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HIGHLIGHTS

- We developed a nonverbal scene memory task to assess memory of what, where, and when.
- AD patients were impaired in spatial and temporal memory but not object memory.
- 8 weeks of memory training significantly improved spatial memory in AD.

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Does Episodic Memory Training Improve Episodic Memory of Older Adults with Alzheimer's Disease?

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Conflict of Interest
The authors have no potential conflicts of interest to disclose.

ABSTRACT

To date, it is unclear whether cognitive intervention on episodic memory (EM) is effective in improving all or a subset of EM components in Alzheimer's disease (AD). Therefore, this study investigated effects of EM training on the elderly aged over 65 with AD. For this study, 13 AD patients and 16 healthy older adults were recruited. The pre- and post-test for components of EM was a memory task designed to test memory for object identity ("what"), spatial location ("where"), and temporal order ("when"). Training in the AD group consisted of 16 sessions of practice remembering temporal sequences of different objects being hidden in various locations. At pre-test, accuracy on the "where" and "when" conditions were impaired in the AD patients compared with the healthy elderly ($p < 0.01$). At post-test, accuracy on the "where" condition was significantly improved ($p < 0.05$) whereas, there were no significant improvements on the "what" and "when" conditions ($p > 0.05$). Interestingly, there were no significant improvements in standard neuropsychological measures. These findings suggest that AD, in its early stages, selectively impaired spatial and temporal memory rather than object memory. Additionally, it was observed that EM training in AD had different effects depending on the components of EM.

Keywords: Episodic memory; Cognitive therapy; Alzheimer's disease; Hippocampus

INTRODUCTION

Episodic memory (EM) refers to the memory of individual events consisting of "what", "where", and "when" information [1]. Several neurophysiological studies have converged on the fact that EM depends largely on hippocampal function [2]. EM impairment detected by hippocampal dysfunction is consistent with evidence from functional neuroimaging, which have indicated decreased EM in patients with hippocampal dysfunction while performing cognitive tasks requiring EM [3]. In addition, it has been reported that hippocampus volume was significantly correlated with performance in EM tasks [4].

In contrast with the gradual cerebral degeneration associated with normal aging, Alzheimer's disease (AD) induces distinct atrophy in medial temporal regions including hippocampus

resulting in EM decline [5]. EM decline interferes with the safety and independent daily activity of older adults with AD [6]. Therefore, interventions for EM decline have gained a lot of attention in hopes for a way to slow down the progression of AD [7].

In order to provide appropriate intervention to older adults with AD, detailed characteristics of progressive EM decline must first be understood. Most of the previous studies on EM of AD patients consistently showed that AD patients were impaired in auditory or visual EM compared to healthy older adults [7,8]. In these studies, conventional neuropsychological assessments, such as the California Verbal Learning Test and the Rey-Kim Auditory Verbal Learning Test, were used to measure EM performance. However, these tests have been identified to have some limitations in sensitively measuring hippocampal contribution to EM as they do not specifically engage hippocampal function and can be influenced by other factors such as verbal ability [8,9]. Indeed, these assessments typically involve object or word memory and do not include tests of spatial and temporal memory, which are more fundamentally dependent on hippocampal function compared to object memory [10]. Accordingly, a variety of non-pharmacological interventions such as reminiscence therapy, errorless learning, and spaced retrieval training only focus on memory for "what" information. Therefore, it is necessary to assess more detailed characteristics of EM of older adults with AD and then to implement intervention based on those characteristics.

Hence, in this study, we developed a new behavioral task to identify components of EM that are impaired in older adults with AD, isolating "what", "where", and "when" information. Then, we investigated the effects of 8 weeks of training on a spatiotemporal EM task in the AD group. The first objective of this study was to investigate a behavioral marker for AD by separately comparing components of EM using a computer-based scene memory task in patients with AD and healthy older adults. Our second objective was to confirm whether components of EM could be improved or maintained after 16 sessions of EM training.

