Cognitive domains associated with performance on the Telephone Interview for Cognitive Status–modified

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Abstract

Global cognitive screening tests are increasingly used in clinical and research settings. However, many have not been developed following systematic psychometric principles; thus, construct validity is not clearly defined. It is the aim of this study to identify the cognitive domains that are associated with the total score from the Telephone Interview for Cognitive Status-modified (TICS-m). Data came from 104 women (75 years of age and older) who were participants in a longitudinal study of dementia and had been given the TICS-m and a battery of standardized neuropsychological tests. Factor analysis of all these neuropsychological tests yielded six interpretable factors: episodic memory for words, episodic memory for contextual information, working memory, episodic memory for nonverbal information, attention, and visuospatial processing efficiency. The TICS-m score showed modest associations with several distinct cognitive domains, including episodic memory for words and nonverbal information and attention.

Key words: cognitive screening, telephone assesment, neuropsychological tests, memory, older women

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Introduction

Screening tests of cognitive functioning are increasingly used for a variety of clinical and research purposes. Clinicians rely on such tests to assist in treatment planning[1,2] and in diagnosis.[3-5] Clinical trial specialists use screening tests to identify potential study subjects for diverse study designs, from pharmacological[6-8] to behavioral interventions.[9] To ease the financial and time demands in large-scale studies of dementing conditions such as Alzheimer's disease (AD), epidemiologists, as well as health services researchers, have adopted diagnostic strategies that rely on the use of initial screening tests.[10-13] In addition, cognitive researchers frequently use screening tests as primary outcome measures when large samples are evaluated.[14,15]

Notwithstanding widespread use, the limitations of cognitive screening tests are legion.[16] Foremost among these limitations is the haphazard process of test development. Screening tests are generally purported to be tests of "global" cognitive performance. However, a systematic approach to item selection, which is needed to maximize content validity, is not described for any of the widely used screening tests. Without such an approach to item selection, it cannot be assumed that such tests do, in fact, reflect global cognitive abilities. Rather, it remains to be determined what domains are being measured and if a given test truly reflects global cognitive functioning on a test-by-test basis.

The aim of this paper is to describe the domains of cognitive functioning, as assessed by standardized in-person tests, that are associated with an increasingly

Table 1. Selection of sample	
	Total
Eligible	210
Died	3
Dropped from parent study	12
Bad phone number or maximum attempts	5
Declined by post card	28
Declined by telephone	58
Completed interview	104

used telephone screening test of cognitive function, the Telephone Interview for Cognitive Status (TICS).[17] The TICS was developed from the "gold standard" of screening tests, the Mini-Mental State Examination (MMSE),[18] and later modified (TICS-m) to better assess episodic memory and to be amenable to administration and scoring in large-scale studies.[19] Although administration of the TICS-m over the telephone can be expected to limit the number of domains effectively assessed, it is designed to assess orientation, comprehension, attention, naming, working memory, verbal abstraction, and immediate and delayed verbal memory.[19] Despite inclusion of items that reflect these domains, it has not yet been reported to what domains the total score, which is uniformly developed and reported, is related.

Methods

This study was reviewed and approved by the Kaiser Permanente Southern California (KPSC) Institutional Review Board for the protection of human subjects.

Procedures

Data for this analysis were derived from a special substudy of the Women's Memory Study, a longitudinal study of the effects of hormone replacement therapy (HRT) on the incidence of dementia. The Women's Memory Study enrolled 3,924 women (1,944 HRT users; 1,980 HRT nonusers) 75 years of age and older in 1998. Sampling and recruitment procedures for the Women's Memory Study are described elsewhere.[13]

As part of a multistage process of dementia identification, all subjects were administered the TICS-m at baseline and on an annual basis. This substudy recruited a smaller sample of women to participate in extensive neuropsychological tests.

