation.

Table 5- The comparison of correlation, significance, and differences of age p-value with Variables testing working memory in healthy individuals before and after rehabilitation.

Age	After rehabilitation	Before rehabilitation
Correct Response	r= 0.280 p-value= 0.002	r= 0.145 p-value=0.114
Error Response	r= 0.447 p-value= 0.000	r= 0.135 p-value= 0.142
Correct Time	r= 0.510 p-value=0.000	r=0.093 p-value=0.315
Error Time	r=0.361 p-value= 0.000	r=-0.316 p-value= 0.000
Last Level	r= 0.448 p-value= 0.000	r=0.096 p-value=0.297
Time Record	r=0.463 p-value= 0.000	r= -0.061 p-value=0.509
Memory Span Percent	r=0.447 p-value= 0.000	r= -0.0640 p-value= 0.491

According to the table, All variables testing working memory rehabilitation have significant P-value relationship in positive direction with age (p<0.05) after rehabilitation. There is also significant relationship between error time variable and age in negative direction (p<0.05) before rehabilitation.

Table 6-The comparison of correlation, significance, differences of sex p-value with Variables testing working memory in healthy individuals before and after rehabilitation.

Sex	After rehabilitation	Before rehabilitation
Correct Response	r= -0.036 p-value=0.001	r= 0.299 p-value= 0.001
Error Response	r=0.101 p-value=0.271	r=0.079 p-value=0.394
Correct Time	r=0.035 p-value=0.003	r=0.269 p-value= 0.003
Error Time	r=0.121 p-value= 0.186	r= -0.011 p-value= 0.905
Last Level	r= 0.049 p-value= 0.595	r= 0.120 p-value= 0.180
Time Record	r= 0.075 p-value= 0.003	r= 0.268 p-value= 0.003
Memory Span Percent	r= 0.049 p-value= 0.002	r= 0.283 p-value=0.002

According to Table 6,the variables of Correct Response , Correct Time, Time Record and Memory Span Percent testing rehabilitation of working memory have significant P-value relationship in positive direction with sex before and after rehabilitation groups (p<0.05).

Table 7- The comparison of correlation, significance, and p-value difference of education with Variables testing working memory in healthy individuals before and after rehabilitation.

Education	After rehabilitation	Before rehabilitation
Correct Response	r=0.018 p-value= 0.842	r= 0.0921 p-value= 0.325
Error Response	r= -0.122 p-value=0.186	r=0.149 p-value= 0.104
Correct Time	r= -0.180 p-value= 0.049	r= -0.019 p-value=0.836
Error Time	r=-.160 p-value= 0.080	r -0.135 p-value=0.0143
Last Level	r= -0.063 p-value=0.491	r=0.182 p-value=0.047
Time Record	r= 0.184 p-value=0.045	r= -0.025 p-value=0.787
Memory Span Percent	r=-0.063 p-value=0.491	r=0.104 p-value=0.258

According to Table 7, there is a relation between the variables of correct time, Error Time and time record with education in the negative direction after Rehabilitation and there is a relation between last level variable with education in the positive direction before Rehabilitation ($p<0.05$).

III. FUTURE SCOPE

We can improve brain functions by increasing our understanding and implementation of effective computerized applications. In addition to the improvement of rehabilitation outcomes, computerized model of brain rehabilitation also displays pragmatic benefits to support rehabilitation practices. In cognitive impairments, cognitive rehabilitation will be a well-designed instruction and a key for facilitating positive efficient and stable outcomes.

IV. CONCLUSION

Recent researchers have identified the fact that the efficiency of working memory processes is related to the individual differences in working memory capacity. Therefore, the ideal function of working memory needs a professional practice of the executive working memory processes [14]. Efficiency of executive processes influences on operation and the whole working memory capacity and also provides more resources for different types of storage. By age increasing, the executive working memory establishes a stronger link with the verbal working memory. But, there must be fewer links with visual-spatial functions of the working memory [15]. However, the strategies that specifically target the strengths and weaknesses of working memory specifications are available [16]. Also, these evaluations are very sensitive to weak memory and those thinking problems which might not be revealed in other ways. When it is mild memory problems, neuro-cognitive computerized tests of memory may be the only way to detect them. This test is useful for assessing memory problems. So in this study, our purpose is to present computerized model of working memory evaluation based on three main variables of age, sex and education. This computerized test is also used to identify problems related to medical conditions that can affect memory and thinking such as Diabetes, high blood pressure, stroke, Parkinson’s disease, Huntington, Fibromyalgia, kidney diseases, cognitive decline after surgery, alcoholism and etc. This communized model also helps to distinguish memory disorders such as Alzheimer’s disease, stroke, dementia, anxiety and depression. This can be used for more effective management of medical and non-medical treatments as well. The obtained results of these computerized tests can be applied for scheduling those treatments that use strengths to compensate weaknesses. Also, these results assist to diagnose memory problems and find applicable strategies. For instance, they can be used for planning and supervising the cognitive rehabilitation or pursuing memory skills recovery after a stroke or traumatic brain injuries[17].

Neuroscientists evaluate the brain functions through objective tests including Executive skills (Reasoning, Planning, etc), the accuracy and speed of information processing, attention and concentration, learning and memory, language, visumotor and sensorimotor functions, auditory processing, visual-spatial processing [18]. By increasing our understanding and implementation of effective methods for memory rehabilitation, cognitive and verbal rehabilitation will be facilitated. In addition to the improvement of rehabilitation outcomes, computerized model of working memory rehabilitation also displays pragmatic benefits to support evidence-based rehabilitation practices. In economic difficulties, memory rehabilitation will be a well-designed instruction and a key for facilitating positive efficient and stable outcomes.

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