MATERIALS AND METHODS

Subjects

Thirteen AD patients were recruited from the senior day care centers in Daejeon, Korea. All AD patients were diagnosed, each by their own neurologist in a hospital in Daejeon, according to the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) criteria. Sixteen healthy older adults also participated in this study and they were recruited from the local senior center. Inclusion criteria were as follow: 1) over 65 years old to match the age of the AD patients; 2) no history of neurological or psychiatric disease to minimize confounding factors that affect EM; and 3) an ability to understand verbal or visual instructions. The number of subjects was calculated by using G*Power 3.1 (Informer Technologies, Dusseldorf, Germany). In accordance with the previous study [7], an effect size was set at 0.77, a α error at a probability of 0.05, and the power at 0.85. A power analysis indicated that a minimum of 12 subjects was required in each group.

This study was approved by the Institute of Review Board of Korea Advanced Institution of Science and Technology (KAIST) (KH2017-91). All participants provided written informed consent before inclusion in accordance with the declaration of Helsinki (2004). The AD patients' consent forms were obtained from their legal guardians.

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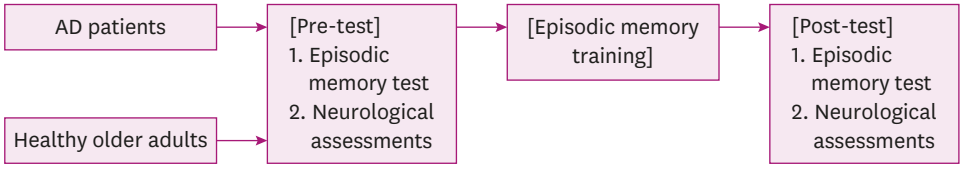

Fig. 1. The flowchart of this study.
AD, Alzheimer's disease.

Design

In this study, an AD pre-test–post-test design was used to evaluate the effects of EM training on older adults with AD; the procedures of this study were shown in a flow chart in Fig. 1. EM test was evaluated using a scene-based test with 3 conditions ("what", "where", "when"). The AD group received a total of 16 training sessions between the pre-test and post-test, which was conducted 2 days a week for 8 weeks. During the sessions, the AD group performed an active behavioral task of EM that required the binding of "what", "where", and "when" information [11] with feedback on each trial. Standard neuropsychological assessments were also implemented before and after the training in random order by a non-blinded occupational therapist. Control subjects were only tested once, without training.

Intervention

Behavioral EM training task

The AD patients performed an active behavioral task designed to induce real-life EM. In the task, the AD patients observed an experimenter hiding 5 out of 7 different objects one-by-one in 5 (out of 7) different boxes in the experimental room (demonstration phase) and were instructed to imitate the experimenter's performance (encoding phase). Then, after a numerical calculation interference task consisting of sequential addition or subtraction, the AD patients were asked to re-enact their own actions (retrieval phase) which were conducted in the encoding phase (Fig. 2). During the retrieval phase, when the AD patients performed differently from their behavior in the encoding phase, the experimenter immediately

