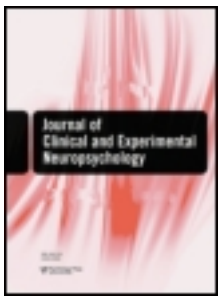

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The Telephone Interview for Cognitive Status (Modified): Relation with a comprehensive neuropsychological assessment

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The modified Telephone Interview for Cognitive Status (TICS-m) is a widely used screening instrument for (Alzheimer's) dementia. Psychometric evaluation of the TICS-m is limited. This study examined the relation between the TICS-m and a comprehensive neuropsychological assessment in older persons ($n = 243$) without cognitive deficits. The TICS-m total score correlated with multiple cognitive domains (range $r = .22$–$.49$). Factor analysis of the TICS-m items yielded four interpretable factors: "verbal memory," "orientation/mental tracking," "language/reasoning," and "attention/working memory," which also showed (modest) correlations with the neuropsychological assessment ($r = .02$–$.48$). The TICS-m appears to reflect a "general cognitive ability" rather than, for example, memory functioning alone.

Keywords: Dementia; Screening; Telephone Interview for Cognitive Status–Modified; Neuropsychological assessment; Validity.

Screening tests for cognitive functioning are increasingly used for both clinical and research purposes. Most of these require face-to-face administration, which is not always feasible, particularly in the follow-up of older persons in research settings. To overcome this limitation, several telephone interview-based cognitive screening instruments have been developed (e.g., Brandt, Spencer, & Folstein, 1988; Go et al., 1997; Roccaforte, Burke, Bayer, & Wengel, 1992). The Telephone Interview for Cognitive status (TICS), developed by Brandt et al. (1988), was modeled after the Mini-Mental State Examination (MMSE) and is currently the most widely used telephone-based screening instrument. In the modified version of the TICS (TICS-m), a delayed verbal recall item was added, to better assess episodic memory in the detection of (early) Alzheimer's disease (Welsh, Breitner, & Magruder-Habib, 1993). Despite its popularity, some authors have raised concerns about the sensitivity of the TICS-m to detect milder forms of cognitive impairment (Lines, McCarroll, Lipton, & Block, 2003; Yaari, Fleisher, Gamst, Bagwell, & Thal, 2006). The TICS-m is purported to be a test of "global" cognitive functioning; however, a systematic approach to item selection in the construction of the test

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is not described. In the absence of a thorough psychometric evaluation of the TICS-m, factor analysis has been performed to examine which cognitive constructs underlie TICS-m performance (Brandt et al., 1993; Buckwalter, Crooks, & Pettiti, 2002; Lines et al., 2003). The relation between the TICS-m and a comprehensive neuropsychological assessment has received even less attention. One previous study examined the relation between the TICS-m and a neuropsychological examination (Crooks, Petitti, Robins, & Buckwalter, 2006). It showed an association between the TICS-m composite score and several cognitive domains, but investigation of the cognitive functions measured *within* the TICS-m was not performed.

The present study examined the construct validity of the TICS-m in a large sample of older persons without known clinically manifest cognitive deficits, by investigation of the relation between the TICS-m and an extensive neuropsychological assessment and by means of factor analysis of the TICS-m items. Examination of this relation in a relatively healthy sample of persons gives an evaluation of the association between these two measures that is unbiased by confounding variables such as disease severity. The study aims to provide insight into two important questions. Does the TICS-m provide a valid reflection of cognitive functioning as measured with a neuropsychological test battery in this group? How are the TICS-m and its underlying constructs related to different cognitive domains in a neuropsychological assessment?

