A Short Screening Instrument for Poststroke Dementia
The R-CAMCOG

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Background and Purpose—The CAMCOG is a feasible cognitive screening instrument for dementia in patients with a recent stroke. A major disadvantage of the CAMCOG, however, is its lengthy and relatively complex administration for screening purposes. We therefore developed the Rotterdam CAMCOG (R-CAMCOG), based on the original version. Our aim was to reduce the estimated administration time to 15 minutes or less and to retain or perhaps even improve its diagnostic accuracy.

Methods—We analyzed the item scores on the CAMCOG of 300 consecutive stroke patients, after exclusion of patients with a severe aphasia or lowered consciousness level, who were entered in the Rotterdam Stroke Databank. The diagnosis of dementia was made independent of the R-CAMCOG score, on the basis of clinical examination and neuropsychological test results. The R-CAMCOG was constructed in 3 steps. First, items with floor and ceiling effects were removed. Next, subscales with no additional diagnostic value were excluded. Finally, we removed items that did not contribute to the homogeneity of the subscales. The diagnostic accuracy of the R-CAMCOG and the original CAMCOG was determined by means of the area under the receiver operating characteristic (ROC) curve.

Results—In the 3 steps, the number of items was reduced from 59 to 25, divided over the subscales orientation, memory (recent, remote, and learning), perception, and abstraction. The subscale orientation did not reach significance in a logistic regression model but was included in the R-CAMCOG because of its high face validity in dementia screening. Internal validation with ROC analysis suggests that the R-CAMCOG and the CAMCOG are equally accurate in screening for poststroke dementia (area under the curve was 0.95 for both tests).

Conclusions—The R-CAMCOG has overcome the disadvantages of the original CAMCOG. It is a promising, short, and easy-to-administer screening instrument for poststroke dementia. It seems to be sufficiently accurate for this purpose, but the test has yet to be validated in a separate, independent study. (*Stroke*. 2000;31:1502-1508.)

Key Words: dementia ■ dementia, vascular ■ stroke

Cerebrovascular disease, in particular stroke, is a major cause of dementia.[1–3] From both a clinical and research perspective, it is therefore important to assess cognitive functioning after stroke. An extended neuropsychological examination, however, may not be necessary in all patients to establish a diagnosis and will be time consuming and costly. On the other hand, brief mental status tests that have been developed to detect dementia compatible with Alzheimer's disease are often not sensitive enough to detect the specific and heterogeneous cognitive disturbances seen in poststroke dementia. Another drawback of these tests is that they rely heavily on language, often contain constructional items, and tend to disregard subcortical disturbances.[4]

The CAMCOG, the cognitive and self-contained part of the Cambridge Examination for Mental Disorders of the Elderly (CAMDEX),[5,6] was developed primarily to detect cognitive disturbances compatible with Alzheimer's disease. Previous studies have nevertheless shown that the CAMCOG is a feasible test for dementia in a stroke population.[7,8] We studied its utility as a screening instrument for dementia in a stroke population and found that the CAMCOG was more accurate than the Mini-Mental State Examination (MMSE). The diagnostic accuracy of the CAMCOG could even be improved when type and site of stroke were taken into account.[8]

A major disadvantage of the CAMCOG, however, is its lengthy administration time for the purpose of screening, by a physician, for dementia in a clinical setting. We therefore adapted and modified the CAMCOG with 2 aims: to reduce its administration time from 25 minutes to approximately 10 minutes and to retain or perhaps even improve its diagnostic accuracy. The results of the present study are based on analyses of the individual items of the CAMCOG performed in a cohort of 300 consecutive stroke patients entered in the Rotterdam Stroke Databank.

