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Research Paper

Associated symptoms of traumatization: A scale validation of Trauma symptoms checklist - 26 (TSC-26)

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ABSTRACT

Background: The Trauma Symptoms Checklist-26 (TSC-26) has been used to measure negative affectivity, somatization, and dissociation in several Danish studies, but it has never been validated.
Method: Using data from five studies involving 1576 participants, the factor structure of the TSC- 26 was explored using confirmatory factor analysis (CFA). Correlation analyses of the associations between scales on the TSC-26 total score, its subscales, and scores on scales measuring related constructs were carried out. Independent samples *t*-tests of exposure variables were conducted. A test-retest analysis was performed, and Cronbach's alpha was calculated as measures of reliability.
Results: The CFA confirmed the expected three-factor structure of the TSC-26, which obtained an acceptable fit with three modifications. The correlation analyses showed strong correlations between TSC-26 and related scales. Independent samples *t*-tests found significant differences in TSC-26 scores between high- and low trauma exposure groups. Both measures of reliability resulted in high reliability coefficients for the whole scale as well as subscales. Reliability measures and test-retest coefficients were excellent.
Conclusion: The total score of the TSC-26 can validly be used to measure negative affectivity, somatization, and dissociation in samples of traumatized individuals. A few scale modifications and the development of a cut-off score are recommended in future studies.

1. Introduction

The development and validation of assessment tools are crucial in psychological research, impacting diagnostic and treatment decisions. The Trauma Symptoms Checklist-26 (TSC-26) is a brief questionnaire with 26 items measuring symptoms of traumatization across the subscales of negative affectivity, somatization, and dissociation. TSC-26 efficiently identifies trauma reaction patterns, their severity, and highlights symptoms beyond diagnostic criteria (Krog & Duel, 2003; Elklit, 1990). Although employed in many Danish studies, the TSC-26 stills lacks validation. Earlier versions showed good psychometric properties (Briere & Runtz, 1989; Krog & Duel, 2003). The primary aim of the study is to investigate the psychometric properties of the TSC-26.

1.1. Beyond diagnostic criteria: the complexity of trauma reactions and treatment implications

Heeke et al. (2020) conducted a study suggesting that 9 % of individuals diagnosed with Post Traumatic Stress Disorder (PTSD) using the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013) fail to meet the diagnostic criteria for PTSD and Complex PTSD (CPTSD) outlined in the International Classification of Diseases 11th edition (ICD-11; WHO, 2019). This illustrates that PTSD reflects diverse trauma reactions and highlights that not all traumatized individuals meet diagnostic criteria for PTSD. In fact, clinically traumatized patients rarely exhibit the 'pure' symptom pattern corresponding to PTSD criteria, observed in research (Lerchner & Yehuda, 2020). Several studies (e.g., Bonanno & Mancini, 2012; Cloitre, 2015; Kilpatrick et al., 2021; McLaughlin et al., 2015) show that individuals meeting only some of these criteria, and thus not qualifying for diagnosis, can experience significant impairment, necessitating treatment. Analyzing data from over 20,000 respondents in the WHO's 'Mental Health Surveys,' McLaughlin et al. (2015) aimed to establish subclinical PTSD criteria and a threshold. While 3 % met PTSD diagnosis criteria, an additional 3.6 % showed significant trauma-related distress, impacting daily life, including suicidal thoughts, reduced functionality,

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and comorbid conditions like anxiety and depression. However, this latter group met only two to three criteria for PTSD (McLaughlin et al., 2015). This presents a societal challenge as a diagnosis of PTSD or other trauma-related disorders is often required for access to treatment and professional support in public healthcare systems (Danske Regioner, 2017).

