Validation of the Route Map Recall Test for Getting Lost Behavior in Alzheimer’s Disease Patients

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Abstract

Getting lost (GL) behavior is among the early symptoms in Alzheimer’s disease (AD). Only a few tests, however, have been developed to screen for this symptom. The aim of this study was to develop an instrument, the Route Map Recall Test (RMRT), for the screening of the GL problem in AD patients. We examined the psychometric properties of the RMRT and its clinical utility to predict the GL risk in 23 AD patients and 43 cognitively healthy older adults. The results showed that the RMRT has a sound reliability (test–retest, \( r = 0.752, p < .001 \); Cronbach’s \( \alpha = 0.887, p < .001 \)). The convergent validity was supported by the high correlations with Trail Making Test A and B. With the optimal criteria (93.5/104), the discriminative validity for the diagnosis of AD showed good sensitivity (86%) and specificity (70%), and sensitivity (100%) and specificity (67%) for GL in AD patients. The findings support the RMRT to be a useful tool for clinical screening of AD patients and their GL risk.

Keywords: Route recall; Alzheimer’s disease; Getting lost; Reliability; Validity

Introduction

The ability to orient oneself in an environment and to move to a specific destination is important in daily life (Barrash, 1998). Topographical disorientation, when it occurs, may result in getting lost (GL), which is one of the early signs observed in Alzheimer’s disease (AD) patients and it becomes more prominent as the disease progresses (Barrash, Damasio, Adolphs, & Tranel, 2000; Hope et al., 2001; McShane et al., 1998). GL is one behavior pattern linked to the dementia-related wandering, which may result from an inner drive to go some place the patient feels a need for, or misrecognizing the environment for finding the familiar route to the patient’s destination (Algase, Moore, Vandeweerd, & Gavin-Dreschnack, 2007). Patients’ GL can have devastating consequences for themselves and their families.

The incidence rate of GL has been reported ranging from 30% to 60% in people with dementia as surveyed in different countries (Kwok, Yuen, Ho, & Chan, 2010). These patients sometimes walked away from their residences and were found lost in an unfamiliar place. GL not only endangers the patients, but also causes enormous stress for caregivers and squanders the resources of the local authorities (Koester & Stooksbury, 1998). Moreover, GL history has been associated with caregiver burden and the decision for institutionalization of the patients (Hope et al., 2001; McShane et al., 1998). Risks may increase for the patients if they are unaware of their deficits. Only a few studies have investigated the GL behaviors, and even fewer tests have been developed to screen for this problem (Cherrier, Mendez, & Perryman, 2001).

Tests of topographic orientation may indicate the risk of GL for the patient with AD (McShane et al., 1998). However, limited instruments are available in clinics to screen the topographical abilities in patients with AD. Their disorientation problems have been investigated with tests consisting of in vivo navigation in a hospital (Pai, 2008), survey of GL experiences...
Neuropsychological tests. The Digit Span (DS), Spatial Span (SS), and Trail Making Test (TMT) A and B (Lezak, Howieson, 2004) and was blinded to this study. The details of the measures are as follows.

The GL problem appears when a person makes mistakes in finding the correct route to a destination. It has been suggested that in AD patients, deficits of visuospatial processing and spatial memory which specifically related the posterior hippocampal region may lead to the difficulties in remembering the route (Barrash et al., 2000; Mapstone, Steffenella, & Duffy, 2003; McShane et al., 1998; Tetewsky & Duffy, 1999). Other deficits related to GL were also included, such as frontal lobe function for planning and problem-solving (Chiu et al., 2004; Pai & Jacobs, 2004; Passini, Rainville, Marchand, & Joanette, 1995), temporal areas for verbal encoding (Barrash, 1998), and parietal dysfunction for spatial attention and orientation (de Leon, Potegal, & Gurland, 1984; Parasuramana, Greenwooda, & Alexander, 2000). However, there is no test that is simple, repeatable, and sensitive enough to detect the risk of GL based on the empirical evidence. Therefore, the purpose of this study was to test the psychometric properties of the Route Map Recall Test (RMRT) that we constructed for visual memory evaluation without a verbal component. We examined its reliability, convergent validity, discriminative validity for people with and without AD, and at risk for GL.

