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Scenery Picture Memory Test: A new type of quick and effective screening test to detect early stage Alzheimer's disease patients

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Aim: It is highly desirable to develop a neuropsychological screening test which is sensitive to the early stage of Alzheimer's disease (AD), and is easy to administer at the primary care physician's (PCP's) office.

Methods: Participants were 128 AD patients and 54 healthy volunteers. Brief cognitive screening tests were administered to the participants including the Mini-Mental State Examination (MMSE), Clock Drawing Test (CDT), Verbal Fluency Test (VFT), a Verbal Category Cued Memory test (CCMT) and the Scenery Picture Memory Test (SPMT). In the SPMT, a scenery picture of a living room containing 23 familiar objects was used. The administration of the SPMT comprised the first shallow memory session (Pict 1) and the second deep memory session (Pict 2). The area under the receiver–operator curve (AUC) was used to compare the efficacy of SPMT with other cognitive tests.

Results: Pict 1, which requires less than 2 min to complete, had the same AUC as Pict 2, and showed significantly larger AUC than MMSE, CDT and VFT for all (MMSE 19–23) and very mild (MMSE ≥ 24) AD patients. When we conducted the similar analysis separately for those younger than 75 years and those aged 75 years or older, we obtained the same results as above among the older age group. Pict 1 showed larger AUC than CCMT in overall sample and also in the older age group, although the difference was not statistically significant.

Conclusion: The SPMT could be useful for detection of mild and very mild AD in settings even where time is limited. **Geriatr Gerontol Int 2010; 10: 183–190.**

Keywords: dementia, picture superiority, primary care physician, screening test, visual memory.

Introduction

As the population ages, the number of those afflicted with AD is expected to increase sharply. Early detection of AD is important for disease management but it is often difficult to distinguish early AD from normal cognitive aging. Early diagnosis is a particular challenge in the primary care setting where there is a lack of time and specialized expertise.[1–3]

It is generally agreed that those with early AD show memory decline greater than that expected for their age group.[4] Changes in cognitive test performance can be powerful diagnostic tools, if neuropsychological assessment could be included in the clinical diagnosis of AD. However, the majority of the familiar cognitive tests are not ideal for detecting early AD; some are too difficult, even for the healthy elderly (floor effect), while others are too easy for patients with early AD (ceiling effect). Tests developed to overcome these shortfalls include memory tests which provide cues during both the encoding and retrieval period,[5–8] and show reasonably high sensitivity and specificity in distinguishing early AD from normal aging. These tests are, however, time-consuming and their administration requires expertise not available in all primary care physician (PCP) offices. Further, older adults are sometimes reluctant to take long and effortful tests.

Visual memory is a key component of everyday life and healthy elderly have a relatively large capacity for memory for visual information encountered in daily life even without active conscious effort.[9–12] Because a central feature of AD is the decline in episodic memory,[13] several well-established visual memory tests, such as the Benton Visual Retention Test and the Rey-Osterrieth complex figure, can be used to assess non-verbal memory.[14,15] However, the abstract figures to be encoded and retrieved in these tests do not reflect daily life and both tests suffer from floor effects among the elderly. The third edition of the Wechsler Memory Scale (WMS-III) introduced the Family Pictures subtest which was designed to assess recall for scene characters, character activity and character location. This test uses non-abstract figures combined with verbal answers.[16] However, the test is time-consuming and complex in scoring, and has been used primarily to study cognition in schizophrenia or temporal epilepsy.[17,18] In the current study, we developed a new type of short and simple memory test assessing visual memory encoded as scenery, combined with verbal answers, to be used to detect mild AD.