1.2. Associated symptoms of traumatization

To diagnose PTSD, criteria encompassing intrusive symptoms, avoidance behavior, and heightened vigilance, must be met (APA, 2013; WHO, 2019; Friedman et al., 2021a), while associated symptoms are frequently overlooked (Korte et al., 2021; Krog & Duel, 2003; Schmidt, 2015). Empirical evidence highlights a variety of associated symptoms, many of which are now accepted symptoms in the DSM-5 as negative cognitions and feelings. These encompass symptoms of depression and anxiety disorders, and emotional challenges including heightened affective instability, feelings of guilt, shame, despair, anger, hostility, interpersonal difficulties, and challenges in emotion regulation, along with suicidal ideation. Furthermore, individuals may experience behavioral challenges such as impulsive behavior, social withdrawal, and substance abuse. There are also physical and cognitive challenges, including somatic symptoms and dissociation (Cloitre, 2015; Krog & Duel, 2003; McLaughlin et al., 2015; Pausch & Matten, 2022; Schnurr et al., 2021), and in severe cases, psychosis and personality disorders may also occur (Elklit, 2004; Friedman et al., 2010; Pilton et al., 2015). The severity of challenges associated with traumatization below the PTSD threshold is less severe than those diagnosed with PTSD (Korte et al., 2021). However, associated symptoms can be more disabling than similar issues experienced by non-traumatized individuals, significantly impacting daily functioning, and influencing treatment paths for those affected (Porcelli & Guidi, 2015). A broader consideration of trauma symptoms is crucial, as well as acknowledging the impact of traumatic events on critical life aspects (Bonanno & Mancini, 2012; Kilpatrick et al., 2021).

1.3. Negative affectivity

Negative affectivity is characterized as a disposition toward negative emotional engagement, triggering heightened awareness of negative experiences, and leading to increased negative emotions and frustrations. High scores are associated with magnifying everyday situations, dwelling on typical challenges such as misunderstandings, disagreements, and rejections, and a lack of adaptive coping skills for managing negative emotions. This disposition is often linked with negative self-perception, low self-esteem, introspection, and elevated psychological distress (Gulley et al., 2015; Heckman & Westefeld, 2006; Raudales et al., 2019). Studies link negative affectivity to neuroticism, defined as a disposition of negative feelings and a general belief that the world is unsafe or threatening (Ogle et al., 2017; Watson & Clark, 1984). Strong correlations have been reported between neuroticism and severity of PTSD symptoms (Jakšić et al., 2012; Ogle et al., 2017), as well as treatment effect and duration, suggesting that a negative worldview might influence the severity of trauma-related symptoms, and may hinder an individual's recovery (Waszczuk et al., 2018). Studies also point to a link between negative affectivity and social withdrawal, influencing PTSD symptom development (van der Hart & Friedman, 2019).

1.4. Somatization

Somatization can be defined as physical symptoms lacking an organic cause. Trauma-exposed individuals often self-report increased somatic symptoms, such as headaches, gastrointestinal issues, palpitations, muscle pain, dizziness, breathing troubles, sleep disturbances, and cognitive problems, acknowledging trauma as a significant risk factor (Gupta, 2013; Pausch & Matten, 2022; Schnurr et. al., 2021; Sundhedsstyrelsen, 2018). Studies suggest an association between trauma exposure and the quantity of somatization symptoms (Schnurr et al., 2021), and propose that PTSD mediates the link between trauma and somatization (Rohlof et al., 2014; Kratzer et al., 2022). PTSD patients with somatic symptoms often exhibit more severe PTSD and higher depression rates than those without (Elklit & Christensen, 2009; Beckham et al., 1998). Furthermore, studies establish a link between somatization and a sense of incompetence and personal stress (Krog & Duel, 2003). Some researchers have found that factors such as depression and poor coping abilities mediate the relationship between PTSD and somatization (Schnurr et al., 2021), along with reduced responsiveness to external stimuli and increased awareness of internal stimuli (McFarlane et al., 1994). Moreover, studies emphasize a strong correlation between PTSD, somatization, and dissociation; individuals with a higher degree of somatic symptoms face a greater risk of developing dissociative symptoms (Kratzer et al., 2022).

