THE MINI-COG: A COGNITIVE ‘VITAL SIGNS’ MEASURE FOR DEMENTIA SCREENING IN MULTI-LINGUAL ELDERLY

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ABSTRACT

Objectives. The Mini-Cog, a composite of three-item recall and clock drawing, was developed as a brief test for discriminating demented from non-demented persons in a community sample of culturally, linguistically, and educationally heterogeneous older adults.

Subjects. All 129 who met criteria for probable dementia based on informant interviews and 120 with no history of cognitive decline were included; 124 were non-English speakers.

Methods. Sensitivity, specificity, and diagnostic value of the Mini-Cog were compared with those of the Mini-Mental State Exam (MMSE) and Cognitive Abilities Screening Instrument (CASI).

Results. The Mini-Cog had the highest sensitivity (99%) and correctly classified the greatest percentage (96%) of subjects. Moreover, its diagnostic value was not influenced by education or language, while that of the CASI was adversely influenced by low education, and both education and language compromised the diagnostic value of the MMSE. Administration time for the Mini-Cog was 3 minutes vs 7 minutes for the MMSE.

Conclusions. The Mini-Cog required minimal language interpretation and training to administer, and no test forms of scoring modifications were needed to compensate for the extensive linguistic and educational heterogeneity of the sample. Validation in clinical and population-based samples is warranted, as its brevity and ease of administration suggest that the Mini-Cog might be readily incorporated into general practice and senior care settings as a routine 'cognitive vital signs' measure. Copyright © 2000 John Wiley & Sons, Ltd.

KEY WORDS—dementia screening; MMSE; clock drawing; three-item recall; Cognitive Abilities Screening Instrument, CASI; education; language

INTRODUCTION

Practical screening for dementia in elderly populations requires very brief tests that can be applied in heterogeneous groups with little loss of perfor-

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Contract/grant sponsor: National Institute of Aging.
Contract/grant number: PS0 AG 05136.
Contract/grant sponsor: National Institute of Mental Health.
Contract/grant number: RO1 MH 57663.
Contract/grant sponsor: Parke-Davis.
Contract/grant sponsor: Health Resources and Services Administration.

formance. The diagnostic value of common screening instruments is adversely affected by age, education, or language biases (Teng et al., 1994; Mungas et al., 1996; Liu et al., 1994; Crum et al., 1993; Murden et al., 1991; Wind et al., 1997; Fratigioni et al., 1993; Tombaugh and McIntyre, 1992; Leopold and Borson, 1997), low sensitivity (Froehlich et al., 1999), or need for specialized training or equipment (Solomon et al., 1998), all of which limit their effectiveness as first-stage screening procedures in general practice and community settings. A brief test that is unbiased by education and language variations, requires no special equipment and little training to use, and classifies subjects with high sensitivity and specificity, could contribute substantially to dementia detection.
The available brief measures share many of the limitations of longer tests. A short form of the CASI is unbiased by education (Teng et al., 1994), but, like the MMSE and full CASI, requires testers highly fluent in the patient’s language. A recently developed cognitive screen which requires about 8 minutes to administer discriminates well between non-demented persons and Alzheimer’s disease patients (Solomon et al., 1998), but requires the use of 16 picture cards by a trained examiner, and has been validated only in English-speaking, relatively well-educated persons. Short screens requiring no special equipment, such as spelling ‘world’ forward and backward and sorting the letters alphabetically (Leopold and Borson, 1997), or telling time and making change (Froehlich et al., 1999), demand a shared language. The time and change test is further limited by low sensitivity relative to specificity, and its validity depends on familiarity with American coins, which limits its use with recent immigrants. The clock drawing task (CDT), administered and scored by varying methods, has acceptable sensitivity as a first-level dementia screening test (Watson et al., 1993; Shulman et al., 1986; Das-toor et al., 1991; Tuokko et al., 1992; Death et al., 1993). Most studies of the CDT are limited by the relative demographic homogeneity of their subjects and by the need for special administration forms and complex scoring rules that are difficult to apply outside research settings. We have used a very brief free-hand version that can be scored without reference to detailed rules, requires little language interpretation for use in diverse ethnolinguistic groups, and is superior to the MMSE in predicting dementia in poorly-educated non-English speakers (Borson et al., 1999). However, its overall sensitivity is not optimal (79%) and it lacks a test of new learning, a principal criterion for diagnosis of dementia. We sought to enhance its effectiveness by adding a simple three-item memory task to create a composite screening instrument, the Mini-Cog.

This report compares the performance of the Mini-Cog to the MMSE and the CASI in a sample of community elderly with highly heterogeneous ethnic, educational, and linguistic characteristics. We hypothesized that the addition of the three-item memory task to the CDT would improve sensitivity to the level achieved by longer measures (MMSE and CASI) with less testing time, and that its performance would be robust despite education or language differences.