Methods

Participants

The patients in the AD group came from outpatient referrals to the memory clinic of the Department of Geriatrics in Kyoto University Hospital. All patients underwent brain computed tomography or magnetic resonance imaging as well as a battery of laboratory tests including thyroid function, vitamin B12, folate and serum calcium concentration. A diagnosis of AD was made according to the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) criteria and the National Institute of Neurological and Communicative Disorders and Stroke–Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) criteria.[19,20] We defined mild and very mild AD according to operational criteria using Mini-Mental State Examination (MMSE) scores:[21] 19–23, mild; and 24 and over, very mild. Of the 128 individuals with AD, 44 were classified as mild AD and 84 very mild AD by this criterion. Those with MMSE scores below 19 were excluded from the current analysis. Separately, 39 consecutive patients attending the memory clinic were recruited to test reliability, regardless of dementia diagnosis or subtype; 14 AD patients and three non-AD patients (two vascular dementia, one Fahr disease) for assessing inter-rater reliability, and 16 AD patients and six non-AD patients (three vascular dementia, one frontotemporal dementia, one depression, one delusion) for assessing test–retest reliability.

Fifty-four healthy volunteers with a Clinical Dementia Rating (CDR) of 0 were recruited from two sources: community-dwelling elderly who belonged to the Sakyo Geriatric Welfare Center, and outpatients in the Department of Geriatrics in Kyoto University Hospital. The inclusion criteria also included being free from depression, cerebral vascular disease, cerebral vascular accident or any other psychological disorder. This study was carried out according to the ethical guidelines for biomedical research involving human subjects set by Kyoto University, and written informed consent was obtained.

Cognitive assessment

Neuropsychologists administered the Scenery Picture Memory Test (SPMT) as part of a neuropsychological test battery that included the MMSE, Clock Drawing Test (CDT), Verbal Fluency Test (VFT) and Verbal Category Cued Memory test (CCMT), independently from the diagnostic assessments. For the CDT, the subject was asked to draw a clock with all the numbers on a blank piece of paper and indicate the time as 10 min after 11 o'clock. We used the 10-point scoring system by Rouleau et al.[22] The CCMT, a modified version of Buschke's Double Memory Test reported previously, is a verbal memory test which contains 16 words from eight categories and uses category cues during encoding and recall.[4,23] In the CCMT, only cued recall but not free recall is tested. The score is the number of items recalled correctly with the maximum score being 16.[23] In VFT, the subject was instructed to name as many vegetables and sports as possible, each within 1 min.[23] The score was the total number of items mentioned in both categories.

The SPMT used a line drawing scenery picture (Fig. 1) of a living room in a house where 23 objects commonly observed in daily life are drawn on an A4 piece of paper: a telephone, a bookshelf, books, a table, chairs, two cups with saucers, a flower vase, a framed
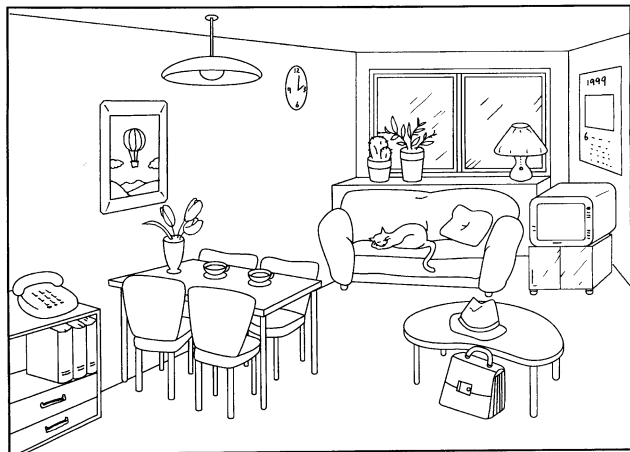
Figure 1 A line drawing scenery picture of a living room used in the Scenery Picture Memory Test.

picture on the wall, a clock, a ceiling lamp, a couch, a cushion, a cat, a low table, a hat on the table, a briefcase, a television, a desk for the television, a calendar on the wall, a flower pot with a cactus, a flower pot with a foliage plant, a table lamp and a window. We collected scores in two ways, which we call "Pict 1" and "Pict 2", respectively. In the first trial, Pict 1, the examinee studies the picture for 1 min and is instructed to remember the items. After this encoding period, we distracted participants by asking them to conduct a brief digits forward test (four digit strings consisting of 4, 5, 6 and 7 digits, respectively). Participants were then asked to recall the objects in the picture without time limitation. This recall time usually takes less than 1 min. The number of items recalled is the score for Pict 1 with no credit for duplicates.