Subjects and Methods

Patients

Patients were recruited from the Rotterdam Stroke Databank, a prospective registry of patients with transient ischemic attack, ischemic stroke, or primary intracerebral hemorrhage, who were admitted to the Department of Neurology of the University Hospital Rotterdam. From March 1, 1993, until January 15, 1996, all consecutive patients who met the criteria for enrolment in The Dutch Vascular Factors in Dementia study were included in the present study.[3] Patients had to be aged ≥55 years and experienced a transient ischemic attack, ischemic stroke, or intracerebral hemorrhage. Patients were excluded when a reliable assessment of dementia could not be made because of aphasia (ie, a score of <3 on the Aphasia Severity Rating Scale from the Boston Diagnostic Aphasia Examination [BDAE]),[9] severe sensory handicaps (eg, deaf or blind), lowered consciousness level, severe psychiatric symptoms, or insufficient command of the Dutch language. Additional reasons for exclusion were a concomitant primary cerebral disorder (eg, parkinsonism) or severe comorbidity with a short life expectancy. Informed consent was obtained from all patients or from close relatives in case of impaired judgment. The local Medical Ethics Committee approved of the study.

Procedure

During hospital admission, we obtained detailed information about cardiovascular risk factors, stroke characteristics, and premorbid mental and physical status. This procedure has been described in detail elsewhere.[8] In addition to a full neurological examination, ancillary investigations consisted of standardized blood tests, chest x-ray, CT scanning and/or MRI of the brain, duplex scanning of the carotid arteries, and a cardiac analysis. Premorbid cognitive functioning was established by an interview with a close relative and the score on the Blessed dementia scale. Between 3 and 9 months after stroke onset, general and cognitive functioning was assessed, and blood and urinary samples were taken. A neurologist who also obtained information about actual cognitive functioning performed the neurological examination. On the basis of clinical presentation, information from a close relative, and the score on the Blessed dementia scale, judgment of cognitive functioning was made by behavioral neurologists and a neuropsychologist. We used the Aphasia Severity Rating Scale of the BDAE to assess the presence and severity of aphasia. A score of 6 indicates no aphasia, and scores of 5,4, and 3 indicate mild to moderate aphasia. Education was categorized by years of schooling completed. An extended neuropsychological examination was carried out in all patients who presented with cognitive complaints or when a close relative mentioned a decline in cognitive functioning. An extended neuropsychological examination was also indicated when the investigators suspected a change in cognitive functioning, even when the patient or close relative had no complaints. Therefore, in all patients in whom there was any suspicion of dementia or cognitive decline, an extended neuropsychological examination was carried out. When patients could not be tested because of cognitive deficits or somatic handicaps or when they refused to cooperate, extended neuropsychological evaluation was not performed. In some patients, only a limited number of tests could be administered. The extensive neuropsychological examination consisted of an intelligence test: either the shortened version of the Groninger Intelligence Test,[10] a Dutch intelligence test, or when this was not administrable, Raven's Colored Matrices,[11] a nonverbal intelligence test. The shortened form of the Boston Naming Test (CERAD)[12] was used to examine word-finding difficulties. Memory was evaluated with Word List Memory (CERAD)[12] and the Rivermead Behavioral Memory Test[13] We used Digit Span forward and backward (WAIS)[14] to assess the span of immediate verbal recall but also as a measure for attentional capacity. Parts of the Trail-Making Test,[15] and the Stroop Color Word Test[16] too were used to examine attention. Scores on verbal fluency (animals, occupations, letter B), Stroop Color Word Test part III,[16] Trail-Making Test B,[15] served as indication for the level of executive functioning. Proverbs and similarities (WAIS)[14] provided a measure for abstraction and verbal concept formation. Visuoconstructive ability was examined by copying the drawing of a circle, diamond, 2 overlapping rectangles, and a cube (CERAD).[12] Visual perception and spatial orientation were examined by Judgment of Line Orientation.[17] Furthermore, in all patients the MMSE and the Geriatric Mental Status[18] and the Dutch version of the cognitive and self-contained part of the CAMDEX (the CAMCOG) was administered.[6] These tests did not act as screening tools but were administered to standardize the procedure as much as possible with the twin population-based part of the study, the Rotterdam Study.[19] Although test behavior during the administration of the CAMCOG may have played a role in judgment of cognitive functioning, the actual test scores were not taken in account. A psychiatric examination was performed in all demented patients to assess the presence of depression.

