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Screening of dementia in Chinese elderly adults by the clock drawing test and the time and change test

以時鐘繪圖法和時間與零錢檢測法測試華裔長者有否患上痴呆症

Objectives. To assess the usefulness, relative ease of administration, and patient acceptance of the clock drawing test as well as the time and change test for detecting dementia in Chinese elderly adults.

Design. Prospective case-controlled study.

Setting. Memory clinic and geriatric clinic of a district hospital, Hong Kong.

Participants. A convenient sample of 85 subjects aged 65 years or older attending the two clinics during the period from September 2002 to June 2003.

Main outcome measures. The clock drawing test scored according to Lam's method; the time and change test with modification to the making change task; and the Chinese version of the Mini-Mental State Examination.

Results. Demented subjects were matched with non-demented ones with respect to age, sex, educational level, and co-morbidity status. The clock drawing test had a comparable sensitivity (89.4%) but a lower specificity (47.1%) when compared with that of the Chinese version of the Mini-Mental State Examination (96.0 and 76.5%, respectively). In contrast, the time and change test had a lower sensitivity (62.7%) but higher specificity (94.1%). Both tests took significantly less time to complete than the Chinese version of the Mini-Mental State Examination. All except four subjects completed the clock drawing test while all subjects accepted the time and change test well.

Conclusions. The Chinese version of the Mini-Mental State Examination is still the best among the three tests despite the longer time to completion. The clock drawing test may be a good alternative to the Mini-Mental State Examination as an effective screening test for dementia when time does not permit. The time and change test, although time-saving, is not suitable to be used alone because of its low sensitivity.

目的：時鐘繪圖法和時間與零錢檢測法為兩種測試華裔長者有否患上痴呆症的方法。本文評估兩法的效用和執行，以及病人的接受程度。

設計：前瞻性病例對照研究。

安排：一所分區醫院的記憶診所和老人科診所，香港。

參與者：2002年9月至2003年6月期間，85位65歲或以上，前往以上兩家診所的長者。

主要結果測量：按林氏方法計分的時鐘繪圖法、經修改的時間與零錢檢測法，以及簡易智能狀況評估(Mini-Mental State Examination)的中文版本。

結果：按年齡、性別、教育程度和其他相關疾病的情況，把痴呆症患者與沒有痴呆症的配對。相比簡易智能狀況評估中文版本的敏感性（96.0%）和特異性（76.5%），時鐘繪圖法的敏感性與前者相若（89.4%），但特異性則較低（47.1%）。時間與零錢檢測法的情況剛好相反，敏感性較低（62.7%）但

Key words:
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特異性較高（94.1%）。比較簡易智能狀況評估中文版本，其餘兩種方法都明顯省時。4位病人不能完成時鐘繪圖法，所有病人都能完成時間與零錢檢測法。

結論：儘管所需時間較長，三種測試中仍以簡易智能狀況評估中文版本最為有效。假若時間不足，時鐘繪圖法不失為前者以外的另一選擇。至於時間與零錢檢測法雖然省時，但由於敏感度低，單獨使用並不適合。

Introduction

Dementia is often under-recognised and under-diagnosed. A significant proportion of patients with moderate-to-severe dementia are unrecognised by primary care physicians as having cognitive impairment.[1] One of the reasons is related to the pitfalls of the commonly used screening tests.

There are two main reasons why physicians under-utilise current dementia screening tests: the time required to administer the tests, and the sometimes unclear correlation with the patients' functional performance in everyday life.[2] For instance, the Mini-Mental State Examination (MMSE) is the most well-known and commonly used screening method for the diagnosis of mental status. However, despite 82.7% of primary care practitioners believing that screening is necessary, only 25.7% perform routine screening using MMSE.[3] Lack of time is the most important perceived barrier. Besides, 92.7% of them would like to use another test called the clock drawing test (CDT) as an alternative because it uses far less time than MMSE. A further perceived strength of CDT is its ability to reflect in composite form the intactness of many interdependent cognitive functions. Another recently developed test called the time and change (T&C) test is a simple, rapid, and performance-based test.[4] It was validated for detecting dementia in the West. In general, the test is diagnostically inferior to the MMSE. The sensitivity and specificity ranged from 63% to 91% and 54% to 93%, with a mean of 79.6% and 82.9%, respectively.[2,4-6] However, the practicality and real-world nature of T&C test offers important advantages over MMSE. The test is also less influenced by educational level than MMSE.