METHOD

Participants

The present study included 243 participants (81 persons without and 162 persons with type 2 diabetes) who were enrolled in two longitudinal studies on cognitive functioning in type 2 diabetes (Utrecht Diabetic Encephalopathy Study, UDES, van den Berg et al., 2010; Anglo–Danish–Dutch Study of Intensive Treatment in People with Screen Detected Diabetes in Primary Care, ADDITION, Ruis et al., 2009). All participants with diabetes were recruited from a primary care setting. Persons without diabetes were recruited among the spouses or acquaintances of these patients. Participants had to be functionally independent and Dutch speaking. Exclusion criteria were a psychiatric or neurological disorder (unrelated to diabetes) that could influence cognitive functioning, a history of alcohol or substance abuse, and a fasting blood glucose $\geq$7.0 mmol/l for those without diabetes. Persons with known dementia were also excluded. Both the UDES and the ADDITION study entailed cognitive assessment at baseline and after 3–4 years; the TICS-m was administered at the follow-up assessment. Thus, for the present analysis, all 243 participants who performed both the neuropsychological examination and the TICS-m at follow-up were included (84% of the baseline UDES sample, 56% of the baseline ADDITION sample). Both studies were approved by the local medical ethics committees and were completed in accordance with the guidelines of the Helsinki Declaration.

The neuropsychological assessment was identical in both studies. To control for possible material-specific learning effects at the follow-up examination, parallel versions were used for memory tests. The results of both studies have been described previously (Ruis et al., 2009; van den Berg et al., 2010). Briefly, compared to the control group, the patients with type 2 diabetes showed modest cognitive decrements, mainly in memory (Ruis et al., 2009), processing speed, and executive functioning (van den Berg et al., 2010). None of the included participants had cognitive deficits that impaired independent daily functioning, and effect sizes for the between-group differences in cognition were generally small to medium (0.2 to 0.5).

Measures

Participants performed an extensive neuropsychological examination either at the university hospital or at home, after which they completed the Dutch version of the TICS-m by telephone (Kempen, Meier, Bouwens, van Deursen, & Verhey, 2007; Welsh et al., 1993). The majority of the participants performed the TICS-m within one month after the neuropsychological assessment, but no later than after six months. The TICS-m has 23 questions, scored as 12 items with a maximum score of 50 (Table 1). The neuropsychological assessment consisted of 11 standard verbal and nonverbal tasks, administered in a fixed order that took about 90 min to complete. The tasks were divided into five cognitive domains to reduce the amount of neuropsychological variables in the analysis and for clinical clarity. This division was made a priori, according to standard neuropsychological practice and cognitive theory, as described in detail in Lezak, Howieson, and Loring (2004), and not by formal factor analysis, to closely resemble everyday clinical practice. The domain *abstract reasoning* was assessed by Raven Advanced Progressive Matrices (12-item

short form). The number of correct responses was recorded. The domain *memory* was divided into four subdomains (*working memory, immediate memory and learning rate, forgetting rate,* and *incidental memory*). *Working memory* was assessed by the forward and backward Digit Span of the Wechsler Adult Intelligence Scale–3rd edition (WAIS–III) and the Corsi Block-Tapping Task. The product score of the maximum span length times the number of correctly recalled sequences was recorded. *Immediate memory and learning rate* was assessed verbally and nonverbally with the Dutch version of the Rey Auditory Verbal Learning Test (RAVLT) and the Location Learning Test (LLT). For the RAVLT, the mean of the total number of words remembered in five learning trials was recorded, and a learning index was calculated as an estimate of the learning curve. For the LLT, both the total number of displacements over five trials and a learning index were calculated. *Forgetting rate*, as a measure of decay over time, was also calculated in the RAVLT and the LLT, in which the scores in the delayed recall condition were corrected for the score obtained in the fifth learning trial. *Incidental memory* was measured with the delayed recall trial of the Taylor Complex Figure Test. This score was also corrected for the score obtained in the copy condition. The domain *information processing speed* was assessed with the Trail Making Test–Part A (TMT–A), the Stroop Color–Word Test Parts I and II, and the Digit Symbol subtest of the WAIS–III. For the TMT–A, the time to complete the task was recorded in seconds. For the Stroop Color–Word Test Parts I and II, the mean of the total time (in seconds) to complete Parts I and II was calculated, and the total correct number of copied symbols within two minutes was recorded for the Digit Symbol. The domain *attention and executive function* consisted of four subdomains (*response inhibition, divided attention, concept shifting,* and *verbal fluency*). *Response inhibition* was assessed by the Stroop Color–Word Test Part III. The time to complete this task was recorded in seconds and was corrected for the time to complete the Stroop Color–Word Test Part II. *Divided attention* was assessed with the Trail Making Test Part B, controlling for performance on TMT–A. *Concept shifting* was assessed by the Brixton Spatial Anticipation Test where the number of errors was recorded. *Verbal fluency* was assessed with both a category naming task (Animal Naming, 2 min) and two letter fluency tasks ("N" and "A," 1 min each). The total number of correct responses was recorded. The domain *visuoconstruction* was assessed by the Copy trial of the Taylor Complex Figure Test.

