ORIGINAL ARTICLE

Effectiveness of multiple mnemonic strategies for improving verbal memory in older adults

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Abstract

Background: Cognitive training is an evidence-based intervention for preserving memory in older adults. The effectiveness of cognitive training varies, depending on the approach used. This study examined the efficiency of cognitive training using multiple mnemonic strategies in older adults.

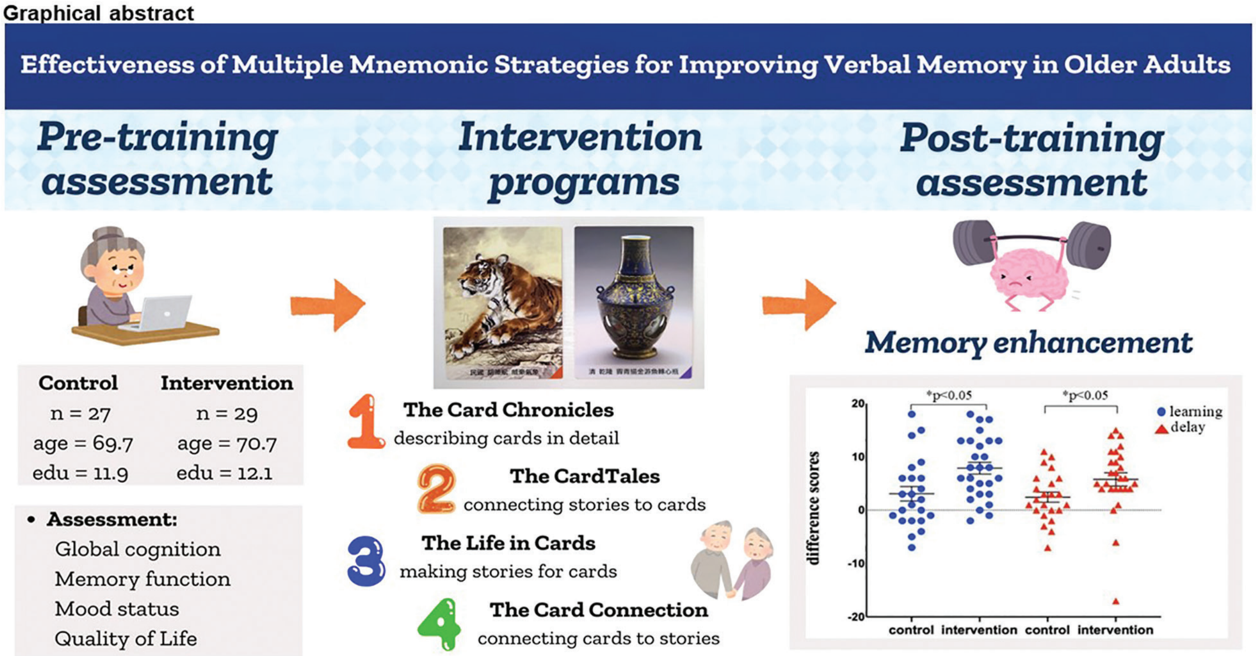
Methods: This study adopted a pretest-posttest control group design, with all participants undergoing two neuropsychological assessments. The cognitive training program consisted of four 60-minute sessions over a month. In the interventions, participants practiced the mnemonic strategies of elaboration and self-reference. The effect of cognitive training was analyzed using both dependent and independent *t* tests.

Results: The mean ages were 69.7 ± 12.0 for the control group (n = 23) and 70.7 ± 5.6 for the intervention group (n = 27), with educational attainment of 11.9 ± 3.2 and 12.1 ± 3.9 years, respectively. Both groups showed an overall improvement in memory tests, but only the intervention group's learning and delayed recall aspects of the verbal memory test remained statistically significant after adjusting for multiple comparisons ($p < 0.00625$).

Conclusion: Our study demonstrates that multiple mnemonic strategy-based cognitive training effectively enhances memory function in older adults and should be regarded as an alternative intervention for older adults.

