RESEARCH PAPER | Medical Science | Volume : 5 | Issue : 1 | Jan 2015 | ISSN - 2249-555X

Assessing and Rehabilitation of Working Memory in Adult With Computerized Test

KEYWORDS

Zarghi A	Zali A	Ashrafi F
MD. MPH. Ph.D, Department of Neuroscience, Functional Neurosurgery Research Center, Shahid Beheshti University MC, TEHRAN-IRAN	Professor, Functional Neurosurgery Research Center, Shohada hospital, Tajrish Avenue, Tehran, Iran	Ass0ssiated Professor, Department of neurology, Functional Neurosurgery Research Center, Shohada hospital, Tajrish Avenue, Tehran, Iran

Moazzezi S	Lotfi M
Medical student, Shahid Beheshti University of Medical Sciences, Shohada hospital, Tajrish Avenue, Tehran, Iran	Master of Science, Department of Psychology, Kharazmi University, Shohada hospital, Tajrish Avenue, Tehran, Iran

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 task 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.*

Introduction:

The first reference to the neurological assessment of working memory can go back to more than 100 years ago. Having a description on the examination of prefrontal cortex damage (PFC), researchers concluded that the cognitive processes of the frontal cortex are more important than sensory processes(1).In recent years, the detrimental effects of frontal damage are shown with delayed response(2). However, its effect on other aspects of eyewitness memory is less clear Researchers have shown that processing speed has a great influence on working memory, because the memory is processed and maintained in a particular time(3).

High processing speed causes more data to be processed in less time. Consequently, function and capacity of working memory increases. The processing speed also reduces the information gap which must be maintained. Thus, the short-term forgetting is reduced. Working memory is a system that actively keeps in mind several passing pieces of information and it can be manipulated. This includes tasks such as verbal and non-verbal reasoning and understanding which are more accessible to future information processing (4). The working memory involves the storage subsystems, manipulated visual images or verbal information as well as an administrative center that will coordinate subsystems. This includes a visual representation of possible movements and awareness about flow of information in and out of memory (5,6). Working memory tasks need to be monitored with the target of regulating the processes of interference, consequence and distraction(7). Required cognitive processes to achieve this target are executive functions, attention and short-term memory control which allow temporary integration, processing, disposal and data recovery(8).

Also, as individuals age, however, working memory performance declines(9), which can lead to difficulty performing a multitude of everyday activities. Age has been shown as the most critical factors that play a role in the decline of cognitive functions and can make Aging Working Memory(3). Several studies have been proposed for this decline. Based on the findings of the theory of aging cognitive processing speed, the overall decline of cognitive processes occurs with aging (10,11). For slower processing, more time is needed for the content of working memory and thus reduces the effective memory capacity which is involved in working memory assessment tests. Moreover, decline of memory capacity can be attributed entirely to age rather than speed (12). It has been argued that a decrease in working memory occurs due to the age in the prefrontal cortex. Studies show that working memory can be promoted in patients via computerized programs(7). This could be involved in the rehabilitation of working memory.

Working memory training period holds a wide range of cognitive abilities and the increase of IQ test score (13). Researchers have found that working memory training leads to changes in the measurable density of cortical Dopamine neuro-receptors among under studied individuals (14). Since sex and education factors affect on cognitive domains (15,16) and cause changes in memory, computerized evaluations should be considered (17). Taking into consideration the working memory assessment and designing computerized model for people have been presented by some researchers in different countries (18). These non-invasive and inexpensive methods of assessment can be conducted in a private and convenient outpatient office. When it is mild memory deficit, neuro-cognitive computerized test of memory may be the only way to detect. These tests are also used to identify problems that can affect

Volume : 5 | Issue : 1 | Jan 2015 | ISSN - 2249-555X

memory and thinking such as diabetes, high blood pressure, stroke, Parkinson, Huntington, fibromyalgia, kidney diseases, cognitive decline after surgery, alcoholism and etc.

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 (15,16,19). 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 (20). 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 (21). Also, other neurological evidences indicate the difference between verbal and visual-spatial sub-systems (22). The first results on neural pathways and neurotransmitters of working memory have been obtained from animal studies (23,24). 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 (18). Determining the role of age, gender and education is of great importance on cognitive abilities of normal individuals in designing the neuro-cognitive tests (16,25).By comparing the obtained results of the mentioned 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.

Research Method:
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.

Population, sample and sampling method:
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.

Research Tools:
In this study, in addition to library of studies that were conducted in order to achieve theoretical background of the research, standardized task were used for gathering information which is needed. The task is as follows: via the changing novel memory modle (17,20). 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 task in milliseconds. In the present study, in order to access validity and reliability of this task, it's used some scientists' comments in validity method of content and it confirmed by supervisor and consultant and for determining reliability of this task, they used Cronbach's Alpha Method. This method is used for computation inner harmony of calculators which calculate various features.