Participants

The sampling frame for this substudy was all nondemented women. More specifically, this included all women 1) who had reported their levels of education, 2) were nondemented as defined by a cut-off score of 28 or higher on the TICS-m,[19] 3) were not known to be deceased by the time of sample selection, and 4) were at least 75 years old and not more than 90 at the time of enrollment in the Women's Memory Study. This resulted in 2, 234 women who were eligible for this substudy. From this sample, 105 were randomly selected who met criteria for HRT use. HRT use was defined as having at least one prescription for oral estrogen filled in a KPSC pharmacy in every calendar year from 1992 to 1998, with continuous enrollment in the health plan from 1992 to 1998. This information was accessed from the KPSC Pharmacy Information Management System. One hundred five nonusers who did not have any HRT prescriptions filled during the same time period were also selected. All subjects were selected on age (75 to 79, 80 to 84, and 85 to 89 years of age) and self-reported education level (less than or equal to grade 11, high school graduate, trade school/some college, college graduate/some postgraduate/postgraduate degree). The analysis of HRT and cognition in this subsample of the Women's Memory Study is reported elsewhere.[20]

The study status of these 210 women is described in Table 1. The 104 women who agreed to participate (57 HRT users and 47 nonusers) were scheduled a time for testing at home or at a medical office. All substudy participants consented in writing to participate before the neuropsychological testing.

Participants were requested to schedule testing at a time when they would not be disturbed. Ninety percent of the tests were conducted in the participants' homes. The examiner assessed the protocol administration using the following coding criteria: 1) test was administered according to protocol, 2) minor breaks in standardization required slight alteration in protocol such as repetition of an item or an examiner error such as misstating a word, 3) major breaks in protocol where testing had to be interrupted for a period of time but the test could be completed after the interruption, and 4) testing began but could not be completed because of an interruption. A second testing session was scheduled to administer the entire test. Two trained neuropsychological examiners, with bachelor's degrees in the behavioral sciences, tested all participants.

Table 2. Demographic information for all recruited subjects

	Consented (n = 104)	Declined participation (n = 102)	p
Baseline TICS-m	32.7 (± 3.1)	33.0 (± 4.1)	ns*
Age	77.8 (± 2.1)	77.2 (± 1.8)	< 0.05
Education			
< High school graduate	5 (63%)	3 (37%)	0.03
High school graduate	26 (36%)	46 (64%)	
Some college/trade school	56 (57%)	42 (43%)	
College graduate or higher	17 (61%)	11 (39%)	
Ethnicity			
White	97 (52%)	89 (48%)	0.14
Nonwhite	7 (35%)	13 (65%)	

* ns: p > 0.2.

Cognitive measures

We used the TICS-m scores collected as part of the Women's Memory Study for this substudy. The neuropsychological evaluations were conducted during year two of the study so the TICS-m score from that year is used in the present analyses. The interval between the phone interview when the TICS-m was administered and the neuropsychological evaluation ranged from two weeks to seven months.

Tests chosen were well standardized and had acceptable reliability and validity. Verbal memory was assessed with the Logical Memory test from the Wechsler Memory Scale-III (WMS III)[21] and the California Verbal Learning Test (CVLT).[22] Nonverbal memory was assessed with the Faces test from the WMS III.[21] Attention was assessed with the Digit Span Forward test from the WMS-III[21] and with the Trail-Making Test A.[23] Working memory was assessed with Letter-Number Sequencing and Digit Span Backward from the WMS-III.[21] Visuospatial perception was tested with the Judgment of Line Orientation (JLO).[24] The Trail-Making Test B[23] and the Controlled Oral Word Association[25] tests evaluated executive functioning. Language skills were tested with the Boston Naming Test (BNT)[26] and Animal Naming.[27]

Analytic strategy

Given the relatively large number of neuropsychological tests available, we first used factor analysis as a data reduction technique and as a method to develop more stable indices of cognitive domains than is possible using a single test score. Principal component factors were extracted using the roots greater than or equal to one criterion for determining the number of factors to be extracted. Factors were then orthogonally rotated using the Varimax procedure. Factors were labeled by considering all tests that loaded on the factor at 0.4 or above. Factor scores were generated for further analysis.[28]

To address our primary question, we tested the association between the TICS-m total score and performance on the factors in separate hierarchical regression models. In each model, the effects of age, education, and ethnicity were adjusted for by forcing appropriately coded variables into the equation before considering the association between the TICS-m and the dependent variable.

Post hoc analyses were conducted to determine which individual tests were significantly associated with the TICS-m. Our final goal was to determine if the cognitive domains related to performance on the TICS-m did so independently of each other. To evaluate this possibility, we entered all factors into a single stepwise regression equation.

