**Journal of**
**Research in Psychopathology**
https://dx.doi.org/10.22098/jrp.2021.1148

**2021; Vol. 2, No. 3**
Pages: 16 - 23

## Original Article

# The effectiveness of rehabilitation of cognitive-metacognitive strategies on visual memory and memory span in the elderly

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## Abstract

Aging is associated with a decrease in various cognitive functions, including memory, and changes in memory function which are not uniform and vary depending on different aspects of memory. This study aimed to investigate the effectiveness of rehabilitation of cognitive-metacognitive strategies on visual memory and memory span in the elderly. The present research method was quasi-experimental pretest-posttest with a control group. The population included all the elderly who lived in the nursing home of Bukan from May to August 2019 (N = 120). Among these people, 30 elderly people (two groups of 15 people) were selected by convenience sampling according to the inclusion criteria and were placed by random assignment into two groups; experimental and control groups. Kim Karad and Wechsler's memory span tests were performed on the groups in the pre-test. Then, the rehabilitation of cognitive-metacognitive strategies was performed and in the next stage, the post-test was performed again. The obtained data were analyzed by multivariate analysis of covariance according to its assumptions. The results showed that after performing cognitive-metacognitive rehabilitation in the experimental group, the mean of straight and reverse components of the memory span test and short, medium, and tall components of the visual memory test increased significantly compared to the pretest ($p < .001$). The results showed that rehabilitation of cognitive-metacognitive strategies can improve visual memory and memory span, and using rehabilitation methods is suggested to improve cognitive functions and memory in the elderly.

## Keywords

Cognition
Metacognition
Memory span
Elderly
Visual memory

**Received:** 2020/09/12
**Accepted:** 2020/10/31
**Available Online:** 2020/11/28

## Introduction

Demographic requirements and the high prevalence of psychological disorders in the elderly have become the most important public health challenges for the next generations (Chiu & Shulman, 2017). The prevalence of the aging population is so high that the growth rate of the population over 65 is expected to increase from 15% in 2014 to 24% in 2060 (Pagnini, Cavalera, Volpato, Comazzi, & Vailati Riboni, 2019). Aging is not a pathological disorder. However, with aging, physical and mental activities are affected. During the aging period, some changes can be observed in the activities of the individuals. These changes are due to psychological and physiological factors and muscular systems which are related to aging (Rezaei, Montazar, Mousavi, & Hosseini, 2018). Everyone complains that when they get older, they make mistakes in expressing their memories and attribute

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this forgetfulness to memory (Baddeley, Eysenck & Anderson, 2015). Memory is one of the abilities that declines in the old age. Also, it is affected with increasing of the age (Pliatsikas, Verissimo, Babcock, Pullman, & Glei, 2018; Warren, Rubin, Shune, & Duff, 2018). One type of memory is the visual memory. It includes memory representations of information about observed perceptual features, the formats of which can range from low-level visual representations in primary visual domains to stored high-level visual representations (Luck & Hollingworth, 2008). It has long been assumed that humans can hold three to four objects in their visual memory at the same time (Matsuyoshi, Osaka & Osaka, 2014). Also, the results of studies by Bennett, Sekuler, McIntosh and Della-Maggiore (2001) showed that visual memory changes and decreases with age. The results of studies by Shin, Lee, Yoo and Chong (2015) revealed that training can increase the capacity of visual memory. The results of a study by Brockmole and Logie (2013) showed that visual memory changes throughout life. In other words, it reaches a maximum at the age of 20 and decreases with the age of 55. Other studies have shown that memory span and visual memories are correlated and people with low memory span may experience a greater decline in visual memory, which is exacerbated by aging (Matsuyoshi et al., 2014).

Another dependent variable of the present study was the memory span. According to the American Psychological Association, memory span is the number of items that can be recalled immediately after a presentation, which can usually include items of letters, words, numbers, or syllables that participants must reproduce in order. Depending on the nature and context of the presentation, there may be differences between visual and auditory memory span. The memory span of a normal adult is between 5 and 9 (Vandenbos, 2015). Age differences in the amount and size of the memory span have been predicted by most theories of cognitive aging. In fact, the concepts of age-related deficiencies in short-term memory, long-term memory, and most importantly in working memory control, either as a mechanism for explaining age-related deficiencies or as a mechanism with a direct or mediated, lead to a wide range. Fluid cognitions have been used as well (Bopp & Verhaeghen, 2005). Wingfield, Stine, Lahar, and Aberdeen (2007), in a study comparing memory span between the elderly and young people, concluded that memory spans in the elderly are significantly different from those in the young age, and the elderly have problems in this regard. Regarding memory span, various studies have shown that memory span decreases with increasing age (Schroeder, 2014).

