PAPER

The seven minute screen: a neurocognitive screening test highly sensitive to various types of dementia

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Background: The seven minute screen (7MS) is a compilation of the temporal orientation test, enhanced cued recall, clock drawing, and verbal fluency. It has been shown to be useful for detecting Alzheimer's disease in a population of patients with memory complaints.
Objective: To assess the predictive validity of the 7MS for various types of dementia, and the influence of depression and other psychiatric conditions on 7MS scores.
Setting: Multicentre: secondary referral sites across the Netherlands.
Subjects: 542 patients with various types of dementia or depression, together with 45 healthy controls.
Results: Alzheimer's disease was diagnosed in 177 patients, other types of dementia in 164. The sensitivity of the 7MS for Alzheimer's disease was 92.9% with a specificity of 93.5%. For other types of dementia the sensitivity was 89.4% and the specificity 93.5%. Cognitive abnormalities were found in 71% of the patients with depression (n = 31). The mean (SD) duration of administration of the 7MS was 12.4 (4.6) minutes, range 8 to 22, depending on dementia severity.
Conclusions: The 7MS is a useful screening tool for discriminating patients with dementia from cognitively intact patients. This not only applies to Alzheimer's disease but also to other types of dementia. Specificity with respect to depression was lower for the 7MS than for the MMSE.

In the past three decades various cognitive screening tests have been described, among which the mini-mental state examination (MMSE) by Folstein *et al*[1] is the best known and most widely used. This test, originally designed to differentiate organic from functional psychiatric syndromes, lacks sensitivity in identifying patients with early symptoms of Alzheimer's disease and mild cognitive impairment. Thus many researchers have tried to construct more sensitive tests. Solomon *et al* published the seven minute screen (7MS),[2 3] which combined four existing brief tests: Benton's temporal orientation,[4] Grober and Buschke's enhanced cued recall,[5] and the widely used verbal fluency and clock drawing tasks. The 7MS showed good diagnostic accuracy in Alzheimer's disease and mild cognitive impairment.[2] Another attractive feature of the 7MS is its briefness, which is captured in the name.

Up to 30% of the cases of dementia in the elderly are caused by conditions other than Alzheimer's disease, such as vascular dementia, frontal-temporal dementia, or dementia with Lewy bodies.[6] Cognitive performance may also be affected by other diseases, most notably depression. Solomon *et al* focused on Alzheimer's disease and did not administer the 7MS to these other diagnostic groups. They presented the 7MS as a sensitive detector of early Alzheimer's disease.

To apply the 7MS adequately in a clinical setting, one needs to know the diagnostic accuracy with regard to dementias other than Alzheimer's disease, and to functional psychiatric syndromes. Remarkably, since its first publication, no studies of the 7MS have been conducted in demented patients with diagnoses other than Alzheimer's disease, or in depressed patients. We therefore studied the diagnostic value of the 7MS in a population of clinically diagnosed dementias, depressed elderly people, and healthy controls in a multicentre secondary referral setting.

METHODS

Subjects

The population under study consisted of a group of patients older than 55 years (n = 335), who visited the geriatric day clinic of the teaching hospital Slotervaart in Amsterdam, and a group of patients (n = 207) who visited the memory clinics of the Alzheimer Centres at the Vrije Universiteit Medical Centre in Amsterdam and Academic Hospital of Maastricht, Netherlands. All patients had been referred in the period 1998 to 2001 by general practitioners, psychiatrists, or neurologists, mainly because of memory complaints.

Exclusion criteria were a cerebrovascular accident within three months of the assessment, active neurological disease, and other acute somatic diseases. Patients who were using psychoactive drugs that could influence cognitive test results or were consuming more than 3 units of alcohol a day were also excluded.

The MMSE and 7MS were administered to each patient, mostly by trained geriatric nurses and sometimes by a physician. Only a single patient was excluded. This person had an MMSE score of 6 and although dementia was evident it was not possible to identify a single underlying cause. The other patients had scores ranging between 10 and 29.