1.5. Dissociation

Dissociative reactions can manifest as changes in perception, weakened memory, or emotional detachment from surroundings (APA, 2013). Trauma-induced dissociation symptoms include emotional numbness, time distortion, memory loss, limited event encoding, distorted reality perception including hallucinations, and it may entail disruptions in personality organization (Bryant, 2007; DePrince et al., 2021). The criteria for PTSD diagnosis encompass some of these symptoms, including flashbacks, and specify that these can have a psychotic quality. DSM-5 includes a dissociative subtype, with approximately 16–45 % of PTSD patients meeting its criteria, requiring symptoms of depersonalization or derealization, defined as an experience of unfamiliarity with oneself or surroundings as unreal (DePrince et al., 2021). Dissociation played a central role in the initial formulation of CPTSD, but there is no direct emphasis on dissociative symptoms in the definitions of PTSD, CPTSD, or other trauma-related disorders in ICD-10 and ICD-11 (Friedman et al., 2021b; WHO, 2019). Not all traumatized individuals manifest dissociative symptoms (Lyssenko et al., 2018; van der Hart et al., 2005; Friedman et al., 2021a); however, studies suggest a link between trauma exposure and the development of dissociative symptoms (Friedman et al., 2007; van der Kolk & van der Hart, 1989). Studies also suggest an association between dissociation and somatization, with the degree of PTSD and trauma exposure proposed as mediating factors (Kratzer et al., 2022), and dissociation and affective symptoms, including depression and negative affectivity (Buswell et al., 2021). Patients with dissociative disorders exhibit a higher number of suicidal thoughts and behaviors when somatization disorder coexists with dissociation (Öztürk & Sar, 2008).

1.6. The trauma symptoms checklist

The developmental process of the TSC involved several revisions and adaptations. Briere and Runtz (1989) originally formulated TSC-33 to assess the long-term effects of sexual abuse. Elklit (1990) expanded on their work and created TSC-35, introducing additional subscales and items. Further modifications, by means of exploratory factor analysis by Krog and Duel (2003) resulted in TSC-23, which has sound psychometric properties; however, it is not recommended for assessing symptoms related to sexual abuse. Subsequent adjustments by Elklit and Molin (2006)) led to the current version, TSC-26, comprising 26 items across three subscales: negative affectivity, somatization, and dissociation. TSC-26 can be administered as a self-report questionnaire or by a clinician. TSC-26 proves beneficial in assessing the impact of a traumatic event on physical, emotional, and cognitive well-being. It also investigates social relationships and self-perception (Krog & Duel, 2003; Elklit, 1990). Scores from TSC-26 should not solely determine trauma disorder diagnoses but be used as a supplement, focusing on disabling

associated symptoms (Elklit, 1990). Thus, the use of TSC-26 serves two purposes: 1) Identifying patients requiring treatment, recognizing debilitating associated symptoms not in ICD-11 and DSM-5 criteria for PTSD, and 2) improve planning treatment planning through increased knowledge of the patient's symptomatology.

2. Methods

2.1. Procedure

To examine the psychometric properties of TSC-26 we employed four different validation methods to gather evidence of criteria- and construct validity and measurement reliability. The factor structure of the TSC- 26 will be explored using confirmatory factor analysis (CFA), which can provide evidence for the construct validity of TSC-26 through convergent validation. Correlation analyses of the association between scores on the TSC-26, its subscales and scores on scales measuring related constructs will be conducted to investigate convergent validation as well as criterion validity. Paired *t*-tests of the total-score difference for groups with different degrees of trauma exposure will be performed to explore discriminative validation. A test-retest study will be carried out, and Cronbach's alpha will be calculated as a measure of internal consistency for TSC-26 and its subscales.

