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New Computer-based Cognitive Function Test for the Elderly

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***Abstract*— We developed a modified trail-making test using a PC and touch panel and compared it with the Mini Mental State Examination (MMSE). *Methods and Patients*: The test consisted of a series of numbers from 1 to 36, randomly arranged across the display. The object of the test was for the subject to touch the numbers in order, beginning with 1 and ending with 36, in as little time as possible. The system consisted of a PC and a liquid crystal display (LCD) touch-panel screen. One hundred and thirty-four patients with dementia performed the test. Sixty of the 134 patients (15 male, 45 female; average age, 81.1 ± 7 years) were diagnosed as having Alzheimer's disease and the others had cerebrovascular dementia. *Results*: Sixty-two of 134 patients (23 male, 39 female; average age, 77.6 ± 8 years; MMSE score, 21.5 ± 5.6 points) completed the test. The correlation coefficient between test performance time and MMSE score was –0.534. *Discussion*: This test may also be a useful indicator of focal frontal lesions and can be used as an early screening test for Alzheimer's disease.**

I. Introduction

In an aging society, the number of dementia patients is increasing. A major problem of dementia, especially of the Alzheimer's type, is that it is fatal, and early diagnosis is necessary for both patient and caregiver. There are several treatments available, either with or without medication. Early diagnosis is essential to initiate early treatment. Computed tomography, magnetic resonance imaging, single photon emission computed tomography, and positron emission tomography are all used as diagnostic tools. Qualitative tests, such as the Mini Mental State Examination (MMSE), are commonly used to screen for the disease. A computer-based MMSE has been developed in which questionnaire results are converted to a digital format. MMSE is a widely used method for assessing cognitive mental status. The evaluation of cognitive functioning is important in a clinical setting because of the recognized high prevalence of cognitive impairment. As a clinical instrument, the MMSE has been used to detect impairment, follow the course of an illness, and monitor response to treatment. The MMSE has also been used as a research tool to screen for cognitive disorders in epidemiological studies and follow cognitive changes in clinical trials. MMSE is a standard screening test, but it takes 5–10 min to complete.

In clinical practice, a shorter duration screening test is required. We thus developed a trail making test (TMT) using a PC and touch panel, which was demonstrated to be a good predictor of general mental ability.

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II. Patients and Methods

A. Patinetse

The test was performed by 134 patients who visited the memory lapse section of Daio Hospital, Japan. Upon clinical examination, 60 of 134 patients (15 male, 45 female; average age, 81.1 ± 7 years) were diagnosed with Alzheimer's disease, 40 (14 male, 26 female; average age ,80.6 ± 6 years) had cerebrovascular dementia, and 34 had other conditions, such as of Parkinson's disease. The experiment was approved by the Ethics Committee of Fujimoto Hayasuzu Hospital, Japan, and informed consent was obtained from all subjects..

B. Method

The test consisted of a series of numbers from 1 to 36 randomly arranged in a frame, as shown in Figure 1a. The object of the test was for the subject to touch the numbers in order, beginning with 1 and ending with 36, in as little time as possible (Figure 1b). The system consisted of a PC (D325; Hewlett-Packard, Palo Alto, CA, USA) and a liquid crystal display (LCD) touch-panel screen (LL-T157TRS; Sharp, Osaka, Japan). The frame size was 173 × 235 mm, which was 50% of the 15" display. The subjects sat 50 cm from the display. The time taken to complete the test, ordering, and errors were recorded and stored as .CSV files. The experiments were performed after a medical examination. The times taken were compared with MMSE scores

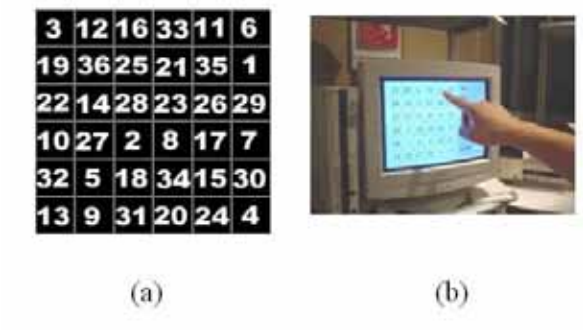

Figure 1. (a) Number arrangement; (b) Experimental view.