Numerous different interdisciplinary interventions have been performed to improve visual memory function and memory span in the elderly including the Choline chloride treatment (Mohs, Davis, Tinklenberg, Hollistar, & Yasavage, 1979), Cortisol treatment (Buchanan & Lovallo, 2001), drug therapy (Glannon, 2006), cognitive therapy (Carrion, Folkvord, Anastasiadou, & Aymerich, 2018) and yoga (Abdollahzadeh Nobjari & Tahmasebi, 2019). The intervention in the present study was cognitive-metacognitive rehabilitation. Cognitive-metacognitive rehabilitation, sometimes popularly known as brain training, is a non-pharmacological intervention that consists of exercises guided by a set of standard tasks to target and improve specific cognitive functions (Bahar-fuchs, Clare, & Woods, 2013). Cognitive training refers to activities that make people smarter so that they can act better in reasoning, problem-solving, and learning. Current cognitive education programs target key cognitive skills such as memory, executive function, attention, and focus on these skills because individuals differ in their abilities and capacity to use them, and these abilities for their behaviors. Also, it should be highlighted that consciousness is essential (Katz, 2017). Tulbure and Siberescu (2013), in a study that looked at the effect of cognitive education on memory span in the elderly, concluded that cognitive education improves memory expansiveness and attention span significantly. In another study, conducted by Fisher and Szokola (2018) on neurological cognitive rehabilitation in people with memory impairments, it was found that these trainings improved a wide range of memory, including visual memory, verbal memory, cognitive memory, as well as attention to overall. Consequently, it can be claimed that the cognitive function has been effective. The results of the study of Norris, Hall and Gathercole (2019) showed that training in general and training in working memory, in particular, can increase both memory span and memory and its various types including visual memory.

Therefore, due to the high growth of the elderly population in recent years and the coming years, according to forecasts and, consequently, the prevalence and increase in physical, cognitive, emotional, economic, and age-related problems, there are few studies in the field of rehabilitation of the elderly. The research gap related to this field seemed necessary to do more research in this field, so the present study sought to answer the following question whether the rehabilitation of cognitive-metacognitive strategies is effective on visual memory and memory span of the elderly.

## Method

### *Participants*

The present research design was a quasi-experimental pre-test-post-test with a control group. Cognitive-metacognitive rehabilitation was considered as an independent variable and visual memory and memory span were considered as dependent variables. The study consisted of all elderly male residents living in the nursing home of Bukan in the period from May to August 1398, whose number was 120 people. The sample consisted of

30 people (15 people for each subgroup) from the population selected by convenience sampling and according to the inclusion criteria and were randomly assigned into two groups of 15 people in the experimental group and the control group. It should be noted that the sample size in the experimental research is sufficient for each group of 15 people (Biyabangard, 2010). Inclusion criteria include the completion of an informed consent form, age range from 65 years to 85 years, ability to read and write, being male, absence of acute and chronic psychological disorders (such as schizophrenia, depression, bipolar disorder, obsession, PTSD, severe anxiety disorder, dementia) based on a specialized interview by a psychologist, the absence of significant physical illness based on physical examination by a physician, the absence of vision and hearing problems based on optometrist and audiometer examination. Exclusion criteria include those who have answered the questions incompletely, attended other psychotherapy sessions at the same time, and cancelled participation. The data were analyzed using descriptive statistics (mean and standard deviation) and inferential statistics (multivariate analysis of covariance with its assumptions) by SPSS-22 software. In order to manage the missing data in the present study, the EM algorithm method was used. In this way, other variables were used to place the missing value and it was checked whether this value was the most probable and if it was not the most probable value, another value would be replaced. This process would continue until reaching the most probable value

## Instrument

### *Demographic Questionnaire*

A researcher-made questionnaire was used to collect demographic information.

### *Kim Karad's Visual Memory Test*

This test was created in 1945 by Kim Karad. It is a part of the visual memory performance test. It includes a 16-cell cardboard plate with a picture of each cell (test page) and a blank 16-cell plate with 16 pieces of cardboard, each with a picture of the main test plate drawn on it. The method of performing the Kim Karad test is that the main cardboard plate is shown to the participants for one minute and then the person has to remember the place of each piece on the cardboard plate with the parts he has and as he sees. The subjects are then asked to correct their work compared to the main page, then this step is repeated for the second time and again the person has to correct his work in the last step (which is the main step and the score obtained from it is calculated). The participants are asked to arrange the blank test page like before without seeing the main page, and the examiner finally calculates the subject score. This test can assess short-term, medium-term, and long-term visual memory. The reliability coefficient of this test is acceptable (r = 0.81) (Marnat, 2005). Also, other studies, using the retest method, have estimated the validity of this test, which has a validity coefficient of 0.5 and a reliability coefficient of 0.62. At a significance level, they have reported 0.01 (Afrooz, Hasanzadeh, Hashemzadeh & Ghasemzadeh, 2013).