Method

Participants

Patients with AD (AD group: n = 23, mean age ± SD = 70.48 ± 7.01 years) were recruited from a dementia clinic in a university medical center. All of the patients met the diagnostic criteria of NINCDS-ADRDA (Dubois et al., 2007), and a senior neurologist made the diagnosis based on their detailed history, neurological examinations, neuropsychological assessments, neuroimaging, and laboratory testing. The Clinical Dementia Rating (CDR) Scale (Hughes, Berg, Danziger, Coben, & Martin, 1982) scores of the AD patients were mostly 1.0 but 0.5 for some. Patients were not recruited if they had evident mood or psychiatric symptoms observed or any psychiatric diagnosis reported by their proxies and had any other major neurological condition (e.g., traumatic brain injury, stroke, dementia other than AD, epilepsy). Cognitively healthy older adults were invited through community advertisements to form the control group (healthy control group, HC: n = 43, mean age ± SD = 68.35 ± 7.21 years). The recruitment criteria for the HC consisted of (a) 60 years old or above; (b) Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) score of ≥ 24; (c) no major visual or auditory impairment, and sufficient visual and auditory acuity after correction with aids, if necessary; (d) no history of any major neurological (e.g., traumatic brain injury, stroke, dementia, epilepsy) or psychiatric disorders (e.g., schizophrenia, bipolar disorder, major depression).

Procedures and instruments

The Institution Review Board of our medical center approved all procedures and protocols and an informed consent form was obtained from each participant before the research procedures. The participants were screened for enrollment using the MMSE and were briefly interviewed for demographic information, neurological and psychiatric history, the presence of memory complaints, and daily living difficulties. Eligible participants were given neuropsychological tests and the RMRT by a trained research assistant and one of the authors (Y.-C. Kuo). They carried out the data collection under the supervision of a senior neuropsychologist. The first 20 participants in the HC group were retested with the RMRT after 3 weeks to examine the test–retest reliability. Another trained research assistant conducted interviews with regard to the GL history by a questionnaire (Pai et al., 2012) and was blinded to this study. The details of the measures are as follows.

Neuropsychological tests. The Digit Span (DS), Spatial Span (SS), and Trail Making Test (TMT) A and B (Lezak, Howieson, & Loring, 2004) were used to assess verbal attention, spatial attention, visual processing, and visual scanning with executive function, respectively, and were used to examine the convergent validity of the RMRT. Since other studies have shown that
these cognitive functions correlated with the cognitive manifestation and the GL behavior of AD, we assumed that the RMRT should correlate with the aforementioned tests (Barrash et al., 2000; Chiu et al., 2004; Pai & Jacobs, 2004; Passini et al., 1995). All tests were completed in 1 week. The DS is a subtest in the Wechsler Memory Scale-III (Wechsler, 1997) and was used to measure auditory attention and short-term memory. The examiner read a series of numbers slowly at 1-s intervals and the examinee then repeated the series of numbers in the correct order forwards or backwards. The SS is used to measure visual-spatial working memory (Wilde & Strauss, 2002). The test procedure is parallel to the DS: The examinee observed and then repeated the specific series of blocks pointed at by the examiner forwards and backwards. Correct responses were recorded. The TMT consists of parts A and B (Lezak et al., 2004); scoring of TMT is based on the task completion time. On the TMT-A, the participants were required to connect a series of randomly positioned numbers in consecutive order on an A4-sized sheet of paper, such as 1-2-3-...-19-20, which required visual search ability and motor speed. TMT-B is associated with executive control which is important to way-finding ability (Passini et al., 1995). A Chinese version of TMT-B (C-TMT-B) connects a series of randomly positioned numbers and animal sequences from the Chinese zodiac interchangeably, such as 1-Rat-2-Ox...-12-Pig, instead of using the letters sequence A, B, C,... in the original TMT. This modification has been widely used in studies with older adults or low-educated Chinese who were unfamiliar with English (e.g., Chen et al., 2009; Hwu et al., 2003; Wang, Hua, Chang, & Lu, 2007).