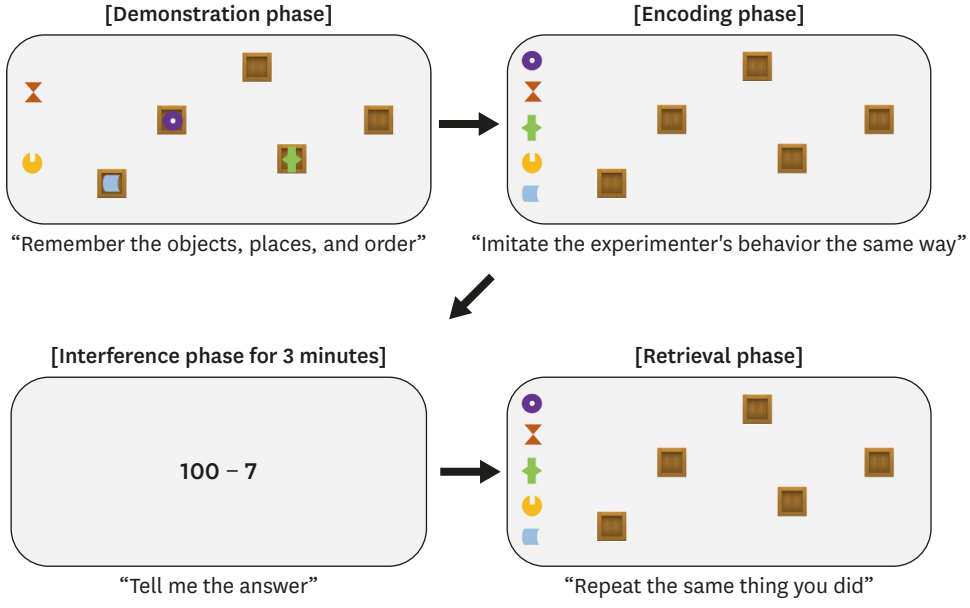

Fig. 2. The flow of the episodic memory training.

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provided feedback and opportunities to modify their performance. Nevertheless, if the AD patients continued to fail to perform correctly, the experimenter gave the correct answer.

This task took about 20 minutes and the AD patients performed the task 3 times in a session with 5 minutes' intervals, resulting in a training session lasting about 70 minutes. Selections of objects and locations and temporal order were randomized every time. This task allowed us to analyze the EM representation so we analyzed the accuracy rates on binding of information concerning an object's identity, its spatial location, and temporal order into one representation between the encoding phase and the retrieval phase (Fig. 2).

Scene-based EM test

The "what-where-when" scene memory test was conducted before and after the 16 training sessions. However, in order to identify differences in EM between the AD group and the healthy group at baseline, the healthy group only performed the scene-based memory test once, without training.

The scene-based memory test was developed by using E-Prime (Psychological Software Tools, Sharpsburg, PA, USA). The visual scene used in this test were taken using a digital camera on a tripod to keep the scenes in the same position when objects in the scenes were changed. This task consisted of 3 blocks of 10 trials each. Each block was a difference condition ("what", "where", and "when"), presented in a random order, in which the participants were given 10 different scenes for 3 seconds each (Fig. 3).

In the "what" condition, the participants were shown a scene that they had seen before, but an object was eliminated from the original image. Then, the participants were instructed to choose between images of 2 objects — the target object from the original scene and a lure object which they had never seen before (Fig. 3A). In the "where" condition, the participants were shown 2 images, one which they had seen and a lure scene in which an object was moved to a new spatial location (Fig. 3B). In the "when" condition, the participants were