On the basis of clinical presentation, information from a close relative, score on the Blessed dementia scale, and the neuropsychological test results, a final judgment of cognitive functioning was made by a diagnostic panel consisting of 2 neurologists, a neuropsychologist, and a trained physician. For the assessment of dementia, the criteria of the DSM-III-R[20] were used. In short, according to these criteria there has to be a demonstrable evidence of impairment in both short-term and long-term memory and disturbances in at least 1 other cognitive domain (ie, impairment in abstract thinking, impaired judgment, other disturbances in higher cortical functioning, such as aphasia, agnosia, apraxia, or a personality change). The disturbances should be severe enough to interfere with daily functioning and not occur exclusively during the course of delirium.

Further differentiation of dementia took place according to the research criteria of the NINDS-AIREN International Workshop for vascular dementia.[21] Patients were diagnosed as suffering from a probable vascular dementia, possible vascular dementia, or possible Alzheimer's disease (AD) with cerebrovascular disease (CVD). This latter category was reserved for patients fulfilling the clinical criteria for possible AD and also presenting clinical or brain imaging evidence of relevant CVD. The severity of dementia was assessed by the Global Deterioration Scale[22] and the Clinical Dementia Rating.[23]

Construction of the R-CAMCOG

The original CAMCOG contains 67 items, 8 of which are not included in the actual CAMCOG score. Five of these 8 items are included for assessment of the MMSE score; the other 3 items are optional and do not affect the total CAMCOG score. The remaining 59 items, divided over 11 subscales, make up the CAMCOG score. Thirty-nine items are scored as right or wrong. Eleven items are gradual scores in which an answer can be wrong, right to a certain degree, or completely right. The remaining 9 items are made up of more questions or commands, and the "item score" is the sum of the number of right answers. In line with the results of a previous study, we assigned zero scores to all items that could not be administered due to upper extremity paresis.[24] Items that were deemed inassessable because of other factors (eg, illiteracy or severe visual disturbances) were regarded as missing values and therefore not included in the statistical analyses.

The construction of the R-CAMCOG took place in several steps (Figure 1.). The methodology and strategy was partly adapted from van Straten et al, who adjusted the Sickness Impact Profile to a stroke population.[25]

In the first step we excluded the items that were considered to provide ceiling or floor effects. When >95% of the patients gave the right response to an item, we considered this a ceiling effect; when <5% of the patients gave the right answer to a question, this was considered a floor effect. In the second step we excluded the shortened subscales that had no additional diagnostic value. We carried out a multiple logistic regression analysis, with the presence of dementia as dependent and the shortened subscales as independent covariates In a stepwise backward elimination procedure, the subscales with the highest diagnostic value were selected (P to enter 0.10, P to exit 0.15). In the final step we excluded items that did not contribute to the statistical coherence of a subscale. The mean
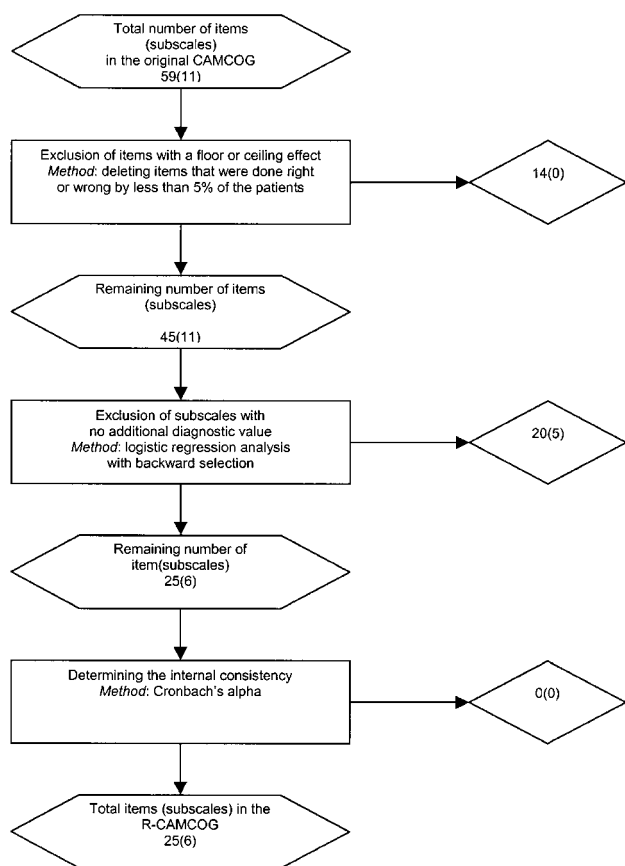
Figure 1. Steps in the construction of the R-CAMCOG.