In Pict 2, to enhance the encoding process, following the first trial, Pict 1, we asked participants to recall the locations of three specific items (telephone, hat and calendar), for example, "do you remember where the telephone was located in the picture?" After these questions, we presented the picture again and asked participants to name the items in the picture. Participants were asked to name at least 12 items. All participants in the current study could name at least 12 items. These tasks were not scored because our intention was to enhance memory by encouraging greater depth of processing. After this deep memory processing period, participants were distracted by the digits forward and backward subtest of the WAIS-R.[24] Finally, they were asked again to recall the items in the picture. The number of the items recalled here was used as the score for Pict 2. The mean approximate administration time of the SPMT is 2 min for Pict 1 and 6 min overall.

Statistical analyses

All data are presented as mean ± standard deviation (SD). Student's t-tests were used to assess differences between group means on continuous variables. Pearson's χ^2-tests were used to assess differences between groups on categorical variables. To measure the accuracy of the tests in discriminating between controls and patients, the area under the curve (AUC) of the receiver–operator curve (ROC) was assessed using the total sample as well as by two age groups (<75 years vs ≥75 years). Because controls in this study were younger and had higher education than AD patients in the total sample, we confirmed the validity of the SPMT in two age groups. We conducted the ROC analysis first using all AD patients and controls, and second using only very mild AD patients (AD with MMSE ≥ 24) and controls. Inter-rater and test–retest reliabilities were analyzed using the Spearman's rank correlation coefficient. The correlation between Pict 1 and Pict 2 was examined using Pearson's correlation coefficient. Test–retest and inter-rater reliabilities of SPMT were tested in the separate group of outpatients from a memory clinic. In this series of tests, two testers participated: one psychologist and one speech therapist. In both cases, two examinations were carried out at least 1 month apart; the average duration between test and retest was 2.3 ± 1.5 months, and the duration between inter-rater examinations was 2.8 ± 2.1 months.

Results

Demographic and basic neuropsychological characteristics of AD patients and controls are presented in Table 1. In each age group (<75 and ≥75 years), there was no difference in age and education distributions between control and AD groups. The SPMT scores in patients and controls suggest no apparent ceiling and floor effects in either group (Fig. 2).

Sensitivity and specificity to detect AD cases by Pict 1 were 85.2% and 88.9% (cut-off 9/10), respectively, and 84.4% and 90.7% (cut-off 12/13) by Pict 2, respectively. Positive and negative predictive values were 94.8% and 71.6% by Pict 1, respectively, and 95.6% and 71.0% by Pict 2, respectively. Given the similar levels of sensitivity, the specificity of MMSE and CCMT were lower than those of the SPMT. Sensitivity and specificity by MMSE were 83.6% and 75.9% (cut-off 27/28), respectively, and 81.3% and 81.5% (cut-off 7/8) by CCMT, respectively. These results were almost the same for very mild AD cases (data not shown). Table 2 shows AUC of different tests. Among the total sample, the AUC of Pict 1 was significantly larger than those of MMSE, CDT and VFT. Among the younger age group (<75 years), the AUC of Pict 1 was significantly larger than those of CDT and VFT. Among the older age group (≤75 years), the AUC of Pict 1 was significantly larger than those of MMSE, CDR and VFT. The AUC of Pict 1 and Pict 2 were very similar among the total sample (Table 2, Fig. 3) as well as within each age group (Table 2). Pict 1