Control subjects (n = 45) were recruited from among relatives or companions who did not complain about their memory and were fully independent. None had a history of psychiatric or neurological disease, and they had not been admitted to hospital in the three months before the screening. Controls did not use psychoactive drugs and did not consume more than 3 units of alcohol a day. The minimum

Abbreviations: ADRDA, Alzheimer's Disease and Related Disorders Association; DSM-IV, *Diagnostic and Statistical Manual of Mental Disorders*, 4th revision; MMSE, mini-mental state examination; NINDS, National Institute of Neurological and Communicative Disorders and Stroke; 7MS, seven minute screen

Table 1 Scores for mini-mental state examination, enhanced cued recall, Benton temporal orientation, clock drawing, and verbal fluency, and total scores in the seven minute screen

Diagnosis	Control (n = 45)	Intact (n = 48)	MCI (n = 87)	AD (n = 177)	VD (n = 62)	FTD (n = 43)	DLB (n = 17)	Subcortical (n = 12)	Other dem (n = 30)	Depression (n = 31)	Other cond (n = 35)
Age	74.56 (6.63)	69.69 (13.38)	74.60 (9.52)	77.46 (8.16)	78.79 (6.51)	78.07 (9.45)	78.94 (7.92)	77.33 (8.38)	75.90 (8.44)	75.74 (10.98)	70.60 (10.53)
% Female	82	72	76	84	78.5	80	70.5	71	71.5	75.5	71.5
Education (y)	10.07 (2.73)	9.00 (2.93)	9.09 (3.39)	8.85 (3.05)	10.27 (3.60)	9.27 (4.04)	9.11 (2.26)	8.50 (2.98)	9.71 (4.06)	9.25 (3.34)	10.00 (2.98)
MMSE	27.96 (1.78)	27.73 (2.31)	25.33 (3.34)	20.56 (4.18)	21.85 (4.00)	22.93 (4.36)	18.82 (3.49)	20.50 (3.97)	21.93 (4.34)	24.26 (3.80)	24.66 (4.21)
BTO	0.13 (0.50)	0.35 (0.56)	6.20 (15.46)	29.69 (34.28)	18.54 (27.53)	6.02 (13.35)	24.53 (29.83)	8.42 (17.03)	15.17 (23.56)	7.45 (20.08)	8.91 (15.43)
ECR	15.38 (0.94)	15.10 (1.21)	12.18 (3.68)	7.25 (4.06)	10.28 (3.66)	11.95 (3.36)	9.00 (4.81)	10.17 (3.97)	10.03 (3.97)	11.26 (3.91)	12.71 (3.74)
CD	6.47 (0.81)	6.27 (1.30)	5.42 (1.78)	3.94 (2.11)	3.80 (2.09)	4.07 (1.86)	2.24 (2.36)	2.92 (2.02)	4.63 (1.63)	5.35 (1.70)	5.03 (1.82)
VF	19.51 (5.64)	19.27 (7.98)	14.80 (5.24)	10.07 (3.81)	8.90 (3.79)	9.93 (4.13)	7.65 (4.33)	8.08 (3.20)	9.13 (3.80)	12.55 (7.91)	13.97 (8.00)
7MS (TS)	−16.09 (8.47)	−14.65 (12.35)	15.46 (55.32)	106.79 (115.39)	66.72 (94.83)	22.74 (45.65)	92.55 (103.42)	36.69 (58.11)	56.31 (81.32)	23.87 (72.16)	22.37 (59.70)

Values are mean (SD).
AD, Alzheimer's disease; BTO, Benton temporal orientation; CD, clock drawing; DLB, dementia with Lewy bodies; ECR, enhanced cued recall; FTD, frontotemporal dementia; MCI, mild cognitive impairment; Other dem, other dementia; Other cond, other conditions; VD, Vascular dementia; VF, verbal fluency; 7MS (TS), seven minute screen (total score).

age of the subjects and controls was 55 years. All subjects gave their written informed consent.

