Psychometric Properties of an English Short Version of the Trier Inventory for Chronic Stress

Katja Petrowski (Katja.Petrowski@tu-dresden.de)
Technische Universitat Dresden https://orcid.org/0000-0001-7297-2093

Elmaer Braehler
Universitatsklinikum Leipzig

Bjarne Schmalbach
Johannes Gutenberg Universitat Mainz

Andreas Hinz
Boston University

Christina Bastianon
Johannes Gutenberg Universitat Mainz

Tomas Ritz
University of East London

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Abstract

Although a variety of instruments are available that capture stress experience, the assessment of chronic stress has been hindered by the lack of economical screening instruments. Recently, an English-language version of the Trier Inventory for Chronic Stress (TICS-EN) consisting of 57 items according to a systemic-requirement-resource model of health in nine subdomains of the chronic stress experience has been introduced. We constructed a new 9-item short version of the TICS covering all nine subdomains and evaluated it in two samples (total N =685). This version showed a highly satisfactory model fit, was invariant across participant gender, demonstrated a very high correlation with the original TICS (r =.94), and showed a moderate correlation (r =.58) with a measure of perceived stress in the past month. Therefore, this theoretically driven instrument can be recommended as a short version of the TICS in English language.

Introduction

According to a recent stress report, the levels of perceived stress have significantly increased in the past decade (1). Consequences of long-lasting or chronic stress are an increased risk for impaired psychological wellbeing and acute physical illnesses (2,3). Associations between psychological stress or depression on the one hand and cardiovascular disease, sleep disorder or chronic pain are on the other hand well-established (4–9). Elevated stress levels also play a role in susceptibility to upper respiratory tract infections, asthma, herpes viral infections, autoimmune diseases, and delayed wound-healing (9). Therefore, measuring chronic stress with a short instrument is of relevance to a wide research field (10).

Cohen and colleagues (3) have provided a thorough overview of assessment instruments for general stress and area-specific stress assessment. To capture aspects of the general chronic stress, the Perceived Stress Questionnaire (11,12) provides a retrospective one-year evaluation in addition to the last four, six, and eight weeks. The Trier Inventory for Chronic Stress (TICS) (13) is an instrument that explicitly captures area-specific chronic stress in one longer questionnaire including Work Overload, Social Overload, Pressure to Perform, Work Discontent, Excessive Demands from Work, Lack of Social Recognition, Social Tensions, Social Isolation, and Chronic Worrying. These nine domains are measured by 57 items (13,14), which had been selected in accordance with the systemic-requirement-resource model of health (15). As the TICS scales were developed based on this model, the authors postulated high content validity as a logical consequence (13). The results of a confirmatory factor analysis (CFA) in a representative German study provided evidence for a good factorial validity (14).

To meet the need for a brief chronic stress assessment inventory in applied research and practice, a 12-item short screening scale of the TICS (Short Screening Scale for Chronic Stress, SSCS) was developed by the original authors (13). Since the factor model showed a strong, unrotated first factor (explained variance 28.4%), the items with the highest loadings on this first factor were chosen for the final version of the scale. However, based on this empirical selection procedure, only four of the nine stress domains were represented in the SSCS. In correspondence with the original TICS, the correlation of the SSCS with

the nine subscales of the 57-item version were modest to high. However, the four scales Chronic Worrying, Work Overload, Excessive Demands from Work, and Lack of Social Recognition, which contributed items to the SSCS, correlated higher (r =.68-.87), whereas the four scales Pressure to Perform, Work Discontent, Social Tensions, and Social Isolation, which did not contribute items, correlated lower with the 12-item SSCS (r =.40-.56). The exception was the Social Overload scale, which contributed one item to the SSCS but as subscale of the long version of the TICS it correlated lower with SSCS (r =.45) (13). Therefore, five of the nine theoretically proposed areas of chronic stress are underrepresented in the SSCS. The procedure of item selection (highest loading) had inadvertently narrowed the content domain and had thereby lessened the validity of this short screening form (16). Thus, the strength and exceptionality of the area-specific chronic stress assessment of the TICS based on a theoretical model of health is not represented in the short screening scale anymore.