The Route Map Recall Test. The RMRT is a route recall and learning test with a self-designed map. In Map 1, every turning point has a landmark, whereas in Map 2 only half of them have on. The map consists of universal landmarks, such as telephone booths, railways at a street intersection, and traffic lights scattered at the intersections of streets (Fig. 1). These landmarks may provide non-verbal cues to elicit the strategy for direction recall of the route and turns. The map comprehension and the test administration do not require any verbal processing. The participants watched the examiner using a pen stick to trace a path from the beginning to the end point on an A4-sized map with no marks made, and then the participants traced the same path from memory, as the completion of one trial. Two maps were used in the same order with a 5-min rest after the completion of Map 1; each participant was given four trials on each map. In each trial, every correct choice of direction on an intersection was scored; any incorrect choice of direction was corrected immediately by the examiner pointing out the correct direction to go and was not scored. Once the examinee understood the test procedure, they followed the demonstration of the path without any verbal instruction. The route on Map 1 crosses the railroad which provides a direction reference; the route on Map 2 remains on one side of the railroad and the path is more crowded than Map 1. There are 14 choice points on Maps 1 and 12 on Map 2. The sum of the eight trial scores was calculated as the indicator of route recall ability. The total score range is 0–104. The test time is ~5 min for each map.

Interview of GL history. The AD patents were interviewed about their GL histories and self-perceptions of their current abilities to travel around familiar and unfamiliar places. A trained research assistant conducted the interviews by a questionnaire (Pai et al., 2012) and was blinded to this study. Patients were asked about their self-perceptions regarding difficulties in finding their way, and their proxies were also interviewed to collect the proxies’ viewpoints of the risks of GL and the strategies to prevent GL incidences for the AD patients. If any difficulties was subjectively reported by the AD patients or their proxies and was evidenced by any of the following: The need for someone’s escort and guidance, wearing a name wristlet or card,
having history of GL after being diagnosed, or the proxy’s report of a risk of GL, then the patient was considered as being at risk for GL.

Data analysis

We used χ² (gender) and t-tests (age, education) to verify sampling biases. The test–retest reliability and internal consistency of the RMRT were examined using Pearson’s product correlations and Cronbach’s α coefficient. For convergent validity, we did a correlation analysis of the RMRT and other neuropsychological tests by Pearson’s product correlations. Stepwise regressions were also used to determine the predictive models of the route memory with the RMRT. To examine the validity of the RMRT for the HC and AD groups, a t-test was used; areas under the curve (AUC) with receiver operating characteristic (ROC) curves analysis was used to determine the optimal criteria for the diagnostic classification accuracy. The AUC is a combined measure of sensitivity and specificity for assessing the inherent validity of a test to classify diseased or non-diseased subjects. To find the optimal criteria, the distance of each observed cut-off point was calculated. The point with minimum distance was recommended as the optimal criterion (Kumar & Indrayan, 2011). Furthermore, the participant’s self-reported experience of GL problems in the AD group was compared with the predicted risk by the RMRT using a discriminant function analysis. We analyzed the data with the Statistical Package for the Social Sciences (SPSS) for Windows, version 17.0 (SPSS Inc., Chicago, IL, USA). The significance level was set at .05.

Results

We recruited 23 patients for the AD group and 43 community-dwelling healthy elderly for the HC group in the current study. According to the clinical manifestation and the results of cerebral magnetic-resonance imaging and hexamethylpropylene amine oxime single-photon emission computed tomography, all participants in the patient group were compatible with a clinical diagnosis of AD. Their demographic data, the descriptive data of the RMRT and neuropsychological tests are shown in Table 1. As expected, the results showed that the characteristics of the participants were comparable, except for some of the neuropsychological tests. Using repeated measured analysis of variance (RMANOVA) to examine the trial and group effect for the RMRT, no interaction or trial effects were found. The group effect was significant for the two subtests (F = 24.03 and 23.28, p < .001 for each group). Using the RMANOVA to examine the map effect and the group effect, the main effects of group and map on scores were significant (group: F = 38.122, p < .001; map: F = 13.421, p = .001) and no interaction effect (p = .11) was detected. The percentage score of Map 1 scored higher than that of Map 2.