### *Wechsler's Digit Span Memory Test*

Wechsler developed its own IQ scale in 1939. It consists of two parts: the verbal scale and functional scale. Wechsler's IQ test has 11 subtests; the verbal scale has 5 subtests and the functional scale has 6 subtests. The cultivar breadth subtest is part of the Wechsler's Intelligence Test Verbal Scale, which measures parrot-like instant memory, focus and accuracy, displacement (the ability to move thought patterns from direct digits to inverted digits), sequencing or chaining, and parrot learning. The range of digits consists of short-term memory and attention test. The examiner reads the list of three to nine digits calmly and loudly. The subject should remember and repeat the auditory information in the appropriate order. In other words, he is supposed to describe it as the memory of a phonetic auditory sequence. Correct answers require a two-step process: First, the information must be received carefully, which requires attention and decryption. Second, the subject must remember the information correctly, consider its sequence, and express it. A high score on inverted digit numbers indicates a person's ability to be flexible, focused, patient with stress, and able to create, maintain, and inspect visual mental images. Direct figures indicate parrot-like memory. Width of cultivars has the highest vulnerability to anxiety (Marnat, 2005). The test is performed in such a way that if the subject is not successful in the first attempt, the digits of the second attempt are executed. If the subject fails in both attempts, the experiment is stopped. The subject's score is equal to the numbers in the last series of digits that he has successfully repeated in the first or second attempt, which is a maximum score of seven for forwarding digits and a maximum score of seven for reverse digits. Also, in some studies, Cronbach's alpha for the test was 0.96 and for all subscales was higher than 0.87 (Mozafari, Mehri Nejad, Peyvstegar & Saghafinia, 2018).

### *Rehabilitation of cognitive-metacognitive strategies*

This program included the rehabilitation of cognitive-metacognitive strategies based on the theory of Hill, Backman and Neely (2000) model in 10 sessions of 45 minutes based on the program schedule. The program is executed as follows in Table 1:

Table 1. Sessions and content of rehabilitation sessions of cognitive-metacognitive strategies

| Sessions | content of rehabilitation sessions |
|---|---|
| First | Introduction and implementation of pre-test |
| Second | In the second session, they were briefly introduced to the concept of learning, the types of memory and its structure, and the causes of forgetfulness. Explaining the concepts of learning motivated the participants. |
| Third | In this session, the strategy of repetition for complex topics was taught. Then, the strategies of keyword, headline, mental imagery, use of intermediaries, and methods of places were taught. People were asked to give examples of each of these strategies. |
| Fourth | In this session, strategies for expanding complex content such as taking notes, summarizing, retelling content in their own language were taught. Each participant read a chapter of a book randomly and was asked to summarize it. They also practiced. |
| Fifth | In this session, description, interpretation, analysis of relationships, and using the information were taught to solve problems. Also, the analogy was taught in the manner of previous sessions. At the end of this session, assignments for the next session were given to individuals. |
| Sixth | Organizing strategy, including categorizing new information based on familiar categories, preparing a list of topics, converting lesson texts to map, drawing a tree plan, preparing diagrams, drawing concept maps, and the conceptual pattern were taught in this session. |
| Seventh | In the sixth session, planning strategies from the subset of metacognitive strategies, including determining the purpose of the study, predicting the time required for the study, determining the speed of the study, and selecting appropriate cognitive strategies were introduced to the participants. |
| Eighth | Monitoring and evaluation strategies were taught from a subset of metacognitive strategies, including evaluation of progress, attention monitoring, and questioning during the study. |
| Ninth | In the eighth session, regulatory strategies were taught, which include sustainable metacognitive adaptations and improvements made by the learner against error feedback. |
| Tenth | After the sessions, post-test was given to three groups. |