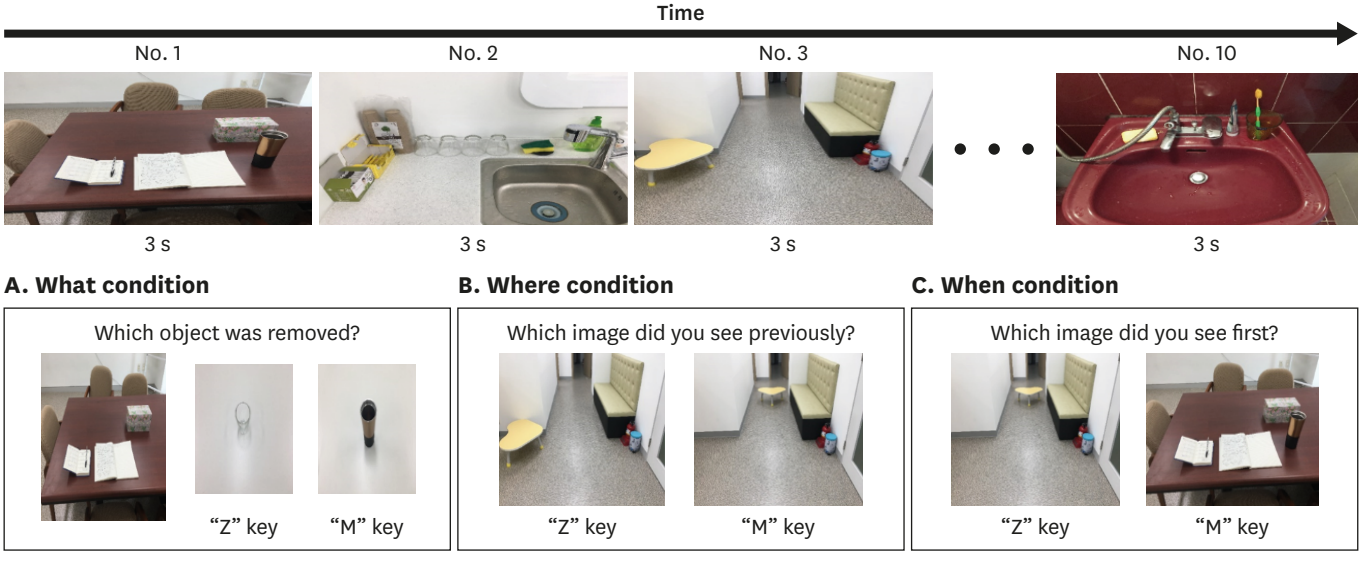

Fig. 3. Episodic memory task consisting of visual scenes. (A) Example of the "what" condition. (B) Example of the "where" condition. (C) Example of the "when" condition.

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given the 10 trials consisting of 2 of the previously shown scene and were requested to judge which scene they had seen earlier in the sequence of scenes (Fig. 3C). Subjects were asked to press the "Z" or "M" key to choose images presented on the left or right side.

Neuropsychological assessment

Three neuropsychological cognitive assessments were implemented at pre-test to both the AD patients and the healthy older adults and only the AD patients performed these assessments at post-test: the Korean version of the Mini-Mental State Examination (MMSE-K) was used to evaluate the AD patients' general cognitive function. The MMSE-K is a 30-point scale with 7 cognitive subtests, with a score below 24 indicating cognitive impairment. It has been shown to have high reliability and validity [12]. The Seoul Verbal Learning Test (SVLT) is a measure of a subject's ability to learn and remember verbal information. It contains 2-word lists that contain 12 items, including 4 words from each of 3 categories (flowers, stationeries, and kitchen tools). The experimenter reads each of 12 words slowly and the subject is asked to memorize them. Then, the subject is instructed to recall the items (immediate recall). After a 20-minute delay, the subject is asked to freely recall the words again (delayed recall), and then asked to identify the 12 words from a larger list containing novel lure words (recognition phase) [13]. Finally, the Korean version of the Boston Naming Test (K-BNT) consists of 60 pictures of objects arranged in order of difficulty. An experimenter evaluates a subject's naming ability by asking a subject to state the name of each item [14].

Statistical analysis

All data were analyzed using SPSS 22.0 version for Windows (SPSS Inc., Chicago, IL, USA). Demographic characteristics of both groups were analyzed using the χ^2 test and the Mann-Whitney U test. In the main analysis, we compared differences in performance in the scene-based EM test between the two groups at baseline using a Mann-Whitney U test. After the 16 training sessions, we conducted a Friedman test to examine the effects of EM training in the AD group. Statistical significance was set at $p < 0.05$.

RESULTS

Participants' general characteristics

There were no significant differences in sex, age, and years of education between the AD group and the healthy group ($p > 0.05$). In neuropsychological assessments, the healthy group showed higher performance in the MMSE-K ($p < 0.01$), recall of the SVLT ($p < 0.01$), and K-BNT ($p > 0.05$) but not in recognition score of the SVLT ($p > 0.05$). The average of the Global Deterioration Scale (GDS) level of the AD group was 4.85, suggesting the AD patients were from mild dementia to moderate dementia (Table 1).