Therefore, a new short version of the TICS was constructed, which represents the theoretically driven and empirically derived nine areas of chronic stress. For the development of this new short version, a representative sample of N = 2,473 respondents from the general population was used by random-route sampling (17). Nine items based on the alphamax algorithm were selected to represent the nine areas of chronic stress of the original TICS. The one-factor-model of this new short version provided a good fit for the latent construct and showed good internal consistency (α =.88). Since this new short version was developed using the German-language original of the TICS, we sought to replicate these findings with the English TICS-EN version (18) and evaluate the psychometric properties of an English-language short form.

Method

Participants and procedure

The data of Sample 1 was collected at two college campuses in the Eastern and Southwestern region of the USA. Participants were undergraduate introductory psychology students who contributed in return for course credit. The final pooled sample consisted of *n* = 501. They received a data protection declaration that is in agreement with the Helsinki Declaration. The study was approved by the institutional review boards of the involved university institutions and all participants provided written informed consent.

Participants of Sample 2 were recruited via Amazon's Mechanical Turk (19), a crowd-sourcing website. MTurk is an international online platform that allows researchers to post tasks or questionnaires that participants complete in return for payment. In the current study, participants signed up via MTurk and were then directed to the online survey to complete the questionnaire. The questionnaire took approximately 5 min to complete and participants were compensated $0.50 for their time. Sample 2 was collected in order to evaluate the factorial structure in a study. The final sample consisted of N = 184 participants.

The study was approved by the ethic review boards of Landesärztekammer Rheinland-Pfalz, Germany, and all participants provided informed consent online by agreeing to take part in the study.

Please insert Table 1

Measures

The Trier Inventory for Chronic Stress (TICS) is a standardized German questionnaire that has been tested with respect to its factorial structure and psychometric properties, showing good to very good reliability (14). Internal consistency (Cronbach's Alpha, α) was good to very good with values ranging from.84 to.91 (mean of α =.87) (13). Nine interrelated factors of chronic stress are assessed: Work Overload; Social Overload; Pressure to Perform; Work Discontent; Excessive Demands at Work; Lack of Social Recognition; Social Tensions; Social Isolation; Chronic Worrying. The nine factors were derived from 57 items rated on a five-point rating scale (1–5, labeled as: "never, "rarely", "sometimes", "frequently", "always"). Participants rated the occurrence/frequency of specific situations with a recall period of the previous three months. The 12 items with the highest loadings constitute the short version by the original authors (13). In addition, a new short version of the TICS was developed based on the alphamax algorithm representing the nine areas of chronic stress of the original TICS. The one-factor-model of this new short version provided a good fit for the latent construct and showed good reliability (α =.88) (17). After the translation state-of-the-art (see Petrowski et al. (18)), the English version of the Trier Inventory of Chronic Stress (TICS-EN) with 57 items was used in the present study (18).

The Perceived Stress Scale (PSS–10) is the most widely used psychological instrument for measuring the perception of stress (20). Respondents report the degree to which situations in one's life have been unpredictable, uncontrollable and overloaded in the past month on a 5-point rating scale (0 = never, 1 = almost never, 2 = sometimes, 3 = fairly often, 4 = very often).

Statistical Analyses

We conducted the analyses in R, using the packages *lavaan, lordif, MBESS,* and *semTools (*21–24*).* Participants with missing values on any of the TICS–9 items were excluded from the analysis: seven and eleven participants, respectively. In addition, we excluded participants who failed the attention checks utilized in Sample 2 (n = 28). Very few participants (less than 5% across all items in both samples) chose the highest response option, making the items essentially ordinally scaled. Previous research suggests that conventional maximum likelihood estimation tends to be inaccurate with four or fewer response categories (25,26). Therefore, we used the robust diagonally weighted least squares estimation method (27).