Keywords: Cognitive training; Dementia; Memory function; Mnemonic strategy; Older adult

Graphical abstract



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1. INTRODUCTION

Global aging has resulted in an increased prevalence of Alzheimer's disease (AD) and other dementias, making it the leading cause of death.[1–3] Dementia due to AD is the most common type of dementia among community-dwelling older adults. The pathophysiology of AD is characterized by the accumulation of beta-amyloid plaques, which initially localize to the medial temporal and parietal lobes before progressively spreading to other regions of the brain.[4] Clinically, AD is characterized by episodic memory impairment, which worsens as tau protein deposition increases in later stages.[5] AD progression leads to significant functional impairment and high direct and indirect costs.[6–8]

Pharmacological treatments, including acetylcholinesterase inhibitors that block the activity of the enzyme acetylcholinesterase-promoting effect on postsynaptic receptors, and N-methyl-D-aspartate (NMDA) antagonists that block NMDA receptors to reduce excessive glutamate activation, offer symptomatic relief.[9–11] Studies have indicated that medications used in combination with non-pharmaceutical treatments result in better outcomes in treating cognitive impairment.[12] Non-pharmaceutical treatments, including cognitive training (CT), have been shown to be effective, convenient, low-cost, and non-invasive interventions to maintain or improve cognitive functions.[13–15] CT has been found to improve daily living skills and relieve depressive symptoms in AD patients.[16,17]

The efficacy of CT on cognitive enhancement varies depending on the training program employed. The level of processing memory model[18,19] suggests that deep processing of materials leads to stronger memory traces. Experimental studies have shown that CT with mnemonic strategies improves older adults' memory performance.[20,21] Although the optimal CT program remains under investigation, a previous meta-analysis suggested that CT programs adopting multiple mnemonic strategies are more effective at enhancing memory function than those based on a single mnemonic technique.[22] A critical factor in successful CT is the ability to transfer skills, meaning that participants can apply mnemonic strategies to new or untrained materials. Given the diverse nature of information that participants encounter in daily life, training programs that employ multiple mnemonic strategies rather than a single strategy may offer greater flexibility and applicability across a variety of everyday situations.[23–25]

The concept of CT has recently garnered attention due to social prescriptions, which encompass a broad spectrum of activities beyond the medical field. Museums, libraries, and archives are no longer seen merely as repositories; instead, they have evolved into memory institutions that offer historical resources, which can engage and interact with older adults.[26–28] Due to global aging, community-based cognitive interventions are urgently needed to cover social commands. This study aimed to evaluate the effectiveness of CT, with a special focus on memory function, employing multiple mnemonic strategies, and to establish a link between CT conducted in medical centers and its implementation in community centers. Specifically, in collaboration with the National Palace Museum, which spans 8000 years of Chinese history, from the Neolithic to the modern period1, we developed a four-session CT program that focuses on elaboration and self-reference mnemonic techniques. This study aimed to examine the efficacy of CT with multiple mnemonic strategies in older adults with or without cognitive impairment and hypothesized that this approach would enhance memory function in older adults.

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2. METHODS

2.1. Participants

Participants were recruited from the memory clinic of Taipei Veterans General Hospital, a tertiary healthcare facility in Taiwan. The patient and a family member, serving as the study partner, were invited to participate in the study. The inclusion criteria were as follows: (1) at least 6 years of education, (2) Mini-Mental State Examination (MMSE) score of 23 to 28, and (3) normal or corrected-to-normal vision and hearing. The exclusion criteria included a history of substance abuse, head injury, or other conditions that hindered participation in cognitive testing or intervention. Participants were randomly assigned to either the control or the intervention group.