Table 1 Characteristics of study participants

	Control Average	SD	AD Average	SD	*P*-value
Both age groups	*n* = 54		*n* = 128		
Age	72.5	6.5	75.3	6.7	0.009
Education	12.2	2.7	11.3	2.8	0.04
Female %	46.3%		65.6%		0.024
Pict 1	13.6	3.5	6.6	3.2	<0.001
Pict 2	17.5	3.6	8.9	4.5	<0.001
MMSE	28.3	1.5	24.6	2.9	<0.001
CDT	9.6	0.8	9.0	1.5	0.004
CCMT	10.3	2.4	5.1	2.6	<0.001
VFT	25.5	6.5	16.7	5.9	<0.001
Age <75 years	*n* = 39		*n* = 51		
Age	69.2	3.3	69.0	4.7	NS
Education	12.2	2.7	11.6	2.9	NS
Female %	43.5%		66.7%		0.034
Pict 1	13.8	3.7	7.5	3.1	<0.001
Pict 2	17.7	3.6	10.0	4.2	<0.001
MMSE	28.5	1.3	25.0	2.7	<0.001
CDT	9.6	0.9	8.9	1.5	0.009
CCMT	10.4	2.5	5.0	2.8	<0.001
VFT	33.5	10.4	19.8	12.2	<0.001
Age ≥75 years	*n* = 15		*n* = 77		
Age	81.1	4.5	79.5	3.9	NS
Education	12.2	2.9	11.1	2.7	NS
Female %	53.3%		64.9%		NS
Pict 1	13.3	3.0	6.0	3.2	<0.001
Pict 2	16.8	3.6	8.2	4.6	<0.001
MMSE	27.7	1.8	24.4	3.0	<0.001
CDT	9.7	0.8	9.1	1.4	0.124
CCMT	10.1	2.2	5.1	2.5	<0.001
VFT	24.1	8.3	12.9	11.1	<0.001

AD, Alzheimer's disease; CCMT, Category Cued Memory Test; CDT, Clock Drawing Test; MMSE, Mini-Mental State Examination; NS, not significant; Pict 1 and Pict 2, Scenery Picture Memory Test 1 and 2; SD, standard deviation; VFT, Verbal Fluency Test (vegetables and sports/1 min each).

showed a larger AUC than CCMT in the overall sample and also in the older age group, although the difference was not statistically significant (Table 2, Fig. 3). The results of ROC analysis restricted to very mild patients remained the same as above.

In both Pict 1 and Pict 2, comparison of the test–retest examination showed excellent correlations ($r = 0.898$, $P < 0.001$ for Pict 1; $r = 0.929$, $P < 0.001$ for Pict 2). Inter-rater reliability was also high ($r = 0.750$, $P < 0.001$ for Pict 1; $r = 0.795$, $P < 0.001$ for Pict 2).

Although the utility of Pict 1 and Pict 2 to detect AD is similar in terms of validity and reliability, to further examine the difference between shallow and deep encoding processes and a learning effect, we compared the result of Pict 1 with that of Pict 2 as a post-hoc analysis. In both control and AD groups, very high correlations between the two test scores were found (controls: $r = 0.726$, $P < 0.001$; patients: $r = 0.773$, $P < 0.001$). We examined the difference between Pict 2 and Pict 1 (i.e. Pict 2 – Pict 1) among patients and controls. The difference in scores was significantly larger among the control than the AD groups (3.8 ± 6.8 vs 2.3 ± 8.3, $P < 0.001$).