interitem correlation in each subscale, to be interpreted as internal consistency, was determined by means of Cronbach's α.[26]

We determined the (clinical) validity of the R-CAMCOG on the original study population. In the multiple logistic regression model, the total CAMCOG score was correlated to the likelihood of dementia. The dependent factor was the presence of dementia, and the independent factor was the total CAMCOG score. Receiver operating characteristic (ROC) analysis was performed to assess and compare the diagnostic accuracy of the 2 tests by calculating the area under the curve.

All statistical analyses were carried out with Stata Software.[27]

Results

During the study period 825 patients entered the Rotterdam Stroke Databank. Of these patients, 198 were excluded because they were aged <55 years, 122 had died, and 42 had experienced a TIA with no neurological signs on examination. Of the remaining 463 patients, 41 had a severe aphasia (ie, BDAE score of <3) and 76 were excluded for several other reasons (ie, lowered level of consciousness, severe sensory handicaps, or insufficient command of the Dutch language). Furthermore, 46 patients refused to participate in the study. From the 300 patients who met the criteria for inclusion in the Dutch Vascular Factors in Dementia Study, 16 were excluded from the present study because the CAMCOG could not be administered due to severe dementia. All 300 patients, however, had a detailed dementia assessment. The baseline and demographic characteristics of the patients of the study population are shown in Table 1. The mean age was 70 years, and 40% of the patients were female. Approximately one

sixth had had a TIA and approximately 10% had had an intracerebral hemorrhage. Right hemispheric stroke was slightly more common than left hemispheric stroke (47% versus 41%). Approximately one quarter of the patients had arm paresis and 7% had aphasia. Demented patients were on average 5 years older than nondemented patients and had on average 1.4 years less education. Demented patients had more often had a right hemispheric stroke or an infratentorial stroke than nondemented patients. Whether this finding is related to the exclusion of severe aphasic patients has been discussed extensively in a previous study.[8]

In the first step of the construction of the R-CAMCOG, the exclusion of items with a ceiling effect, we excluded 14 items that were failed by <5% of our total study population. Most of the items that were removed were part of the subscale language, in particularly comprehension (Table 2). There were no items with a floor effect in the scores. The exclusion of items with a ceiling effect did not affect the number of subscales. In the second step we excluded the subscales with the lowest diagnostic value (Table 3). In the stepwise logistic regression with a backward selection on the 11 subscales, the shortened subscales orientation, language (comprehension and expression), attention, praxis, and calculation were excluded, and abstraction, perception, and all 3 memory subscales were retained.

All subscales showed a high average interitem correlation and scale reliability coefficient, except for the subscale perception. This may be explained by the fact that this subscale is divided into 2 presumably distinct cognitive domains, tactile and visual perception. Therefore, the low inter-item correlation has no implications for the validity of the test, and the subscale perception was included in the R-CAMCOG.

The shortened subscale orientation did not reach significance in the logistic regression model but was included in the R-CAMCOG because it has high face validity in dementia screening. The final version of the R-CAMCOG (Appendix) contained 25 items divided over 6 subscales: orientation, memory (recent, remote, and learning), perception and abstraction. Some items, such as naming of objects and writing an address, were included because they were required to test recall in the memory subscale. These items, nevertheless, were not included in the R-CAMCOG score.