So far, there have only been a few studies comparing two or more mental status tests. Moreover, the usefulness of the T&C test in our locality is not documented. The overall aim of this study thus was to examine the usefulness and acceptance of the CDT and the T&C test as screening tests for dementia in Hong Kong, with the MMSE as the reference standard. This approach has an advantage in that all tests were collected from the same set of subjects, thereby providing the basis for direct comparison.

Methods

Participants

Subjects were recruited from two clinics, namely the Memory Clinic and the Geriatric Clinic of the United Christian Hospital, Hong Kong. The subjects were recruited as a convenient sample of patients attending the two clinics during the period from 1 September 2002 to 30 June 2003. The criteria for inclusion were an age of 65 years or older, Chinese ethnicity, and consent for participation. Subjects were excluded with an age younger than 65 years, severe blindness, impairment in dominant hand function, or for any other reason resulting in non-communicable status.

Assessment

All subjects underwent a comprehensive clinical interview, as well as neurological and mental state examination by a qualified geriatrician and/or psychogeriatrician in the clinic to ascertain the presence or absence of dementia and its subtypes using the DSM-IV criteria.[7] Relevant investigations including imaging studies were performed whenever necessary.

An investigator blind to the psychiatric status performed a subsequent interview. Baseline demographic characteristics were collected. Assessment included the Chinese version of the MMSE (C-MMSE),[8] the CDT, and the T&C test (Box).[9] After completion of each test, the subjects were asked about the acceptability of the test and whether they would like to have the test repeated if necessary in the coming future. Refusal to complete the test was recorded as not accepting the test.

Statistical analyses

Data analyses included descriptive statistics of the demographic characteristics, examination of the properties of the screening tests, and comparison of the timing required for each of the tests. Demographic characteristics collected included the age, sex, years of education, and Charlson's risk index.[10,11]

Properties of the C-MMSE and the CDT included sensitivity and specificity with 95% confidence interval, positive and negative predictive values, likelihood ratio, area under receiver operating character-

Chinese version of Mini-Mental State Examination procedure

- Standard questionnaire was used and followed[8]
- There was no time limit for completion and the response time was recorded
- Cut-off score was according to educational level: 18 for illiterate, 20 for 1-2 years, and 22 for more than 2 years of education

Clock drawing test procedure

- An A4-sized paper with a pre-drawn circle of 2.5-inch diameter was placed on a well-lighted tabletop. The subject was cued: "Please view the circle as a clock face and complete it by drawing the numbers and arms indicating the 3 o'clock position." The instruction was repeated if the subject could not understand the command. Lines at the appropriate position instead of numbers were allowed if the subject was illiterate. The subject's response time was measured with a stopwatch that was started immediately after the cue was given. There was no time limit for completion and the response time was recorded
- The clocks were scored by the investigators according to the scoring criteria defined by Lam et al.[9] Cut-off score was 3/4

Time and change test procedure

Telling time task

- A large clock-face diagram with the hands set at 11:10 was held 14 inches from the subject's eyes. The subject was cued: "Please tell me what time it says on this clock." The subject's response time was measured with a stopwatch that was started immediately after the cue was given. The subject was allowed two trials within a 60-second period. If the subject failed to respond correctly after two trials, the task was terminated and an error was recorded. Response time was recorded

Making change task

- The original task used the currency of the United States, which was not familiar in the local setting. Thus, modifications were made, based on the intention to be comparable in both the intended function and difficulty level. Local currencies were used instead
- A standard amount of change (three $2 coins, seven $1 coins, and seven 50¢ coins) was placed on a well-lighted tabletop. A $10 coin was placed aside as well. The subject was asked to identify each type of coin at the beginning. Then the subject was cued: "Please give me 10 dollars' worth of change." The subject's response time was measured with a stopwatch that was started immediately after the cue was given. The subject was allowed two trials within a 120-second period. If the subject failed to respond correctly after two trials, the task was terminated and an error was recorded. Response time was recorded

Scoring

- If the responses were incorrect on either or both the telling time and making change tasks, then the time and change test was scored as indicating dementia, a positive result. Correct responses on both the telling time and making change tasks were considered correct, a negative result[4]

istics (ROC) curve, mean time to complete the test, and acceptability by the subjects. Properties of the T&C test were essentially the same as the other two except that the ROC curve was not plotted. In addition, inter-rater and intra-rater reliabilities of the CDT were determined by calculating the kappa values. Correlations of the CDT with C-MMSE and some demographic characteristics were assessed by using Spearman's rho test.