Results

There was a small but significant difference in age between the participants and nonparticipants, with the consenting group being older (Table 2). Education also differed significantly, with a larger number of persons with a high school graduate degree declining participation and a higher percentage of those with a college degree choosing to participate. There was a tendency for nonwhites to participate at lower rates, although this was not statistically significant ($p > 0.1$).

Descriptive statistics on the neuropsychological tests for the 104 women included in this substudy are presented in Table 3.

The factor analysis resulted in six factors with eigenvalues above one. These factors accounted for 67 percent of the total matrix variance. Factor loadings are presented in Table 4. The factors were labeled as 1) episodic memory for words, 2) episodic memory for contextual information, 3) working memory, 4) episodic memory for nonverbal information, 5) attention, and 6) visuospatial processing efficiency.

Three of the factors were significantly associated with the TICS-m total score after adjusting for age, education, and ethnicity. The adjusted correlation was 0.21 ($p = 0.04$) for Factor 1 (episodic memory for words), 0.22 ($p = 0.025$) for Factor 4 (episodic memory for nonverbal information), and 0.28 ($p = 0.004$) for Factor 5 (attention). Adjusted p values were above 0.5 for the remaining three factors.

When all six factors were entered into a single stepwise regression, again first forcing age, education, and ethnicity into the equation, the three factors that had significant separate associations with the TICS-m also met criteria for entry into the equation, and each accounted for a significant portion of variance. Effect sizes (r) were 0.19 ($p = 0.04$) for Factor 1, 0.22 ($p = 0.02$) for Factor 4, and 0.27 ($p = 0.006$) for Factor 5. None of the other factors met criteria for entry.

Table 5 provides correlations between the TICS-m and all individual tests. For Factor 1 (episodic memory for words), all tests that loaded on the factor were significantly associated with the TICS-m except Trial 1 and Trial 5 from the CVLT. For Factor 2 (episodic memory for contextual information), Logical Memory 2 and Logical Memory recognition tests were significantly related to the TICS-m score, whereas Logical Memory 1 and CVLT List B were not. For Factor 3 (working memory), of the three tests that loaded on the factor, Digit Span Backward was the only test significantly related to the TICS-m score. On Factor 4 (episodic memory for nonverbal information), the associations between the TICS-m and both Faces Immediate and Delayed recall were significant. Both Factor 5 tests (attention), the JLO and Digit Span Forward tests, were significantly associated with the TICS-m. For Factor 6 (visuospatial processing efficiency), Trails B was significantly associated with the TICS-m, whereas Trails A was not.

Discussion

Conducting the majority of interviews in the participants' homes was helpful in recruiting these very elderly women. We found that transportation and mobility problems would have minimized their ability to participate. Home interviews were accessible, convenient, and comfortable for participants. In addition, the familiar home environment minimized test anxiety and created a cooperative alliance with the interviewers. Neuropsychological tests were administered in a standardized manner, and every effort was made to ensure that the interviews were conducted in a secure, private, and quiet place in the home. We recognize the limitation that home interviews are less efficient, more costly, and have greater potential for interruptions than in a controlled office environment. In the 104 cases, however, there were only two cases where minor interruptions (Code 2) occurred, and these did not seem to affect the results in a significant way.

The composite score from the TICS-m shows modest associations with several distinct cognitive domains. It is independently related to performance on episodic memory for words, episodic memory for nonverbal information, and attention. It was not associated with performance on episodic memory for contextual information, working memory, or visuospatial processing efficiency.

It is important to qualify the discussion of the implications of this pattern of results by considering the effects of our exclusionary criteria, notably our exclusion of women with TICS-m scores less than 28. This TICS-m cut-point has been shown to have excellent sensitivity (> 99 percent) and good specificity (86 percent)[29] in identifying dementia. Thus, we have adequate assurance that our sample included few demented subjects, although evaluation of the ranges of the neuropsychological tests indicates that dementia is possible in this sample. Moreover, the relatively high education of the sample may have masked the potential of dementia among these participants. Little is known about how factor structure changes in dementia. Work by Plassman et al.[30] suggests that the inclusion of demented subjects may increase the magnitude of associations seen between the TICS-m and other neuropsychological tests. The factor structure that emerged from our data may be limited by our exclusion of most individuals with probable dementia in a way we cannot infer in an informed manner.

