Original article

Spot the Difference for Cognitive Decline: A quick memory and attention test for screening cognitive decline

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A B S T R A C T

Background: Dementia is currently one of the most common conditions in older adults, and early detection of cognitive decline is crucial for identifying dementia. We developed a new type of short-term memory and attention test that uses a spot-the-difference task: Spot the Difference for Cognitive Decline (SDCD). The purpose of the present study was to examine the accuracy of the SDCD test for the identification of cognitive impairment in community-dwelling older adults.

Methods: The participants were 443 Japanese community-dwelling older adults. The SDCD test uses two scenery pictures. Participants were instructed to memorize the details of the first picture for 30 seconds, after which the first picture was taken away and the second picture was shown. Next, the participants were asked to identify as many differences as possible between the first and second pictures, which were presented sequentially. The number of correct responses comprises the SDCD score (scores: 0–10). The Mini-Mental State Examination and Scenery Picture Memory Test were used to measure the participants’ cognitive function. We used receiver-operating characteristic analysis to examine the power of the SDCD test and identify the optimal cutoff value of the SDCD score.

Results: Of the 443 participants, 30 (6.77%) had some cognitive impairment based on the Mini-Mental State Examination scores. Participants without cognitive impairment had higher SDCD scores than those with cognitive impairment (p < 0.001). The SDCD scores were significantly associated with the Mini-Mental State Examination (r = 0.333) and Scenery Picture Memory Test (r = 0.402) results. The receiver-operating characteristic curve used for the identification of cognitive impairment had a comparatively high area under the curve (0.798) for the SDCD score with a cutoff value of 1/2 (with >1 being normal; sensitivity: 70.5%; and specificity: 80.0%).

Conclusion: The present study found that the SDCD test could be an effective clinical tool for the identification of cognitive impairment in older adults.

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1. Introduction

Dementia can drastically influence one's daily life and is currently one of the most common conditions in older adults. Dementia affects 5–8% of the population over 65 years of age and up to 30% of the people aged ≥85 years. Currently, the number of people with dementia is increasing. It has been estimated that approximately 48% of the patients with Alzheimer's disease (AD), the most common form of dementia, live in Asia, and this percentage is projected to grow to 59% by 2050. Dementia and AD have been associated with mortality; therefore, prevention and early detection of cognitive decline are crucial.

The presence of cognitive decline increases the risk of progression to mild cognitive impairment (MCI) and AD. It is generally agreed that older adults with early AD, compared to healthy older adults, exhibit a greater decline in memory function and working memory than in other major domains of cognitive function. A central feature of AD is the decline in episodic memory. Visual memory, which is included in episodic memory,
an important component of daily life. There are several well-established visual memory tests, such as the Benton Visual Retention Test and the Rey-Osterrieth Complex Figure Test, that can be used to assess nonverbal visual memory. However, these tests are not reflective of situations and activities encountered in daily life, are time consuming, and have complex scoring systems.

Deficits in working memory functions (e.g., attention and executive function) caused by AD are thought to contribute to a range of significant problems such as impairments in performing everyday tasks (e.g., keeping track of conversations, walking while talking, and packing a bag). Thus, the attentional function would appear to be important for the early detection of cognitive decline, as this function decreases with the progression of cognitive decline.

We developed a new short-term visual memory and attention test called the Spot the Difference for Cognitive Decline (SDCD) test. The SDCD test is a brief and simple test that uses pictures of familiar-looking sceneries. Examinees are asked to find the differences between two scenery pictures. This test can be used in clinical or community-based settings with a large population. In a previous study, it was reported that poor visual memory predicts the onset/progression of dementia. The spot-the-difference task has been used as a cognitive test in previous studies, although its usefulness for detecting cognitive impairment had not been described. These spot-the-difference tasks have often been used in memory function training for older adults with dementia in many countries, including Japan. However, the effects of this training have not been examined empirically. We hypothesized that the SDCD score would be associated with cognitive function, and this test would be able to identify community-dwelling older adults with cognitive impairment. The purpose of the present study, therefore, was to examine the accuracy of the SDCD test for the identification of cognitive impairment in community-dwelling older adults.

2. Methods

2.1. Participants

Participants for this study were recruited through advertisements in the local newspaper. A total of 443 Japanese people aged ≥65 years (mean age, 73.1 ± 5.3 years) responded. We included only community-dwelling older adults who were able to perform their activities of daily living independently. A screening interview was conducted to exclude participants with severe cardiac, pulmonary, or musculoskeletal disorders, as well as those using medications that affect attention (e.g., psychoactive drugs or drugs prescribed for sleep). Written informed consent was obtained from each participant in accordance with the guidelines of the Kyoto University Graduate School of Medicine, Kyoto, Japan and the Declaration of Helsinki, 1975. The study protocol was approved by the Ethics Committee of the Kyoto University Graduate School of Medicine.