2.2. Participants and sample

The sample consists of questionnaire data from 1576 respondents from five empirical studies. The participants all completed the TSC-26 and have been exposed to various traumatic events, including 1) residing in the area hit by an explosion disaster (n = 506) (Elklit & Molin, 2006), 2) serving as a first responder to an explosion disaster (n = 453) (Elklit & Molin, 2007), 3) losing a loved one to cancer (n = 153) (Elklit & Reinholt, 2007), 4) witnessing a stabbing or being present at the scene (n = 318) (Elklit & Kurdahl, 2007), and 5) experiencing partner violence (n = 146) (Eriksen et al., 2014). Table 1 presents demographic data of the samples and relevant scales utilized in each study. In addition, first-year psychology students from the University of Copenhagen filled out the TSC-26 on two separate occasions (n = 67). Demographic data is not available for this sample and will only serve as the basis for a test-retest reliability analysis. The data were filtered to remove mistakes including non-integers and incorrect values. The collected sample included a total of 5 % missing values, which was handled with multiple imputation using the Mice package (version 3.15.0) in the statistical programming language R (version 4.3.3) in accordance with guidelines presented by Graham (2009).

2.3. Measures

In the studies from which we draw our sample, the participants completed two additional questionnaires relevant to the present study.

2.3.1. Harvard trauma questionnaire (HTQ-17)

HTQ-17 is a widely used and validated checklist for measuring PTSD symptoms in traumatised populations, and consists of three subscales: invasion, avoidance, and hyperarousal (Mollica et al., 1992). The HTQ-17 scale has shown excellent psychometric properties in different cultural contexts (Mollica et al., 1992; Oruc et al., 2009; Choi et al., 2006; Mughal et al., 2020) including a large Danish sample (Bach, 2003), and is therefore a sound measure against which to measure the TSC-26. HTQ-17 was used in all five samples included in the CFA. The reliability values were excellent: invasion $\alpha = 0.851$; avoidance $\alpha = 0.817$; hyperarousal $\alpha = 0.871$; total score $\alpha = 0.932$.

2.3.2. NEO personality inventory revised (NEO-PI-R)

NEO-PI-R is a validated scale based on the five-factor-model of personality (McCrae et al., 1998; McCrae & Costa, 2003; Hansen & Mortensen, 2006). Specifically, the neuroticism trait of this model has been described as close to synonymous with negative affectivity (Ogle et al., 2017; Watson & Clark, 1984), and is thus a solid measure against which to measure the TSC-26. NEO-PI-R was used in one of the samples included in the CFA. The reliability coefficient was good for the neuroticism subscale (Cronbach's $\alpha = 0.784$).

3. Analysis

3.1. CFA

A CFA was performed to provide support for the construct validity of the TSC-26 through convergent validation by demonstrating that items are associated with related constructs (factors), as well as each other, in a theoretically consistent way (Brown, 2015; Harrington, 2008; John & Benet-Martinéz, 2014). The sample (n = 1576) was split into two random subsets, in which 70 % (n = 1050) of the data composed the training set and 30 % (n = 526) of responses composed the validation set (Gholamy et al., 2018; James et al., 2013) using the R packages, Caret, caTools and tidyverse. Table 2 shows an equal distribution of the different subject populations in the new datasets.

The initial analyses of the three different models of the TSC-26 data showed that the first-order model with three intercorrelated factors displayed the closest fit to data as expressed through the chosen fit indices (CFI = 0.951, SRMR = 0.057, TLI = 0.946, RMSEA = 0.068), compared to the first-order model with one general factor (CFI = 0.800, SRMR = 0.067, TLI = 0.783, RMSEA = 0.123), as well as the second-order model with three factors loading on a single general factor (CFI

Table 2
Distribution of samples in the training- and validation sets.

	Training set (n = 1050)	Validation set (n = 526)
Resident survivors of an explosion disaster	337 (32.1 %)	169 (32.1 %)
First responders at an explosion disaster	303 (28.9 %)	150 (28.6 %)
Bereaved family members of cancer patients	102 (9.7 %)	51 (9.7 %)
High school students witnessing stabbing	211 (20.1 %)	107 (20.3 %)
Women exposed to partner violence	97 (9.2 %)	49 (9.3 %)

Table 1
Overview of studies.