Diagnosis

All patients underwent a structured interview, neurological examination, detailed neuropsychological work up, and laboratory investigations. Computed tomography or magnetic resonance imaging was done in a subset of patients only. The 7MS and MMSE were administered at the initial contact with the patient. The gold standard to which the results of the 7MS were compared was the clinical diagnosis, which was made by a multidisciplinary team of experienced clinicians using published consensus criteria for various types of dementia. In the two university hospitals, the clinicians were not informed of the 7MS results of their patients (n = 207). In the teaching hospital (n = 335) the clinicians were not blinded to the 7MS scores, but for the present analyses the diagnoses of all patients from this hospital were checked afterwards against the same sets of dementia criteria, without taking the 7MS scores into consideration. We refer the reader to Lindeboom *et al* (2002) for a more detailed description of this procedure.[7]

The clinical diagnosis was made using DSM-IV criteria for dementia, vascular dementia, and Alzheimer's disease[8] and NINCDS-ADRDA criteria[9] for probable and possible Alzheimer's disease; the consensus on frontotemporal lobar degeneration for fronto-temporal dementia[10]; and the guidelines by McKeith *et al* for dementia with Lewy bodies.[11] The diagnostic criteria of Cummings and Benson[12] were used for the diagnosis subcortical dementia. We categorised patients into a group termed ''other dementia'' if the underlying process could not be diagnosed. We used the original criteria of Petersen *et al* for the concept of mild cognitive impairment.[13 14] In this concept of amnestic mild cognitive impairment, the diagnosis of mild cognitive impairment meets the following criteria: complaint of defective memory; normal activities of daily living; normal general cognitive function; abnormal memory function for age; and absence of dementia. Depression was diagnosed according to DSM-IV criteria.

Seven minute screen

We used a Dutch translation of the 7MS.[2] The 7MS consists of four brief cognitive tests:

- *Benton temporal orientation*[4]: In this test the orientation in time is measured and quantified in degree of error. The maximum score is 113 (10 error points for a year, 5 points for a month, 1 for the date and the day of a week, and 1 for each 30 minute deviation in time).
- *Enhanced cued recall*[5]: The subject has to identify 16 pictures, which are recalled immediately and after a brief interval. The investigator gives a semantic cue (for example an eagle is cued as a bird). The subject has to name and memorise four pictures at a time. When all four pictures are successfully recalled (the subject may see them twice), another set of pictures is shown. After a short period in which another task is presented, the subject is asked to recall all pictures. The investigator gives the respective semantic cues for pictures, which are not spontaneously recalled by the subject. The total score (maximum 16) is the number of pictures, remembered either freely or after a cue is given.
- *Clock drawing*: In this widely used cognitive test the subject has to draw the face of a clock and place the hands of the clock at a fixed time. The maximum score is 7 points.
- *Verbal fluency*: The subject has to name as many different animals as possible in one minute time. There is a maximum score of 45.