TABLE 1
Telephone Interview for Cognitive Status–Modified

Item	*TICS-m question*	*Points*
1	Name (first, last)	2
2	Orientation (day of week, date, season)	5
3	Age & phone number	2
4	Counting backwards from 20 to 1	2
5	10-word list immediate recall	10
6	Count backward from 100 by 7s	5
7	Naming ("tool to cut paper?")	4
8	Repeat phrase ("postbankspaarboekje")[a]	2
9	Information ("present queen?")	4
10	Tap 5 times on phone	2
11	Opposites ("opposite of east?")	2
12	10-word list delayed recall	10
	Total score	50

Note. TICS-m = Telephone Interview for Cognitive Status–Modified.
[a]Example in English version: "Methodist Episcopal."

The raw test scores were standardized into *z* scores per cognitive domain. These *z* scores were calculated by using the pooled mean of baseline scores of the whole study sample. The *z* score for each domain was derived by calculating the mean of the *z* scores for tests comprising that domain. A composite *z* score was also calculated by averaging the domain scores to represent "global cognition." Premorbid intelligence was estimated with the Dutch version of the National Adult Reading Test (NART; Schmand, Lindenboom, & van Harskamp, 1992).

Statistical analysis

Categorical variables were reported as numbers and percentages, continuous variables as means with standard deviations (*SD*s), and nonnormally distributed variables as median with interquartile range (IQR). The relation between the TICS-m total score and the cognitive domains was performed with Spearman rank correlation analysis (alpha $< .01$ was considered significant). Principal axis factoring with oblique (oblimin) rotation was used to examine the factor structure of the TICS-m items, using the roots greater than one criterion to determine the number of factors. Factor loadings greater than 0.30 were considered relevant in interpreting the factor. Correlations between TICS-m factor scores and cognitive domain scores were examined with Spearman rank correlation analysis. Because patients with type 2 diabetes were overrepresented in our sample, sensitivity analysis was performed adjusting the correlation analysis for diabetes status.

Bland and Altman (1986) illustrated in an influential paper that a high correlation does not necessarily mean that there is sufficient *agreement* between two measures (e.g., whether they give an equally high or low estimation of true values). In secondary analyses, Bland–Altman plots were therefore used to examine agreement between performance on the TICS-m and the cognitive domains by plotting the mean of the two measurements (x-axis) against the difference between the measurements (y-axis; both expressed as standardized z scores) with the accompanying 95% limits of agreement (Bland & Altman, 1986). These plots show a quantification of the differences between performance on the TICS-m and the neuropsychological assessment and provide an interval within which 95% of the differences between the two instruments are expected to lie. A narrow 95% interval indicates greater agreement between the TICS-m and the neuropsychological assessment.

RESULTS

Table 2 shows the characteristics of the participants as well as the raw neuropsychological data. The distribution of the TICS-m scores in the total sample followed a normal distribution (Kolmogorov–Smirnov $z = 1.03$, $p = .24$; skewness 0.001 ± 0.17, kurtosis -0.15 ± 0.34). The TICS-m score showed significant correlations with age ($r = -.16$, $p < .05$) and estimated IQ ($r = .39$, $p < .001$).

The correlations between the TICS-m total score and the neuropsychological domain scores are presented in Table 3. In the total study sample, the TICS-m score showed statistically significant correlations with all five cognitive domains and with the composite sum score (range .22 to .49). The correlation with visuoconstruction was lowest ($r = .22$). Adjusting the correlation analysis for diabetes status yielded similar results (data not shown).