Table 1. Demographic data and test scores of the participants

<table>
<thead>
<tr>
<th></th>
<th>HC group (n = 43)</th>
<th>AD group (n = 23)</th>
<th>p-value</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard deviation</td>
<td>Mean</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>19</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>24</td>
<td></td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>73.46</td>
<td>6.30</td>
<td>73.53</td>
<td>6.90</td>
</tr>
<tr>
<td>Education</td>
<td>9.77</td>
<td>3.74</td>
<td>8.70</td>
<td>3.30</td>
</tr>
<tr>
<td>MMSE</td>
<td>27.26</td>
<td>2.56</td>
<td>22.30</td>
<td>2.99</td>
</tr>
<tr>
<td>RMRT</td>
<td>97.42</td>
<td>3.27</td>
<td>87.74</td>
<td>9.22</td>
</tr>
<tr>
<td>SS-F</td>
<td>8.07</td>
<td>1.64</td>
<td>7.04</td>
<td>1.82</td>
</tr>
<tr>
<td>SS-B</td>
<td>6.70</td>
<td>1.67</td>
<td>5.43</td>
<td>1.47</td>
</tr>
<tr>
<td>DS-F</td>
<td>12.42</td>
<td>2.16</td>
<td>10.91</td>
<td>2.04</td>
</tr>
<tr>
<td>DS-B</td>
<td>6.28</td>
<td>2.12</td>
<td>5.04</td>
<td>1.58</td>
</tr>
<tr>
<td>TMT-A</td>
<td>53.14</td>
<td>18.67</td>
<td>87.57</td>
<td>38.14</td>
</tr>
<tr>
<td>C-TMT-B</td>
<td>97.00</td>
<td>46.21</td>
<td>228.74</td>
<td>112.40</td>
</tr>
</tbody>
</table>

Notes: HC = cognitively healthy controls; AD = Alzheimer’s disease; MMSE = Mini-mental State Examination; RMRT = Route Map Recall Test; SS-F = Spatial Span forward; SS-B = Spatial Span backward; DS-F = Digital Span forward; DS-B = Digital Span backward; TMT-A = Trail Making Test part A; C-TMT-B = Chinese Trail Making Test part B.

*p < .05.

**p < .001.
Reliability

The RMRT consists of two map subtests. The Cronbach’s α for the two subtests was 0.831 and 0.802, respectively. The Cronbach’s α for the full test was 0.887, which indicates a good internal consistency, and suggests that it is appropriate to use the RMRT total score as a single measure for further analysis. Regarding the test–retest reliability of the RMRT, one participant was dropped out from the retest because of illness. The result shows that the correlation was 0.752 (p < .01, n = 19).

Convergent validity

The demographic data and test scores with their effect sizes of group differences are shown in Table 1. The RMRT scores between the AD and the HC group were significantly different (p < .001; Table 1). The RMRT score was not correlated with age or education years in either groups (p = .144–.833). Table 2 shows the Pearson correlation coefficients between the RMRT score and other neuropsychological tests. There were high correlations between the RMRT and the TMT-A and -B, and a mild correlation with the SS and the DS. Stepwise regression analysis, used to compare the relative contribution of the variables to the RMRT performance, showed that the RMRT performance was best predicted by the combination of TMT-A and C-TMT-B (R² = .614, SE = 4.81, p < .001). The regression model showed that TMT-A (β = −0.436, t = −3.531, p = .001) explained 55% of the total variance. Another predictor, C-TMT-B, explained 6.4% (β = 0.397, t = 3.215, p = .002) of the variance added to the model. These findings indicate that performance on the RMRT is highly related to executive control of attention.

Discriminative validity for the AD and non-AD groups

We used ROC curve analysis to decide the optimal cut-off point for test sensitivity and specificity. The criteria decided by minimum distance (d) suggested 93.5 as the optimal cut-off score of the RMRT (86% sensitivity and 70% specificity; Table 3). The AUC value was 0.87 ± 0.047 (95% CI = 0.78–0.96; Fig. 2). The RMRT had an AUC value close to 0.9 which indicates sufficient power to discriminate between patients with AD and without AD (Hosmer & Lemeshow, 2000).