Discussion

With ongoing advances in the treatment of AD, early detection will become increasingly important for intervention, and counseling of patients and families. It would be highly beneficial for both patients and caregivers if the PCP could assess memory deficits in a simple and easy manner. In this study, we examined a new
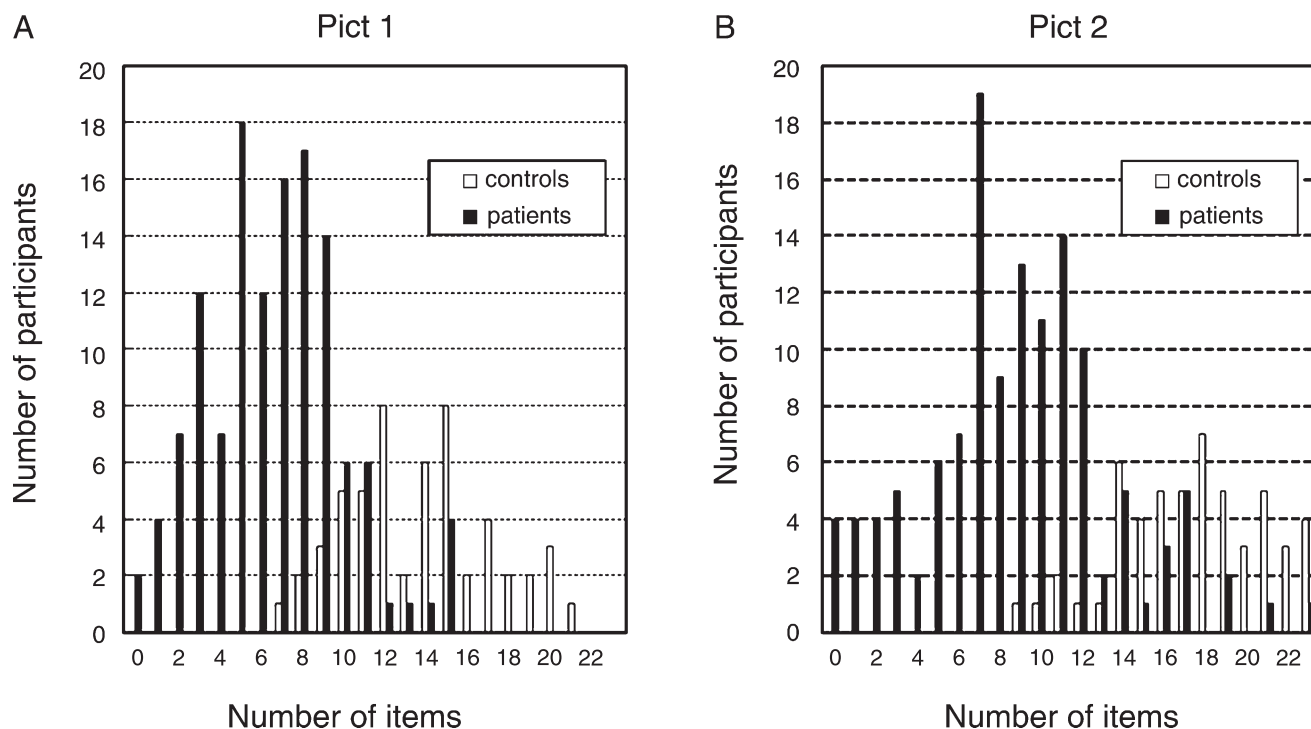
Figure 2 Score distribution of Pict 1 (a) and Pict 2 (b). In (a) and (b), horizontal axes indicate the number of items in the picture reported by participants. Vertical axes indicate number of participants. Closed bars indicate results from Alzheimer's disease patients, and open bars from control participants.

Table 2 Area under the curves and the differences among tests

	Control vs all AD		Control vs very mild AD	
	AUC (95% CI)	*P*-value	AUC (95% CI)	*P*-value
Both age groups				
Pict 1	0.93 (0.89–0.96)	Reference	0.90 (0.85–0.95)	Reference
Pict 2	0.92 (0.88–0.96)	NS	0.89 (0.84–0.94)	NS
CCMT	0.92 (0.88–0.95)	NS	0.89 (0.84–0.94)	NS
MMSE	0.87 (0.82–0.92)	0.046	0.80 (0.73–0.87)	0.027
VFT	0.82 (0.76–0.88)	<0.001	0.76 (0.68–0.83)	0.001
CDT	0.63 (0.56–0.71)	<0.001	0.60 (0.52–0.68)	<0.001
Age <75 years				
Pict 1	0.90 (0.84–0.96)	Reference	0.88 (0.80–0.95)	Reference
Pict 2	0.90 (0.84–0.96)	NS	0.89 (0.81–0.96)	NS
CCMT	0.91 (0.86–0.96)	NS	0.88 (0.81–0.95)	NS
MMSE	0.89 (0.82–0.95)	NS	0.85 (0.77–0.93)	NS
VFT	0.79 (0.70–0.88)	0.03	0.73 (0.62–0.85)	0.02
CDT	0.65 (0.55–0.75)	<0.001	0.61 (0.51–0.72)	<0.001
Age ≥75 years				
Pict 1	0.95 (0.90–0.99)	Reference	0.92 (0.86–0.99)	Reference
Pict 2	0.92 (0.87–0.98)	NS	0.89 (0.81–0.97)	NS
CCMT	0.92 (0.87–0.98)	NS	0.90 (0.83–0.98)	NS
MMSE	0.82 (0.72–0.92)	0.023	0.70 (0.54–0.86)	0.014
VFT	0.79 (0.69–0.88)	0.003	0.72 (0.59–0.85)	0.009
CDT	0.64 (0.52–0.76)	<0.001	0.60 (0.47–0.73)	<0.001