Authors	Participants	N*	Gender distribution in% m/f	Age range in years	Standardized scales**
Elklit and Molin (2006))	Resident survivors of an explosion disaster	506	49.4/50.6	18–87	HTQ-17, TSC
Elklit and Molin (2007))	First responders at an explosion disaster	453	93.3/6.7	19–80	HTQ-17, TSC,
Elklit and Reinholt (2007)	Bereaved family members of cancer patients	153	24.7/75.3	16–73	HTQ-17, TSC
Elklit and Kurdahl (2007)	High school students witnessing stabbing	318	37.8/62.2	16–20	HTQ-17, TSC, NEO-PI-R
Eriksen et al. (2014)	Women exposed to partner violence	146	0/100	21–55	HTQ-17, TSC

* Number of TSC-26 responses:.
** Harvard Trauma Questionnaire-17 (HTQ-17), TSC (Trauma Symptoms Checklist), The Revised NEO Personality Inventory (NEO-PI-R).

= 0.840, SRMR = 0.057, TLI = 0.825, RMSEA = 0.110). Thus, the three-factor model was chosen for continued analysis.

An initial analysis to compare the fit of three different models to data was performed. A first-order model with three intercorrelated factors (negative affectivity, somatization, and dissociation), as well as a first-order model in which all items load on one general factor, and a second-order model with three factors loading on a single higher-order factor was fitted to the training data using the Lavaan package for R (version 0.6–13; Rosseel, 2011). The 26 items were specified as either indicators of a single factor, or in the case of the first- and second-order models containing three-factors, indicators of their respective factors (subscales) (Appendix 1). The latent variables were scaled automatically by Lavaan by fixing the first indicator of every factor to 1 (Rosseel, 2011). Data was treated as categorical rather than continuous to avoid potential model misspecification and biased parameter estimates. Robust diagonally weighted least squares (DWLS) was used to estimate the model parameters (Flora & Curran, 2004; Li, 2016; Sellbom & Tellegen, 2019; Wirth & Edwards, 2007).

The models' fit to data was evaluated based on four commonly used fit indices: the Standardized root mean square (SRMR), the Root mean square error of approximation (RMSEA), the Comparative fit index (CFI) and the Tucker-Lewis index (TLI) (Boateng et al., 2018; Dimitrov, 2012; Floyd & Widaman, 1995). Following recommendations made by Hu and Bentler (1999) values above 0.95 for CFI and TLI, values below 0.06 for RMSEA and 0.08 for SRMR will be taken as indicative of model fit. The Chi-square ($\chi 2$) value of overall fit will be reported, but not factored in with the evaluation of model fit, as this has been shown to overestimate significance in large samples (Dimitrov, 2012; Sellbom & Tellegen, 2019). Modification indices (MIs) for the model were calculated.

Based on the initial analyses of the three suggested models, the model displaying the best fit to data was chosen, and revisions of this model were made one at a time, testing the fit of the model after each modification by running the analysis of the revised model on the training data until all indices indicated fit of the model. Changes were made based on MIs when these could be theoretically justified (Jöreskog, 1993). When acceptable fit was reached, the CFA was run on the data of the validation set to cross-validate the model.

3.2. Correlation analyses

Correlation analyses were conducted in SPSS to investigate the criteria- and construct validity of TSC-26 by demonstrating associations between total- and subscale scores on the TSC-26 and the HTQ-17 (n = 1575) and NEO-PI-R (n = 318). The conducted correlation analyses are visually explained in Fig. 1. Scores on the different scales were treated as continuous data, and Pearson's correlation analysis was chosen for the analyses in line with recommendations made by Khamis (2008).

Firstly, Pearson's r was calculated for the association between total scores on the TSC-26 and the HTQ-17. HTQ-17 and TSC-26 are both intended to measure trauma symptoms, therefore a strong (but not perfect) correlation between the two will be taken as evidence of the construct validity of the TSC-26. Furthermore, HTQ-17 can be argued to represent a criterion for TSC-26, why a strong association between the scales will also be assumed evident of criteria validity of the TSC-26.