EM performance in AD patients

The AD group was significantly lower in accuracy, compared to the healthy group, in the "where" and the "when" conditions ($p = 0.002$; $p < 0.001$, respectively) but not in the "what" condition ($p > 0.05$) (Table 2). Interestingly, compared with a chance level (50%), the AD group showed above-chance accuracy only in the "what" condition ($p < 0.05$), were not different from chance in the "where" condition ($p = 0.873$), and significantly below chance in the "when" condition ($p < 0.01$) (Fig. 4A). In contrast, the healthy group performed above chance in all conditions ("what": $p < 0.05$; "where": $p < 0.001$; "when": $p < 0.05$, respectively) (Fig. 4B).

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Table 1. Participants' general characteristics

Characteristic	AD group (n = 13)	Healthy group (n = 16)	p
Sex (male/female)	2/11	5/11	0.410
Age (yr)	83.00 (3.00)	82.00 (2.00)	0.083
Education period (yr)	6.00 (12.00)	10.00 (6.00)	0.329
MMSE-K	22.00 (5.00)	27.00 (7.00)	0.001†
SVLT			
Recall	14.00 (13.00)	23.50 (11.00)	0.001†
Recognition	17.00 (5.00)	20.00 (4.00)	0.132
K-BNT	43.00 (11.00)	50.50 (8.00)	0.022*
GDS	5.00 (2.00)	-	-

Shown are median values (interquartile range).
AD, Alzheimer's disease; MMSE-K, Korean version of Mini-Mental State Examination; SVLT, Seoul Verbal Learning Test; K-BNT, Korean version of the Boston Naming Test; GDS: Global Deterioration Scale.
*p < 0.05; †p < 0.01.

Table 2. Accuracy on the 3 conditions in the AD group and the healthy control group

Accuracy (%)	AD group (n = 13)	Healthy group (n = 16)	p
What	60.00 (10.00)	70.00 (17.50)	0.509
Where	50.00 (20.00)	65.00 (10.00)	0.002*
When	40.00 (5.00)	60.00 (17.50)	< 0.001†

Shown are median values (interquartile range).
AD, Alzheimer's disease.
*p < 0.01; †p < 0.001.

Effects of EM training

After the 16 training sessions, there was a significant improvement in accuracy on the "where" condition in the AD group ($p < 0.05$) but not on the "what" ($p > 0.05$) and the "when" conditions ($p > 0.05$) (Fig. 4A). More specifically, there was a significant improvement in accuracy on the "where" condition in the AD patients with GDS Level 4 (mild dementia) but not in the patients with GDS Level 5 or 6 (moderate to severe dementia) (Table 3).

Meanwhile, in the neuropsychological assessments, there were no significant improvements in the MMSE-K ($p > 0.05$), recall score on the SVLT ($p > 0.05$), recognition score on the SVLT ($p > 0.05$), and the K-BNT ($p > 0.05$) (Table 3).