METHODS

Subjects

The sample included 249 older adults (173 women, 76 men) identified through community-based social services agencies and evaluated in the University of Washington Alzheimer’s Disease Research Center. Ethnicities included non-Hispanic white (n = 31), white Hispanic (n = 24), Asian Pacific Islander (n = 114), African American (n = 61), Native American (n = 18), and mixed (n = 1). One hundred and twenty-five spoke English as their primary language, and 124 spoke Spanish, Korean, or a Chinese or Filipino dialect. Subjects with a history of severe brain injury, CNS infection, active alcohol/drug abuse, poorly controlled diabetes, or kidney, heart, or respiratory failure were excluded. All subjects or their proxies gave written informed consent using a multiple-language protocol approved by the University of Washington IRB. For comparison of testing times for the Mini-Cog and MMSE, an independent sample of 44 older adults was tested by a single rater blind to subjects’ clinical characteristics.

Evaluations

Subjects were evaluated with a knowledgeable informant (usually a family member) using a protocol slightly modified from that of the Consortium to Establish a Registry for Alzheimer’s Disease (CERAD; Morris et al., 1989) employing its structured dementia history format for non-physician raters, the Clinical Dementia Rating scale (CDR; Hughes et al., 1982), and an abbreviated cognitive assessment including the CDT, MMSE, and CASI administered in that order in subjects’ primary spoken languages. For non-English speakers, foreign-born native speakers also fluent in English were trained to administer cognitive tests and all met formal competency criteria.

Based on the informant’s history of cognitive decline and current functioning (information readily obtainable during a clinical interview), subjects were classified as probably demented (n = 129) or probably non-demented (n = 120) without consideration of their scores on formal cognitive tests. Using all available cognitive, medical, and laboratory data, subjects were subsequently classified as having probable or possible Alzheimer’s disease (AD) another specific dementia, or no dementia using CERAD, DSM-IV (American Psychiatric Association, 1994), and NINCDS-ADRDA.
McKhann et al., 1984) criteria; subjects with uncertain or very mild cognitive impairment (CDR 0.5) were excluded from the present analyses. Post hoc dementia diagnoses were probable AD in 92 (71%), possible AD (mixed states, usually AD plus clinically significant vascular brain disease) in 16 (12%), vascular dementia in 13 (10%), and other dementias in 8 (6%).

The CDT was scored with reference to CERAD templates (described in Borson et al., 1999) by two independent raters blind to all other data, yielding four possible scores (0 = normal to 3 = severe impairment; reliability intra-class correlation = 0.97). Data were reduced to simple binary scores (0 = normal, 1–3 = abnormal) for predictive analyses. We considered the CDT normal if all numbers were present in the correct sequence and position, and the hands readable displayed the requested time. The Mini-Cog was constructed by combining the CDT with uncued three-word recall derived from the CASI. To assess testing time, 33 elderly subjects (15 with a variety of dementing disorders, 17 with depression or anxiety or who were caregivers) were asked to repeat three unrelated words (possible score 0–3), then to draw a clock (scored as normal or abnormal), which served simultaneously as the recall distracter, and then to recall the three previously-presented items (scores 0–3). The same subjects were then given the MMSE using a different set of three registration and recall items to reduce practice effects.

Data analyses

ANOVA and chi square tests were used to compare demented and non-demented subjects on demographic variables and cognitive test scores. Chi square tests were used to determine sensitivity and specificity of each screen for clinically-defined probable dementia. Conventional cut-off points were used for the MMSE (23–24/30) (Folstein et al., 1975) and CASI (80–81/100) (Teng et al., 1994). An optimal classification algorithm for the Mini-Cog was empirically derived from the data set (Scanlan and Borson, submitted) and its sensitivity and specificity were compared with those of the MMSE and CASI. Logistic regression was used to compare the different cognitive tests for educational and linguistic biases. Post hoc chi square tests were then applied to determine whether the superior predictive value of the Mini-Cog was maintained when subjects were grouped by final diagnosis [Alzheimer’s disease (n = 97) and other dementias (n = 32)].

RESULTS

Demographic and cognitive characteristics of ADRC sample

Demented subjects were older than non-demented [mean age 77.9 ± 9.1 vs 69.0 ± 9.0, F(1,247) = 61.3, p < 0.001] and less well educated [mean years 9.8 ± 9.4 vs 12.9 ± 4.3, F(1,247) = 11.2, p < 0.001], but equivalent in gender composition (74 vs 65% women, p > 0.05) and proportion who spoke a language other than English (51 vs 50%, p > 0.05). English and non-English speakers did not differ in mean years of education or percentage demented. As expected, mean scores on the CDT, three-item RECALL, MMSE and CASI were significantly lower in demented than non-demented groups on the CDT (1.9 ± 1.2 vs 0.1 ± 0.5); three-item recall (0.2 ± 0.5 vs 2.4 ± 0.8); MMSE (14.1 ± 6.7 vs 27.5 ± 2.4); and CASI (51.0 ± 20.0 vs 91.0 ± 6.1), all p < 0.001.