Table 2. Correlations between the RMRT and other cognitive measures

<table>
<thead>
<tr>
<th></th>
<th>MMSE</th>
<th>DS-F</th>
<th>DS-B</th>
<th>SS-F</th>
<th>SS-B</th>
<th>TMT-A</th>
<th>C-TMT-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMRT</td>
<td>.626**</td>
<td>.286*</td>
<td>.311*</td>
<td>.276*</td>
<td>.328**</td>
<td>−.740**</td>
<td>−.732**</td>
</tr>
<tr>
<td>MMSE</td>
<td>1</td>
<td>.150</td>
<td>.385*</td>
<td>.254*</td>
<td>.513**</td>
<td>−.516**</td>
<td>−.652**</td>
</tr>
<tr>
<td>DS-F</td>
<td>1</td>
<td>.399**</td>
<td>.169</td>
<td>.186</td>
<td>−.240</td>
<td>−.310*</td>
<td>−.410**</td>
</tr>
<tr>
<td>DS-B</td>
<td>1</td>
<td>.108</td>
<td>.346**</td>
<td>.164</td>
<td>−.164</td>
<td>−.228</td>
<td></td>
</tr>
<tr>
<td>SS-F</td>
<td>1</td>
<td>.338**</td>
<td>−.362**</td>
<td>−.344**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SS-B</td>
<td>1</td>
<td>.769**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TMT-A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-TMT-B</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: MMSE = Mini-mental State Examination; RMRT = Route Map Recall Test; SS-F = Spatial Span forward; SS-B = Spatial Span backward; DS-F = Digital Span forward; DS-B = Digital Span backward; TMT-A = Trail Making Test part A; C-TMT-B = Chinese Trail Making Test part B.

Table 3. Sensitivity and specificity for the RMRT score by the ROC curve analysis

<table>
<thead>
<tr>
<th>RMRT cut-off score</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>d²</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;85.50</td>
<td>1.000</td>
<td>0.304</td>
<td>0.48</td>
</tr>
<tr>
<td>&lt;87.50</td>
<td>1.000</td>
<td>0.391</td>
<td>0.37</td>
</tr>
<tr>
<td>&lt;89.50</td>
<td>1.000</td>
<td>0.522</td>
<td>0.22</td>
</tr>
<tr>
<td>&lt;90.50</td>
<td>1.000</td>
<td>0.565</td>
<td>0.18</td>
</tr>
<tr>
<td>&lt;91.50</td>
<td>0.930</td>
<td>0.609</td>
<td>0.15</td>
</tr>
<tr>
<td>&lt;92.50</td>
<td>0.907</td>
<td>0.609</td>
<td>0.16</td>
</tr>
<tr>
<td>&lt;93.50</td>
<td>0.860</td>
<td>0.696</td>
<td>0.11</td>
</tr>
<tr>
<td>&lt;94.50</td>
<td>0.767</td>
<td>0.739</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Notes: RMRT = Route Map Recall Test; d² = [(1 − Sensitivity)² + (1 − Specificity)²]; d is the distance between the point (0, 1) and the observed cut-off point on the receiver operating characteristic (ROC) curve.
We compared the interview results of the risk of GL with the cut-off point score of 93.5, from the RMRT in the AD group. Three AD participants who scored 60, 87 and 87 on the RMRT did not complete the interviews because of being tired. Therefore, we only collected data from 20 participants in the AD group. The discriminant function analysis was used to examine how accurately the RMRT score predicted the risk of GL. The result shows that the RMRT score significantly classified the risk of GL (Wilks’ $\lambda = 0.599$, $\chi^2 = 10.164$, $p = .001$). Furthermore, if the measures of MMSE, TMT-A, C-TMT-B, and RMRT were entered into the linear discriminant function with a stepwise method, the result still showed that the RMRT was the only entered variable for GL behavior. The estimates of other variables were MMSE: Wilks’ $\lambda = 0.813$, $F = 4.41$, $p > .05$, TMT-A: Wilks’ $\lambda = 0.607$, $F = 11.67$, $p = .003$; and C-TMT-B: Wilks’ $\lambda = 0.622$, $F = 10.935$, $p = .002$. The sensitivity for screening out the risk of GL in the AD group was 100%; the specificity of identifying the GL behavior was 67%. The RMRT correctly classified 80% for the risk of GL, which was also good. The classification results with positive predictive value (PPV) and negative predictive value (NPV) are summarized in Table 4.

