INTERNATIONAL JOURNAL OF GERIATRIC PSYCHIATRY
Int J Geriatr Psychiatry 2004; **19**: 1188–1194.
Published online in Wiley InterScience (www.interscience.wiley.com). **DOI**: 10.1002/gps.1239

Adaptation of the ACE for a Malayalam speaking population in southern India

P. S. Mathuranath[1,2]*, John R. Hodges[2,3], Robert Mathew[1], P. Joseph Cherian[1], Annamma George[1] and Thomas H. Bak[3]

[1]*Cognition and Behavioural Neurology Center (CBNC), Department of Neurology, Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Trivandrum, Kerala, India*
[2]*University of Cambridge Neurology Unit, University of Cambridge, Addenbrooke's Hospital, Cambridge, UK*
[3]*MRC Cognition and Brain Sciences Unit, Cambridge, UK*

SUMMARY

Objective To adapt the Addenbrooke's Cognitive Examination (ACE) as a dementia-screening tool in a community in south India. To establish that items in the adapted version are equivalent to that in the original.
Methods The ACE was adapted into the local language, Malayalam (m-ACE), following cultural/linguistic modifications. To establish equivalence, qualitative comparisons were made (on the distribution of scores, percentage scoring at ceiling, and relative difficulty across items) between a UK sample receiving the ACE ($n = 50$; mean age $= 67.9 \pm 7.4$; education ≥ 9, mean $= 10.9 \pm 2.5$) and a community-based educationally-stratified Indian sample receiving the m-ACE: 'India ≥ 9' ($n = 50$; mean age $= 67.8 \pm 5.2$; education ≥ 9, mean $= 13.9 \pm 2.7$) and 'India ≤ 8' ($n = 50$; mean age $= 67.1 \pm 5.3$; education ≤ 8, mean $= 3.1 \pm 2.0$).
Results Most ACE items were retained. The score distribution (mean $\pm$ 1SD), percentage at ceiling, and relative difficulties across items is comparable between the UK and the educationally equivalent India ≥ 9 groups. Language, Naming, Attention and Orientation are relatively easy ($\geq 80\%$ at ceiling) and Recall and Verbal fluency are relatively difficult ($\leq 22\%$ at ceiling). Although the percentage at ceiling were lower for the India ≤ 8 group, the order of relative difficulty was similar and the percentage scoring at floor was $\leq 10\%$ on all except visuospatial item.
Conclusions The m-ACE provides a culture-fair Malayalam adaptation of the ACE with component items of equivalent difficulty. Copyright © 2004 John Wiley & Sons, Ltd.

KEY WORDS — ACE; MMSE; cognitive test; elderly; dementia; developing countries; India

INTRODUCTION

The Mini Mental Status Examination (MMSE) (Folstein *et al.*, 1975), modified and adapted into local languages, (Katzman *et al.*, 1988; Ganguli *et al.*, 1995; de Silva and Gunatilake, 2002; Brucki *et al.*, 2003; Xu *et al.*, 2003) is a widely used cognition screening test in many parts of the world. It has limitations, however, in screening multiple cognitive domains and detecting early dementia (Teng and Chui, 1987; Naugle and Kawczak, 1989; Feher *et al.*, 1992).

Screening for early dementia in epidemiological studies requires a sensitive assessment of cognition. The Addenbrooke's Cognitive Examination (ACE), a global cognition screening battery, is a reliable and sensitive tool that also helps differentiate early Alzheimer's disease from Frontotemporal Dementia (Mathuranath *et al.*, 2000). It is structurally similar to the neuropsychological battery of the Consortium to Establish a Registry for Alzheimer's Disease (CERAD) for diagnosing dementia (Morris *et al.*, 1989) and has a global cognitive scale (MMSE), and tests for memory (immediate and delayed recall of a seven-item address list), verbal fluency (initial

*Correspondence to: Dr P. S. Mathuranath, Department of Neurology, SCTIMST, Trivandrum-695 011, India. Tel: +91 (0) 471 2524523; 2524584. Fax: +91 (0) 471 2446433; 2440790.
E-mail: mathu@sctimst.ac.in

Contract/grant sponsor: Sir Ratan Tata Trust, Mumbai, India.