## Procedure

After obtaining the required permissions from the university and welfare centers and referring to the nursing home of Bukan and selecting a sample and placing them randomly into the experimental and control groups, the research began. Initially, in the pre-test stage, Wechsler's Digit Span Memory and Kim Karad visual memory tests were performed on both groups. Then, one week after the pre-test and in the stage of applying the experimental variable, the experimental group received rehabilitation of cognitive-metacognitive strategies in 10 sessions, each lasting 45 minutes, i.e. twice a week, approximately for five weeks. The control group did not receive any independent educational and therapeutic variables; however, it should be noted that 10 sessions each lasting 45 minutes were held with the control group on issues and topics related to the normal and daily life of the people. After the rehabilitation sessions, the post-test was held immediately. In the post-test phase, the experimental and control groups were re-tested for Wechsler's Digit Span Memory and Kim Karad's visual memory. This research has an ethical code from Urmia University of Medical Sciences with the ID IR.UMSU.REC.1398.142 and a clinical trial code with the number IRCT20190910044737N1. In this study, most of the ethical considerations in the research, including professional competence (having a professional training certificate), integrity (dealing with honest respect without offending the participants), professional and educational responsibility (responsibility for their work), gaining the trust of others, respecting the rights of individuals and maintaining their human dignity and respect for diversity of beliefs, social responsibility (taking into account the public interest), confidentiality, avoiding harm to others and not distorting information were observed. After confirming the effectiveness of independent variables, rehabilitation methods of cognitive-metacognitive strategies were performed on the control group.

## Results

Thirty elderly people with a mean and standard deviation of age 71.3 and 4.2, single 67%, married 33%, education level (below diploma) 85%, diploma to bachelor (15%) participated in this study.

Table 2. Mean and standard deviation of experimental and control groups in memory span components in pre- and post-test

| Variable | Experimental group | | | | control group | | | |
|---|---|---|---|---|---|---|---|---|
| | Pre-test | | Post-test | | Pre-test | | Post-test | |
| | M | SD | M | SD | M | SD | M | SD |
| straight | 7.86 | 1.35 | 9.8 | 1.47 | 8.46 | 1.24 | 9.33 | 1.58 |
| reverse | 5.93 | 1.53 | 7.66 | 1.39 | 6.33 | 1.29 | 7 | 1.5 |

Based on the results of Table 2, the mean (and standard deviation) post-test of the memory span of the experimental group in the straight span component is 9.8 (1.47) and reverse span is 7.66 (1.29).

Table 3. Mean and standard deviation of experimental and control groups in visual memory components in pre- and post-test

| Variable | Experimental group | | | | control group | | | |
|---|---|---|---|---|---|---|---|---|
| | Pre-test | | Post-test | | Pre-test | | Post-test | |
| | M | SD | M | SD | M | SD | M | SD |
| Short | 6.83 | 0.89 | 10.2 | 0.94 | 7.13 | 0.89 | 7.33 | 0.97 |
| Medium | 7.16 | 1.15 | 9.26 | 1.03 | 7 | 1.11 | 7.3 | 0.84 |
| Tall | 9.36 | 0.76 | 11.16 | 0.67 | 9.5 | 0.88 | 9.3 | 1.11 |

Based on the results of Table 3, the mean (and standard deviation) post-test of the visual memory of the experimental group in the short component is 10.2 (0.94), medium is 9.26 (1.03) and tall is 11.16 (0.67).

Table 4. Results of the multivariate covariance analysis conducted to compare the experimental and control group in visual memory and memory span

| Effect | Test | Variable | Value | F | Hypothesis df | Error df | sig | Partial Eta Squared |
|---|---|---|---|---|---|---|---|---|
| Group | Pillai's Trace | Visual memory | 1.02 | 13.394 | 6 | 76 | 0.001 | 0.514 |
| | | Memory span | 0.904 | 16.482 | 4 | 80 | 0.001 | 0.452 |
| | Wilk's Lambda | Visual memory | 0.036 | 52.539 | 6 | 74 | 0.001 | 0.810 |
| | | Memory span | 0.104 | 41.062 | 4 | 78 | 0.001 | 0.678 |
| | Hotelling Trace | Visual memory | 24.89 | 149.36 | 6 | 72 | 0.001 | 0.926 |
| | | Memory span | 8.576 | 81.469 | 4 | 76 | 0.001 | 0.811 |
| | Roy's Largest Root | Visual memory | 24.823 | 314.425 | 3 | 38 | 0.001 | 0.961 |
| | | Memory span | 8.56 | 171.351 | 2 | 40 | 0.001 | 0.895 |

Based on the results of Table 4, the value of Wilk's Lambda is 0.036 for the visual memory variable, and 0.104 for the memory span, which is significant at the level ($p < .001$). The smaller value of the Wilk's Lambda shows that there is a significant difference between the groups. Also, the results of the Levene's test showed that the difference of variances in the variables between two groups in the scores of the components of straight span, reverse span from the variable of memory span, and short, medium, and tall visual memory from the variable of visual memory was not significant. Based on these results, the assumption of homogeneity of variances in the above variables in the study groups was confirmed. This test was not significant for any of the variables. In other words, the variances are equal in the two groups. As a result, the use of parametric tests is unrestricted.