Mini-Cog: scoring algorithm

Cross-tabs of classification by CDT (normal vs abnormal) and three-item memory (0–3) scores and methods for combining them into a single instrument, the Mini-Cog, were examined (Table 1). Using this information, various classification rules were tested on the entire sample and yielded a simple decision tree (Fig. 1; Scanlan and Borson, submitted). The optimal algorithm had the following three rules: subjects recalling none of the words were classified as demented; those recalling all three words were classified as non-demented; and those with intermediate word recall (1–2) were classified based on the CDT (abnormal = demented, normal = non-demented).

Efficacy of screening tests in classifying subjects (Table 2)

The Mini-Cog ranked first among the three tests in sensitivity (99%) and diagnostic value (96%) and had acceptable specificity (93%), but was less efficient than the CASI in classifying non-demented subjects (96%). The MMSE was the least sensitive (91%) and specific (92%). Examination of the Mini-Cog’s two component tests shows that its most powerful element is the three-
Table 1. Correct classification of subjects by three-item recall and CDT scores (frequency and %)

<table>
<thead>
<tr>
<th>Number of words correctly recalled</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDT score</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 ND (%)</td>
<td>3</td>
<td>9</td>
<td>34</td>
<td>65</td>
</tr>
<tr>
<td>D (%)</td>
<td>27</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1 ND (%)</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>D (%)</td>
<td>90</td>
<td>4</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

CDT: 0 = normal, 1 = abnormal.
Bold type represents subjects judged demented by the algorithm. Italic type represents subjects judged non-demented by the algorithm.

Fig. 1. Mini-Cog scoring algorithm

item recall, but that addition of the CDT improves both sensitivity and diagnostic value.

Comparative test performance: logistic regressions (Table 2)

Logistic regressions examined the performance of the different cognitive screens and the influence of education and language on classification. In these analyses, classification was coded as 1 (demented) or 0 (non-demented) and used as the criterion variable. Preliminary analyses including all measures in a single regression showed that the Mini-Cog was first to enter the equation; subsequent analyses were done on each measure separately to avoid multicolinearity. The relative ranks (chi square) of the three measures in predicting dementia corresponded to the ranking based on percentage correctly classified. Significant differences between measures were found for all paired test comparisons.

The effects of education and primary language
on each test were then examined, first forcing the test into the analysis, then allowing years of education or English-speaking status (yes/no) to enter. The predictive power of the Mini-Cog or of its components was not improved by inclusion of education as a modifying variable. In contrast, education had borderline effects \((0.10 > p > 0.05)\) on the classificatory power of the full CASI and MMSE. Only the MMSE was significantly influenced by the subjects’ language (English/non-English).

**Confirmatory post hoc evaluation of tests by dementia diagnosis**

Tests were compared in controls vs subjects with a post hoc criterion-based diagnosis of probable AD and other dementias. The Mini-Cog correctly identified all 92 subjects with probable AD and 36/37 with other dementia diagnoses (possible AD, vascular dementia, or other). Chi squares for probable AD vs controls were 234.4 for the Mini-Cog, 198.0 for the CASI, and 145.3 for the MMSE. For other dementia diagnoses vs controls, chi squares were 118.3 for the Mini-Cog, 113.6 for the CASI, and 96.6 for the MMSE (all \(p < 0.001\)). These analyses lend additional weight to the validity and relative superiority of the Mini-Cog in the highly heterogeneous sample studied here.

**Test time for the Mini-Cog and MMSE**

Administration time for the Mini-Cog given as a single test was \(3.2 \pm 2\) minutes \((3.7 \pm 2\) for demented, \(2.5 \pm 1\) for non-demented subjects), while the MMSE required \(7.3 \pm 5\) minutes \((8.5 \pm 5\) for demented, \(5.6 \pm 3\) for non-demented subjects).

**DISCUSSION**

The hypotheses were supported. Addition of a brief memory task to the CDT resulted in superior prediction of dementia status relative to the CDT alone (Borson et al., 1999) and the CASI and MMSE. Testing time was less than half that required for the MMSE and less than one-sixth of that reported for the CASI (Teng et al., 1994). No education or language bias was found for the Mini-Cog, in contrast to the CASI and MMSE in the present and previously cited studies. The Mini-Cog appears to have specific advantages over other very short screens when data from this study are compared with published findings. It is more sensitive and specific than the time and change test, less time-, equipment-, and training-intensive than the 6-minute screen, and highly accessible to persons with low education and to non-English speakers. Its cost in materials (paper and pencil) is negligible. In addition, the Mini-Cog appears highly acceptable to patients and families; subjects were readily engaged in its performance, whereas the MMSE and CASI frequently caused distress and temporary derailment when demented persons failed items early in testing. Finally, the Mini-Cog produces a visible performance indicator (a clock face) that conveys information not revealed by numerical scores alone, reducing the risk that poor test performance could be due to inadequate test administration in non-research settings.