2.2. Neuropsychological assessment

In this study, we used a pretest-posttest design with intervention and control groups. Each participant underwent two neuropsychological assessments conducted by experienced neuropsychologists who were blinded to participants' group assignments. In the intervention group, participants were directed to finish the pretest cognitive assessment two months before starting the training program and to complete the post-training assessment within 2 months after the end of the intervention. In the control group, participants were asked to perform both assessments within a similar timeframe as in the intervention group. This assessment encompassed the evaluation of the following domains: (1) general cognitive functioning, assessed by the MMSE, which ranges from 0 to 30, with scores below 26 indicating cognitive impairment to ensure optimal sensitivity and specificity[29]; (2) severity of dementia, evaluated through the clinical dementia rating (CDR),[30] with the CDR-sum of boxes calculated by summing six domains, indicating that a higher score corresponds to greater severity; (3) memory function, assessed by the Logical Memory (LM) subtest of the Wechsler Memory Scale-III for verbal memory[31] which includes learning (range from 0 to 75) and delayed recall scores (range from 0 to 50), and by the Free and Cued Selective Reminding Test (FCSRT) for visual memory, with both learning and delayed scores ranging from 0 to 16.[32] Higher scores on the LM and FCSRT indicate superior memory function; (4) mood status, as determined by the Geriatric Depression Scale-15 item (GDS-15), where higher scores indicate greater depressive severity;[33] and (5) quality of life (QoL), measured using the World Health Organization Quality of Life-BREF,[34] where higher scores indicate better QoL. This study was approved by the Institutional Review Board of Taipei Veterans General Hospital (No. 2023-08-001B), and all participants provided signed informed consent forms before their inclusion in the study.

2.3. CT program

The CT program, conducted at Taipei Veterans General Hospital, consisted of four 60-minute sessions held weekly from October 23 to November 13, 2023. Participants were divided into six

Fig. 1 A card set developed in collaboration with the National Palace Museum. Two examples from the LMG cards. The LMG cards are categorized into 10 themes across three life stages—childhood, adulthood, and late adulthood—with color-coded corners for easy identification. LMG = Life-stage Memory Game.

groups guided by a psychologist or occupational therapist per group.

2.3.1. Intervention materials

A card set, created in collaboration with the National Palace Museum, comprising 60 Life-stage Memory Game Cards (LMG cards) categorized into 10 themes, was used (Fig. 1). The LMG cards, selected for their relevance and familiarity to the lives of older adults, have been utilized in previous CT programs and community-based activities.[32,48,49]

2.3.2. Intervention group task

During sessions 1 and 3, the elaboration mnemonic strategy was employed. In session 1, participants described the detailed characteristics of six LMG cards, including their color, texture, and sound, before recalling the name of each card. Sessions 2 and 4 focused on self-reference. In session 2, participants recalled nine personal life experiences of themselves and selected nine LMG cards that corresponding to those experiences. After a 20-minute delay, they were asked to recall the names of these cards. In session 3, participants were given six LMG cards at random and tasked with creating a sentence related to each card's content, ultimately combining them into a cohesive story. Following a 20-minute delay, they were required to recall the names of six LMG cards. In session 4, participants shared personal life experiences linked to three LMG cards and then recalled their names.

2.3.3. Control group task

The control group participants watched a 40-minute video per week pertaining to Chinese cultural history with no memory tests performed during this period.

2.4. Statistical analysis

The Shapiro-Wilk test was applied to check the normality assumption. If the normality assumption remained, we used an independent t test for between-group analysis and a paired t test for within-group differences such as pre-and post-training assessments. When the assumption of homogeneity of variance (Levene's test) was not met, we reported a corrected t value. If the normality assumption was rejected, we conducted the Mann-Whitney U test for between-group comparisons and the Wilcoxon signed-rank test to examine the differences between pre- and post-training assessments. To maintain the maximum sample size, we adopted an intention-to-treat design, where we analyzed participants who completed two neuropsychological assessments. We set the α level at 0.05 for the demographic and clinical analyses. To avoid the inflation of type one error rate, we adjusted the α level to 0.05/8 for correction of multiple comparisons to examine changes from pre-training to post-training within each group, as suggested by Kirk.[35] Cohen's d was used when test results were considered statistically significant. All statistical analyses were performed using the IBM SPSS software (version 26.0; IBM, Armonk, NY).