### Discussion

We found that the RMRT is a reliable and valid instrument for detecting route recall impairment in people with AD. Moreover, the RMRT demonstrated its value in screening for the risk of GL, which helps to make the patients and their caregivers more aware of the problem and to provide assistance when necessary.

According to the effect sizes of the measures used in this study, MMSE had the largest effect size, indicating that our recruitment of the AD and HC groups was valid regarding the discrete discrepancies in their general cognitive abilities.
The RMRT and the TMT also showed large effect sizes, indicating that the AD participants demonstrated a major deficit in visual encoding and executive control of visual information.

The TMT-A and C-TMT-B accounted for 61.4% of the total variance of the RMRT performance and this supports the role of visuospatial attention and executive control in the performance on the RMRT (Reitan & Wolfson, 2005). This is consistent with previous studies. Williamson and Barrow (1994), for example, investigated the travel experience of the healthy elderly and concluded that errors in finding their way were mostly due to inattention or environmental factors (e., too many distractions). Chiu and colleagues (2004) also reported that directed attention and executive function were associated with mental difficulties in choosing a turn and were predictive to the GL behavior in AD patients. In the same way, Pai and Jacobs (2004) suggested that the risk of GL in AD patients would increase as executive dysfunction increases.

Regarding the discriminative validity for AD patients, though the sensitivity was satisfactory (100%), the specificity was only 67%. The ROC curve analysis displays the trade-off between the sensitivity and specificity and finds the least misclassification of diseased or non-diseased subjects. In addition to the small sample size, another reason may be that most of the AD patients in this study were between very mild (CDR 0.5) and mild (CDR 1.0) in severity, and patients at this stage may exhibit very heterogeneous symptoms from one individual to another. Therefore, some patients performed well on the RMRT because their impaired episodic memory did not affect their topographic abilities. If the recall test is not semantic, and the executive function is still well preserved, the individual with very mild AD may not reveal his or her deficits in daily life nor fail in tasks like those on the RMRT. Though the RMRT is a paper test designed to assess the route recall ability for GL behavior in the AD group, the test also processes with good validity in differentiating the AD group of those who had GL and those who did not.

Another merit of the RMRT is its non-verbal character. Most neuropsychological assessments rely heavily on the verbal component and are often less suited to the uneducated, hetero-linguistic, or those with aphasia. The RMRT requires the subjects to recall the route paths by visual demonstration that does not require learned knowledge or verbal processing and is not related to the educational level. It is thus a potential useful instrument for cognitive screening of low-educated older adults. Moreover, the involvement of spatial attention and the synthesis of visual information for decision planning, which are related to the executive function being assessed in the RMRT, also plays an important role for the map recall. Even with a lower route recall score on every trial, we observed that AD patients retained the route information and showed an improvement in performance trial by trial, a phenomenon very similar to our previous study (Jheng & Pai, 2009). Based on these characteristics, as a non-verbal map test, the RMRT is recommended to test people with AD so that they and their caregivers can take precautions when the patients travel and to prevent the GL problem.

The RMRT score is only minimally correlated with the auditory and spatial attention span scores. This indicates that a good phonological or visuospatial memory span does not guarantee a good performance on the RMRT. Executive control, such as information retention and manipulation for a decision plan, is definitely needed. These findings are consistent with Cherrier and colleagues (2001), who used a route learning task with a real walk in an outdoor space to examine the topographical disorientation of their AD patients. They found no correlation between route learning and measures of visuospatial abilities (e.g., geographic memory, spatial orientation, visual organization, and discrimination) except with the Money’s Road Map Test. This test needs a decision-making process very similar to the testing procedure of the RMRT, but the former requires more left–right discrimination ability than does the RMRT. In addition, selective visual attention is an important function for human navigation, and crowding in the visual field has an adverse effect on visual processing (Lee & Pai, 2012). This was also observed in the present study as the crowding of the route in Map 2 increased the difficulty in route recall and error production when compared with the performance in Map 1 (p = .001).