Some limitations of this work must be noted. Thus far, the Mini-Cog, like the 7-minute screen (Solomon et al., 1998) has been examined only in samples highly enriched for demented cases, which inflates the performance of all cognitive screening tests. Assessment of its field utility requires inde-
dependent validation of its performance characteristics and scoring algorithm in population-based samples. The component of the Mini-Cog most vulnerable to varying interpretations is the CDT scoring method, which relies on the examiner’s global judgement of clock integrity; we are encouraged by preliminary analyses showing that agreement between ratings by researchers and test-naive, untrained individuals was >90%. The use of informant-based history and functional data to classify subjects carries a potential risk of misclassification when the informant’s appraisal of cognition is inaccurate. However, a similar approach has been validated (Jorm, 1997) as a first-line dementia detection strategy, and for purposes of test construction, this method escapes the circularity that results from examining a screen in subjects classified by another cognitive test that includes overlapping items (such as word recall). Moreover, post hoc tests in subjects grouped by final dementia diagnosis suggest that the initial grouping into ‘probably demented’ and ‘probably non-demented’ based solely on historical information about cognition and function was a reasonable choice.

Strengths of this study are its heterogeneous sample composition, including persons with widely varying ethnocultural and language backgrounds, educational histories (0–16+ years), occupational attainment (labourer to professional), dementia severities (mild to severe), and etiological diagnoses, and the use of trained bilingual interpreters to administer cognitive tests in the several primary languages represented. In this highly diverse sample, the Mini-Cog performed very well, surpassing the MMSE and CASI on criteria of simplicity, brevity, sensitivity, low cost in materials, testing and training time, and subject acceptability. The excellent performance of the three-item memory task by itself is notable. This single component of the Mini-Cog classified subjects about as well as the full CASI, had excellent specificity, and accounted for most of the power of the Mini-Cog. However, its sensitivity as a sole screening test was considerably lower than that of the Mini-Cog. The hazard of expensive and unnecessary work-up for dementia in subjects with false positive Mini-Cog screens is likely to be minimal in actual practice.

In population-based screening, a reasonable second step is confirmation of progressive deficits by informant-based methods prior to initiation of a full-scale dementia work-up. It should be noted that the Mini-Cog, like other screening tests, cannot be substituted for diagnostic evaluation based on multiple sources of information and thoughtful clinical judgment.

Provided its sensitivity remains robust when challenged in population-based samples, the advantages of the Mini-Cog could make widespread dementia screening of heterogeneous populations practical and cost-effective. The total time required to screen a community population of 1000 elderly persons using the Mini-Cog, MMSE and CASI would be 50, 117, and 300 hours, respectively. If used by physicians to screen 1000 elderly patients per year at a cost of US$1/minute, the total costs of screening would be US$3000 (Mini-Cog), US$6990 (MMSE), and US$18 000 (CASI). However, actual Mini-Cog costs might be still lower. Because of its simplicity and minimal training requirements, non-physicians can perform this test, reducing costs by at least 50%, and yielding high-sensitivity dementia detection for US$1.50 per person (Mini-Cog) vs lower-sensitivity detection for US$7 (MMSE) or US$18 (CASI).

The argument for dementia screening has become compelling with the emergence of useful treatments and the promise of meaningful strategies for delaying dementia progression. Simple screens such as the Mini-Cog help improve dementia detection and thereby promote the health and welfare of an aging population. Its use in under-served as well as mainstream communities may help to promote parity in health care access and participation in research on new therapies.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the consultative contributions of E. Teng and the invaluable assistance of S. Neher, J. Cashman, M. McLaughlin Sta Maria, J. Roques, E. Gil, D. Beekly, R. Barnhart, G. van Belle, and the staff of the Chinese Information and Service Center and Sea Mar Community Care Center, Seattle, WA, the Korean Women’s Association, Tacoma, WA, and the Washington State Aging and Adult Services Administration.

Supported by grants from the National Institute of Aging [P50 AG 05136, Alzheimer’s Disease Research Center Satellite Core (S. Borson)], National Institute of Mental Health (RO1 MH 57663, P. Vitaliano), Parke-Davis (S. Borson) and the Health Resources and Services Administration (Respite Care Demonstration Project for Under-
served Elders with Alzheimer’s Disease, Washington State Aging and Adult Services Administration).

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