One-way analysis of variance was used as an assessment if there was any significant difference between the time required for the three tests. A two-tailed P value of less than 0.05 was considered significant. Statistical Package for the Social Sciences (Windows version 10.0; SPSS Inc, Chicago, United States) was used.

Results

Demographic characteristics

Eighty-five subjects were recruited into the study. There were 43 females and 42 males with a mean age of 78.6 (standard deviation [SD], 6.5) years. The mean educational level of all subjects was 3.1 (SD, 3.1) years, with 34.1% being illiterate. The mean Charlson's risk index was 2.0 (SD, 1.3). Of these 85 subjects, 51 (60%) were diagnosed as having dementia, of which 23 had Alzheimer's disease, 26 had vascular dementia, and two had other types of dementia. The mean C-MMSE score for the demented was 13.4 (SD, 4.5). Table 1 shows the demographic characteristics of the demented and non-demented subjects.

Table 1. Demographic characteristics of the demented and non-demented subjects

	Demented group	Control group	P value
Mean age (SD*) [years]	78.8 (6.9)	78.4 (6.1)	0.768
No. of male subjects (%)	22 (43.1)	20 (58.8)	0.156
Mean time of education (SD) [years]	3.1 (2.9)	3.1 (3.3)	0.977
Corrected Charlson's risk index (SD)	1.3 (1.1)	1.7 (1.4)	0.144

* SD standard deviation

No significant difference in demographic characteristics except the Charlson's risk index was found between the demented and non-demented subjects. This was expected because the diagnosis of dementia itself would have contributed one point to the index. After adjustment of the scores of the demented subjects, there was no significant difference between the two groups in the morbidity index.

Table 2. Properties of the screening tests

Property*	Mini-Mental State Examination† (Chinese version)	Clock drawing test‡	Time and change test
Sensitivity (95% CI) [%]	96.0 (91.8-100)	89.4 (82.7-96.1)	62.7 (52.4-72.9)
Specificity (95% CI) [%]	76.5 (67.4-85.6)	47.1 (36.2-57.9)	94.1 (89.1-99.1)
PPV (%)	85.7	70.0	94.1
NPV (%)	92.9	76.2	62.7
LR+	4.09	1.69	10.6
ROC (AUC)	0.964	0.806	-

* CI denotes confidence interval, PPV positive predictive value, NPV negative predictive value, LR+ likelihood ratio positive, ROC receiver operating characteristics, and AUC area under curve
† Cut-off score: illiterate=18, 1-2 years of education=20, >2 years of education=22
‡ Cut-off score: non-demented=0-3, demented=4-10

Table 3. Time required to complete the screening tests

Characteristic*	Mini-Mental State Examination (Chinese version)	Clock drawing test	Time and change test
Mean time (SD) [sec]			
All patients (n=85)	399.8 (151.9)†	90.9 (61.8)†	65.6 (50.6)†
Demented group	437.3 (178.7)	89.6 (58.2)	92.2 (53.7)
Control group	347.0 (103.7)	93.2 (68.1)	32.8 (28.7)
ROC (AUC)	-	-	0.834
Cut-off time (sec)	-	-	45
Sensitivity (95% CI) [%]	-	-	74.5 (65.2-83.8)
Specificity (95% CI) [%]	-	-	88.2 (81.3-95.1)

* ROC denotes receiver operating characteristics, AUC area under curve, and CI confidence interval
† P<0.001

Properties of the screening tests

Table 2 shows the properties of the screening tests, and the Figure shows the ROC curves of C-MMSE and CDT. The mean score of C-MMSE was 17.70 (range, 4-30; SD, 6.70), and that of CDT was 5.98 (range, 0-10; SD, 3.41). Fifty-one (60%) subjects passed the T&C test.