Secondly, Pearson's r was calculated for the association between subscale scores of the TSC-26 and the HTQ-17 in order to strengthen the claim of construct validity by demonstrating strong correlations with other scales that represent similar constructs: the TSC-26 *dissociation* subscale and the HTQ-17 *invasion* subscale both involve an involuntary re-experiencing of the traumatic event (DePrince et al., 2021; Friedman et al., 2021), and the TSC-26 *somatization* subscale and HTQ-17 *hyperarousal* subscale both include sleep problems.

A third Pearson's r was calculated for the association between the TSC-26 subscale for *negative affectivity* and the NEO-PI-R subscale for *neuroticism*. A strong correlation between the subscales will be taken as indicative of construct validity of the TSC-26 negative affectivity subscale.

3.3. T-tests of group differences by exposure

Research and theory have indicated a dose-response relationship between a degree of exposure to a traumatic event and trauma

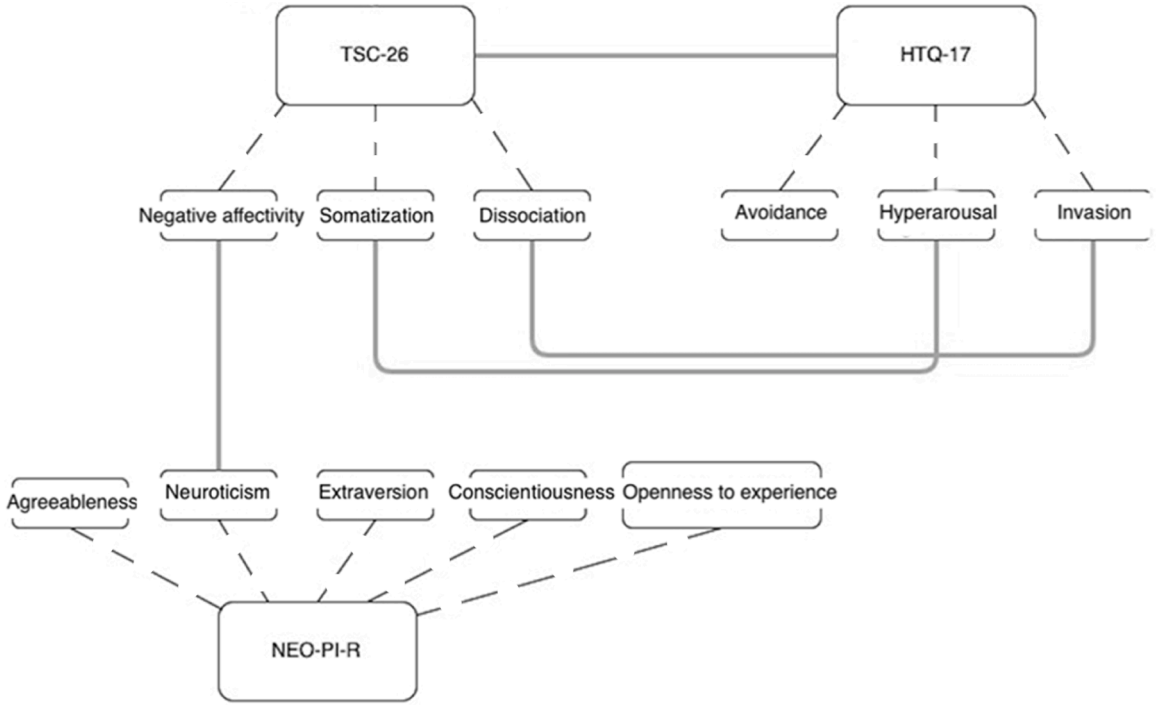


Fig. 1. Illustration of correlation analyses and expected associations.
Note: Grey lines represent expected positive correlations, dotted lines represent the affiliations of subscales.

symptoms (Bonanno et al., 2006; De Soir et al., 2015; Galea et al., 2002; van der Kolk & van der Hart, 1989). A significant difference in TSC-26 scores between individuals with varying degrees of trauma exposure, will support the construct validity of the TSC-26 through discriminative validation of extreme groups (Streiner & Norman, 2008). A single measure of exposure has not been used in the included studies, thus proxy variables serving as approximations of trauma exposure for three samples were chosen (Elklit & Kurdahl, 2007; Elklit & Molin, 2006; Elklit & Reinholt, 2007).