To evaluate model fit we considered the following measures and cutoff values (28–30): The χ^2-statistic should ideally be non-significant and is calculated by χ^2 divided by the degrees of freedom of the model,

which should < than 2 to indicate good, or < 3 to indicate acceptable, fit. The Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI), which should be >.95 for good, or >.90 for acceptable fit, and finally, the Root Mean Square Error of Approximation (RMSEA) and the Standardized Root Mean Square Residual (SRMR), which should be lower than.08 to indicate acceptable, or <.05 to indicate good fit. Additionally, we report the 90% confidence interval for the RMSEA. In line with Dunn et al. (31), we tested reliability using McDonald's ω (32), accompanied by a 95% confidence interval.

In order to test for measurement invariance across gender groups, we used the approach of comparing increasingly constrained models as described by Milfont et al. (33). Since we were dealing with ordered categorical data we modified the procedure in the way described by Wu et al. (34): First, we compared the unconstrained (configural) model to a model with item thresholds fixed to be equal across groups. Second, the threshold-invariant model was compared to the metric model (item loadings constrained). Third, the metric model was compared to the scalar model (item intercepts constrained). To evaluate the model comparisons, we primarily used the differences in CFI and gamma hat (GH) between models—which should not exceed.01. Additionally, we tested for significant differences in χ^2. To avoid selecting a non-invariant marker variable we estimated all factor loadings freely and set the variance of the latent variable to 1 instead. In addition, we analyzed differential item functioning using a logistic ordinal regression framework to be able to pinpoint the origin of whatever instances of measurement non-invariance we encountered (35–37).

Results

Item descriptive statistics

We report descriptive statistics for the TICS–9 items in Table 2 and mean scores by sociodemographic group membership in Table 1. All corrected item-total correlations were above the commonly used cutoff value of.50.

Please insert Table 2

CFA and reliability analysis

We report the results of the CFA in Table 3. Model fit was acceptable in both samples: Only the χ^2-test indicated a significant deviation from the theoretical model. All fit indices presented evidence for acceptable, even good model fit. Internal consistency was satisfactory in both samples: ωSample1 =.868 [.850;.887], ωSample2 =.872 [.816;.927]. In comparison, the 57-item long version, which was included in Sample 1, had a substantially higher reliability coefficient, ω =.969 [.965;.974].

Please insert Table 3

Measurement invariance

Next, we tested for measurement invariance across gender using Sample 1. Since not all items in all groups had sufficient frequencies for all response options, we collapsed the two highest replies “4” and “5”, putting the items on a four-point scale for the analysis of invariance. Utilizing the procedure described above we found evidence for invariance across gender. Only the χ^2 statistic showed a significant deviation, which was limited to the final comparison. CFI and GH never exceeded the cutoff of.01 between levels of constraints, indicating that women and men do not differ meaningfully in terms of their response behavior to the TICS–9.

When considering the indices of non-compensatory differential item functioning (NCDIF) presented in Table 2, it becomes clear that most of the gender-specific differences are attributable to Items 3 and 7, with both of them exceeding the cutoff of NCDIF $\leq$ 0.054 for four-point items (38). Thus, item-specific comparisons—specifically for these two items—are discouraged. However, considering the entire scale, differential test functioning (the sum of compensatory differential item functioning (CDIF), which accounts for the different directions of DIF; DTF = 0.2614), was below the critical value of 9 *.054 = 0.486. Thus, overall there was a slight trend for women to choose higher response options than men, given the same trait level of stress (see Figure 1). However, this difference was so small that it was unlikely to meaningfully influence interpretation of test scores. This was also evident from Figure 1, which shows response behavior on the scale level across trait values.

Please insert Table 4

Please insert Figure 1.