The CDT had a comparable sensitivity but a lower specificity than the C-MMSE. The positive predictive value, negative predictive value, likelihood ratio, and the area under the ROC curve were also lower than those of the C-MMSE.

The T&C test had a lower sensitivity but higher specificity than the C-MMSE. It had a good positive predictive value which was comparable to that of C-MMSE but a poor negative predictive value.

Combining the CDT and the T&C test resulted in a better sensitivity (92.2%) than either tests but similarly low specificity (47.1%) as that of CDT alone. The intra-rater and inter-rater reliabilities of the CDT were high (κ=0.967 and 0.934, respectively). The CDT was correlated significantly with C-MMSE (r= –0.686, P<0.01) but not with demographic characteristics (age, r=0.199, P=0.075; educational level, r= –0.173, P=0.123; corrected Charlson's risk index, r=0.030, P=0.788).

Time to complete the tests

Table 3 shows the time required to complete individual tests. The CDT and the T&C test required significantly less time to complete than the C-MMSE for all subjects. The time required to complete both the CDT and the T&C test (156.5 sec) was still significantly less than that of the C-MMSE. In addition, demented subjects took significantly longer time to complete the C-MMSE, the T&C test, and combined CDT and T&C test than the non-demented ones. By using 45 seconds as the cut-off time limit for the T&C test regardless of the test results, better specificity at the expense of lower sensitivity was achieved.

Acceptability of the tests by the subjects

All the three screening tests were highly acceptable by the subjects. One demented subject refused to perform the C-MMSE and the CDT, while three demented subjects refused the CDT. All performed the T&C test.

Discussion

For decades, clock drawing tasks have been used to

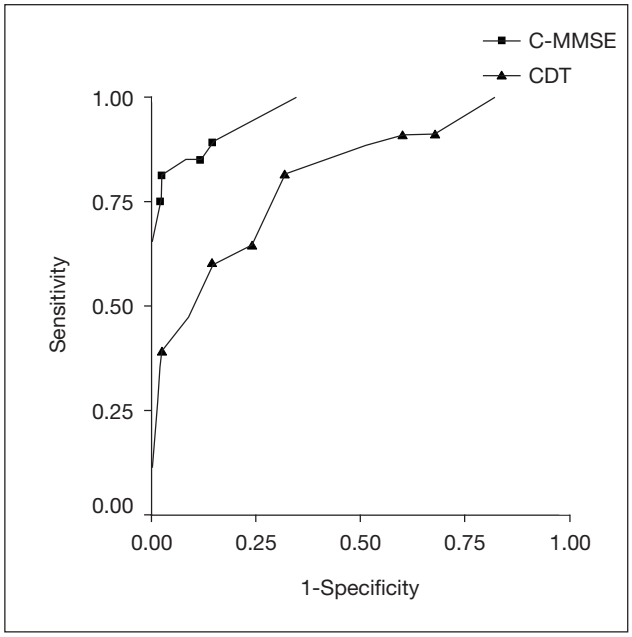

Fig. Receiver operating characteristics curves of the Chinese version of the Mini-Mental State Examination (C-MMSE) and clock drawing test (CDT)

assess the mental status of patients with various neurological or psychiatric disorders. They are widely accepted cognitive screening tools, despite the lack of a single standard for administration or scoring.

There have been a number of formal scoring protocols developed, each differing in their administration and scoring systems.[12-15] Despite significant variations, the psychometric properties of all the clock tests have been shown to be remarkably consistent.[16] Sensitivity and specificity levels are both at a mean of 85% for all published studies with excellent inter-rater reliability and good concurrent and predictive validity. However, they did not consistently perform as well or better than the MMSE.[8,17,18] All scoring methods worked well in identifying subjects without dementia and subjects with severe dementia. However, in cases of mild and moderate dementia, some were clearly better than others.[19] In the present study, both the sensitivity and specificity (89.4% and 47.1%) of the CDT were lower than those of the C-MMSE (96.0% and 76.5%). The area under the ROC curve is an unbiased measure of test accuracy that captures the interplay between sensitivity and specificity.[20] Again, the area was lower in the CDT (0.806) than that in the C-MMSE (0.964).