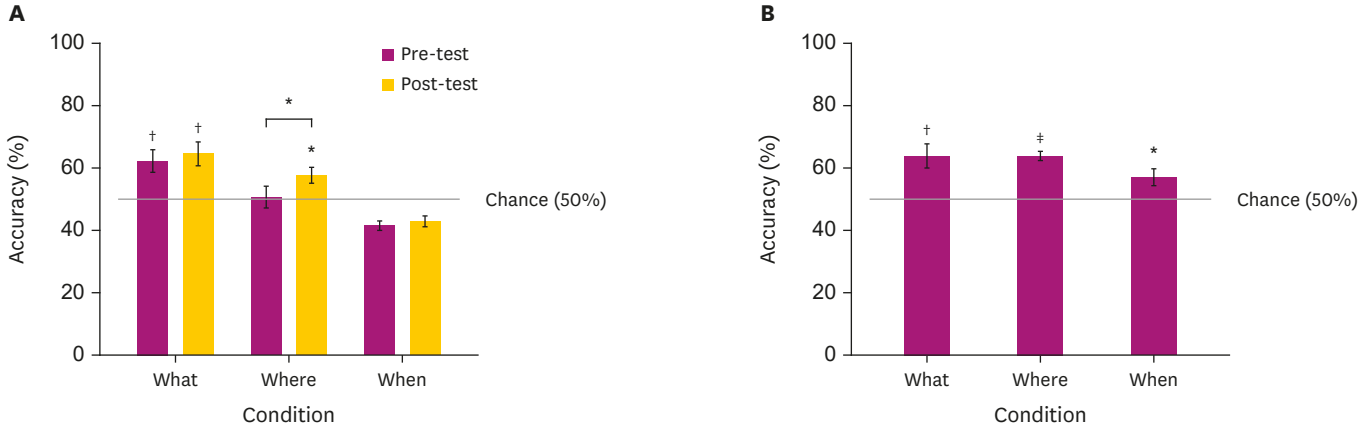

Fig. 4. (A) Accuracy on the "what", "where", and "when" conditions in older adults with Alzheimer's disease at pre-/post-intervention. (B) Accuracy on the 3 conditions in healthy older adults.
*p < 0.05; †p < 0.01; ‡p < 0.001.

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Table 3. Effects of episodic memory training on accuracy on each of the 3 conditions in the AD group

Episodic memory	GDS	Pre-test	Post-test	p
Accuracy				
What	4	60.00 (15.00)	7.00 (20.00)	0.581
	5	70.00 (15.00)	70.00 (10.00)	0.705
	6	50.00†	40.00†	0.100
Where	4	50.00 (20.00)	60.00 (15.00)	0.034*
	5	50.00 (20.00)	50.00 (15.00)	0.564
	6	60.00†	60.00†	0.414
When	4	40.00 (10.00)	40.00 (5.00)	0.564
	5	40.00 (10.00)	40.00 (10.00)	0.157
	6	40.00†	50.00†	0.564
Neuropsychological assessment				
MMSE-K		24.00 (6.00)	22.00 (4.00)	0.658
SVLT				
Recall		22.00 (11.00)	16.00 (12.00)	0.072
Recognition		19.00 (5.00)	18.00 (4.00)	0.061
K-BNT		49.00 (11.00)	44.00 (10.00)	0.856

Shown are median values (interquartile range).
AD, Alzheimer's disease; GDS, Global Deterioration Scale; MMSE-K, Korean version of Mini-Mental State Examination; SVLT, Seoul Verbal Learning Test; K-BNT, Korean version of the Boston Naming Test.
*$p < 0.05$; †Interquartile range was not calculated.

DISCUSSION

This study was aimed at investigating the "what", "where", and "when" components of EM in older adults with AD, as well as the effects of EM training on each of those components. These results indicate that while spatial and temporal order memory were negatively affected by AD, only spatial memory could be enhanced by the cognitive training provided in this study.

Hippocampus-dependent EM declines with the progression of AD [10]. In this study, the differences in performance on 3 conditions between the AD group and the healthy group were consistent with previous studies indicating that the hippocampal activity is more highly correlated with the representation of the spatiotemporal context compared to object memory [10,15]. Indeed, these studies indicated that older adults with AD performed the task requiring memory about "what" information similarly to healthy older adults [10,15]. Additionally, it was confirmed that patients with medial temporal lobectomy had no difficulty in recalling object information [16], which is also consistent with the present results.

After the 16 training sessions, we observed a significant improvement in spatial memory of the AD group while there were no significant improvements in object and temporal order memory. Specifically, only the AD patients at mild stage showed the improvement in spatial memory. What could explain this selective improvement of spatial coding? A previous study suggested that goal-directed navigation could be effective in enhancing EM [17]. Goal-directed navigation requires the mental representation of spatial locations in a temporal order and is closely related to hippocampal mechanisms that also underlie EM [18]. The task used for training in our study also required subjects to navigate around the room in a goal-directed manner, in order to place objects in various spatial locations in a particular sequence. Interestingly, however, the EM training selectively improved spatial memory not object and temporal order memory. This might indicate that the spatial component of EM might be improved through the compensatory engagement of unaffected areas of the brain such as the network of cortical areas involved in visual scene processing [19]. In contrast, the temporal binding of memory components, which has been shown to require an intact hippocampus [11]

may be irreversibly damaged by the time an AD patient reaches GDS 4, given the deterioration of the hippocampus and entorhinal cortex from the earliest stage of AD [20].