Received 20 April 2004
Accepted 18 August 2004

letter P and categories of animals), confrontation naming (ten-items), and constructional praxis (copying two line-drawings). It also assesses executive functions and constructional ability (clock-drawing) (Brodaty and Moore, 1997), remote memory and language.

Over the past three years, our experience in an Indian population from varying socio-economic and educational strata showed that simple and literal translation of many items in the ACE provide good comprehensibility. This, added to its comprehensive nature as a screening test, the provision for obtaining item-wise and composite scores and its high sensitivity in detecting early dementia in the UK population (for whom it was developed), prompted us to attempt a formal adaptation of the ACE as a dementia screening tool in the first of a two-phase (screening and evaluation) epidemiological study in the southern Indian state of Kerala.

Our first objective was to make a culture-fair adaptation of the ACE in Malayalam (m-ACE), a Dravidian language, spoken by 31 million people in Kerala (Director of Census Operations Kerala, 2001). For any meaningful comparison of the cognitive profiles of two populations it is imperative that the tests used be analogous (if not identical) and equivalent. Thus, our second objective was to determine if the tests in the m-ACE were equivalent to and had a comparable relative difficulty as that in the original ACE.

METHODOLOGY

Development of test battery

A literal translation of the ACE in Malayalam was pre-tested on 30 volunteers for the relevance of the items, their comprehensibility, the adequacy of the instructions for administration and the scoring system. Following this certain cultural and linguistic changes were made (Table 1). In attention/calculation, we dropped the item of saying 'world' backwards as most subjects did not attempt it. In the tests of repetition, word reading and address recall replacements with words of equivalent frequency, syllable length and grammatical form in Malayalam

Table 1. Comparison between the original and the adapted versions of the ACE

Item	Original	Adaptation
Orientation	Year, Season, Date, Day, Month	Unchanged. Appropriate Malayalam month and year accepted as correct response
	Country, County, Town, Hospital, Floor	Country, State, Town *
Attention/Calc.	100-7 up to five subtractions	Unchanged
	'WORLD' spelt backward	This item was not included
Memory	Lemon, Key, Ball	Unchanged
	Seven-word address	Seven-word address of local relevance
Remote Memory	UK PM (current and previous), UK (opposition leader), US (President)	Indian Capital, Indian Currency, State Chief Minister, City where Taj Mahal is located
Verbal Fluency	Letter 'P' and Animal	Malayalam equivalent of 'P' and animal
Naming	Pen, Watch, Giraffe, Pig, Crown, Goat, Camel, Helicopter, Kite	Unchanged. Both helicopter and plane accepted as correct answers
	Windmill, Kangaroo, Barrel	Replaced with Sickle, Zebra and Candle
Language Comprehension	Read and obey and 1-stage, 3-stage and complex grammar	Unchanged
Repetition	Brown, Conversation, Articulate	Replaced with Malayalam words of comparable frequency and length
	Phrases	Replaced with Malayalam phrase of comparable complexity and length
Reading	Regular words	Replaced with regular words of comparable frequency and word length
	Irregular words	Replaced with regular words of comparable frequency and word length as there are no irregular words in Malayalam
Visuospatial	Overlapping Pentagon, Wire cube, Clock-face Drawing	Unchanged

*At the time of this study, suitable alternatives for these two items (hospital and floor), from a community perspective, were not yet available. Because of this the orientation score on the m-ACE in this study was 8 as against that of 10 on the original ACE. After the completion of this study, 'Street name' for 'Hospital' and 'House name/number' for 'Floor', have been included as the alternatives.