Despite the improved sensitivity and specificity of MMSE, CDT has the advantage of higher inter-rater and intra-rater reliabilities, as shown in various studies and the present study. Lam et al[9] derived a scoring method which was validated in Chinese elderly adults. At a cut-off point of 3/4, the test had a sensitivity of 83% and specificity of 79%. In the present study, the same method was applied to the subjects yielding a similar sensitivity of 89.4% but a much lower specificity of 47.1%. One of the possible reasons accounting for the marked discrepancies in specificity might be related to the different morbidity profiles of the non-demented subjects between the two studies.

The correlation between the C-MMSE total scores and the CDT scores was significant in the present study, which is supported by preceding studies. It indicates that the CDT has a good construct validity, which is one of the important properties of a screening test. The T&C test is a relatively new test developed by Inouye et al.[5] It has two components: telling time from a pre-set clock and making change for a dollar using ordinary coins. The rationale for its development is related to complexity, considerable time of administration, and sometimes questionable correlation with real-world functioning of previously established screening tests, especially the MMSE.

There have been only a handful of studies addressing the usefulness of the T&C test in dementia screening.[2,4-6] In general, the test is diagnostically inferior to the C-MMSE. The mean sensitivity and specificity was 79.6% (range, 63%-91%) and 82.9% (range, 54%-93%), respectively. However, it has the advantages of not being influenced by age, education, nor disability.

An important point to note in the present study is that the making change component was modified significantly in order to suit the local setting. In the original version, the subjects were presented with three quarters, seven dimes, and seven nickels which were the currencies of the United States. They were asked to give one dollar in change. In order to apply the test in the local setting, the subjects were presented with three $2 coins, seven $1 coins, and seven 50¢ coins, and asked to give 10 dollars in change. Despite the modifications, the low sensitivity (62.7%) and high specificity (94.1%) were observed, remarkably close to the results of the previous study. The present study was not intended to be a validation study for the T&C test, indeed, it could be viewed as a pilot study for future research purposes.

In the present study, subjects took significantly longer time to complete the C-MMSE (mean time,

399.8 sec) than the CDT or T&C test (90.9 and 65.6 sec, respectively). There was no significant difference between the CDT and the T&C test. This finding could be translated into having at least 5 more minutes during the consultation period for further assessment if required. It would be more acceptable to both patients and physicians if dementia screening could be more rapidly performed at their clinics. However, the time-saving advantage should be considered in the light of the compromised sensitivity and specificity of the CDT and the T&C test. Some may advocate the combination of the two tests, because one has a lower sensitivity but a higher specificity and the other has the reverse. In fact, the sensitivity and specificity of combining the two tests (92.2% and 47.1%) were not significantly better than those of the CDT (89.4% and 47.1%) in the present study.

Another significant finding of the present study was that there were significant differences with regard to the time taken to complete the C-MMSE and the T&C test between the demented and non-demented subjects. The area under the ROC curve of the T&C test was 0.834. A cut-off time of 45 seconds without considering the results of the test improved the sensitivity of the test to 74.5% at mild expense of specificity (88.2%).

Four subjects refused the CDT. It was still considered to be quite acceptable, especially in the local setting where a significant proportion of subjects were illiterate. Traditional thoughts that individuals who have never held a pen or pencil do not comply with tests requiring them to write or draw may need to be reconsidered. Even for those who could not write the numbers, they might still be able to complete the test with lines at appropriate places instead.

All the subjects completed the T&C test, confirming the acceptability of a real-life performance screening test.

There are a number of limitations in this study that need to be addressed. Firstly, due to limited resources, only a convenient sample of subjects were recruited. Such a method of recruitment is obviously inferior to a truly randomised method of subject collection. Secondly, the clinical pathways of subjects undergoing assessment in the two involved clinics were not completely equivalent. This might have an impact on the final diagnosis. Adherence to the diagnostic criteria of the DSM-IV would minimise the effects of discrepancies. Thirdly, the investigator was not totally blind to the diagnosis for two reasons: those who were seen in the memory clinic were intrinsically of higher probability of having dementia, and the diagnosis of the subjects who were severely demented would be obvious to the investigator during the interview. Lastly, the mean C-MMSE of the demented subjects in this study was 13.4, indicating that most of them had dementia of at least moderate severity. The results of the present study thus may not be applicable to those with a mild grade of dementia or who only have mild cognitive impairment. Subsequent studies should focus on subjects who are in a mild stage of disease because they will benefit more from early diagnosis and treatment.