3. RESULTS

3.1. Study participants

This study recruited 57 participants from Taipei Veterans General Hospital. Of the 57 participants who completed the pretraining assessment, 29 were assigned to the intervention group and 27 to the control group. One participant was excluded because of incomplete data of cognitive tests. In the follow-up session, we excluded two participants from the intervention group because they missed the follow-up tests. Four participants in the control group were excluded from the study due to the loss of follow-up tests. According to the definition of cognitive impairment adopted in this study, four participants in the control group and six in the intervention group were classified as having cognitive impairment. We conducted a χ^2 test to assess the difference in the proportion of individuals with cognitive impairment (MMSE < 26) between groups, and the result was not statistically significant ($\chi^2(1) = 0.406$, $p = 0.524$). Fig. 2 illustrates the procedure, and Table 1 provides detailed demographic information and clinical characteristics.

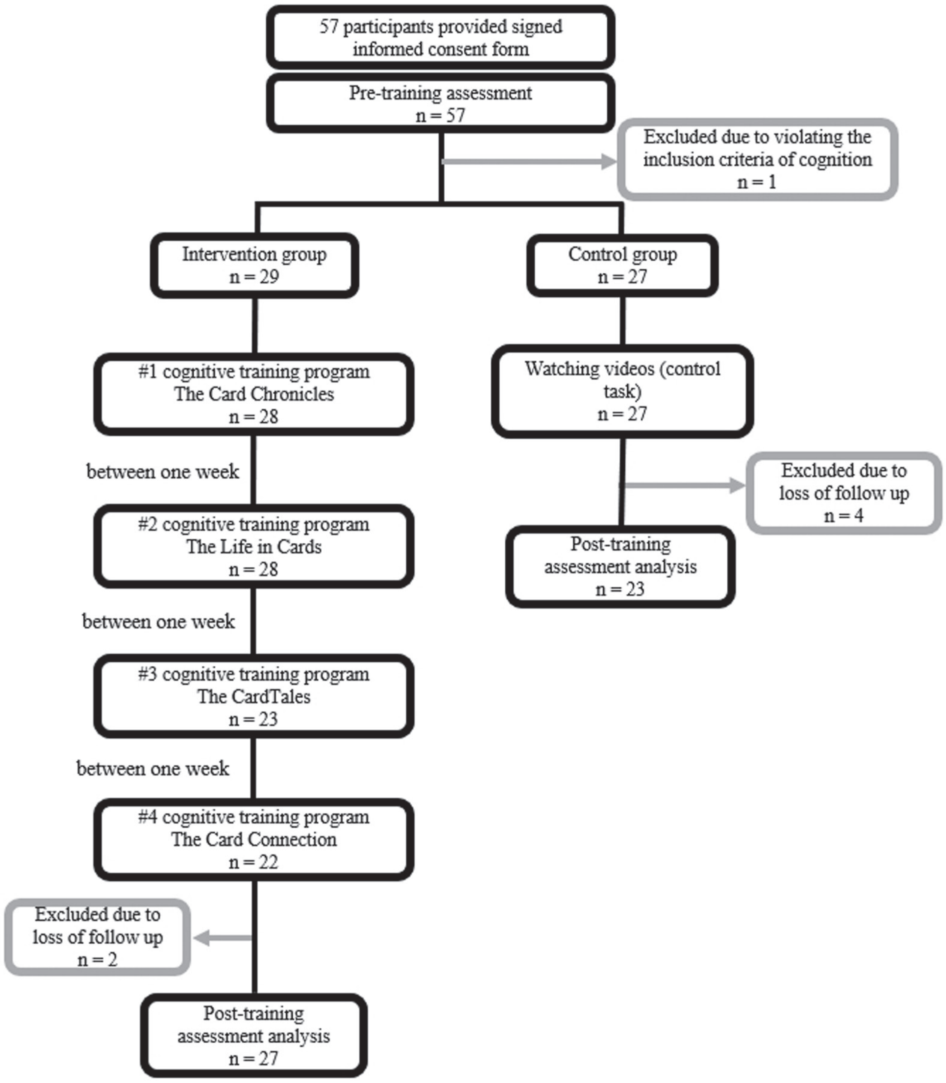

Fig. 2 Flow diagram of the recruitment process.