were made. Literal translation of the phrase 'no ifs, ands, or buts', is meaningless and has poor sensitivity, specificity and positive predictive value (Werner *et al.*, 1999). It was replaced with a meaningful Malayalam phrase of comparable length and grammatical complexity. To improve cultural relevance, items of remote memory and confrontation naming underwent substantial changes as described in Table 1. The m-ACE was then back translated into English. Changes to the instructions for administration and the scoring were also made. When asked the country (i.e. India) some subjects repeated the state name (i.e. Kerala). Hence, the example of Sri Lanka was provided to invoke the concept of a country. The year, month, and date response in orientation was accepted as correct if it tallied with any one of the three, locally popular systems of calendars (the Lunar, the Hindu and the Muslim) familiar to the subject. Subjects were not penalized if they reported winter or spring as rainy or summer as the former two months are very brief in Kerala. In an earlier study, we found that the raw scores on fluency in the elderly in this population was low (letter ('pa'), 5.5 ± 3.6 and category (animals), 7.8 ± 3.6) (Mathuranath *et al.*, 2003). We, therefore, rescaled the scores for verbal fluency using the percentile distribution of raw scores in this population (Table 2).

Establishing the equivalence of tests between the m-ACE and the ACE

A qualitative comparison of the tests (rather than comparison of the absolute scores) between the two versions of a cognitive battery is a more appropriate method of assessing the adequacy of the adaptation and the equivalence on test items (Ganguli *et al.*, 1995). We proposed to do this by determining if: (a) the test scores had comparable distributions in the UK and the Indian populations; (b) comparable proportions obtained perfect scores on each tests and (c) the relative difficulty of the tests were comparable in the two populations.

The UK group ($n = 50$, males $= 25$) consisted of subjects above the age of 60 years and included spouses of the attendees at an orthopedic clinic ($n = 13$), or members of the Medical Research Council volunteer panel ($n = 37$). Mean age was 67.9 ± 7.4 and education 10.9 ± 2.5 years. The Indian cohort (males $= 43$) consisted of community-dwelling asymptomatic subjects $\geq$55 years of age. Mean age and education were 67.2 ± 5.5 and 8.5 ± 5.9 years respectively. As the minimum education of the UK cohort was nine years, the Indian cohort was educationally stratified into two groups- 'India $\geq$9' ($n = 50$ with education $\geq$9) and 'India $\leq$8' ($n = 50$ with education $\leq$8) so as to allow for an education-fair cross-national comparison. Here we made an assumption that the neuropsychological performance of the UK group (with an education of $\geq$9) will be more analogous to that of the India $\geq$9 group than to that of the entire Indian cohort, as education influences the neuropsychological performance (Le Carret *et al.*, 2003a,b). All participants were interviewed, examined by a neurologist (to confirm that they were cognitively asymptomatic and unimpaired) and received the ACE (in the UK) or the m-ACE (in India). Failure to complete a component of a test attracted a score of zero for that component. Approvals from institutional ethical committees were obtained both in the UK and in India for the collection of the data presented in this study.

Statistics

The mean scores and the percentage of subjects scoring at the ceiling (i.e. the maximum possible score)

Table 2. The table shows the percentile distribution of the raw scores of randomly selected 153 community based elders on the letter and animal fluency in a previous study (Mathuranath *et al.*, 2003) which was used for deriving the new scaled scores for these components on the m-ACE

	Raw score for fluency		Range of raw scores used for scaling		Scaled score
	Letter	Category	Letter	Category	
Mean (SD)	5.5 (3.6)	7.8 (3.6)			
1st percentile	0	0	<2	<2	1
5th percentile	2	2	2	2–3	2
25th percentile	3	5	3–4	4–6	3
50th percentile	6	8	5–7	7–9	4
75th percentile	9	11	8–10	10–12	5
95th percentile	12	14	11–12	13–15	6
99th percentile	16	20	>12	>15	7

and low level (i.e. 10% of the maximum possible score rounded to the nearest full integer) were calculated on all the ACE components. One of our objectives was to estimate the relative difficulty of the components in the m-ACE for the Indian population and compare that with the relative difficulty of the components in the ACE for the UK population. While absolute percentages of people scoring at ceiling on a test is useful in estimating the relative difficulty of the tests in a battery within a given population, it may not be a clinically meaningful measure for comparing the order of relative difficulty of the tests between demographically and culturally differing populations. In contrast, ranking the performance on the tests can provide a simple and practical measure for estimating the relative difficulty of the tests within a population and comparing it between populations. We therefore ranked all the tests from easy (i.e. the test with maximum percentage at ceiling level receiving rank 1) to difficult, similar to the methodology followed by Ganguli *et al.* (1995).