1. Computerized Working Memory Task (CWMT):
First in this task, some information is given to the person regarding to the implementation method of the test. Then, the participant should click on a specific part of the page or press the Space or Enter button for starting the task.

In this 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 task by clicking the Close button. The user can precede to the last step of this task (step 50) where the task window will be closed automatically. This method use in the last study, it is the roles of working memory and intervening task that repetition has benefit for improvement of memory (4).

Time
Display time duration of the Ready phrase at the beginning of the task: 2000 milliseconds

Display time duration of each stage: 5000 milliseconds

Display time duration of the Correct and Incorrect phrases: 2000 milliseconds

Time duration of the user's reply in each stage: 10000 milliseconds

The entire time duration of the task is considered 15 minutes. The user has the opportunity to finish the task in this time, otherwise; it will be closed automatically after 15 minutes.

Variables
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 task in milliseconds

Volume : 5 | Issue : 1 | Jan 2015 | ISSN - 2249-555X

Research Finding:
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	0.39	0.36
Error Time	120	5.94	0.81	0.74
Last Level	120	27.12	0.20	1.86
Time Record	120	2.97	0.22	0.20
Memory Span Percent	120	54.21	40.85	3.72

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

Table 2- The comparison of correlation and age of healthy individuals with working memory 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 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 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 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	0.39	0.36
	Before rehabilitation	120	4.01	0.40	0.37
Error time	After rehabilitation	120	2.72	0.81	0.74
	Before rehabilitation	120	5.94	0.25	0.23
Last level	After rehabilitation	120	6.43	20.40	1.86
	Before rehabilitation	120	27.12	2.96	0.27
Time record	After rehabilitation	120	2.97	2.20	0.20
	Before rehabilitation	120	9.63	0.49	0.45
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	0.145 r= 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	0.299 r= 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	0.0921 r= 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 ($p<0.05$).

Conclusion: By increasing our understanding and implementation of effective methods for memory assessment, the rehabilitation of the memory also can be facilitated. In addition to the improvement of rehabilitation outcomes, pragmatic benefits also exist 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 among memory disorders(26). Several researchers such as Baddeley and Hitch have found different models with different factors (27). The role of age, sex and education in working memory test has been evaluated on the basis of different variables (21). 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(3). 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(28). Also, the short-term memory of phonology has the last link with the executive working memory. Phonetics capacity increases even without co-existing with the increase of the executive working memory. This method helps to assess and train the working memory and many studies have been successful in working memory training. These studies have a few experimental results (5). However, the strategies that specifically target the strengths and weaknesses of working memory specifications are available (29).

This study focuses on the assessment of designed working memory in healthy subjects. This method involves a personal and face to face assessment to determine the status of designed working memory test. This non-invasive method of assessment is done in a private and outpatient

Volume : 5 | Issue : 1 | Jan 2015 | ISSN - 2249-555X

comfortable office which specifies the memory capacities of the person that is retained or dropped at any age. These evaluations have been proposed when the signs or symptoms are present in working memory (30). 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 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 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 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 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 (31).

It is important to determine whether age, gender and education variables have a role on cognitive abilities of normal individuals or not. By comparing the pattern of these results with capabilities of the subjects before injury and correlating the results with the nature of trauma, the diagnosis of brain damage will be confirmed. Also, the individual's cognitive strengths and weaknesses will be determined. 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, visual-motor and sensori-motor functions, auditory processing, visual-spatial processing (8).

By increasing our understanding and implementation of effective methods for memory rehabilitation, cognitive and verbal rehabilitation will be facilitated (28). In addition to the improvement of rehabilitation outcomes, computerized model of working memory rehabilitation also displays pragmatic benefits to support evidence-based rehabilitation practices (26).In economic difficulties, memory rehabilitation will be a well-designed instruction and a key for facilitating positive efficient and stable outcomes.