We compared the diagnostic accuracy of the original CAMCOG and the R-CAMCOG on the original data that were used to construct the R-CAMCOG (Figure 2.). ROC analysis suggests that the R-CAMCOG is equally accurate in screening for poststroke dementia (area under the ROC curve for both the original CAMCOG and R-CAMCOG: 95%). The sensitivity and specificity at the optimal cutoff point is equal for the CAMCOG and the R-CAMCOG (CAMCOG cutoff point 77, sensitivity 91%, specificity 88%; R-CAMCOG cutoff point 33, sensitivity 91%; specificity 90%). The diagnostic accuracy improved slightly when site and type of stroke were taken into account (area under the curve for both the original CAMCOG and R-CAMCOG: 96%), similar to the results of our previous study.

TABLE 1.   Baseline Characteristics of the Study Population

	Total Study Group (n=284)	Not Demented (n=229)	Demented (n=55)
Age*	69.2 (8.1)	68.2 (8.0)	73.0 (7.3)‡
Years of education*	8.7 (3.1)	9.0 (3.0)	7.6 (2.9)§
Female sex†	114 (40)	84 (37)	30 (55)‖
CAMCOG*	83.3 (14.1)	88.2 (8.7)	63.2 (14.1)‡
MMSE*	25.4 (4.3)	26.7 (2.7)	19.9 (5.2)‡
Type of stroke†			
TIA	46 (16)	43 (19)	3 (5)
Cerebral infarction	203 (71)	164 (71)	39 (71)
Intracerebral hemorrhage	35 (12)	22 (10)	13 (24)§
Site of stroke†			
Right hemisphere	133 (47)	104 (45)	29 (53)
Left hemisphere	116 (41)	100 (44)	16 (29)
Infratentorial	35 (12)	25 (11)	10 (18)
Dementia type†			
Possible VaD			5 (9)
Probable VaD			35 (64)
Possible AD+CVD			15 (27)
Aphasia†	19 (7)	16 (7)	3 (5)
Apraxia†	9 (3)	3 (1)	6 (11)§
Any arm paresis†	69 (24)	49 (21)	20 (36)‖

VaD indicates vascular dementia; AD+CVD, Alzheimer's disease with cerebrovascular disease.
*Values are means with standard deviations in parentheses.
†Values are number of patients with (column) percentages in parentheses.
‡Demented patients significantly different from nondemented patients (p<0.001).
§Demented patients significantly different from nondemented patients (p<0.01).
‖Demented patients significantly different from nondemented patients (p<0.05).

Discussion

In this study, we have developed a short and feasible screening instrument for poststroke dementia, the R-CAMCOG, based on the original CAMCOG. We analyzed the individual item scores of the CAMCOG of 300 consec-utive stroke patients of the Rotterdam Stroke Databank, who were aged ≥55 years, without severe aphasia or sensory handicaps, and with a normal consciousness level. In 3 steps, the number of items was reduced from 59 to 25, divided over the subscales orientation, memory (recent, remote, learning),

TABLE 2.   Distribution of the Items and Subscales in the CAMCOG and the R-CAMCOG

Subscales	CAMCOG	Step 1: Exclusion of Items With Ceiling Effect	Step 2: Exclusion of Least-Relevant Subscales	Step 3: Internal Consistency	R-CAMCOG
Orientation	10	2	8	8	8
Language					
Comprehension	9	6	3	3	
Expression	8	2	6	6	
Memory					
Learning	3		3	3	3
Recent	4	1	3	3	3
Remote	6	1	5	5	5
Concentration	2		2	2	
Praxis	8	1	7	7	
Calculation	2		2	2	
Perception	3	1	2	2	2
Abstraction	4		4	4	4
Number of items (subscales)	59 (11)	14 (0)	45 (11)	20 (5)	25 (6)	0 (0)	25 (6)

TABLE 3. Relationship of CAMCOG Subscales to the Probability of Dementia in a Multiple Regression Model After Backward Elimination of the Subscales

	OR	95% CI	*P*
Orientation	0.99	0.63–1.56	0.97
Memory			
Learning	0.46	0.34–0.60	0.00
Recent	0.57	0.32–1.03	0.06
Remote	0.77	0.53–1.10	0.15
Abstraction	0.74	0.58–0.93	0.01
Perception	0.64	0.43–0.96	0.03

perception, and abstraction. The administration time was reduced to approximately 10 minutes. Analyses in our original study population showed that the sensitivity and specificity were high and generally equal for the original CAMCOG and the R-CAMCOG.