RESULTS

Table 3 shows that the proportions at the ceiling level show more variation than the mean scores across the three groups. In the India ≤8 group, low-level scores were seen for 22% on visuospatial, and between 4% and 10% on recall, remote memory and attention. Visuospatial also showed a low mean score of 0.8. As expected, the absolute mean scores and the proportion at ceiling on all components were higher in India ≥9 than in the India ≤8 group. The absolute mean scores were higher for the UK than for the India ≥9 on all except remote memory. For both the groups, however, the proportion at ceiling was more than 80% on orientation, attention, language and naming and was less than 25% on recall and verbal fluency, thereby suggesting that on these components the proportion obtaining the perfect score were relatively comparable between the two groups. Figure 1 shows that the distribution of the scores across the means, represented as mean ± 1SD, was comparable between the UK and the India ≥9 group on most components of the ACE except registration, naming and visuospatial where the India ≥9 group had a wider distribution.

As evident in the ranking, the relative difficulties on orientation, attention, naming and language (relatively easy, with ≥80% scoring at the ceiling level and ranking within the first four) and on verbal fluency and recall (relatively difficult, with ≤22% scoring at ceiling level and ranking 7 and 8) were

Table 3. Scores, percentage of subjects with performance at Ceiling or Low levels and the rank order of the ACE components in the UK and the Indian groups with ≥9 years (India ≥9) and ≤8 years (India ≤8) of education

Group	UK						India ≥9				India ≤8			
	Max	Mean	SD	% Ceiling	Rank	% low	Mean	SD	% Ceiling	Rank	% low	Mean	SD	% Ceiling	Rank	% low
Age		67.9	7.4				67.8	5.2				67.1	5.3			
Education		10.9	2.5				13.9	2.7				3.1	2.0			
ACE	100*	93.9	3.2				83.6	6.7				59.0	10.5			
MMSE	30*	29.1	0.8				26.8	1.5				21.1	3.4			
Orientation	10	9.8	0.4	100	1		7.8*	0.5	88	2		6.4*	1.4	28	2	
Attention	5	4.9	0.2	94	4		4.8	0.6	86	3		3.1	1.5	26	3	10
Remote memory	4	3.4	0.8	56	6	2	3.8	0.4	84	4		2.1	1.0	4	5	6
Registration	24	23.6	0.8	98	2		20.1	3.1	42	5		13.7	4.1		7	
Recall	10	8.9	1.4		8		7.3	1.9		8	2	4.7	1.5		7	4
Verbal Fluency	14	10.7	2.3	22	7		9.1	2.2	8	7		7.1	2.2		7	
Language	16	15.8	0.5	96	3		15.9	0.3	100	1		13.2	2.1	34	1	
Naming	12	11.9	0.4	98	2		11.2	1.4	84	4		7.7	2.3	12	4	
Visuospatial	5	4.8	0.5	88	5		3.6	1.5	40	6	6	0.8	1.3	2	6	22

*Maximum possible score on the ACE and the MMSE for the Indians was 98 and 28 since the maximum possible score on orientation component was 8, as explained in the footnote of Table 1.