Validity

In Sample 1, we found a very high correlation between the TICS–9 and the TICS–57, r(499) =.944, p <.001. Additionally, in Sample 2, there was a moderately high association of TICS–9 with PSS–10, $r_{Sample2}$(182) =.583, p <.001.

Discussion

A reliable English nine-item short version of the English TICS-EN was constructed for the assessment of chronic stress. This short scale captures all areas of a systemic-requirement-resource model of health. Furthermore, the actual approach to develop the nine items short version of the TICS-EN has the advantage that it follows the proposed approach for the development of short forms by Smith et al. (39). By this, all the typical methodological problems of short form developers were avoided (13,15,39). Questionnaires choosing those items with the highest item-total correlations for a given factor (39–42), a high internal consistency estimate of reliability is preserved, but the content domain is inadvertently

narrowed and the validity of the short form is lessened (39,42). Using the alphamax algorithm, one item from each of the nine scales of the TICS was present in the TICS–9, this methodological problem was avoided. Another potential challenge is the lack of full content coverage of the construct and lack of validity with fewer items. In order to avoid this, TICS–9 covered all nine domains of the systemic-requirement-resource model of health (15) with one item each. The strength of the original long form of the TICS was based on a theoretical model of health (13,15) and with this strategy of item selection this advantage was also transferred to the TICS–9.

From a practicality perspective, our short form combines the validity of the full-length form with an economical format that is particularly suitable for large multivariable studies. It shows a very good factorial structure and correlates high with the long version. Due to the given invariance analyses of gender and age specificities in multivariate studies are possible. Furthermore, the psychometric properties are similar to the original German long as well as short version of the TICS (17,18).

The study has the strength that separate samples were drawn in order to replicate the factorial structure. However, some limitations need to be acknowledged. The item selection algorithm based on the optimization of Cronbach's alpha has the side effect of simultaneously increasing model fit for a one-factorial solution. The better psychometric properties of the new nine-item solution compared to the 12-item version is, thus, partly due to the design, see Petrowski et al. (17). Another limitation is the comparison with the PSS only. Associations with additional instruments for negative affect and chronic stress assessment should be implemented in future studies to examine convergent and divergent validity fully. Future research should also explore the relationship with external ratings of chronic stress to establish criterion validity. A design with repeated measurements would allow for calculation of retest-reliability, the comparison of factor structures across time, and the determination of possible cohort effects.

In conclusion, our study presents a brief 9-item version of the TICS for measurement of chronic stress that is theoretically based and features measurement invariance across participant gender and strong reliability and emerging evidence for validity. It can be recommended as an economical screening instrument for multivariable studies in psychology, medicine, and epidemiology.

Abbreviations

JAS = Job Anxiety Scale

WPS = Workplace Phobia Scale

CFI = Comparative Fit Index

TLI = Tucker-Lewis Index

RMSEA = Root Mean Square Error of Approximation

SRMR = Standardized Root Mean Square Residual

GH = Gamma Hat

ICD = International Statistical Classification of Diseases and Related Health Problems

DSM = Diagnostic and Statistical Manual of Mental Disorders

STAI-T = Stait-Trait-Anxiety Inventory

HEALTH = Hamburg Modules for the Assessment of Psychosoical Health

Declarations

Ethics approval and consent to participate:

All participants volunteered and received a data protection declaration in agreement with the Helsinki Declaration. The gave both, written and verbal, informed consent. The study was approved according to the ethical guidelines by the Ethical commission of the Medical Faculty of the Technische Universität Dresden (EK 79032011).

Consent for publication:

Not applicable

Competing interests:

The authors declare that they have no competing interests.

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Authors' contributions:

KP and TR provided data and supervised the process of creating this paper. EB and MS contributed substantially to conception and design. All authors have made substantial contributions to analysis and interpretation of data. BS and AH executed the statistical analyses. BS, KP, and TR drafted the manuscript and all authors revised it critically for important intellectual content. All authors read and approved the final manuscript.