Table 5. Box Test of Equality of Covariance Matrices

| | |
|---|---|
| **Boxes M** | 7.463 |
| **F** | 1.098 |
| **df1** | 6 |
| **df2** | 568.302 |
| **Sig** | 0.361 |

The results of Table 5 show that the value F (1.098) is not significant at the level of 0.05, and as a result of the observed variance-covariance matrices, the dependent variables are equal between the two groups, and their homogeneity assumption is correctly observed.

The homogeneity test of regression slope was examined through the pre-test interaction of subscales of visual memory test (short, medium, and tall) and the independent variable, i.e. cognitive-metacognitive strategies in the post-test stage. The interaction of these pre-tests with the independent variable is not significant and indicates that the homogeneity of regression slope is established ($F= 8.52$, $P = 0.547 > .05$).

Table 6. Results of multivariate analysis of covariance (MANCOVA) on variables in experimental and control groups

| Source | Variable | | Sum of Squares | df | Mean Square | F | Sig | Partial ETA Sauared |
|---|---|---|---|---|---|---|---|---|
| Group | Visual memory | Short | 164.630 | 2 | 82.315 | 155.379 | 0.001 | 0.888 |
| | | Medium | 94.201 | 2 | 47.100 | 127.472 | 0.001 | 0.867 |
| | | Tall | 81.830 | 2 | 40.915 | 77.292 | 0.001 | 0.799 |
| | Memory span | Straight | 74.309 | 2 | 37.154 | 78.624 | 0.001 | 0.797 |
| | | Reverse | 69.799 | 2 | 34.899 | 67.495 | 0.001 | 0.771 |

The results of Table 6 show that there is a significant difference in the level of visual memory between the elderly of the experimental and control groups ($p < .001$). In other words, the visual memory of the experimental group is different after cognitive-metacognitive rehabilitation. Also, there is a significant difference in the level of memory span between the elderly of the experimental and control groups in memory span ($p < .001$). In other words, the memory span of the experimental group is different after cognitive-metacognitive rehabilitation.

## Discussion

The main purpose of this study was to investigate the effectiveness of rehabilitation of cognitive-metacognitive strategies on visual memory and memory span in the elderly. The results of multivariate analysis of covariance (MANCOVA) showed that the rehabilitation method of cognitive-metacognitive strategies is effective and the experimental group is significantly different from the control group in terms of the post-test. The first finding of the present study was that rehabilitation of cognitive-metacognitive strategies is effective and improves the visual memory of the elderly. This finding has been consistent with a research by Hayati, Ramazanzadeh and Farrokhi (2015), Shin et al. (2015), Gilchrist, Duarte and Verhaeghen (2015). The results of Crawford and Allen's (1983) research on visual memory showed that the use of cognitive strategies improves dual encryption and deep processing of visual memory. Baddeley (2007) believes that cognitive education affects the process of coding in memory and improves visual memory by influencing the process of attention. He believes that items related to gestalt principles are better encoded and recalled. It also performs better, and cognitive training, in focusing on the Gestalt method, helps people to have a better visual memory. Some studies have shown that cognitive rehabilitation improves memory functions by stimulating the brain (Taya, Sun, Babiloni, Thakor & Bezerianos, 2015). Other studies have shown that cognitive rehabilitation increases neural activity through the connection of nerve vessels and reduces cognitive and memory problems by increasing brain plasticity (Chapman, Aslan, Spence, Hart, & Bartz, 2013). A study by Boyke, Driemeyer, Gaser, Buchel and May (2008) showed that cognitive rehabilitation increases gray matter volume in the hippocampus and improves learning and memory performance. Another study by Ihssen, Linden and Shapiro (2010) also indicated that teaching continuity and repetition strategies, as the component of cognitive strategies, improves visual memory performance. Brown and Wesley (2013) believe that visual memory can be improved by using hybrid strategies, semantic coding, and excessive speaking strategy.