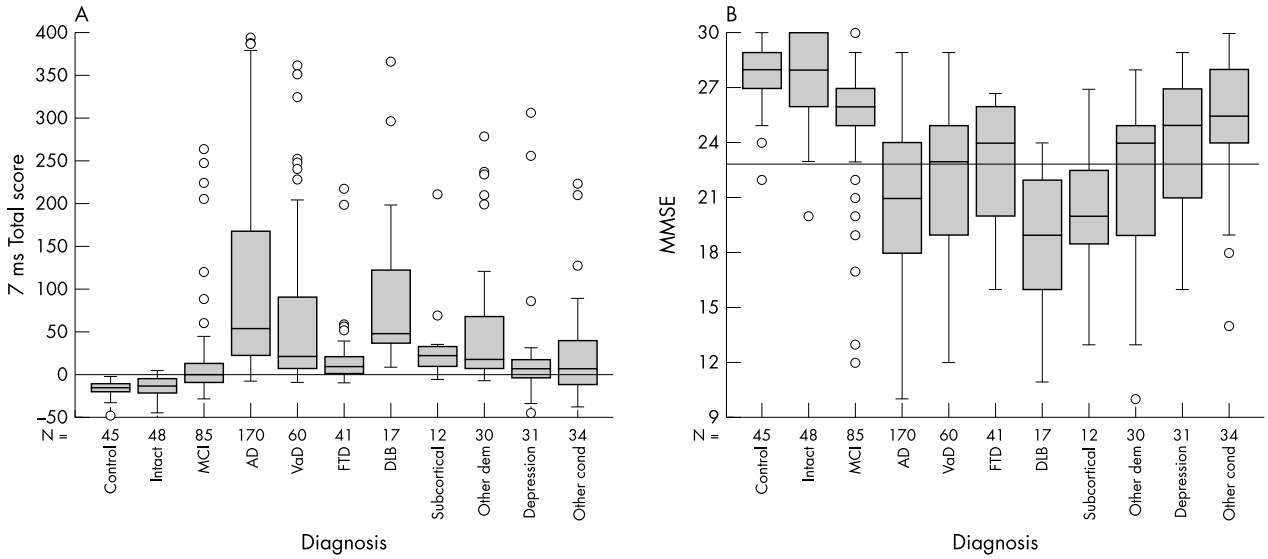

Figure 1 Total scores in the seven minute screen (7MS) (A) and the mini-mental state examination (MMSE) (B) in controls (n = 45), intact patients (n = 48), Alzheimer's disease (AD, n = 177), dementias other than Alzheimer's disease (Other dem, n = 164), mild cognitive impairment (MCI, n = 85), depression (n = 31), and other conditions (Other cond, n = 34). The boxes contain 50% of each group; the upper and lower whiskers denote the first and fourth quartile. The circles represent outliers. The median score in each group is marked by the bold horizontal line in each box. The thin horizontal lines indicate the cut off scores.

Data analyses

As our population under study is comparable with respect to age, education, and selection (secondary referrals) to the population in Solomon's study,[2] the raw scores of the four subtests of the 7MS can be summed with the logistic regression formula found in that study:

$$\text{Ln}\,[P/(1-P)] = 35.59 - 1.303*\text{ECR} - 1.378*\text{VF} + 3.298*\text{BTO} - 0.838*\text{CD}$$

where P is the probability of having dementia, and ECR, VF, BTO, and CD are the scores for the enhanced cued recall, verbal fluency, Benton temporal orientation, and clock drawing, respectively. Solomon estimated the formula by using the scores of the four tests from the screening battery as predictor variables. The natural logarithm (ln) of P/(1−P) is equal to the total 7MS score of the above logistic regression formula. The probability of having dementia decreases with a lower total score. For example if the total score is −4.6, the probability of having dementia is less than 1%. If the total score is 0, the probability of dementia is 50%; when more than 7 the risk is more than 99.9%.

We divided the patients and controls in different groups: cognitively intact patients and controls (n = 93), Alzheimer's disease patients (n = 177), and non-Alzheimer dementia (n = 164). For the MMSE the cut off was set to a generally accepted score of 23. We looked separately at patients with mild dementia syndromes (MMSE >21, n = 165). In order to calculate sensitivity and specificity rates for the 7MS, we used a test cut off score of 0. In this case there is an equal chance that the patient was demented or cognitively intact. The 7MS is positive at scores of 0 or higher.

We used the area under the curve (AUC) in receiver operating characteristic (ROC) curves as a measure of predictive value of the test. The AUC can vary between 0.5 and 1. The ideal test has an AUC of 1, meaning 100% sensitivity and specificity. We also examined the sensitivity of MMSE and 7MS to depression and other psychiatric conditions, as well as the influence of demographic characteristics (age, sex, and education).

The duration of the test administration was recorded in a proportion of the sample (n = 190).

RESULTS

Patient characteristics

We included 542 patients and 45 healthy controls in the study. There were no significant differences in age and years of education between controls and patients. The mean (SD) age of the patients was 75.8 (9.4) years. The mean age of the controls was 74.6 years. The level of education was 9.4 (3.3) years for patients and 10.1 (2.7) years for controls.