3.2. Between-group comparison of pretest

No significant differences in age, sex, or years of education were found between the groups. Baseline clinical characteristics showed no significant differences in the MMSE scores, the CDR-sum of boxes, GDS-15 scores, or scores for QoL (Table 1).

3.3. Within-group comparison of the control group

Wilcoxon signed-rank tests showed no significant differences in the MMSE scores or the CDR-sum of boxes scores within the control group. Improvements were noted in the learning (p = 0.049) of the LM and recall components of the LM (p = 0.022) and FCSRT (p = 0.043), but these results did not reach statistical

Table 1

Demographical and clinical characteristics of participants in both groups

	Control (n = 23) M ± SD	Intervention (n = 27) M ± SD	Statistics	p
Demographics				
Age (y)	69.7 ± 12.0	70.7 ± 5.6	−0.38	0.705
Education (y)	11.9 ± 3.2	12.1 ± 3.9	−0.49	0.621
Gender (female/male)	12/11	15/9	0.69	0.406
Clinical characteristics				
Pretest MMSE	26.8 ± 1.6	26.4 ± 1.7	−0.94	0.346
Pretest CDR-sum of boxes	0.9 ± 0.7	1.4 ± 1.2	−0.09	0.929
Pretest GDS-15	5.2 ± 4.2	3.5 ± 2.8	−1.33	0.182
Pretest QoL	94.2 ± 14.6	96.0 ± 13.4	−0.46	0.647

CDR = Clinical Dementia Rating; GDS-15 = Geriatric Depression Scale-15; M = mean; MMSE = Mini-Mental Status Examination; QoL = quality of life.

Table 2

Differences between pretest and post-test on cognitive, mood, and quality of life in control group

	Pretest (n = 23)	Post-test (n = 23)		
	M ± SD	M ± SD	Statistics	p
MMSE	26.8 ± 1.6	27.2 ± 2.2	1.38	0.167
CDR-sum of boxes	0.9 ± 0.7	1.0 ± 0.8	0.79	0.429
LM-I	30.7 ± 13.9	33.7 ± 14.6	1.97	0.049*
LM-II	15.8 ± 11.6	18.2 ± 13.1	2.28	0.022*
FCSRT learning	8.2 ± 1.2	8.7 ± 1.1	−2.29	0.403
FCSRT delay	9.6 ± 4.2	10.3 ± 4.4	−2.15	0.043*
GDS-15	5.2 ± 4.2	4.2 ± 3.3	−1.49	0.137
QoL	94.2 ± 14.6	92.0 ± 14.6	1.56	0.632

CDR = Clinical Dementia Rating; FCSRT delay = delayed free recall score of the free and cut selective reminding test; FCSRT learning = total learning free recall score of the Free and Cued Selective Reminding Test; GDS = Geriatric Depression Scale-15; LM-I = learning detail score of the Logical Memory subtest of the Wechsler Memory Scale-III; LM-II = delayed recall score of the Logical Memory subtest of the Wechsler Memory Scale-III; M = mean; MMSE = Mini-Mental Status Examination; QoL = quality of life.

*p < 0.05, not significant after adjusting for multiple comparisons.

Table 3

Differences between pretest and post-test on cognitive, mood, and quality of life in intervention group

	Pretest (n = 27)	Post-test (n = 27)		
	M ± SD	M ± SD	Statistics	p
MMSE	26.4 ± 1.7	27.5 ± 2.7	−2.84	0.004*
CDR-sum of boxes	1.4 ± 1.2	1.1 ± 1.1	−2.26	0.024**
LM-I	27.4 ± 14.4	35.3 ± 12.4	−4.34	<0.001*
LM-II	14.9 ± 10.6	20.6 ± 10.0	−3.50	<0.001*
FCSRT learning	8.9 ± 3.2	10.5 ± 3.5	−3.63	<0.001*
FCSRT delay	9.9 ± 4.2	11.3 ± 4.5	−2.71	0.007**
GDS-15	3.5 ± 2.8	3.2 ± 3.2	−0.87	0.387
QoL	96.0 ± 13.4	96.6 ± 13.3	−0.36	0.716