C. *Evaluation of test*

The proposed test may be a useful tool for identifying general frontal lobe dysfunction. To confirm this postulate, we performed the test on eight healthy male (aged 35.6 ± 8 years) and six healthy female volunteers (aged 39.8 ± 9 years). This study was approved by the Ethics Committee of Fujimoto Hayasuzu Hospital, Japan, and all subjects gave written informed consent before examination.

All magnetoencephalography (MEG) measurements were made in a magnetically shielded room at the hospital using a whole-scalp system (PQ1160C; Yokogawa Electric Corporation, Tokyo, Japan) consisting of 160 coaxial gradiometers (dc SQUID; resolution: 5fT√Hz or less). The average distance between gradiometers was 25 mm. The total resolution of this system was 10fT√Hz or less. MEG was performed at a sampling frequency of 500 Hz.

The cognitive function test consisted of projecting a number on the screen inside a shielded room. A fiber optic pen was used to touch the number, and MEG signals were detected and calculated as topographic images. MEG signals were low-pass filtered at 50 Hz and resampled at 100 Hz. Continuous wavelet transform was used to extract α and β components and the topographic signals were evaluated. Furthermore, the time between two numbers picked up was compared with the computer-based cognitive function test and MEG.

III. Result

A. Cognitive function test

The test was completed by 62 of 134 patients (23 male, 39 female; average age, 77.6 ± 8.0 years; MMSE score, 21.5 ± 5.6 points), as shown in Figure 2. Patients with a MMSE score <10 were not able to complete the test. Thirty-three of 60 patients with Alzheimer's disease (9 male, 24 female; average age, 79.3 ± 7.2 years; MMSE score, 20.5 ± 5.7 points) completed the test. Sixteen of 40 patients with cerebrovascular dementia (9 male, 24 female; average age, 79.3 ± 7.0 years; MMSE score, 21.3 ± 5.4 points) completed the test. Thirty-two patients were unable to complete the test and had a MMSE score of 14.8 ± 5.2 points. The MMSE scores in the group that completed the test were significantly different from those in the group that did not complete the test ($P < 0.01$). Five of the subjects who did not complete the test were either uneducated, bedridden, or had extremely poor vision. No one was averse to using and touching the LCD panel.

The average performance time in the group that completed the test, the patients with Alzheimer's disease, and those with cerebrovascular dementia was 209.5 ± 103.4 s, 218.4 ± 109.2 s, and 221.5 ± 107.1 s, respectively. There were no significant differences between the average performing times and MMSE scores. The correlation coefficients between the performing time and MMSE score were –0.534, –0.510, and –0.647 in the group that completed the test, the patients with Alzheimer's disease, and those with cerebrovascular dementia, respectively ($P < 0.01$) (Figures 3 and 4).

B. MEG

Figure 5 shows a typical example of frontal activation during the cognitive function test. The area of activation moved from the frontal to the occipital and temporal regions. Finally, the motor cortex was activated during the touching of the numbers.

The performance times were 126.5 ± 3.2 s for the proposed cognitive function test and 116. 4 ± 5.6 s for the MEG. There was no significant difference in performance time between the MEG and the proposed test.

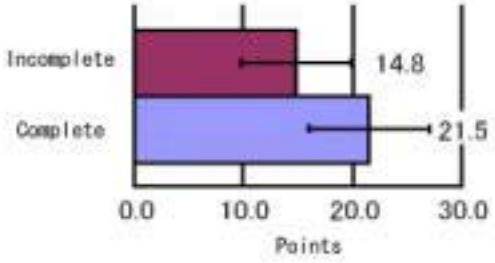

Figure 2. Experimental result

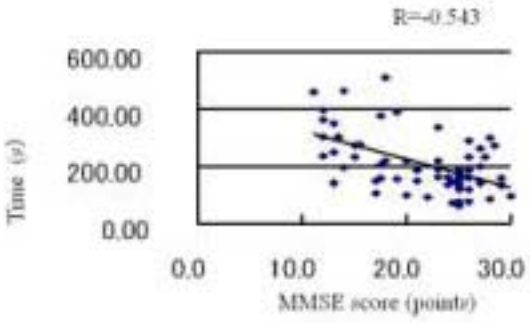

Figure 3. Relationship between MMSE score and performance time in the group that completed the test

IV. Discussion

A computer-based cognitive function test was proposed. The subjects enjoyed performing this test. Psychological tests are often conducted in the presence of a therapist, and this occasionally inhibits the subjects from continuing with the test. This proposed test uses a computer and can be performed on an individual basis. Furthermore, the results, including errors, can be stored in the computer and used for further analysis.