Diagnoses and scores

These results are given in table 1 and fig 1. Forty eight patients (8.9%) proved to be cognitively intact. These patients had subjective memory complaints, but no clinical or neuropsychological signs of dementia or mild cognitive impairment could be found. Dementia syndromes were divided in different subtypes. Alzheimer's disease was diagnosed in 32.7% of the patients (n = 177), vascular dementia in 11.4% (n = 62), fronto-temporal dementia in 7.9% (n = 43), and dementia with Lewy bodies in 3.1% (n = 17). In 5.5% of the demented patients (n = 30) no specified diagnosis could be made. Mild cognitive impairment was found in 16.1% of patients (n = 87) and a minor or major depression in 5.7% (n = 31). In 6.5% of the patients (n = 35) the cognitive abnormality was caused by other conditions such as schizophrenia, obsessive-compulsive disorder, or alcohol abuse.

Total scores of the 7MS

The mean total 7MS score was negative in the control group and in the cognitively intact patient group, and it was positive in all other patient groups. The MMSE and 7MS score distributions of all groups are shown in fig 1. Visual inspection and comparison of panels A and B shows that sensitivity and specificity of the 7MS are superior to those of the MMSE.

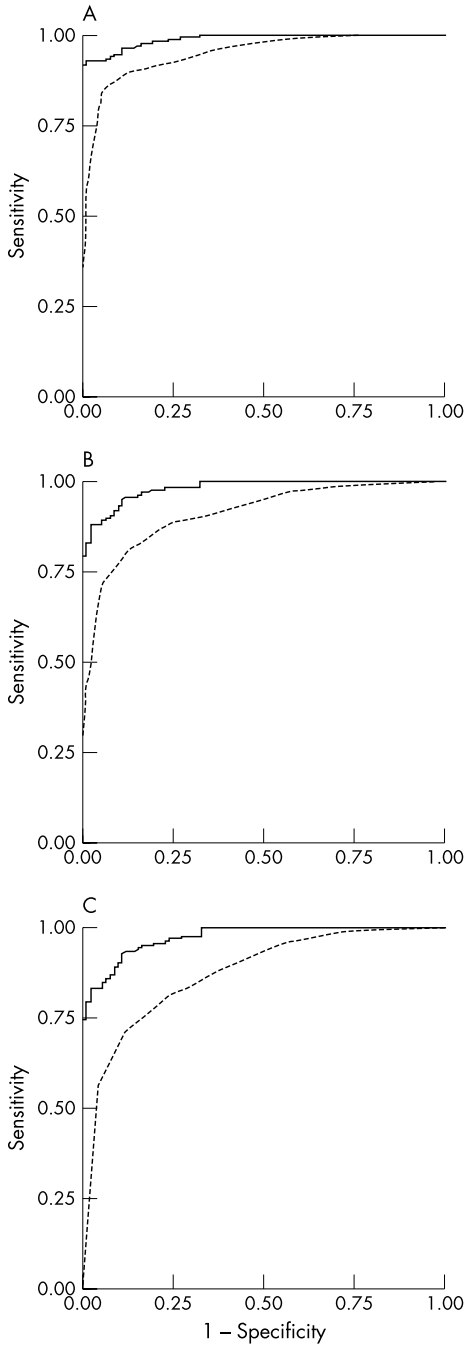

Figure 2 Receiver operating characteristic curves. (A) Mini-mental state examination (MMSE, dashed line) and seven minute screen (7MS, solid line) in Alzheimer (n = 177) and intact subjects (n = 93). (B) MMSE (dashed line) and 7MS (solid line) in other (non-Alzheimer's disease) dementias (n = 164) and intact subjects (n = 93). (C) MMSE (dashed line) and 7MS (solid line) in mild dementia (MMSE >21; n = 165) *v* intact subjects (n = 92)

Sensitivity and specificity

The overall sensitivity of the 7MS for all dementia cases versus controls and cognitively intact patients was 91.2% (n = 331). The sensitivity for Alzheimer's disease was 92.9% (n = 177). Sensitivity for detecting other dementias was 89.4% (n = 164). Specificity was 93.5% (n = 93). The overall specificity of the MMSE (cut off score 23) for all dementias was 96.8% with a sensitivity of 71.8% for detecting Alzheimer's disease and 59.8% for other dementias.