Availability of data and materials section:

All data and materials are available from the corresponding author upon reasonable request.

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Tables

Table 1

Sample description

	Sample 1 (n = 501)			Sample 2 (n = 184)		
	n	%	TICS M (SD)	n	%	TICS M (SD)
Gender						
Female	366	73.1	2.47 (0.72)	96	52.2	2.44 (0.85)
Male	118	23.6	2.54 (0.70)	88	47.8	2.46 (0.89)
Missing	17	3.4	2.05 (0.84)			
Age (in years)	M = 19.97, SD = 2.84			M = 37.86, SD = 11.35		
≤20	366	73.1	2.50 (0.70)	2	1.1	3.44 (0.31)
21-25	116	23.2	2.42 (0.79)	16	8.7	2.78 (0.79)
≥26	19	3.8	2.37 (0.72)	166	90.2	2.41 (0.87)
Ethnicity						
White	391	78.0	2.49 (0.67)	148	80.4	2.35 (0.81)
Black or African American	22	4.4	2.58 (0.69)	16	8.7	2.26 (0.81)
Asian or Pacific Islander	25	5.0	2.28 (0.81)	6	3.3	2.41 (0.87)
Hispanic or Latino	6	1.2	2.74 (0.44)	13	7.1	2.94 (0.98)
Multi-ethnic	6	1.2	3.67 (0.78)	3	1.6	2.70 (0.39)
Other	25	5.0	2.12 (0.97)			
Missing	26	5.2	2.34 (0.91)	2	1.1	2.67 (0.63)

Note. TICS = Trier Inventory for Chronic Stress

Table 2

Descriptive statistics for the TICS-9 (Sample 1)

Item	M	SD	Skewness	Excessive Kurtosis	r_{it}	$CDIF$	$NCDIF$
1	1.838	0.910	0.949	0.467	.537	0.0117	0.0116
2	2.319	1.003	0.414	-0.306	.650	-0.0559	0.0356
3	3.275	1.066	-0.318	-0.358	.543	0.1627	0.1067
4	2.385	1.061	0.475	-0.444	.674	0.0288	0.0066
5	2.218	1.042	0.492	-0.504	.651	0.0082	0.0040
6	2.154	0.993	0.512	-0.510	.608	-0.0222	0.0029
7	2.669	1.184	0.236	-0.787	.594	0.1162	0.0771
8	2.375	1.001	0.406	-0.286	.573	-0.0276	0.0221
9	3.024	1.075	-0.193	-0.508	.580	0.0394	0.0062

Note. r_{it} = Corrected item-total correlation; $CDIF$ = Compensatory differential item functioning

; *NCDIF* = Non-compensatory differential item functioning

Table 3

Model fit in both samples

	χ^2 (*df*)	*p*	χ^2/df	*CFI*	*TLI*	*RMSEA* [90% *CI*]	*SRMR*
Sample 1	116.878 (27)	< .001	4.329	.988	.984	.082 [.067; .097]	.060
Sample 2	40.614 (27)	.045	1.504	.997	.995	.073 [.011; .117]	.057

Table 4

Analysis of measurement invariance across gender (Sample 1)

Model	χ^2 (*df*)	$\Delta\chi^2$	Δdf	*p*	*CFI*	ΔCFI	*GH*	ΔGH
Configural inv.	327.328 (56)				.956		.889	
Male	77.251 (28)				.966		.915	
Female	250.077 (28)				.952		.881	
Threshold inv.	340.100 (65)	12.772	9	.173	.955	.001	.888	.001
Loading inv.	346.736 (72)	6.636	7	.468	.955	.000	.888	.000
Intercept inv.	378.449 (80)	31.713	8	< .001	.951	.004	.879	.009