CDR = Clinical Dementia Rating; FCSRT delay = delayed free recall score of the free and cut selective reminding test; FCSRT learning = total learning free recall score of the Free and Cued Selective Reminding Test; GDS = Geriatric Depression Scale-15; LM-I = learning detail score of the Logical Memory subtest of the Wechsler Memory Scale-III; LM-II = delayed recall score of the Logical Memory subtest of the Wechsler Memory Scale-III; M = mean; MMSE = Mini-Mental Status Examination; QoL = quality of life.

*p < 0.00625.

**p < 0.05, not significant after adjusting for multiple comparisons.

significance after adjusting for multiple comparisons (Table 2). Additionally, tests for depressive symptoms and QoL reported nonsignificant findings, implying no substantial changes in mood or QoL during this period.

3.4. Within-group comparison of the intervention group

Wilcoxon signed-rank tests were utilized to evaluate the effects of CT in the intervention group. The results showed higher scores on the post-training MMSE test, indicating an improvement in global cognition (p = 0.004, r = 0.55). The CDR-sum of boxes analysis did not produce significant findings after correction for multiple comparisons (p = 0.024), suggesting no substantial interval change of dementia severity after the intervention. No significant changes were observed in depressive symptoms or QoL. In terms of memory function, significant enhancements were noted in both learning (p < 0.001, r = 0.83) and recall (p < 0.001, r = 0.67) components of the LM subtests. Significant improvements were also noted in both the learning (p < 0.001, r = 0.70) and recall (p = 0.007, r = 0.52) aspects of the FCSRT. After adjusting for multiple comparisons, improvements in learning scores on the LM and FCSRT and recall scores on the LM remained statistically significant (Table 3). To further investigate the effect of CT on memory performance, Mann-Whitney U tests were conducted for between-group difference scores (postintervention − preintervention) of the learning and delayed recall aspects of the LM, and learning scores on the FCSRT. Only the differences in learning scores (p = 0.008, Cohen's d = 0.78) and delayed recall scores of the LM were significant (p = 0.006, r = 0.39) (Fig. 3), indicating a training effect on verbal memory compared with visual memory.

4. DISCUSSION

This study investigated the impact of CT using multiple mnemonic strategies on older adults with or without cognitive impairment. We collaborated with the National Palace Museum and applied the LMG cards set as material to develop a four-session CT program. These results support the effectiveness of multiple mnemonic strategy-based CT in improving memory function. Specifically, deeper processing and self-referential processing significantly enhanced verbal memory function among older adults.

The level of processing model posits that deeper information processing leads to a more robust memory trace.[18,19] During the first and third training sessions, participants were instructed to describe the color, texture, or sound of the selected LMG cards in great detail or to create a new story related to the LMG cards, which is believed to deepen the process of material, resulting in enhanced memory performance based on the level of processing model. In the second and fourth sessions, participants were asked to recall their personal experiences associated with the LMG cards. Although we did not collect brain imaging data in the current study,