Also, this test may be a useful indicator of focal frontal lesions, which can be used as an early screening test for Alzheimer's disease. The subjects search the target and touch it, and this appears to allow evaluation of working

memory and selective attention. The results of this proposed computer-based cognitive test correlated significantly with those of conventional neuropsychological tests measuring similar cognitive domains, such as the MMSE.

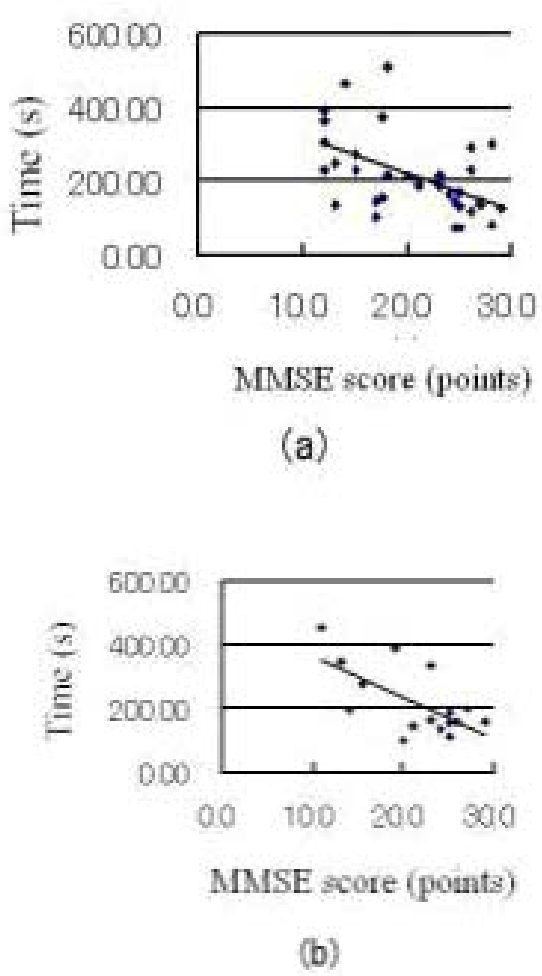

Figure 4. (a) Relationship between MMSE score and performance time in patients with Alzheimer's disease. (b) Relationship between MMSE score and performance time in patients with cerebrovascular dementia

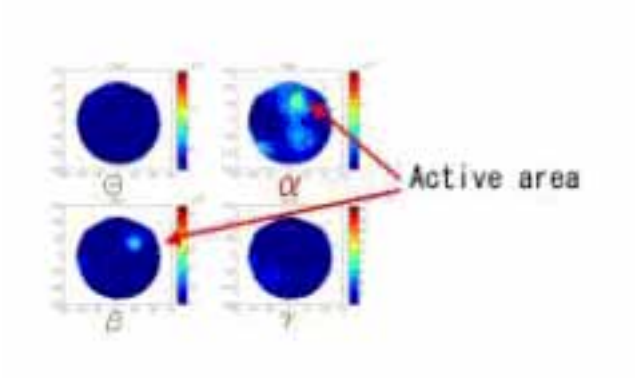

Figure 5. Topographic image of activity in the frontal area during the proposed cognitive function test.

V. Conclusion

Computer-based testing is an effective screening methodology for detecting mild cognitive impairment in the elderly, although this particular test has important limitations. Broader applications of computer-based testing will require extensive population-based validation. Future studies should recognize that normal control subjects without a history of disease who are typically used in validation studies may have a high incidence of unsuspected abnormalities in neuro-diagnostic studies.

Acknowledgment

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