We used the measures emphasizing information encoding (e.g., auditory, spatial, and visual attention) and executive function to establish the convergent validity. We did not include any traditional semantic memory test because semantic processing is highly linked to language processing (Gabrieli et al., 1996). The RMRT is similar to the Money’s Road Map Test, which is based on spatial relations and with minimal relations to a verbal component (Bertella, Marchi, & Riva, 2000; Lezak et al., 2004). The other concern was about using a real route memory test for convergent validity. Studies of Chen and colleagues (2002) and Cherrier and colleagues (2001) have applied route learning memory tests to explore the way-finding ability with the tests of visuospatial perception and spatial orientation in AD patients, and their route learning tests had good ecological face validity. However, there is no such published test that can be administered in a standardized procedure when testing in another lab. A recent study of navigation abilities in healthy older adults (Sanders, Holtzer, Lipton, Hall, & Verghese, 2008) used psychological measures to correlate with navigation testing by a floor lined map in the lab room, and testing of the free recall ability by describing a local route around their familiar neighborhoods. Findings from the above also showed that attention/executive function were the most significant predictors. Though using a paper format, our test showed the consistent results for the related variables.
We used the GL data in the AD group to establish predictive validity. The results showed that a positive screen result from the RMRT was good to confirm a risk of GL (PPV = 69%) and those who scored below the cut-off point (93.5) in the RMRT but did not have a GL history should be followed up to monitor any mild change in cognitive performance. Since the RMRT score was highly correlated with attention and executive functions, a score of <93.5 in the test may indicate a decline in these abilities. The RMRT did, however, correctly identify 100% (the sensitivity) of all patients with GL problems. A negative test result means good performance in the RMRT and is very good to assure that a patient does not have the GL problems currently (NPV = 100%). The test correctly identified 67% (the specificity) of those who did not have GL. The false-positive screen were 4 of 20, and patients in this category showed difficulties in the RMRT but did not have any GL history. They should be monitored closely for their daily activities including travel due to possible deficits in attention and executive function.

This study has some limitations. We used short and simple cognitive assessments to provide evidence of validity in a relatively small sample of patients with mild AD. Neuropsychological assessments for convergent validity may be further investigated with instruments of visuospatial memory, semantic memory, and other road map tests in a larger study population or in patient groups with different localized defects. These are necessary to help delineate the relationship between the concept of GL and the cognitive functions. The executive function was measured by the C-TMT-B test which was not re-examined for the reliability and validity in this study. Though some may concern with the attributes of the Chinese version, the C-TMT-B version demonstrated its validity to discriminate the AD patients with normal controls (Wang et al., 2007); for being a criterion-related test with the Modified Card Sorting test validation in middle and old adults of 0–18 education years (Kao, 2009) and associated with the frontal periventricular white matter of low-educated AD patients (Chen et al., 2009). Further research may validate the C-TMT-B with a large norm, since it is a short and simple tool for executive function.

In addition, information about GL behavior was collected by interviews with both patients and their proxies. There were chances that patients and their proxies gave incongruent statements. Though the data were verified by objective evidences, such as wristlet use and GL history, the reliability concerns with subjective reports may still exist. A real indoor route recall test designed in a standardized space and used to validate the RMRT may be helpful to address the ecological validity.

In summary, the findings of this study support that the RMRT is feasible for detecting route recall function in patients with AD. The RMRT was confirmed to be a stable and convenient instrument without being biased in favor of people with more education or higher-level verbal abilities. Its clinical utility was evidenced by good discriminative validity. Additional work is recommended to correlate other psychological measures and route recall ability in real environments.

Conflict of Interest

None declared.

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