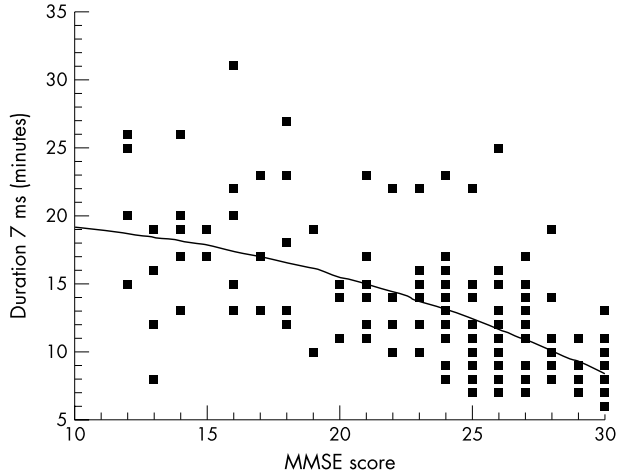

Figure 3 Mean duration of the seven minute screen (7MS) as a function of mini-mental state examination (MMSE) score (n = 190)

Predictive value

In order to give a measure to the diagnostic accuracy, prognostic values were calculated. The positive predictive value (PPV) for the 7MS was 98.0% and negative predictive value (NPV) was 75%. For the MMSE the PPV was 98.6% and the NPV 43.9%.

Alzheimer's disease versus intact subjects

Figure 2A shows the relation between sensitivity and 1-specificity (ROC curves) of the 7MS and MMSE when differentiating Alzheimer's disease (n = 177) from intact subjects (intact patients and controls, n = 93). When differentiating patients with Alzheimer's disease from cognitively intact subjects, the 7MS had a significantly better AUC of 0.989 (95% confidence interval (CI), 0.981 to 0.997) than the MMSE test, which had an AUC of 0.949 (0.924 to 0.974].

Non-Alzheimer dementia versus intact subjects

Figure 2B shows ROC curves of MMSE and 7MS tests for non-Alzheimer dementias (n = 164) and intact subjects (n = 93). The AUC of the 7MS total score was 0.981 (0.970 to 0.993), and of the MMSE, 0.910 (0.875 to 0.945), implying that the 7MS has a better predictive value than the MMSE in differentiating other dementias from intact subjects.

Mild dementia of all-cause (MMSE >21) versus intact patients and controls

In fig 2C, ROC curves are shown for the MMSE and 7MS relating to the discrimination between mildly affected individuals (MMSE scores above 21; n = 165) and intact persons. The 7MS had an AUC of 0.974 (0.959 to 0.989), versus 0.872 (0.828 to 0.916) for the MMSE. The difference is significant.

Depression and other conditions

Of the patients with clinical depression (n = 31, according to DSM-IV criteria), 22 (71%) scored abnormally on the 7MS, while the MMSE screening was abnormal (score lower than 23) in 18 (58.1%). At the time of diagnosis, these patients did not meet the DSM-IV criteria for dementia. In other conditions—such as abuse of benzodiazepines and alcohol, schizophrenia, and other psychiatric disorders—the 7MS was abnormal in 55.9% of the patients (n = 19), whereas the MMSE was abnormal in 25.7% (n = 9).

Influence of age, sex, and education

Spearman rank correlations between 7MS total score and demographic characteristics in the control and cognitively intact patient group (n = 93) were substantial. The correlation with age was 0.64 ($p<0.001$; older persons performing worse); with sex, 0.31 ($p = 0.002$; women performing worse); and with education, −0.43 ($p<0.001$; persons with low education performing worse). For the MMSE the correlations were less marked: age, −0.42 ($p<0.001$); sex, −0.18 (NS); and education, 0.14 (NS).

Mean duration of the 7MS

The mean duration of the 7MS test administration was measured in 190 patients. Figure 3 shows the mean duration as a function of the MMSE scores. Patients with more severe cognitive decline needed a longer testing time. The mean duration in Alzheimer's disease patients (n = 63) was 15.6 (4.2) minutes. Intact subjects could be tested in 8.5 (1.3) minutes. The mean test duration was 12.4 (4.6) minutes.