Conclusion

In this study, two screening methods not commonly used in the local setting were evaluated against the most commonly used screening method, the C-MMSE, to evaluate the performance of the latter. The CDT has good sensitivity at the expense of low specificity, while the reverse holds true for the T&C test. They both require much less time to complete than the C-MMSE. All three tests are highly acceptable to the screening subjects. The C-MMSE is still the best screening method among the three, despite its more time-consuming nature. The CDT may be a good alternative to C-MMSE as an effective screening test for cognitive dysfunction when time does not permit. However, the T&C test is not a suitable test to be used alone for dementia screening, because trade-offs between sensitivity and specificity were unacceptable. To meet desirable standards for dementia detection, the test requires refinement and re-calibration.

References

1. Gifford DR, Cummings JL. Evaluating dementia screening tests: methodologic standards to rate their performance. Neurology 1999;52:224-7.
2. Mussi C, Foroni M, Valli A, Ascari S, Tolve I, Salvioli G. The "time and change" test: an appropriate method to detect cognitive decline in the elderly. J Geriatr Psychiatry Neurol 2002;15:12-5.
3. Bush C, Kozak J, Elmslie T. Screening for cognitive impairment in the elderly. Can Fam Physician 1997;43:1763-8.
4. Froehlich TE, Robison JT, Inouye SK. Screening for dementia in the outpatient setting: the time and change test. J Am Geriatr Soc 1998;46:1506-11.
5. Inouye SK, Robison JT, Froehlich TE, Richardson ED. The time and change test: a simple screening test for dementia. J Gerontol A Biol Sci Med Sci 1998;53A:M281-6.
6. Butler KA, Crisostomo PR, Webster JR, Moran MB. Validating the time and change test to screen for dementia in an older Hispanic population. J Am Geriatr Soc 2002; 50:397-8.
7. Diagnostic and statistical manual of mental disorders.

4th ed. Washington DC: American Psychiatric Association; 1994.
8. Chiu HF, Lee HC, Chung WS, Kwong PK. Reliability and validity of the Cantonese version of mini-mental state examination—a preliminary study. Journal of Hong Kong College of Psychiatrists 1994;4(Suppl 2):25S-28S.
9. Lam LC, Chiu HFK, Ng KO, et al. Clock-face drawing, reading and setting tests in the screening of dementia in Chinese elderly adults. J Gerontol B Psychol Sci Soc Sci 1998;53B:353-7.
10. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987; 40:373-83.
11. D'Hoore W, Sicotte C, Tilquin C. Risk adjustment in outcome assessment: the Charlson comorbidiy index. Methods Inf Med 1993;32:382-7.
12. Esteban-Santillan C, Praditsuwan R, Ueda H, Geldmacher DS. Clock drawing test in very mild Alzheimer's disease. J Am Geriatr Soc 1998;46:1266-9.
13. Lin KN, Wang PN, Chen C, et al. The three-item clock-drawing test: a simplified screening test for Alzheimer's disease. Eur Neurol 2003;49:53-8.
14. Sunderland T, Hill JL, Mellow AM, et al. Clock drawing in Alzheimer's disease. A novel measure of dementia severity. J Am Geriatr Soc 1989;37:725-9.
15. Watson YI, Arfken CL, Birge SJ. Clock completion: an objective screening test for dementia. J Am Geriatr Soc 1993;41:1235-40.
16. Shulman KI. Clock-drawing: is it the ideal cognitive screening test? Int J Geriatr Psychiatry 2000;15:548-61.
17. Lorentz WJ, Scanlan JM, Borson S. Brief screening tests for dementia. Can J Psychiatry 2002;47:723-33.
18. Rai GS, Blackman I. Dementia diagnosis: usefulness of mini mental state examination and clock drawing test. Clin Gerontol 1998;19:68-70.
19. Lee H, Swanwick GR, Coen RF, Lawlor BA. Use of the clock drawing task in the diagnosis of mild and very mild Alzheimer's disease. Int Psychogeriatr 1996;8:469-76.
20. Storey JE, Rowland TJ, Basic D, Conforti DA. Accuracy of the clock drawing test for detecting dementia in a multicultural sample of elderly Australian patients. Int Psychogeriatr 2002; 14:259-71.