Table 3. Neuropsychological test results	
Test	**Mean (SD) [Range]**
Nonverbal	
Faces Immediate	32.8 (4.4) [23 – 41]
Faces Delayed	33.6 (4.5) [24 – 44]
Verbal memory	
Logical Memory Immediate	35.4 (8.2) [13 – 57]
Logical Memory Delayed	21.4 (6.2) [2 – 37]
Logical Memory Recognition	25.1 (2.7) [17 – 30]
CVLT Trial 1	5.5 (1.7) [2 – 10]
CVLT Trial 5	10.2 (2.2) [6 – 15]
CVLT List B	5.5 (2.0) [0 – 11]
CVLT Short Delay Free	7.9 (3.0) [0 – 14]
CVLT Short Delay Cued	9.9 (2.3) [4 – 15]
CVLT Long Delay Free	8.8 (3.1) [0 – 14]
CVLT Long Delay Cued	9.7 (2.6) [3 – 15]
CVLT Recognition	13.6 (2.2) [8 – 16]
Boston Naming Test	51.6 (6.7) [30 – 60]
Attention	
Digit Span Forward	6.0 (1.0) [4 – 8]
Judgement of Line Orientation	21.1 (5.3) [0 – 30]
Visuospatial processing efficency	
Trails A (seconds)	47.5 (17.1) [21 – 115]
Trails B (seconds)	132.7 (67.0) [55 – 397]
Executive functioning/working memory	
Controlled Oral Word Association	34.3 (11.3) [11 – 68]
Digit Span Backward	4.5 (1.1) [2 – 7]
Letter-Number Squencing (Span)	4.6 (1.0) [2 – 7]
Animal Naming	16.6 (4.7) [7 – 29]

The significant association between the TICS-m and episodic memory for words is expected given the inclusion of a 10-item word list with an immediate and delayed recall condition on the TICS-m. Whereas the original TICS did not include this word list, it was specifically added in the modification to better assess this domain sensitive to the onset of dementia.[19] A significant association with this factor suggests that the total score from the TICS-m does reflect ability in this domain. Notably, the post-hoc analyses suggest that the TICS-m score is not associated with learning word lists but rather with their recall. Given the relevance of recall in the identification of dementia,[31] such an association speaks favorably to the relevance of the TICS-m in dementia screening.

Of interest in the attention factor is the loading of the Judgment of Line Orientation on this factor. This test is widely viewed to reflect a perceptual process.[32] However, its loading on this factor, in combination with such tasks as the Digit Span Forward, suggests that performance involves more than visuospatial perception. The demands of holding in mind the orientation of the two stimuli lines while comparing these lines with the array of possible lines may require attention. That the

Table 4. Factor loadings of neuropsychological tests

	Episodic memory for words 1	Episodic memory for contextual information 2	Working memory/ executive functioning 3	Episodic memory for nonverbal information 4	Attention 5	Visuospatial processing efficiency 6
Faces Immediate Recall				0.794		
Faces Delayed Recall				0.771		
Logical Memory 1		0.880				
Logical Memory 2		0.849				
Logical Memory Recognition		0.731				
Digit Span Forward					0.628	
Digit Span Backward			0.577			
Judgement of Line Orientation					0.642	
Boston Naming Test	0.409					
Trails A (time)						0.872
Trails B (time)						0.532
Animal Naming			0.594			
Controlled Oral Word Association			0.761			
CVLT Trial 1	0.491					
CVLT Trial 5	0.749					
CVLT List B		0.496				
CVLT Short Delay Free Recall	0.782					
CVLT Short Delay Cued Recall	0.875					
CVLT Long Delay Free Recall	0.858					
CVLT Long Delay Cued Recall	0.885					
CVLT Recognition	0.528					
Letter Number Sequencing			0.628			
Proportion of total variance explained	0.32	0.088	0.081	0.072	0.057	0.049