To our knowledge, no dementia screening instruments have been developed especially to screen for poststroke dementia. Some existing mental status tests, however, have been used and studied for this purpose. The MMSE is still a frequently used test in patients with a recent stroke but has several disadvantages because of its emphasis on language and constructional items. We compared the MMSE to the

Figure 2. ROC curves to determine the diagnostic accuracy of the original CAMCOG and the R-CAMCOG.

CAMCOG in the Dutch Vascular Factors in Dementia Study and found that it was a less-accurate screening instrument than the CAMCOG.[8] Tatemichi et al[28] used the MMSE as a screening instrument and found that it can be of use when adjustments are made for the high rate of false-positive scores however, an independent, prospective evaluation has not been carried out. Grace et al[29] performed a study in a geriatric stroke population, in which the original MMSE was compared with a modified version, the 3 MS. In this study the 3 MS was not better than the MMSE in diagnosing dementia. Thus, with its longer administration time, the 3 MS had no clear advantage in clinical use in a geriatric stroke population.

Two other neuropsychological instruments that have been used in a stroke population, the Neurobehavioral Cognitive Status Examination[30] and the Mattis Dementia Rating Scale,[31] are also classified as screening instruments. Considering the structure of these tests and the administration time, however, these tests are in fact microbatteries and, in our opinion, do not serve the purpose of a dementia screening instrument

Previously, we found that the CAMCOG is a feasible screening instrument in a stroke population,[8] which confirmed an earlier study.[7] Nevertheless, the CAMCOG still has drawbacks when applied in patients with a recent stroke. The CAMCOG contains items that seem inassessable in some stroke patients due to upper extremity paresis or aphasia; this will lead to missing values. Recently, we studied the significance of missing values due to upper extremity paresis and concluded that this does not affect the discriminatory ability of the constructional items of the CAMCOG.[24] Another major drawback of the CAMCOG is its lengthy and relatively complex administration. In the R-CAMCOG, these disadvantages have been overcome.

The domains and items of the R-CAMCOG overlap with other dementia screening instruments, such as the MMSE,[32] 3 MS,[33] and the short Blessed Test.[34] All mental status tests contain orientation and memory questions. In our study, the subscale orientation did not reach significance in a stepwise logistic regression analysis, but we included the orientation items because of their high face validity in clinical settings.[4,35] Memory items are also represented in virtually all dementia screening instruments, but the extent to which memory is measured varies distinctively between the different tests. An advantage of the R-CAMCOG is that it emphasizes memory, by definition the most important feature of dementia. The R-CAMCOG, however, examines different aspects of memory and is therefore better able to detect subcortical features of memory disturbances, as can be seen in poststroke dementia. In the R-CAMCOG, visual and verbal memory are tested, with a recall measure and a recognition condition to distinguish learning from retrieval deficits. Memory for remote and recent facts is also included in the R-CAMCOG.

Decreased abstraction is recognized as a possible feature of dementia, yet most mental status tests tend to neglect this ability. In the R-CAMCOG, the level of abstraction is measured by means of similarities.

The subscale perception of the R-CAMCOG includes tactile perception of coins and recognition of objects from an
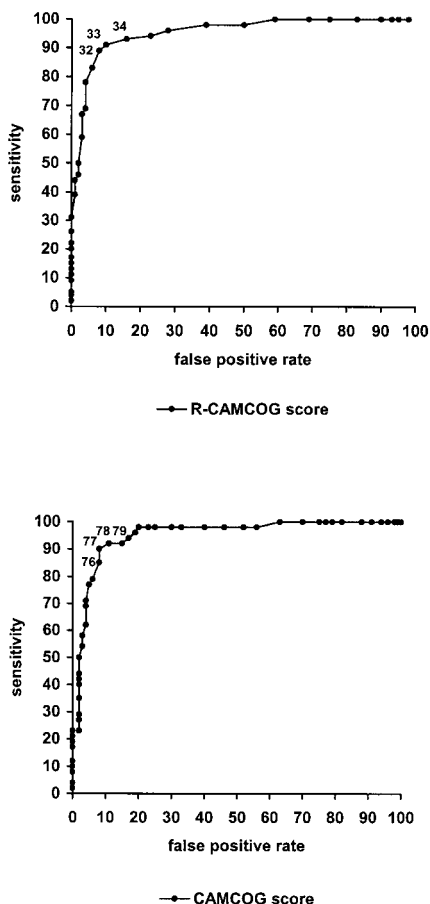
unusual view. Even though (visual) agnosia is a well-known feature of dementia that is often included in diagnostic criteria, most mental screening tests do not test the presence of visual perceptual deficits other than in an object-naming task. In our experience, however, the item "unusual views" (in which objects to be named are photographed from an unusual angle) is generally more difficult and complex than merely naming objects and may be better in screening for more subtle visual disturbances.