REFERENCE

1.Fuster J: The prefrontal cortex (4 ed.). Oxford, UK: Elsevier p. 126,2008. | 2.Benton AL: "The prefrontal region: Its early history". In Levin, Harvey, S.; Eisenberg, Howard, M.; Benton, Arthur, L. Frontal lobe function and dysfunction p. 19, 1991. | 3.Hale S, Rose NS, Myerson J, Strube MJ, Sommers M, Tye-Murray N, Spehar B: The structure of working memory ability across the adult life span. Psychology & Aging 26:(1) 92-110, 2011. | 4.Bui DC, Maddox GB, Balota DA: The roles of working memory and intervening task difficulty in determining the benefits of repetition. Psychonomic Bulletin & Review 20:(2) 341-347, 2013. | 5.Shipstead Z, Redick TS, Engle RW: Does working memory training generalize? Psychologica Belgica 50:(3&4)245–276, 2010. | 6.Walker P, Hinkley L: Visual memory for shape colour conjunctions utilises structural descriptions of letter shape. Visual Cognition10: 987-1000, 2003. | 7.Bui DC, Friedman MC, McDonough IM, Castel AD: False memory and importance: Can we prioritize without consequence? Memory & Cognition 41:1012-1020, 2012. | 8.Lilienthal L, Tamez E, Shelton JT, Myerson J, Hale S: Dual n-back training increases the capacity of the focus of attention. Psychonomic Bulletin & Review 20:135-141, 2013 | 9.Bopp KL, & Verhaeghen P: Aging and verbal memory span: A meta-analysis. Journal of Gerontology: Psychological Sciences 60: 223-233, 2005. | 10.Salthouse TA, Atkinson TM, Berish DE: Executive functioning as a potential mediator of age-related decline in normal adults. Journal of Experimental Psychology: General 132: 566-594, 2003. | 11.Logie RH, Maylor EA: An internet study of prospective memory across adulthood. Psychology and Aging 24: 767-774, 2009. | 12.Mayr U, Kliegl R, Krampe RT: Sequential and coordinative processing dynamics in figural transformation across the life span. Cognition 59 :(1)61–90, 1996. | 13.Olesen PJ, Westerberg H, Klingberg T:Increased prefrontal and parietal activity after training of working memory. Nature Neuroscience, 7 :(1) 75–9, 2004. | 14.McNab F, Varrone A, Farde L: Changes in cortical dopamine D1 receptor binding associated with cognitive training. Science Signaling 323:(5915) 800–2, 2009. | 15.Zarghi A, Zali A, Tehranidost M, Zarindast MR, Ashrafi F, Doroodgar S, Khodadadi SM: The Relationship between Age, Sex and Education Variables with Selective, Sustained Attention and Planning through Cognitive Tasks among Healthy Adults. Basic and Clinical Neuroscience 2:(3) 58-67, 2011. | 16.Zarghi A, Zali A, Tehranidost M, Zarindast MR, Ashrafi F, Doroodgar S, Khodadadi SM: Comparative assessment of neuro-cognitive impairments among patients with brain tumor and healthy adults. Turkish Neurosurgery 22:309-316, 2012. | 17.Tamez E, Myerson J, Hale S: Contributions of associative learning to age and individual differences in fluid intelligence. Intelligence 40: 518-529, 2012. | 18.Ashby FG., Ell SW, Valentin VV., Casale MB:"FROST: a distributed neurocomputational model of working memory maintenance". Journal of Cognitive Neuroscience 17 :(11)1728–43, 2005. | 19.Zarghi A, Zali A, Ashrafi F, Moazezi M: Neuroscience and Neuro-cognitive Rehabilitation. Basic Research Journal of Medicine and Clinical Sciences 2:(8) 83-87, 2013. | 20.Baddeley, AD: Working memory, thought, and action. New York: Oxford University Press , 2007. | 21.Hedden T, Yoon C: Individual differences in executive processing predict susceptibility to interference in verbal working memory. Neuropsychology 20:511-528, 2006. | 22.Prabhakaran V, Narayanan K, Zhao Z, Gabrieli JD: Integration of diverse information in working memory within the frontal lobe. Nature Neuroscience 3: 85-90, 2000. | 23.Jacobsen CF: Studies of cerebral function in primates. Compsychol Monogr 13:1–68, 1938. | 24.Fuster JM. Unit activity in prefrontal cortex during delayed-response performance: neuronal correlates of transient memory. Journal of Neurophysiology 36 :(1)61–78, 1973. | 25.Rose NS, Myerson J, Roediger H, Hale S: Similarities and difference between working memory and long-term memory: Evidence from the levels-of-processing span task. Journal of Experimental Psychology: Learning, Memory, and Cognition 36:(2)471-483, 2010. | 26.Kane MJ, Engle RW: Working memory capacity, proactive interference, and divided attention: Limits on long-term memory retrieval. Journal of Experimental Psychology: Learning, Memory, & Cognition 26: 333-358, 2002. | 27.Baddeley A:"Working memory: looking back and looking forward". Nature Reviews. Neuroscience 4: (10)829–39, 2003. | 28.Pickering SJ, Gathercole SE: Working Memory Test Battery for Children. Psychological Corporation UK, 2001. | 29.Alloway TP, Alloway RG: Investigating the predictive roles of working memory and IQ in academic attainment. Journal of experimental child psychology 20-29, 2010. | 30.Stankiewicz BJ, & Hummel JE: Automatic priming for translation- and scale-invariant representations of object shape. Visual Cognition 9:719-739, 2002. | 31.Brandimonte, MA, Hitch GJ, & Bishop DVM: Influence of short-term memory codes on visual image processing: Evidence from image transformation tasks. Journal of Experimental Psychology: Learning, Memory, Cognition 18:157-165, 1992. |