Principal axis factoring (PAF) with oblique (oblimin) rotation was used to examine the factor structure of the TICS-m items in the total sample (Table 4). The Kaiser–Meyer–Olkin measure of sampling adequacy was .60, and Bartlett's test of sphericity was significant, $\chi^2(55) = 434.8$, $p < .001$, indicating high sampling adequacy. Item 1 (first and last name) was dropped from the analysis as all participants showed the maximal score on this item. The PAF yielded a multicomponent solution consisting of four factors with eigenvalues >1.0 that accounted for 57% of the variance. Items 5 and 12 (10-word list immediate and delayed recall) loaded high on the first factor, which could be regarded as a *verbal memory* factor (eigenvalue 2.47, 22% of variance explained). The second factor encompassed high loadings for Items 2 (orientation),

TABLE 2
Characteristics of the participants

Characteristic	*Total sample*
n	243
Age	67.7 ± 5.7
Male sex: *n* (%)	127 (52)
Estimated IQ	100 ± 18
Educational level median (IQR)	4 (4–5)
TICS-m total score	36.1 ± 4.5
TICS-m <28 points: *n* (%)	7 (3)
Neuropsychological assessment	
Raven APM (short form)	7.0 ± 2.5
WAIS–III Digit Span forward[a]	45.1 ± 22.1
WAIS–III Digit Span backward[a]	24.6 ± 18.1
Corsi Block-Tapping forward[a]	37.8 ± 12.0
Corsi Block-Tapping backward[a]	37.8 ± 14.2
RAVLT Total Trials 1–5	42.4 ± 11.3
RAVLT Delayed Trial	8.8 ± 3.2
RAVLT Recognition	28.7 ± 1.8
LLT Total Trials 1–5[b]	21.7 ± 19.9
LLT Learning Index	0.59 ± 0.30
LLT Delayed Recall[b]	3.0 ± 6.8
Complex Figure Test–Copy	33.1 ± 3.1
Complex Figure Test–Delay	17.5 ± 6.0
Stroop Color–Word Test I[b]	49.3 ± 9.3
Stroop Color–Word Test II[b]	63.9 ± 12.5
Stroop Color–Word Test III[b]	117.9 ± 39.3
TMT Part A[b]	42.6 ± 17.5
TMT Part B[b]	106.2 ± 58.9
WAIS–III Digit Symbol	56.7 ± 16.5
Letter fluency (mean N + A)	10.9 ± 4.5
Category fluency (Animals)	32.6 ± 9.7
Brixton Spatial Anticipation Test[b]	18.8 ± 6.1

Note. Data are means ± standard deviations unless otherwise specified. IQR = interquartile range. TICS-m = Telephone Interview for Cognitive Status–Modified. APM = advanced progressive matrices. RAVLT = Rey Auditory Verbal Learning Test. LLT = Location Learning Test. TMT = Trail Making Test. WAIS–III = Wechsler Adult Intelligence Scale–Third Edition.
[a]Product score defined as span length × number correct.
[b]Higher test scores reflect worse performance.

TABLE 3
Correlation analysis between TICS-m total score and cognitive domain scores in the total sample

Cognitive domain	*TICS-m total score*
Information processing speed	.45**
Attention & executive functions	.38**
Memory	.40**
Abstract reasoning	.33**
Visuoconstruction	.22*
Sum score	.49**

Note. Unadjusted Spearman rank correlation coefficients. TICS-m = Telephone Interview for Cognitive Status–Modified. $n = 243$.
*$p < .01$. **$p < .001$.

TABLE 4
Factor loadings of principal axis factoring of the TICS-m items

TICS-m item	*Verbal memory* 1	*Orientation/ Mental tracking* 2	*Language/ Reasoning*[a] 3	*Attention/ Working memory* 4
5	.79			
12	.97			
2		.37		
4		.44		
10		.50		
7			.65	
11			.60	
6				.44
8				.45
Eigenvalue	2.47	1.46	1.25	1.05
Variance explained (%)	22	13	11	10

Note. Factor loadings <.30 removed. TICS-m = Telephone Interview for Cognitive Status–Modified.
[a]Factor loadings for Factor 3 were inversed for interpretation.