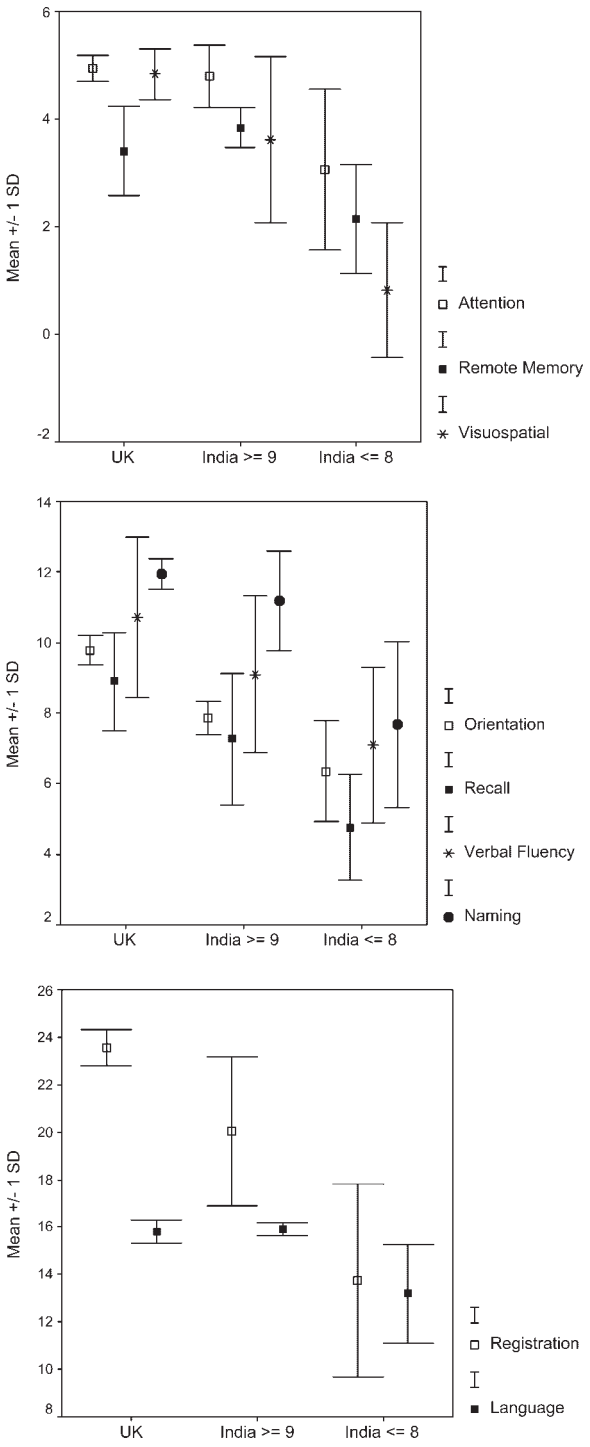

Figure 1. The distribution of scores (represented as Mean ± 1SD) of the UK, India ≥9 and India ≤8 groups on the various components of the ACE

comparable between the UK and the India ≥9 groups. The relative difficulties of registration and visuospatial (easier for the UK group and ranking 2 and 5) and remote memory (easier for the India ≥9 and ranking 4) differed between the two groups. The order of relative difficulty remains essentially the same for the India ≤8 group as for the India ≥9 group. On forward regression analysis, education, but not age or gender, showed significant effect on the ACE composite [$p < 0.001$; coefficient = 2.3; 95% Confidence Intervals (CI) = 1.99–2.69] and the MMSE ($p < 0.001$; coefficient = 0.54; 95% CI = 0.45–0.63) scores.

DISCUSSION

Ganguli *et al*. (1995) developed a Hindi MMSE for a largely illiterate (74%) rural population in Ballabgarh in North India. In contrast to the population used in their study, the population we intend to survey in Kerala is largely literate (91%), multi-religious mixture of urban, semi-urban and rural Malayalam speaking elders (Director of Census Operations Kerala, 1991). These differences and the need for a more extensive battery prompted the adaptation of the ACE.