In the neuropsychological assessments, although the AD group showed lower performance in recall memory than the healthy group, the groups were similar in recognition memory performance. A decline in recall has been identified one of hallmarks of AD but there is controversy over whether there is impairment in recognition in the early stages of AD. Previous studies have indicated that generally AD patients are also impaired in recognition as well as recall since sensory processing also seems to be affected in AD [21]. Indeed, the previous study showed that recognition was impaired in a patient with hippocampal lesion [22]. However, there is a possibility that object recognition impairments could not be obviously observed at mild AD stage [23], which is line with the result of this study. In this study, since the older adults with AD were confirmed by the GDS being at the mild to moderate stage, the SVLT might not have detected problems of their recognition. This indicates that recognition in AD at mild to moderate stage depends on a type of test. Meanwhile, a previous study suggested that test of verbal fluency such as the result of the K-BNT was better for distinguishing mild to moderate AD from severe AD rather than discriminating mild AD patients from healthy older adults [24]. In this study, there was no significant difference in the K-BNT between the AD group and the healthy group. Additionally, there were no significant improvements in all the assessment after the 16 training sessions. Given these findings, we could conclude that general cognitive function, verbal EM, and verbal fluency were not proper tests for identifying early AD patients.

This study, however, has 2 limitations. First, we could not confirm the mechanism of spatial memory improvements since we did not use brain imaging devices such as functional magnetic resonance imaging and positron emission tomography. Second, because no control group was involved in the training part of this study, it is not possible to compare the effects of EM training in AD to healthy participants.

In conclusion, an impairment in spatial and temporal memory can be one of the cognitive hallmarks of AD, and spatial memory could be enhanced by EM training in early stages of AD. As such, clinicians may consider using assessments and training programs that include spatiotemporal contexts rather than using conventional assessment that focus mainly on object memory.

REFERENCES

1. Kessels RP, Hobbel D, Postma A. Aging, context memory and binding: a comparison of “what, where and when” in young and older adults. Int J Neurosci 2007;117:795-810.
PUBMED | CROSSREF
2. Hayes SM, Ryan L, Schnyer DM, Nadel L. An fMRI study of episodic memory: retrieval of object, spatial, and temporal information. Behav Neurosci 2004;118:885-896.
PUBMED | CROSSREF
3. Viard A, Piolino P, Desgranges B, Chételat G, Lebreton K, Landeau B, Young A, De La Sayette V, Eustache F. Hippocampal activation for autobiographical memories over the entire lifetime in healthy aged subjects: an fMRI study. Cereb Cortex 2007;17:2453-2467.
PUBMED | CROSSREF
4. Dubois B, Feldman HH, Jacova C, Cummings JL, Dekosky ST, Barberger-Gateau P, Delacourte A, Frisoni G, Fox NC, Galasko D, Gauthier S, Hampel H, Jicha GA, Meguro K, O'Brien J, Pasquier F, Robert P, Rossor M, Salloway S, Sarazin M, de Souza LC, Stern Y, Visser PJ, Scheltens P. Revising the definition of Alzheimer's disease: a new lexicon. Lancet Neurol 2010;9:1118-1127.
PUBMED | CROSSREF