4 (counting backwards), and 10 (tapping), which could be regarded as an *orientation/mental tracking* factor (eigenvalue 1.46, 13% variance explained). Items 7 and 11 (naming, opposites) showed high negative loadings high on the third factor. These factor loadings were reversed to aid interpretation, after which the third factor could be regarded as *language/reasoning* (eigenvalue 1.25, 11% of variance explained). The final factor encompassed high loadings for Items 6 and 8 (counting backwards in 7s, repeat phrase), which could be regarded as an *attention/working memory* factor (eigenvalue 1.04, 10% of variance explained). Items 3 and 9 showed negligible factor loadings. In secondary sensitivity analysis, the factor analysis was repeated in persons with and without diabetes separately, both of which yielded four-factor solutions that were highly similar to the primary analysis (data not shown).

Table 5 shows the correlations between the factor loadings of the TICS-m factors and the domain scores of the neuropsychological test battery. Overall, these results show a rather nonspecific pattern with correlations in the .20 to .50 range between information processing speed, attention and executive functions, memory and abstract reasoning, and all four TICS-m factors. For memory, it is noteworthy that the highest correlations are with the expected factors (i.e., memory correlates .33 with factor "verbal memory" and .32 with factor "attention/working memory"). Also, visuoconstruction was unrelated to factors "verbal memory" and "orientation/mental tracking." Adjusting the correlation analysis for diabetes status yielded similar results (data not shown).

Figures 1a–1f show Bland–Altman plots comparing agreement between performance on the TICS-m and the neuropsychological assessment, with accompanying 95% limits of agreement. These plots show that the TICS-m total score may be up to 0.75 standard deviations above or below the composite *z* scores for the neuropsychological domains (Figure 1a). Similar limits of agreement are shown for the comparison between the TICS-m score and the individual cognitive domains (Figure 1). In individual persons, these results indicate that compared to the neuropsychological assessment, the TICS-m is able to detect cognitive *impairments* (defined as ≥1.5 *SD*s below average), but is less able to detect subtle decrements that are smaller in size (i.e., ≤0.75 *SD*s below average). Moreover, the negative relation that is depicted in Figures 1a and 1c–1e indicate that for persons with low cognitive functioning (e.g., mean *z* score ≤–2) the TICS-m slightly underestimates the performance compared to the neuropsychological assessment. For those with good cognitive functioning, the TICS-m slightly overestimates the performance on the neuropsychological assessment, possibly reflecting a ceiling effect in the TICS-m.

TABLE 5
Correlation analysis between TICS-m factors and cognitive domain scores

Cognitive domain	*Verbal memory* 1	*Orientation/Mental tracking* 2	*Language/Reasoning*[a] 3	*Attention/Working memory* 4
Information processing speed	.40**	.27**	.22*	.40**
Attention and executive functions	.32**	.43**	.21*	.48**
Memory	.33**	.20*	.16	.32**
Abstract reasoning	.29**	.27**	.27**	.36**
Visuoconstruction	.14	.02	.23**	.24**

Note. Unadjusted Spearman rank correlation coefficients. TICS-m = Telephone Interview for Cognitive Status–Modified.
*$p < .01$. **$p < .001$.
[a]Factor loadings for Factor 3 were inversed for interpretation.