Demographic factors such as education, age and gender (Escobar *et al.*, 1986; O'Connor *et al.*, 1989) and cultural factors such as religion, social setting (urban or rural), comprehensibility of the tests and familiarity with the language used for testing can all affect performance on cognitive tests. Wide variations in these factors in a population makes the task of developing a test very challenging (Chandra *et al.*, 1998). Having different versions of the same test for different sections of the population or alternatively, simplifying the tests to improve the specificity in the low-level performers may help in such situations. However, using multiple versions of the battery causes practical inconvenience in field studies and over-simplifying the tests compromises the sensitivity. In our proposed field survey we aspire for early detection of dementia using the m-ACE. As this requires high sensitivity we propose using separate cut-offs stratified for the demographic factor most affecting the performance. We also intend to retain the operational convenience by using a single version of the instrument. As those screening positive on the m-ACE in this survey will undergo further detailed evaluation before a diagnosis of dementia is made, we hope to minimize the false-positives. This study shows that education was the only demographic factor affecting the m-ACE and the MMSE. We therefore

intend to derive educationally stratified cut-off on the elderly in the community in a future study.

Qualitative comparisons show that the distribution of scores and the relative difficulty on most of the nine components on the ACE was similar across the UK and the better-educated Indian group. Attention, orientation, language and naming were relatively easier while verbal fluency and recall relatively difficult. The performance on remote memory and registration varied, perhaps attributable to the substantial changes (to the items in remote memory and the seven-word address) made to these two items in the m-ACE. The lower score for the Indians (compared to the UK) on the visuospatial component, we feel, is because of a failure of a proportion of subjects to complete these tests (and thereby earning a score of 0) rather than because of a difference in difficulty. These subjects requested the testing to be terminated before completion (as a result of non-cognitive reasons such as fatigue or loss of interest) and as the visuospatial tests appear at the end of the battery, they were the tests most often left incomplete. The relative difficulty across components was also comparable between the two Indian groups.

Large floor effects (measured here as percentages at low level) limits the utility of any screening test. During the adaptation of the ACE, this was of particular concern to us, especially in the less educated subjects. Our results show, however, that even in less educated subjects, low level scores were uncommon, seen in less than a third on the visuospatial (with low mean scores) and a tenth on three other components (with good mean scores). This suggests that with the exception of the visuospatial component, which was somewhat difficult, the other tests were not too difficult for the vast majority of the less educated. The low level scores are possibly an effect of cultural (such as opportunity) rather than cognitive factors. Eliminating the visuospatial component would unduly hamper testing this domain in subjects with better education and therefore we retained it. Thus, this study shows that the m-ACE provides a culturally fair Malayalam adaptation of the ACE with component items of equivalent difficulty.

KEY POINTS

- Malayalam adaptation (m-ACE) of the Addenbrooke's Cognitive Examination (ACE) was intended to screen for dementia in the community in a Southern Indian state.
- A qualitative comparison of the performance of the local population on the m-ACE with that of a UK population on the ACE showed good equivalence of the two versions of the tool.
- To make meaningful interpretation on the m-ACE, education-stratified cut-off scores are essential.

ACKNOWLEDGEMENTS

We would like to thank Dr Usha Neelakandan (Department of Linguistics, University of Kerala) for assisting in the process of translation. We gratefully acknowledge the support and input provided by Mrs Meera Pattabi (from the Trivandrum Chapter of the Alzheimer's and Related Disorders Society of India: ARDSI), Mr Radhamoni (from the ARDSI and the Senior Citizen's Forum, Trivandrum), Dr S. Sarma (from the department of Epidemiology and Medical Statistics, Achutha Menon Center for Health Sciences Studies, Trivandrum), and the office bearers of various Residents Associations in Trivandrum. This study was funded in part by a grant from the Sir Ratan Tata Trust, Mumbai, India.

REFERENCES

Brodaty H, Moore CM. 1997. The Clock Drawing Test for dementia of the Alzheimer's type: a comparison of three scoring methods in a memory disorders clinic. *Int J Geriatr Psychiatry* **12**: 619–627.

Brucki SM, Nitrini R, Caramelli P, Bertolucci PH, Okamoto IH. 2003. [Suggestions for utilization of the mini-mental state examination in Brazil]. *Arq Neuropsiquiatr* **61**: 777–781.