5. Carlesimo GA, Oscar-Berman M. Memory deficits in Alzheimer's patients: a comprehensive review. Neuropsychol Rev 1992;3:119-169.
PUBMED | CROSSREF
6. Pai MC, Jacobs WJ. Topographical disorientation in community-residing patients with Alzheimer's disease. Int J Geriatr Psychiatry 2004;19:250-255.
PUBMED | CROSSREF
7. Plancher G, Tirard A, Gyselinck V, Nicolas S, Piolino P. Using virtual reality to characterize episodic memory profiles in amnestic mild cognitive impairment and Alzheimer's disease: influence of active and passive encoding. Neuropsychologia 2012;50:592-602.
PUBMED | CROSSREF
8. Thompson JC, Stopford CL, Snowden JS, Neary D. Qualitative neuropsychological performance characteristics in frontotemporal dementia and Alzheimer's disease. J Neurol Neurosurg Psychiatry 2005;76:920-927.
PUBMED | CROSSREF
9. Tierney MC, Yao C, Kiss A, McDowell I. Neuropsychological tests accurately predict incident Alzheimer disease after 5 and 10 years. Neurology 2005;64:1853-1859.
PUBMED | CROSSREF
10. Burgess N, Maguire EA, O'Keefe J. The human hippocampus and spatial and episodic memory. Neuron 2002;35:625-641.
PUBMED | CROSSREF
11. Mastrogiuseppe M, Bertelsen N, Bedeschi MF, Lee SA. The spatiotemporal organization of episodic memory and its disruption in a neurodevelopmental disorder. Sci Rep 2019;9:18447.
12. Park JH, Kwon YC. Modification of the mini-mental state examination for use in the elderly in a non-Western society: Part I. Development of Korean version of mini-mental state examination. Int J Geriatr Psychiatry 1990;5:381-387.
CROSSREF
13. Kang YW, Na DL. Seoul Verbal Learning Test (SVLT). Seoul: Human Brain Research & Consulting Co.; 2003.
14. Kim HH, Na DL. Korean version of Boston Naming Test (K-BNT). Seoul: Hakjisa; 1997.
15. Kyle CT, Smuda DN, Hassan AS, Ekstrom AD. Roles of human hippocampal subfields in retrieval of spatial and temporal context. Behav Brain Res 2015;278:549-558.
PUBMED | CROSSREF
16. Pigott S, Milner B. Memory for different aspects of complex visual scenes after unilateral temporal- or frontal-lobe resection. Neuropsychologia 1993;31:1-15.
PUBMED | CROSSREF
17. Sauzéon H, N'Kaoua B, Arvind Pala P, Taillade M, Guitton P. Age and active navigation effects on episodic memory: a virtual reality study. Br J Psychol 2016;107:72-94.
PUBMED | CROSSREF
18. Lövdén M, Schaefer S, Noack H, Bodammer NC, Kühn S, Heinze HJ, Düzel E, Bäckman L, Lindenberger U. Spatial navigation training protects the hippocampus against age-related changes during early and late adulthood. Neurobiol Aging 2012;33:620.e9-620.e22.
PUBMED | CROSSREF
19. Epstein R, Kanwisher N. A cortical representation of the local visual environment. Nature 1998;392:598-601.
PUBMED | CROSSREF
20. Braak H, Braak E. Staging of Alzheimer's disease-related neurofibrillary changes. Neurobiol Aging 1995;16:271-278.
PUBMED | CROSSREF
21. Nordin S, Murphy C. Impaired sensory and cognitive olfactory function in questionable Alzheimer's disease. Neuropsychology 1996;10:113-119.
CROSSREF
22. Holdstock JS, Mayes AR, Roberts N, Cezayirli E, Isaac CL, O'Reilly RC, Norman KA. Under what conditions is recognition spared relative to recall after selective hippocampal damage in humans? Hippocampus 2002;12:341-351.
PUBMED | CROSSREF
23. Westerberg CE, Paller KA, Weintraub S, Mesulam MM, Holdstock JS, Mayes AR, Reber PJ. When memory does not fail: familiarity-based recognition in mild cognitive impairment and Alzheimer's disease. Neuropsychology 2006;20:193-205.
PUBMED | CROSSREF
24. Lee SM, Kim SR, Kim JD. Confrontation naming and verbal fluency of Alzheimer's disease and vascular dementia. Audiol Speech Res 2017;13:345-351.
CROSSREF