The next finding of the present study was that the rehabilitation of cognitive-metacognitive strategies is effective in the memory span of the elderly and it improves their memory capacity. These results are in line with McNab, Varrone, Farde, Jucaite, and Bystritsky (2009), Klingberg (2010), Takeuchi, Sekiguchi, Taki, Yokoyama, and Yomogida (2010), McAvinue, Golemme, Castorina, Tatti, and Pigni (2013), and Kim, Yang, Choi and Kim (2013). Hill et al. (2000) argue that cognitive rehabilitation uses a learning strategy to teach individuals how to retain information, how to encrypt, and how to store information so that they can easily retrieve later, especially when confronted with stimulus cues. Also by doing so, they increase the memory capacity. Some studies have shown that some of the causes of reduced memory span in aging are distraction and poor control of distraction (McNab, Zeidman, Rutledge, Smittenaar, and Brown, 2015). Also, the results of a study by Mayas, Parmentier, Andres and Ballesteros (2014) revealed that education reduces distraction and increases alertness significantly. These results showed that cognitive education is effective in strengthening cognitive flexibility and increasing memory span. McNab et al. (2009), in their research, showed that cognitive and memory training increase and improve memory span. Further explanation of this finding is that the imaging and neurophysiological studies of Constantinidis and Klingberg (2016) showed that cognitive training increases the activity of frontal cortex neurons and strengthens the connections between the frontal cortex and occipital cortex. As a result, it increases memory span and cognitive flexibility. In another explanation of this finding, it should be said that in the cognitive-metacognitive rehabilitation program, one of the training given to the elderly is how to rearrange or fragment information or numbers in a meaningful way and larger pieces, and various studies have shown that this segmentation method increases memory span and ultimately improves memory (Gilbert, Boucher & Jemel, 2014: Yamaguchi, Randle & Wilson, 2017).

## Conclusion

The results of the present study showed that rehabilitation of cognitive-metacognitive strategies is effective on memory-related functions in the elderly. Therefore, clinicians are recommended to use this method along with other interventions. Among the limitations of the present study was the participation of only the male elderly, conducting research only on the elderly living in Bukan city care center, available sampling, and non-implementation of a follow-up program. Other cities should be cautious regarding these limitations.

## Disclosure statement

The authors of this article declare that there was no conflict of interest.

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## References

Abdollahzadeh Nobjari, M., & Tahmasebi, S. (2019). Improvement of women's visual memory during 36 session intervention based on yoga. 1th national congress of Iranian motor behavior and sport psychology association. Tehran, Iran.

Afrooz, G. A., Hasanzadeh, S., Hashemzadeh, V. & Ghasemzadeh, S. (2014). The investigation and comparison of visual memory in hearing girl students and hearing impaired at 11 to 18 years in Tehran. *Applied Psychological Research Quarterly*, 4(4), 109-121. doi: 10.22059/ JAPR.2014.55057.

Baddeley, A. (2007). *Working memory, thought, and action*. New York: Oxford University Press.

Baddeley, A., Eysenck, M., & Anderson, M. (2015). *Memory* (second Edition). Psychology Press, Taylor & Francis Group. London and New York.

Bennett, P., Sekuler, A. B., McIntosh, A. R., & Della-Maggiore, V. (2001). The effects of aging on visual memory: evidence for functional reorganization of cortical networks. *Acta Psychologica, 107*, 249-273. doi: 10.1016/s0001-6918(01)00037-3.

Biyabangard, I. (2010). *Research methods in psychology and educational sciences* (v1). Tehran: Doran Publishing.

Bopp, K. L., & Verhaeghen, P. (2005). Aging and verbal memory span: a meta-analysis. *The journal of Gerontology: Series B, 60* (5), 223-233. doi: 10.1093 /geronb/60.5.p223.

Boyke, J., Driemeyer, J., Gaser, C., Buchel, C., & May, A. (2008). Training-induced brain structure changes in the elderly. *The Journal of Neuroscience, 28*(28), 7031-7035. doi: 10.1523/JNEUROSCI.0742-08.2008.

Brockmole, J., Logie, R. H. (2013). Age-related change in visual working memory: a study of 55.753 participants aged 8-75. Frontiers in Psychology. *Original Research Article, 4*(12), 1-5. doi: 10.3389/fpsyg.2013.00012.

Brown, L. A., Wesley, R. W. (2013). Visual working memory is enhanced by mixed strategy use and semantic coding. *Journal of Cognitive Psychology, 25*(3), 328-338. doi:10.1080/20445911.2013.77300 4.

Buchanan, T., Lovallo, W. (2001). Enhanced memory for emotional material following stress-level cortisol treatment in humans. *Psychoneuroendocrinology*. *26*, 307-317. doi: 10.1016/s0306-4530(00)00058-5.

Carrion, C., Folkvord, F., Anastasiadou, D., & Aymerich, M. (2018). Cognitive therapy for dementia patients: a systematic review. *Dementia and Geriatric Cognitive Disorders*, *46*, 1-26. doi:10.1159/000490851.