Table 5. Correlations between TICS-m and neuropsychological tests			
	Factor(s)	**r**	**p**
Faces Immediate Recall	4	0.30	0.002
Faced Delayed Recall	4	0.23	0.02
Logical Memory 1	2	0.10	ns
Logical Memory 2	2	0.20	0.05
Logical Memory Recognition	2	0.20	0.04
Digit Span Forward	5	0.26	0.008
Digit Span Backward	3	0.27	0.006
Judgement of Line Orientation	5	0.24	0.015
Boston Naming Test	1	0.32	0.001
Trails A (time)	6	-0.06	ns
Trails B (time)	6	-0.23	0.02
Animal Naming	3	0.17	0.09
Controlled Oral Word Association	3	0.02	ns
CVLT Trial 1	1	0.09	ns
CVLT Trial 5	1	0.12	ns
CVLT List B	2	0.12	ns
CVLT Short Delay Free Recall	1	0.26	0.007
CVLT Short Delay Cued Recall	1	0.21	0.03
CVLT Long Delay Free REcall	1	0.33	0.001
CVLT Long Delay Cued Recall	1	0.27	0.006
CVLT Recognition	1	0.20	0.05
Letter Number Sequencing	3	0.11	ns

JLO is not solely a measure of visuospatial processes is further implied by the fact that, in the post-hoc analyses, the TICS-m was significantly associated with the JLO.

The final factor significantly associated with the TICS-m (episodic memory for nonverbal information) further draws into question both the domains assessed by the neuropsychological tests that comprise the factor as well as the domains assessed by the TICS-m. In a broad sense, the significant association of the TICS-m total score with the episodic memory for nonverbal information factor suggests that the TICS-m provides information on more than one cognitive domain. However, the Faces test, which comprises the factor, is designed to tap a nonverbal domain, specifically episodic memory that cannot be easily encoded verbally. An association between a test administered over the telephone and Faces could suggest that either individuals use visualization to encode information provided over the telephone or that they use verbal processes to encode information from the Faces test.

This interpretation of the possible reasons for an association between the nonverbal information factor and the TICS-m does not take into account a recent criticism of Faces. This critique finds that Faces does not relate to other widely used nonverbal measures to the extent one would expect.[33] Further studies using tests other than Faces are needed to confirm our present interpretation.

The domains not associated with the TICS-m are also of interest and include episodic memory for contextual information, working memory, and visuospatial processing efficiency. Because timed items are not included in the TICS-m, the lack of association of Visuospatial Processing Efficiency with the TICS-m is understandable. The lack of an association between the TICS-m and working memory notably reflects the inability of the TICS-m to assess tasks that require executive functioning, as do word generation tasks.[34,35] The lack of association may also be partially explained by our study design, which attempted to exclude demented participants, who would be most likely to exhibit working memory problems. It is also noteworthy that there is a lack of association of the TICS-m with the episodic memory for contextual information factor. That this factor, comprised largely of components of the Logical Memory subtest, is not associated with the TICS-m in the same manner as the factor defined by the CVLT challenges suggestions that these are interchangeable tests of verbal memory.[36] The different pattern of association we find between the TICS-m and word list vs. contextual factors may indicate that learning and recalling language in context may involve different processes than learning lists of words. Regardless, we find no indication that the TICS-m assesses a domain similar to that assessed by Logical Memory.

Our findings, in aggregate, lead to several conclusions. First, the total score from the TICS-m, a global screening test, does seem to carry information that is associated with several cognitive domains. Second, cognitive assessment conducted over the telephone may assess domains that include visuospatial components, given that the JLO was part of our attention component. Finally, the TICS-m does not seem to include elements that assess processing efficiency, executive functioning, or the ability to learn and recall contextual language.

Although the TICS-m does not have the psychometric properties needed to engender great enthusiasm for its use as a definitive measure of cognition or as a single screening test for dementia, these results suggest that telephone interviews may be a method of screening multiple cognitive domains. The largely theoretically coherent pattern of associations between the TICS-m and standardized in-person tests supports this. Given the high proportion of people with telephones, screening tests developed specifically for telephone administration provide a unique option for studying the epidemiology of cognitive decline. Psychometrically valid, brief telephone tests sensitive to cognitive changes and dementia in the elderly are needed. The next logical step is additional developmental work that specifically validates the assessment of multiple cognitive domains over the telephone. This process should include careful item selection from numerous cognitive domains that are usable over the telephone and have shown validity and reliability. Following this, the selected cognitive domains should be measured over the telephone and validated along with well-standardized tests of the same cognitive domains that are administered in person.

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