2.2. SDCD test protocol

The SDCD test uses two scenery pictures (Figs. 1 and 2) on A4 size papers. Fig. 1 is called the “first picture” and Fig. 2 the “second picture”. There are 10 differences between the two pictures: the shape of the chimney smoke, shape of the doorknob, height of the fountain, shape of the mountain (seen between the house and the fountain), number of fruits on the tree, direction that the dog on the right is facing, shape of the leftmost flower, shape of the child’s mouth, presence of a bird versus a butterfly, and presence of the father’s backpack. First, the examinees are instructed to memorize

Fig. 1. First picture used in the Spot the Difference for Cognitive Decline test. The examinees were instructed to memorize the details of the picture, which was presented for 30 seconds.
the details of the first picture for 30 seconds. They are also told that there are “some” differences between the first and second pictures. The examiners do not inform the participants that there are 10 differences in total. After showing the first picture, the examiner takes the first picture away and shows the participants the second picture. The examinees are then asked to find the differences in the second picture, within 1 minute and without any hints. The number of the correct answers is then counted to determine the SDCD score. If the examinees’ answers are close but not exactly correct (e.g., a flower type or increase in the fruit), these answers are marked as incorrect and not included in the SDCD score. In a sample of 21 participants, the SDCD had a high test–retest reliability [intertrial correlation coefficient (ICC) = 0.801; \( p < 0.001 \)] between the two measurements with a 1-week interval.

2.3. Cognitive function

Participants’ cognitive function was measured by two neuropsychological tests: the Mini-Mental State Examination (MMSE)\(^ {17} \) and the Scenery Picture Memory Test (SPMT).\(^ {18} \)

Global cognitive function was assessed using the MMSE, a standard test used in cognitive aging research for assessing mental status. Five areas of cognitive function—orientation, registration, attention and calculation, recall, and language—are tested. It has 11 questions in total and a maximum possible score of 30.

The SPMT is a simple memory test that assesses visual memory combined with verbal responses. This test uses a line drawing of a living room in a house on an A4-size paper, depicting 23 objects that are commonly observed in daily life. The examinee is instructed to look at the picture for 1 minute and remember the items. After this encoding period, participants are given a distractor task (a brief forward digit-span test). Participants are then asked to recall the objects in the picture without a time limit. Recall of the items usually takes approximately 2 minutes. The number of items recalled is the SPMT score. Higher scores indicate a better cognitive function.

2.4. Statistical analysis

We divided the participants into two groups (normal and cognitive impairment groups) based on the cutoff score of the MMSE (23/24). Differences between these two groups were statistically analyzed, using the unpaired \( t \)-test for continuous variables and the \( \chi^2 \) test for categorical variables. Differences between the SPMT and SDCD scores were examined using an analysis of variance. When a significant effect was found, the Tukey-Kramer post hoc test was used to examine the differences. In addition, the criterion-related validity was determined by evaluating the correlation between the SDCD score and the two neuropsychological tests using Spearman’s rank correlation coefficient. Following this, we performed a multiple logistic regression analysis to determine whether the SDCD score was associated with cognitive impairment independently. For this analysis, the two groups (i.e., the normal group and the cognitive impairment group) were the dependent variables, and the SDCD score was the independent variable. We controlled age, sex, body mass index, medications, and the length of education. Furthermore, a receiver-operating characteristic (ROC) analysis was used to examine the power of the SDCD score and determine the optimal cutoff value of the SDCD score as a state variable. The area under the curve, sensitivity, and specificity of the SDCD score were calculated based on the ROC curve. The cutoff value for the SDCD score was determined based on the optimal sensitivity and specificity. Consequently, we performed a univariate logistic regression analysis to determine the correlation between...
the SDCD and the five subtests of the MMSE (orientation, registration, attention and calculation, recall, and language). For this analysis, the groups formed on the basis of the cutoff value of the SDCD were the dependent variables and each subtest of the MMSE was the independent variable.

Data were analyzed using SPSS Statistics for Windows, version 20.0 (SPSS Inc., Chicago, IL, USA). A p value of <0.05 was considered statistically significant.

3. Results

Of the 443 participants, 30 (6.77%) were identified as having cognitive impairment based on an MMSE cutoff score of 23/24. Demographic characteristics of the participants are shown in Table 1. The normal group had a higher SDCD score (2.21 ± 1.38) than the cognitive impairment group (0.77 ± 0.86; p < 0.001). The normal group also had a higher SPMT score than the cognitive impairment group (p < 0.002). There were no significant differences in age, sex, body mass index, or the use of medication between the two groups.

The participants were reclassified into five groups according to their SDCD scores; differences in the MMSE and SPMT scores between the groups are shown in Figs. 3 and 4. There were significant differences in the MMSE scores (F = 15.7, p < 0.001) as well as in the SPMT scores (F = 22.6, p < 0.001) between the five groups. Results of the post hoc tests are shown in Figs. 3 and 4. In addition, the SDCD scores were moderately and positively correlated with the MMSE scores (r = 0.798, p < 0.001) as well as in the SPMT scores (r = 0.402, p < 0.001).