Chapman, S., Aslan, S., Spence, J., Hart, J., Bartz, E., & Defina, L. (2015). Neural mechanisms of brain plasticity with complex cognitive training in healthy seniors. *Cerebral Cortex*, *25*(2), 396-405. doi: 10.1093/cercor/bht234.

Chiu, H., Shulman, K. (2017). *Mental health and illness of the elderly*. Mental Health and Illness Worldwide 2, Springer International Publishing. doi: 10.1007/978981-10.0370-7_1-1.

Constantinidis, C., Klingberg, T. (2016). The neuroscience of working memory capacity and training. *Nature Reviews Neuroscience*, *17*, 438-449. doi: 10.1038/nrn.2016.43.

Crawford, H. J., Allen, S. N. (1983). Enhanced visual memory during hypnosis as mediated by hypnotic responsiveness and cognitive. *Journal of Experimental Psychology*, *112*(4), 662-685. doi:10.1037/0096-3445. 112.4.662.

Fisher, B., Szokola, D. (2018). The benefit of neurocognitive training in an ongoing therapeutic Program for memory/neuropsychological deficits in children. *Journal of Clinical Psychiatry and Neuroscience.1* (3), 25-26. Corpus ID: 165153262.

Gilbert, A., Boucher., & Jemel, B. (2014). Perceptual chunking and its effect on memory in speech processing: ERP and behavioral evidence. *Frontier in Psychology*, *Language Sciences*. doi: 10.3389/fpsyg.2014.00220.

Gilchrist, A., Duarte, A., & Verhaeghen, P. (2015). Retrospective cues based on object features improve visual working memory performance in older adults. *Neuropsychology Development and Cognition.23*(2), 184-195. doi: 10.1080/13825585.2015.1069253.

Glannon, W. (2006). Psychopharmacology and memory. *Journal of Medical Ethics, 32*(2), 74-78. doi: 10.1136/jme.2005.012575

Hayati, M., Ramzanzadeh, N., & Farrokhi, N. (2015). Effect on the cognitive processing training on visual memory and comprehension of students with learning to read third grade to fifth in Karaj. *European Psychiatry, 30*(1), 28-31. doi:10.1016 /S0924-9338(15)30795-1.

Hill, R. D., Backman, L., & Neely, A. S. (2000). *Cognitive rehabilitation in old age*. New York: Oxford university Press. Ihssen, N., Linden, D., & Shapiro, K. (2010). Improving visual short-term memory by sequencing the stimulus array. *Psychonomic Bulletin & Review*, *17*(5), 680-686. doi:10.3758/PBR.17.5.680.

Katz, B. (2017). *Moderators of cognitive training: individual differences and motivational factors* [Unpublished doctoral dissertation], University of Michigan. doi: 10.12/2027.42/138651.

Kim, HJ., Yang, YS., Choi, KH., & Kim, TY. (2013). The effect of a computer-based cognitive training program on cognition. *Dementia and Neurocognitive Disorders*, *12*(4), 87-93. doi:10.12779/dnd.2013.12.4.87.

Klingberg, T. (2010). Training and plasticity of working memory. *Trend in Cognitive Sciences. 4,317*-324. doi: 10.1016/j.tics.2010.05.002.

Luck, S. J., & Hollingworth, A. (2008). *Visual memory*. New York: Oxford University Press. doi:10.1093/acprof:oso/9780195305487.001.0001.

Marnat, G. G. (2005). *Handbook of psychological assessment*. New York: Wiley.

Matsuyoshi, D., Osaka, M., & Osaka, N. (2014). Age and individual differences in visual working memory deficit induced by overload. *Frontiers in Psychology*, *Cognitive Science*. 5, 384-391. doi: 10.3389/fpsyg. 2014.00384.

Mayas, J., Parmentier, F. B., Andres, P., & Ballesteros, S. (2014). Plasticity of attentional functions in older adults after non – action video game training: a randomized controlled trial. *PloseOne*, *9*(3), e92269. doi:10.1371/journal.pone.0092269.

McAvinue, L., Golemme. M., Castorina, M., Tatti, E., Pigni, F., & Robertson, I. (2013). An evaluation of a working memory training scheme in older adults. *Frontiers in Aging Neuroscience*. doi: 10.3389/fnagi. 2013.00020.

McNab, F., Varrone, A., Farde, L., Jucaite, A., Bystritsky, P., & Klingberg, T. (2009). Changes in cortical dopamin d1 receptor binding associated with cognitive training. *Science*, *323*, 800-802. doi:10.1126/science. 1166102.