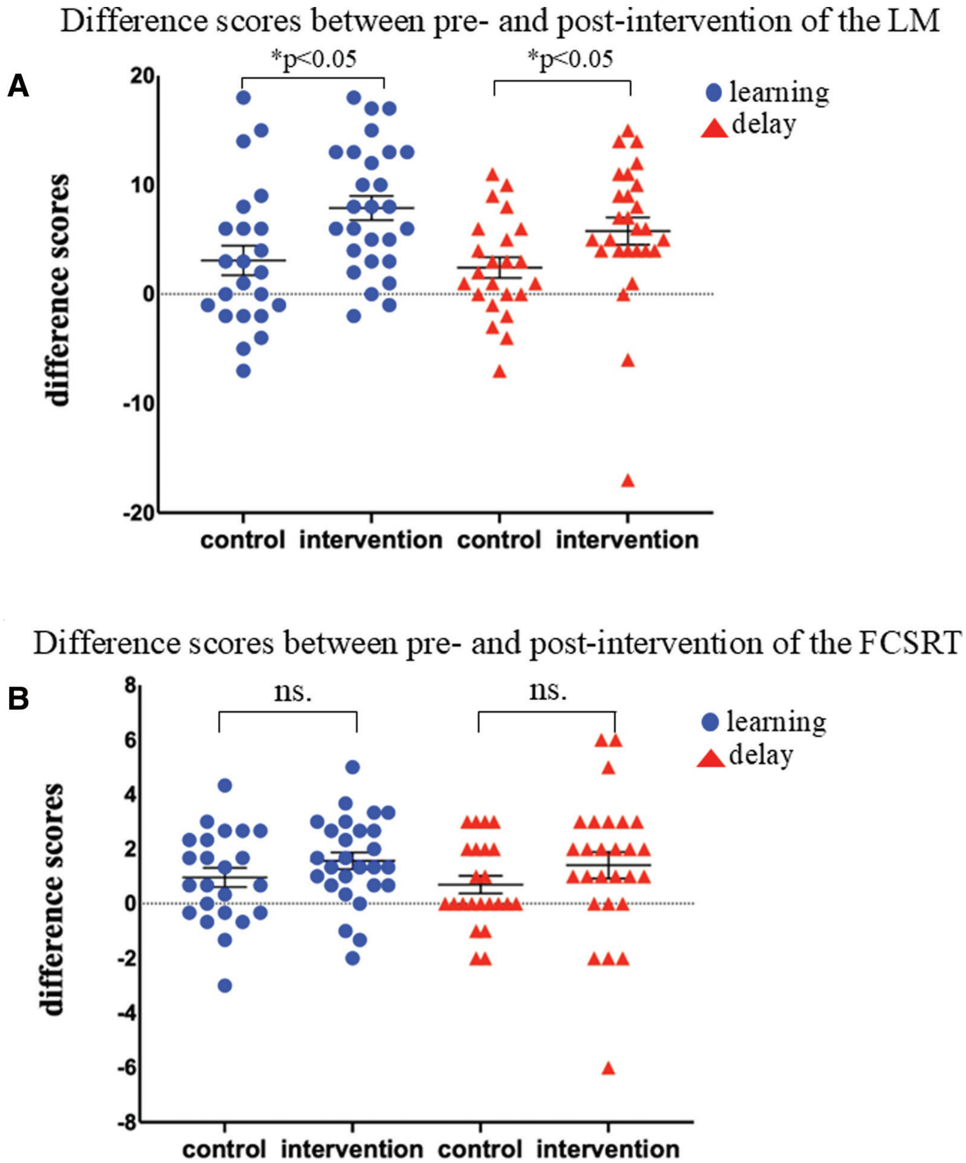

Fig. 3 Difference scores (postintervention – preintervention) of learning and delayed recalls on the LM (A) and the FCSRT (B) in control and intervention groups. The error bars denote the SE. FCRST = Free and Cued Selective Reminding Test; LM = Logical Memory; ns.=Non significant.

according to previous research self-referential processing is evidenced to enhance memory function by elevating the activation of the medial prefrontal cortex.[36–38] Further studies are recommended to validate our findings by examining the relationship between improvements on memory function and activation of medial prefrontal cortex.

Moreover, enhancement in memory can likely be attributed to the use of multiple mnemonic strategies rather than a single mnemonic strategy during training sessions. Previous studies have suggested that the number of mnemonic strategies used in a program predicts the effects of CT.[22] However, the efficacy of CT employing multiple strategies remains uncertain, owing to the scarcity of published research. Previous studies have suggested that the superior efficacy of multiple strategies compared with a single strategy may be due to the ability of CT with multiple strategies to allow participants to transfer the training effect to their daily practice.[23–25] Our CT program, which utilizes a combination of strategies, including story mnemonics, association, and self-reference, offers supportive evidence of the effectiveness of these multiple-strategy approaches.