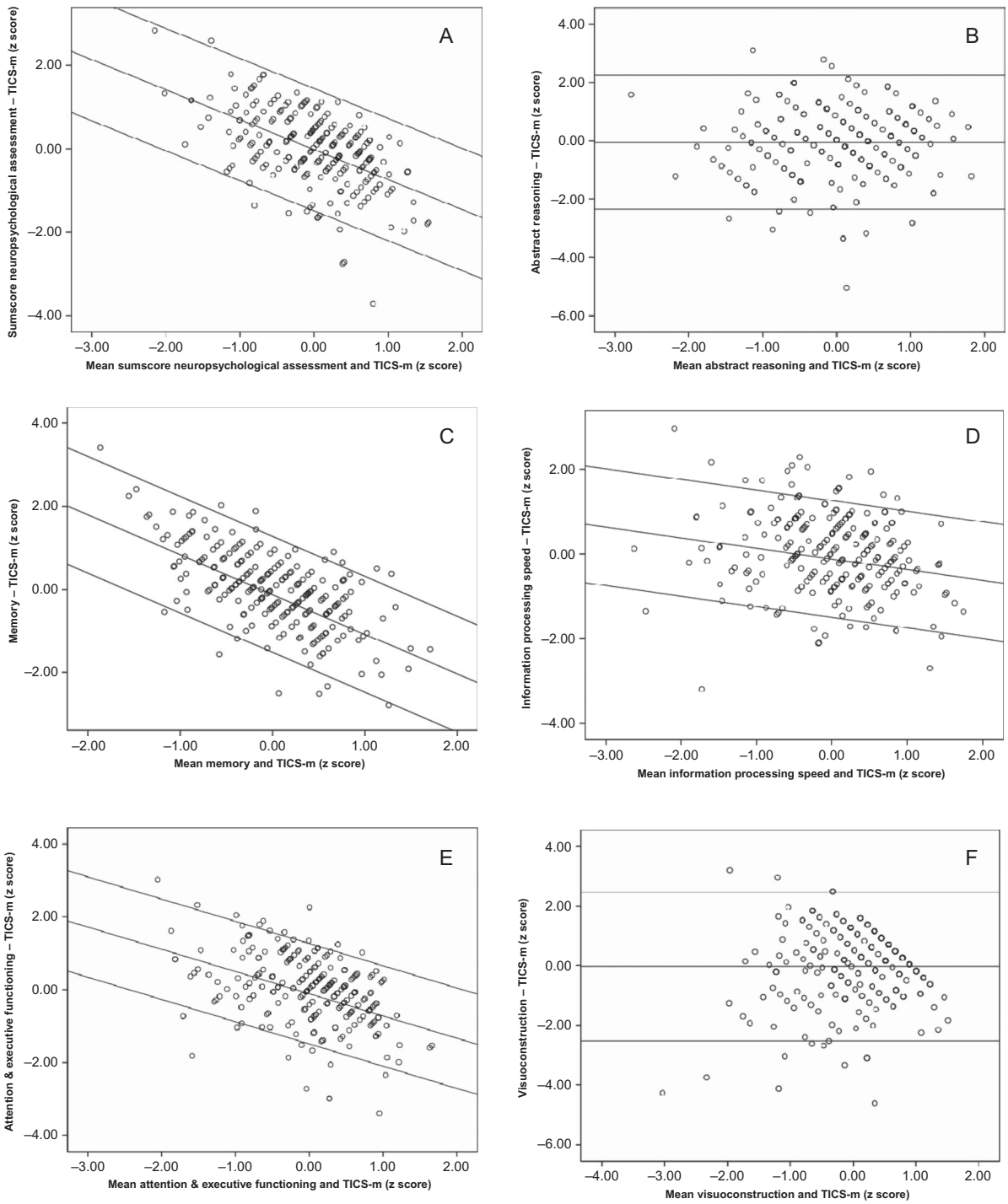

Figure 1. Bland–Altman plots comparing TICS-m (Telephone Interview for Cognitive Status–Modified) and neuropsychological assessment. Differences (*y* axis; neuropsychological assessment minus TICS-m) are plotted against means (*x* axis). All data are expressed as standardized *z* scores.

DISCUSSION

The present study provides a detailed examination of the relation between a comprehensive neuropsychological assessment and a screening instrument for cognitive functioning that is administered by telephone (TICS-m) in a large sample of older persons without dementia. Overall, the results showed that the TICS-m is correlated with different cognitive domains ($r = .22$–$.49$), suggesting that in persons without marked cognitive deficits, the TICS-m total score reflects a "general

ability" rather than a single cognitive function, such as verbal memory. The strongest associations were observed between the TICS-m total score and the domains information processing speed, attention & executive functioning, and memory, which are vulnerable to decline due to aging or dementia (Salthouse, 2010). Factor analysis of the TICS-m items yielded four interpretable factors: "verbal memory," "orientation/mental tracking," "language/reasoning," and "attention/working memory" that also showed (modest) correlations with the neuropsychological assessment (r = .02–.48). Furthermore, analysis of agreement showed differences between the TICS-m and the neuropsychological assessment up to 0.75 standard deviations, thereby indicating that the TICS-m can measure impairments that exceed this bandwidth (i.e., >2 *SD*s below the mean), as would be encountered in dementia, but the ability to measure more subtle cognitive decrements in individual persons may be limited. For screening purposes at the group level (provided that the sample size is large enough), this difference between the TICS-m and neuropsychological assessment would not necessarily lead to "misclassifications" as there was only a slight bias (i.e., over- or underestimations) in the estimations of the TICS-m as compared with the neuropsychological assessment. One should keep in mind that formal evaluation of the sensitivity and specificity of the TICS-m was not performed in the present study because of the (relatively) healthy nature of the study sample.