Chandra V, Ganguli M, Ratcliff G, *et al.* 1998. Practical issues in cognitive screening of elderly illiterate populations in developing countries. The Indo-US Cross-National Dementia Epidemiology Study. *Aging (Milano)* **10**: 349–357.

de Silva HA, Gunatilake SB. 2002. Mini Mental State Examination in Sinhalese: a sensitive test to screen for dementia in Sri Lanka. *Int J Geriatr Psychiatry* **17**: 134–139.

Director of Census Operations Kerala. 1991. *District Census Handbook, Trivandrum. Village and Town Directory. Village, Panchayat and Townwise Primary Census Abstract*. Census of India, Series 12. Director of Census Operations, Kerala: Tiruvananthapuram.

Director of Census Operations Kerala. 2001. *Provisional Population Totals*. Census of India 2001, Series 33. Director of Census Operations, Kerala.

Escobar JI, Burnam A, Karno M, Forsythe A, Landsverk J, Golding JM. 1986. Use of the MMSE in a community populaiton of mixed ethnicity: cultural and linguistic artifacts. *J Nervous Mental Dis* **174**: 607–614.

Feher EP, Mahurin RK, Doody RS, Cooke N, Sims J, Pirozzolo FJ. 1992. Establishing the limits of the Mini-Mental State. Examination of 'subtests'. *Arch Neurol* **49**: 87–92.

Folstein MF, Folstein SE, McHugh PR. 1975. 'Mini-mental State'. A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* **12**: 189–198.

Ganguli M, Ratcliff G, Chandra V, *et al.* 1995. A Hindi Version of the MMSE: The Development of a Cognitive Screening Instrument for a Largely Illiterate Rural Elderly Population in India. *Int J Geriatr Psychiatry* **10**: 367–377.

Katzman R, Zhang MY, Ouang Ya Q, *et al.* 1988. A Chinese version of the Mini-Mental State Examination: impact of illiteracy in a Shanghai dementia survey. *J Clin Epidemiol* **41**: 971–978.

Le Carret N, Lafont S, Mayo W, Fabrigoule C. 2003a. The effect of education on cognitive performances and its implication for the constitution of the cognitive reserve. *Dev Neuropsychol* **23**: 317–337.

Le Carret N, Rainville C, Lechevallier N, Lafont S, Letenneur L, Fabrigoule C. 2003b. Influence of education on the benton visual retention test performance as mediated by a strategic search component. *Brain Cogn* **53**: 408–411.

Mathuranath P, George A, Cherian P, Alexander A, Sarma S, Sarma P. 2003. Effects of age, education and gender on verbal fluency. *J Clin Exp Neuropsychol* **25**: 1057–1064.

Mathuranath PS, Nestor PJ, Berrios GE, Rakowicz W, Hodges JR. 2000. A brief cognitive test battery to differentiate Alzheimer's disease and frontotemporal dementia. *Neurology* **55**: 1613–1620.

Morris JC, Heyman A, Mohs RC, *et al.* 1989. The Consortium to Establish a Registry for Alzheimer's Disease (CERAD). Part I. Clinical and neuropsychological assessment of Alzheimer's disease. *Neurology* **39**: 1159–1165.

Naugle RI, Kawczak K. 1989. Limitations of the Mini-Mental State Examination. *Cleve Clin J Med* **56**: 277–281.

O'Connor DW, Pollitt PA, Treasure FP, Brook CPB, Reiss BB. 1989. The influence of education, social class and sex on Mini-Mental State scores. *Psychological Med* **19**: 771–776.

Teng EI, Chui HC. 1987. The Modified Mini-Mental State (3MS) Examination. *J Clin Psychiatry* **48**: 314–318.

Werner P, Heinik J, Lin R, Bleich A. 1999. 'Yes' ifs, ands or buts: examining performance and correlates of the repetition task in the mini-mental state examination. *Int J Geriatr Psychiatry* **14**: 719–725.

Xu G, Meyer JS, Huang Y, Du F, Chowdhury M, Quach M. 2003. Adapting mini-mental state examination for dementia screening among illiterate or minimally educated elderly Chinese. *Int J Geriatr Psychiatry* **18**: 609–616.