The subscales praxis and language were not included in the logistic regression model, even though these items seem by themselves useful in screening for dementia. A possible explanation for this may be the redundancy of the items. A substantial number of items of the extensive subscale language was removed because of a floor effect in the first step of the construction of the R-CAMCOG. The low complexity of the language comprehension questions may be an explanation for this finding.

Executive functioning is assumed to play an important role in dementia but is not tested in the R-CAMCOG. This may be largely inherent to the original CAMCOG, which hardly contains tasks that measure executive functioning. As yet, it is unknown whether the absence of executive tasks is a limitation of the R-CAMCOG. It seems plausible, however, that many of the tasks that measure executive functioning are too demanding for stroke patients, in view of the somatic handicaps.

The final version of the R-CAMCOG shows overlap with other mental status tests with measures of orientation and memory but lacks specific language items and constructional commands such as drawing. Consequently, the R-CAMCOG can be used to screen for dementia without the disadvantage of confounding by the direct consequences of a stroke, such as upper-extremity paresis or mild aphasia. Clinical validation of the R-CAMCOG on the original data that were used to construct the R-CAMCOG showed a high sensitivity and specificity. External validation and assessment of reliability in a different series of stroke patients will be necessary to determine the value of the R-CAMCOG as a dementia-screening instrument in patients with a recent stroke.

Appendix

The Items of the R-CAMCOG

Naming

Shoe Typewriter Scales Suitcase Barometer Lamp

Orientation

What day of the week is it?	/1
What is the date today? Date Month Year	/3
Can you tell me where we are now?	
For instance, in what province are we in?	/1
What is the name of this town (city)?	/1
What floor of the building are we on?	/1
What is the name of this place?	/1

Remote memory

Can you tell me when the First World War began?	/1
Can you tell me when the Second World War began?	/1
Who was the leader of the Russians in the Second World War?	/1
What was Mae West famous for?	/1
Who was the famous flyer whose son was kidnapped?	/1

Recent memory

What is the name of the present Queen?	
Who will follow her?	/1
What is the name of the prime minister?	/1
What has been in the news in the past week or two?	/1

Recall

Can you tell me what were the objects in the colored pictures I showed you a little while ago?	
Shoe Typewriter Scales Suitcase Barometer Lamp	/6

Recognition

Which of these did I show you before?	
Shoe Typewriter Scales Suitcase Barometer Lamp	/6

Writing an address

Write this name and address on the envelope:

Mr. John Brown   42 West Street   Bedford

Perception

I am going to place a coin into your hand and I want you to tell me what it is without looking at it.	
Nickel Dime	/2
These are pictures of objects taken from unusual angles. Can you tell me what they are?	
Spectacles Shoe Purse/Suitcase Cup and Saucer Telephone Pipe	/6

Abstraction

In what way are an apple and a banana alike?	/2
In what way are a shirt and a dress alike?	/2
In what way are a table and a chair alike?	/2
In what way are a plant and an animal alike?	/2

Recall address

What was the name and address you wrote on the envelope a short time ago?	
Mr. John Brown 42 West Street Bedford	/5

Orientation	**/8**
Memory (recall and recognition)	**/17**
Remote memory	**/5**
Recent memory	**/3**
Abstraction	**/8**
Perception	**/8**
R-CAMCOG score	**/49**

Acknowledgments

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