McNab, F., Zeidman, P., Rutledge, R., Smittenaar, P., Brown, H., & Dolan, R. (2015). Age-related changes in working memory and the ability to ignore distraction. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, *112*(20), 6515-6518. doi: 10.1073/pnas.1504162112.

Mohs, R. C., Davis, K. L., Tinklenberg, J. R., Hollistar, L. E., Tesavage, J. A., & Kopell, B. S. (1979). Choline chloride treatment defects in the elderly. *American Journal of Psychiatry*, *136*, 1275-1277. doi: 10.1176/ajp.136.10.1275.

Mozafari, M., Mehri Nejad, S., Peyvstegar, M., & Saghafinia, M. (2018). Investigating cognitive complications following of mild traumatic brain injury in executive function and working memory of patients. *Journal of Cognitive Psychology*, *6*(3), 37-46.

Norris, D. G., Hall, J., & Gathercole, S. E. (2019). Can short-term memory be trained? *Memory & Cognition*, *47*(5), 1012-1023. doi:10.3758/s13421-019-00901-z.

Pagnini, F., Cavalera, C., Volpato, E., Comazzi, B., Vailati Riboni, F. & Langer, E. (2019). Ageing as a mindset: a study protocol to rejuvenate older adults with a counterclockwise psychological intervention. *BMJ Open*, *9(*7), e030411. doi:10.1136/bmjopen-2019-030411.

Pliatsikas, C., Verissimo, J., Babcock, L., Pullman, M. Y., Glei, D., & Uliman, M. T. (2018). Working memory in older adults declines with age, but is modulated by sex and education. *Quarterly Journal of Experimental Psychology*, *72*(6), 1308-1327. doi:10.1177/ 174702 1818791994.

Rezaei, S., Montazar, E., Mousavi, S.V., & Hosseini, S. P. (2018). Physical activity and function in the elderly population. *Caspian Journal of Neurological Sciences*, *4*(14), 121-127. doi:10.29252/cjns.4.14.121.

Schroeder, P. J. (2014). The effect of age on processing and storage in working memory span tasks and reading comprehension. *Experimental Aging Research*, *40*(3), 308-331. doi: 10.1080/0361073X.2014.896666.

Sejunaite, K., Lazana, C., & Riepe, M. W. (2019). Everyday memory in healthy aging: porous but not distorted. *Frontiers in Aging Neuroscience*, *11*, *153*. doi:10.338/fnagi.2019.00153.

Shin, E., Lee, H., Yoo, S., & Chong, S. C. (2015). Training improves the capacity of visual working memory when it is adaptive, individualized and targeted. *Plos One*. *10*(4), 1-14. doi: 10.1371/journal .pone.0121702.

Takeuchi, H., Sekiguchi, A., Taki, Y., Yokoyama, S., Yomogida, Y., & Kawashima, R. (2010). Training of working memory impacts structural connectivity. *The Journal of Neuroscience*, *30*(9), 3297-3303. doi:10.1523/JNEUROSCI.4611-09.2010.

Taya, F., Sun, Y., Babiloni, F., Thakor, N., & Bezerianos, A. (2015). Brain enhancement through cognitive training: a new insight from brain connectome. *Frontiers in Systems Neuroscience*, *9*, 44. doi:10.3389 /fnsys.2015.00044.

Tulbure, B. T., & Siberescu, I. (2013). Cognitive training enhances working memory capacity in healthy adults. a pilot study. *Social and Behavioral Sciences*, *78*, 175-179. doi:10.1016/j.sbspro.2013.04.274.

Vandenbos, G. (2015). *APA dictionary of psychology, second edition*. Washington DC. American Psychological Association. doi:10.1037/146-46-000.

Warren, D. E., Rubin, R., Shune, S., & Duff, M. C. (2018). Memory and language in aging: how their shared cognitive processes, neural correlates, and supporting mechanisms change with age. In M. Rizzo, S. Anderson, & B. Fritzsch(Eds), The Wiley Handbook on the Aging Mind and Brain (p.270-295). Wiley Blackwell. doi:10.1002/ 9781118772034.ch14.

Wingfield, A., Stine, E., Lahar, C., & Aberdeen, J. (2007). Does the capacity of working memory change with age? *Experimental Aging Research*, 14(2-3),103-107.

Yamaguchi, M., Randle, J., & Wilson, T. (2017). Pushing typists back on the learning curve: memory chunking improves retrieval of prior typing episodes. *Journal of Experimental Psychology, Learning, Memory and Cognition*, *43*(9), 1432-1447. doi:10.1037/ xlm00003 85.