DISCUSSION

In this study we corroborated the results of Solomon *et al*, showing that the 7MS had a sensitivity and specificity of 92.9% and 93.5% for Alzheimer's disease. In addition we showed that the 7MS also has a high diagnostic accuracy for dementia in general, but lacks specificity for other psychiatric disorders such as depression. The chief aim of cognitive screening is to detect dementia in an early stage. The MMSE is known to have a low sensitivity for mild forms of dementia.[15] Our findings show that the 7MS is superior in this respect.

The 7MS consists of four short tests, which can also be used as single instruments to detect dementia. The clock drawing test has become increasingly popular as a single test to detect dementia, with a mean sensitivity and specificity of 85% for diagnosing probable Alzheimer's disease.[16] However, the clock as a single test lacks capacity in very mild forms of dementia.[17] The verbal fluency test (animal category) as a single test is also often used, but it proved inferior in comparison with the MMSE in a study using ROC curve analysis.[18] The influence of age, sex, and education on MMSE scores has already been reported.[15] In contrast to Solomon's study, the 7MS appeared to be even more sensitive to these influences. However, given the high sensitivity and specificity, score corrections are probably not necessary, but this warrants further study.

We also found a longer average test duration than the seven minutes reported by Solomon *et al*. The increase in test duration in more severely affected patients was clearly evident. There was no difference in dementia severity between Solomon's study and our sample. The investigation method (allowing the patient more time to give an answer) could explain this difference. A longer test time has also been demonstrated in another validation study of the 7MS in Alzheimer's disease patients.[19]

A significant number of patients with depressive illness in our study proved to have cognitive problems. This was not only because of mental slowness (fluency task), but it was also clear on memory tasks (enhanced cued recall) and visuoconstruction (clock drawing). These patients did not meet the DSM-IV criteria for coexisting dementia at the time of diagnosis. This means that depression substantially influenced the test results. The occurrence of depressive symptoms in patients with mild cognitive impairment and dementia is well known[20 21] and there is an association between depressive symptoms and the development of Alzheimer's disease in the elderly.[22] Therefore we can assume that the abnormal 7MS results of these patients are not all false positives, and it is to be expected that a significant number of depressive patients will develop dementia after a certain time. Elderly people who present with cognitive disorders in late life depression are at high risk of developing dementia after treatment.[23] In the present study there was no systematic follow up of patients after treatment of their depression. At the time of screening it was not possible to predict which patients would go on to develop dementia in the future. This also holds true for patients with other psychiatric diseases, who had abnormal 7MS scores in more than half the cases. In this heterogeneous group of psychiatric diseases, the MMSE (using a cut off score of 23) showed fewer false positives. A possible explanation for this could be a greater appeal of the 7MS to mental concentration. This particularly applies for the memory tasks such as the enhanced cued recall, in which 16 items have to be remembered, whereas in the MMSE only three items have to be recalled freely. The clock drawing test also requires more mental concentration than copying a figure, which is used in the MMSE to test visuoconstruction.

If the clinician is not acquainted with the 7MS, the scoring system can appear difficult. The raw scores can be summed in the formula to calculate a total score, which is a predictor of having dementia. It is not always necessary to calculate the exact dementia risk in clinical practice. The raw scores themselves often predict whether the 7MS is positive or negative. If more than two of the subtests are abnormal, it is very likely that the 7MS is positive. If only one or two of the tests are (slightly) abnormal, calculation of the total score can be useful. Highly positive or negative scores are clinically irrelevant (such as scores more than 5 or less than −5), because the calculated risk approximates 1. The scoring can be simplified in a calculation table. We can supply more details on request.

From our study we conclude that the 7MS is a useful cognitive screening instrument. It is brief, tests several cognitive abilities, and shows high sensitivity and specificity for all dementias. However, specificity with regard to depression or other psychiatric conditions is poor, which may limit its use as a general screening instrument, although this needs further research. In our study the mean duration of the test was 12 minutes, which would suggest that the name is a little optimistic. The significant influence of age, sex, and education also deserves further investigation.

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