Although previous studies have indicated that the effect sizes for verbal and visual memory are approximately 2.16,[39] we observed a more prominent enhancement in verbal memory than in visual memory. We hypothesized that this result may be related to the modality of the materials. The primary distinction between these memory tasks is that the LM test requires participants to recite a story rather than listing items but the FCSRT requires participants to remember those presented pictures. During the intervention, participants were instructed to create a narrative with the materials to be remembered or to relate a personal life story to the materials. This approach closely aligns with the LM test requirements. Previous brain imaging studies based on the level of processing model have shown that memory performance is related to whether the sensory regions activated during initial learning are subsequently reactivated during retrieval. This suggests that the more similar the modality between training programs and memory tests, the better the performance on the memory tasks. Consequently, the observed improvement on memory in the intervention group may be due to similar processing between CT and memory tasks.[40,41] Another potential factor that may have influenced the results was the inherent difference in the complexity of the materials used for visual memory. The LMG Cards employed in our course are rich in detail, including aspects such as the texture, color, and historical context of the artifacts. By contrast, the visual stimuli utilized in the assessment were simple black-and-white 2D images composed of basic lines. Such neutral and minimalist stimuli may have posed a greater challenge for participants in employing the memory strategies learned in the course. However, we propose that if more detailed images or objects were chosen for the memorization task, participants might have been better able to apply the techniques they learned, thereby enhancing their visual memory retention.

Further analysis revealed a remarkable effect of CT on learning compared to the delayed recall of memory functions. A previous study indicated that mnemonic strategy tends to reduce errors while learning. As a result, using a mnemonic strategy tends to enhance learning but not the delayed recall aspect of memory functions.[39]

Finally, demographic variations did not account for the improvements on verbal memory function in the intervention group, because the two groups shared similar demographic and clinical variables as well as baseline cognitive profiles. Moreover, the improvement could not be solely attributed to a practice effect, as no enhancement was observed in the control group.

According to the present study, depressive symptoms and overall QoL did not improve significantly. In contrast to other interventions that focus on mood or social interactions, such as reminiscence therapy, the current training program is based on theoretical memory models, which may lead to the absence of an effect on mood. On the other hand, previous intervention programs aimed at promoting mood and quality of sleep have adopted a longer period of intervention lasting more than three weeks. Consequently, the unremarkable effect on mood and QoL may have resulted from a relatively short period of intervention.[43,44] Studies have shown that museum-based interventions can improve the emotional well-being and QoL of individuals with dementia. Over a 10-year observation period, sustained museum engagement might reduce the incidence rate as a function of bolstering the cognitive reserve. In future studies, the use of CT programs with greater museum involvement may promote older adults' general well-being.[45–47]

This study has several limitations. Although we observed a significant training effect, the sample size of the current study was relatively small, which may have resulted in insufficient power to detect subtle changes from training. Future studies with larger sample size are required to confirm these findings. Furthermore, previous research suggests improvements in mood require a longer intervention period compared to improvements in cognition.[41,42] In the current study, we employed a relatively short intervention duration compared with existing studies, which likely contributes to the lack of significant findings on mood enhancement in current findings. Future studies are needed to investigate the relationship between intervention duration and mood improvement. The inclusion of participants with varying cognitive status also limited the ability to analyze the effects separately for each group. Future studies should explore the long-term effects of mnemonic strategy-based cognitive interventions by using neuroimaging data. Finally, the activities of the control group involved watching Chinese cultural videos. Although we selected these videos for their historical context, similar to the materials used in the intervention group, watching them requires little to no memory ability, leading to less similar cognitive processing compared to the training programs. Future studies should use cognitive tasks involving similar cognitive processing.

In conclusion, although future research with a larger sample size is needed to validate our results, our study demonstrates that CT using multiple mnemonic strategies can enhance cognitive function in older adults. Our findings indicate the development of CT may be important to maintain older adults' cognitive health.

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