The ROC curve for the SDCD scores used for the identification of cognitive impairment was based on the MMSE cutoff score (23/24). The area under the curve was comparatively high for the SDCD score (0.79, p < 0.001), and the cutoff value of the SDCD score was 1.1 (with ≥1 being considered normal) with a 70.5% sensitivity and 80.0% specificity. A univariate logistic regression analysis showed that there were significant correlations between the SDCD scores and the four subtests of the MMSE (p < 0.05), except for the registration subtest (refer to Table 2).

4. Discussion

We examined a new type of short-term memory and attention test, the SDCD, which used a spot-the-difference task to identify cognitive impairment. In the present study, we showed that the SDCD test is a very quick and reliable screening tool for the identification of cognitive impairment in community-dwelling older adults.

The SDCD test is moderately and positively correlated with global cognitive and memory functions. The SDCD test includes a “memory” phase and a “recall and name the differences” phase. These phases require not only memory functions, but also other cognitive functions, such as attention. Some studies in the past have used similar spot-the-difference tasks as cognitive tests, and only one previous study has investigated brain activation in a test...
using a spot-the-difference task. Although the abovementioned test did not include a memory phase (unlike that included in the SDCD test), the results indicated that the brain areas related to visual information and attention was activated while carrying out the task. Our results indicated that the SDCD was associated with most of the subtests of the MMSE. Thus, the SDCD test appears to be associated not only with attention and memory, but also with global cognitive function. We need to minutely assess and investigate other cognitive functions (e.g., executive function and processing speed) and their association with the SDCD test in future studies.

The ROC curve for the SDCD score indicated that the SDCD test identified cognitive impairment with a high degree of accuracy. Previous studies have reported that some picture-based memory tests can reliably detect dementia.\textsuperscript{21,22,23} These studies support the results of the present study. Moreover, the SDCD test is able to detect dementia in less time compared to other tests studied previously. Picture-based memory tests have some advantages over verbal memory tests. First, pictures are remembered better than words, a phenomenon known as the “picture superiority effect”.\textsuperscript{24} Previous studies showed that superiority of memory for pictorial material was often applied as a mnemonic aid for older adults.\textsuperscript{22,23} Second, picture-based memory tests are not limited by the patient’s level of education. Some verbal memory tests cannot be used for a population that has a low level of education. Some verbal memory tests cannot be used for a population that has a low level of education. Some verbal memory tests cannot be used for a population that has a low level of education.\textsuperscript{22,23} This is because they are limited by the patient’s level of education. Some verbal memory tests cannot be used for a population that has a low level of education.\textsuperscript{22,23} In the present study, participants took approximately 10 words, a phenomenon known as the “picture superiority effect”.\textsuperscript{24}

Previous studies have reported that some picture-based memory tests can be an effective clinical tool for the identification of cognitive impairment. The present study indicates that the SDCD test can be an effective clinical tool for the identification of cognitive impairment in older adults.

<p>| Table 2: Correlation between SDCD score and subtests of MMSE.\textsuperscript{a} |
|---------------------------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Subtests (total score)</th>
<th>Subtest score</th>
<th>SDCD score &lt; 2 (n = 146)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation (10)</td>
<td>≤8</td>
<td>20 (13.7)</td>
<td>Reference</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>30 (20.5)</td>
<td>0.26 (0.11—0.62) **</td>
</tr>
<tr>
<td>Registration (3)</td>
<td>≤2</td>
<td>4 (2.7)</td>
<td>Reference</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>142 (97.3)</td>
<td>0.61 (0.16—2.30)</td>
</tr>
<tr>
<td>Attention and calculation (5)</td>
<td>≤2</td>
<td>69 (47.3)</td>
<td>Reference</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>10 (6.8)</td>
<td>1.10 (0.47—2.59)</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>18 (12.3)</td>
<td>1.19 (0.61—2.34)</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>49 (33.6)</td>
<td>0.57 (0.36—0.88) *</td>
</tr>
<tr>
<td>Recall (3)</td>
<td>≤1</td>
<td>22 (15.1)</td>
<td>Reference</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>51 (34.9)</td>
<td>0.21 (0.09—0.50) **</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>73 (50.0)</td>
<td>0.13 (0.06—0.31) **</td>
</tr>
<tr>
<td>Language (9)</td>
<td>≤7</td>
<td>14 (9.6)</td>
<td>Reference</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>38 (26.0)</td>
<td>0.18 (0.06—0.59) **</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>94 (64.4)</td>
<td>0.12 (0.04—0.36) **</td>
</tr>
</tbody>
</table>

\textsuperscript{a} p < 0.05.  
\textsuperscript{**} p < 0.01.  
\textsuperscript{CI} = confidence interval; MMSE = Mini-Mental State Examination; OR = odds ratio; SDCD = Spot the Difference for Cognitive Decline.

**5. Conclusion**

We developed a new type of short-term memory and attention test that uses a spot-the-difference task for the identification of cognitive impairment. The present study indicates that the SDCD test can be an effective clinical tool for the identification of cognitive impairment in older adults.

**Conflicts of interest**

The authors declare no conflicts of interest.

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**References**