One previous study examined the association between the TICS-m and a neuropsychological examination in 104 women >75 years of age participating in a longitudinal study to detect clinical dementia (Crooks et al., 2006). Correlation analysis between the composite TICS-m score and six distinct cognitive domains (derived from principal component analysis, PCA) showed modest but statistically significant correlations with measures of episodic memory and attention, but not with working memory or visuospatial processing, which is largely comparable to the results reported in the present study. Associations with information processing speed, clearly demonstrable in the present study, were not found, probably because only a single speed measure was included.

Three previous studies performed factor analysis on the TICS-m to examine the underlying latent constructs in large samples of older persons (Brandt et al., 1993, n = 11.497, mean age ~66 years, 46% variance explained; Buckwalter et al., 2002, n = 3,506 females, mean age 78.8 ± 3.3 years, 42% variance explained; Lines et al., 2003, n = 6,090, age >65 years, 47% variance explained). In these studies, three or four factors were extracted, all of which included a strong verbal memory factor, whereas the remaining factors vary somewhat in encompassing TICS-m items and interpretation. The factor solution found in the present study, albeit with a smaller sample size, is consistent with these previous studies. Interestingly, the present factor solution explained more variance (57%), possibly reflecting the use of principal axis factoring (PAF), instead of the principal component analysis (PCA) that was used in the previous studies, which is more suitable for analyzing factors that are intercorrelated (Pett, Lackey, & Sullivan, 2003), as is generally the case with cognitive data.

Strengths of this study include the detailed assessment of cognitive functioning by means of a comprehensive neuropsychological assessment in a relatively healthy study sample and the use of PAF to best suit the nature of the cognitive data. Limitations include possible heterogeneity in the study sample by inclusion of both diabetic and nondiabetic participants. In our view, this sample of persons without clinically significant cognitive impairments, which still included a relatively wide performance range in both the neuropsychological assessment and the TICS-m, provides valuable insight in the relation between the two measures that cannot be easily deduced from samples that include demented participants. Generalization of these results towards populations with more prominent cognitive decline or dementia should, however, be done with caution. The cognitive domains in the neuropsychological assessment were determined a priori instead of with factor analysis. Previous studies by our group have shown that both patient and control samples show differential performance in these predefined domains (e.g., van den Berg et al., 2008). This procedure was thus preferred over factor analysis on the data from the neuropsychological assessment, which, given the wide range of different test measures, often results in factors that are difficult to interpret and show weak resemblance to clinical practice. Additional support for the validity of this domain division was found in the present study showing significant correlations with some domains but not with others. The present study included follow-up data of two unrelated studies in which all participants performed a neuropsychological assessment two times (baseline and follow-up) but the TICS-m only once (follow-up). One could argue that the analyses reported in the present study are influenced by learning effects on the neuropsychological assessment. While this may have been the case for cognitive testing in general (participants are no longer "naïve" to a testing-situation), material-specific

learning effects were prevented by the use of parallel versions. Finally, although the correlation analysis showed statistically significant results, the total amount of explained variance was fairly modest, indicating that other variables may play a substantial role as well.

In sum, the TICS-m, which is primarily used as a screening instrument for dementia, shows modest correlations with a comprehensive neuropsychological assessment in older persons without dementia. It reflects multiple cognitive domains, or a "general cognitive ability," and thus appears to give a qualitative assessment of cognition that is broader than memory functioning alone. Present results further indicate that, compared with a neuropsychological assessment, the value of the TICS-m lies mainly in detecting impairments rather than subtle decrements in cognitive functioning in individual persons.

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