P-value indicates differences in area under the curve (AUC) compared with Pict 1. AD, Alzheimer's disease; CCMT, Category Cued Memory Test; CDT, Clock Drawing Test; MMSE, Mini-Mental State Examination; NS, not significant; Pict 1 and Pict 2, Scenery Picture Memory Test 1 and 2; VFT, verbal fluency (vegetables and sports/1 min each).
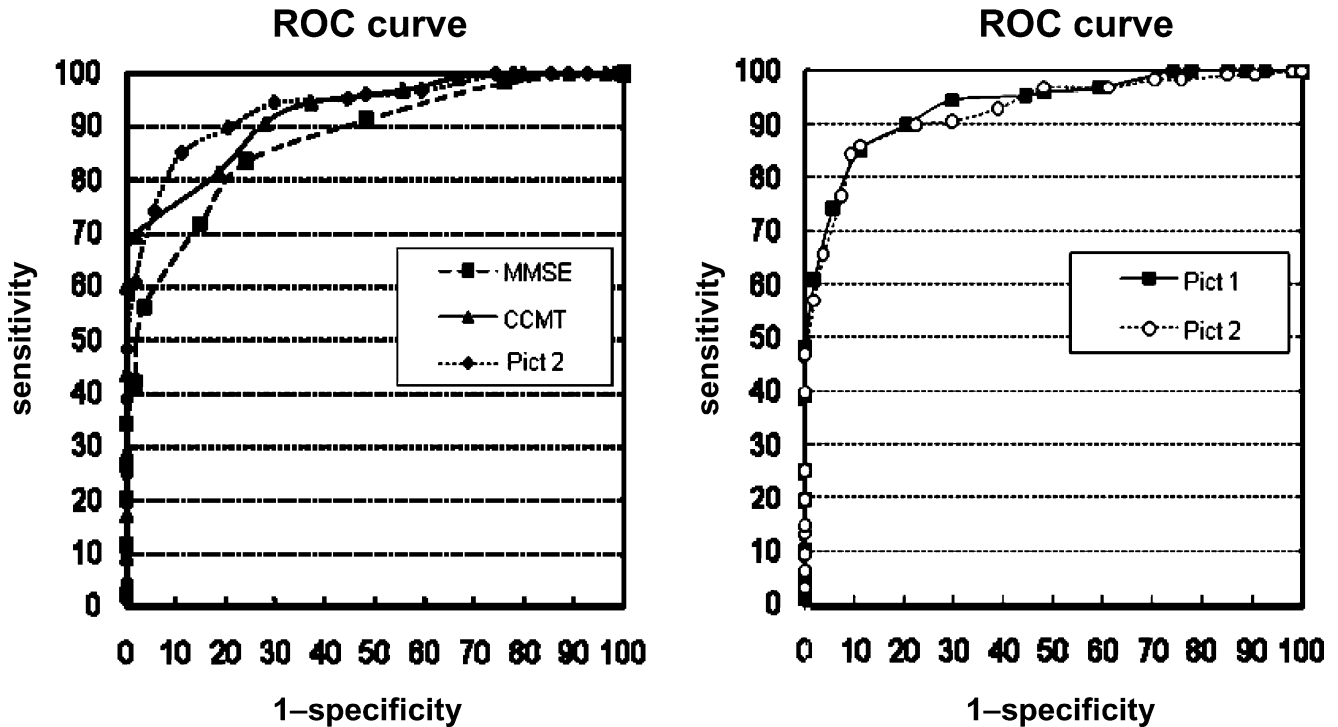
ROC curve