Figures

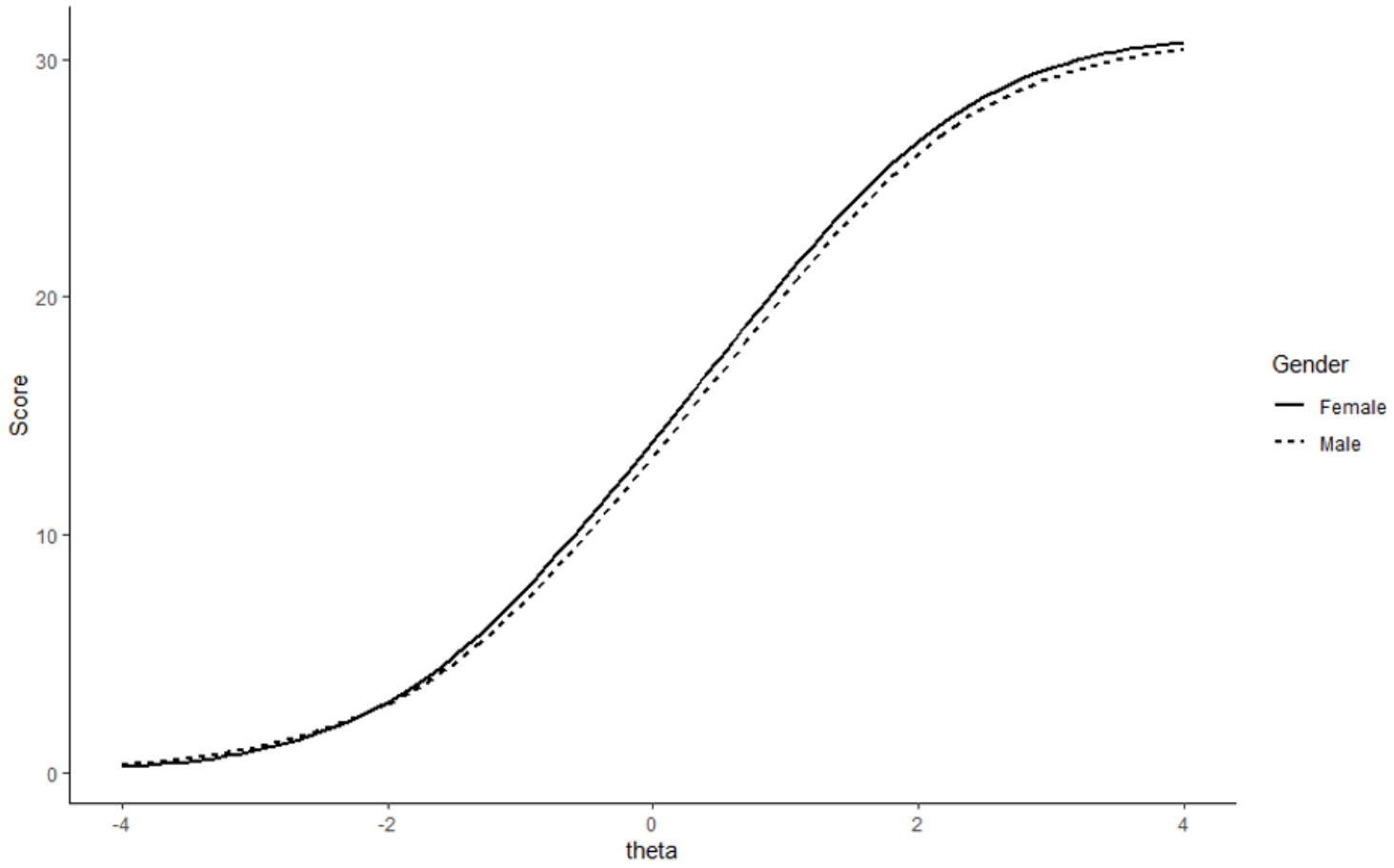

Figure 1

Gender-specific test characteristic curves. The scale range differs from the empirical distribution because items were rescaled to minima of 0 and groups of insufficient size were collapsed.