ROC curve

Figure 3 Receiver–operator curve (ROC) curves indicating results from control participants vs Alzheimer's disease (MMSE >19). MMSE, Mini-Mental State Examination; CCMT, Category Cued Memory Test; Pict 1, Scenery Picture Memory Test 1; Pict 2, Scenery Picture memory Test 2.

screening test, SPMT, to distinguish patients with early stages of AD from cognitively healthy elderly individuals. The SPMT had a larger AUC to identify even the very mild AD cases (AD with MMSE ≥ 24) compared with those of MMSE, VFT and CDT. The SPMT also demonstrated satisfactory test–retest and inter-rater reliabilities. Moreover, the test format was acceptable to elderly participants, without being intimidating or taxing.

There are several potential reasons for the high efficacy of this test in detecting early AD patients. First, pictorial material is usually easier to remember than materials presented by words, a phenomenon known as the "picture superiority effect".[9,10,12,25] Superiority of memory for pictorial material over verbal material was often applied as a mnemonic aid for elderly.[26,27] Potentially, the memory decline associated with normal cognitive aging could be ameliorated by the picture superiority effect, making it easier to distinguish AD patients from control participants.

Second, we used a picture of a living room with common furniture and objects familiar to most elderly. The scene may have multiple cues to enhance recall; each object in the scene becomes a cue for another object. In other words, once a part of the scene is recalled, other parts could be recalled because the scene is not unique but shares many common aspects of daily life. Categorically related or visually integrated

cues are shown to be more effective in terms of encoding than unrelated or non-interacting cues.[28] It has been also shown that the recognition of a scene as a context enhances memory of specific details.[29,30] Buschke *et al.* reported in their case–control study that subjects free from dementia could encode and retrieve more effectively in the category cued recall memory tests than the demented. They suggested encoding specificity deficit in dementia patients.[5] The multiple cues in the scenery picture in the SPMT may have resulted in facilitated encoding and retrieval of the items in the scene by the healthy elderly but not by AD patients, making it more effective in distinguish the two groups.

Additionally, in a recent functional imaging study, Gutches *et al.* reported that older adults compensate for their decrement of memory function in medial temporal lobe by activation of frontal systems, when pictorial materials are presented.[31] Possibly, the pathological process of AD may hamper this compensatory function, resulting in the discrepancy in SPMT scores between the control and AD groups.

We examined the effect of shallow and deep memory processing on the performance of SPMT. Although the results showed more benefit for deep memory processing or a potential learning effect for cognitively normal elderly, Pict 1 and Pict 2 seem to be equivalent in the effectiveness of distinguishing AD

patients from the controls. Because Pict 1 takes only 2 min to administer and has sufficient validity, Pict 1 may be more useful.

Limitations of the present study include the following. As mentioned above, because controls in this study were younger and had higher education than AD patients in the total sample, we confirmed the validity of the SPMT in two age groups. Further study in a large sample size would be required to generalize our results. Second, we tested in this study utility of the SPMT to distinguish early stage AD patients from controls. It would be important to further investigate how to use it in a PCP's office or a memory clinic, because other types of patients with memory deficit such as those with vascular dementia and depression may appear. Third, we used here only the CCMT to test specifically the memory domain of cognition. Although the CCMT is assumed to be an effective memory test as well as other standard memory tests such as the Logical Memory Subtest of the Wechsler Memory Scale – Revised or the California Verbal Learning Test, direct comparison of the SPMT with such memory tests would be required.[32,33] Finally, AD patients who participated in this study came from outpatient referral to the memory clinic. These subjects might be different in various characteristics from those with AD, but do not visit memory clinics. Therefore, the generalization of our results could be limited.

In conclusion, we present a new type of memory test which seems to be very useful in identifying early stage AD patients. The distribution of test scores had neither ceiling nor floor effects, and it was very easy to administer. We believe the scenery picture test will be a useful tool for routine clinical evaluations.

Acknowledgments

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