An independent sample *t*-test of the statistical significance of the difference in total TSC-26 scores between differently exposed groups within the same sample was performed using SPSS. The proxy variables were chosen on an empirical basis, mirroring previous findings of circumstances around the traumatic event likely to increase trauma symptoms. The exposure variable chosen for the sample of bereaved caregivers of cancer patients was: 'Municipality/external assistance with caregiving'. This is granted when the caretaking of the dying is extremely demanding ('Yes' or 'No'; Dumont et al., 2006; Ringgaard, 2020; Tuinmann et al., 2004). 'Distance from the murder scene' for the sample of high school students during the stabbing ('in the hall' or 'outside the hall'; Elklit, 1994; Pynoos et al., 1987; Kaplan et al., 2001). 'Degree of destruction of the home' for the sample of residents exposed to a firework factory explosion ('House damaged' or 'Minor damaged'; Bonnano et al., 2006, de Soir et al., 2015).

3.4. Reliability analysis: Cronbach's alpha and test-retest

Reliability estimates of the TSC-26 were calculated for the whole scale and each subscale separately. Cronbach's alpha values were calculated using the psych package in R. Alpha values of $\geq$.90 for the total TSC-26 and values of $\geq$.70 for the subscales will be interpreted as indicative of acceptable reliability (Ponteretto & Ruckdeschel, 2007). Change in alpha values if individual items were removed was calculated for the total TSC-26 and subscales.

In addition, an investigation of the test-retest reliability was conducted on a sample of 67 first year psychology students from the University of Copenhagen who filled out the TSC-26 in SurveyXact two times (T1 and T2) 8 weeks apart. The students were asked to create a unique ID which was used to match the responses at the different time points. The test-retest reliability coefficient was calculated using bivariate correlation in SPSS. According to Charter (2003), setting up general guidelines for the interpretation of the correlation coefficient in test-retest studies is difficult, seeing that what can be considered a strong correlation will vary between studies. Nonetheless, values around 0.70 or higher will be considered indicative of good reliability (Charter, 2003).

4. Results

4.1. CFA

The initial analyses of the three different models of the TSC-26 data showed that the first-order model with three intercorrelated factors displayed the closest fit to data as expressed through the chosen fit indices (CFI = 0.951, SRMR = 0.057, TLI = 0.946, RMSEA = 0.068), compared to the first-order model with one general factor (CFI = 0.800, SRMR = 0.067, TLI = 0.783, RMSEA = 0.123), as well as the second-order model with three factors loading on a single general factor (CFI = 0.840, SRMR = 0.057, TLI = 0.825, RMSEA = 0.110). Thus, the three-factor model was chosen for continued analysis.

While displaying the closest fit of the three tested models, the first analysis of the fit of a three-factor model on the training set resulted in mixed robust fit indices, of which CFI and SRMR showed acceptable fit, and the RMSEA and TLI did not indicate fit of the model (CFI = 0.951, SRMR = 0.057, TLI = 0.946, RMSEA = 0.068). Three modifications on the model were made in accordance with MI values. The modifications were guided by theory and only made when deemed theoretically meaningful. Modifications were made one at a time, testing the fit and calculating new MIs after every alteration of the model until reaching acceptable fit (Jöreskog, 1993; Sellbom & Tellegen, 2019). Changes to the model are presented in Table 3. Testing and changes were based on the Danish version of TSC-26. After reaching acceptable fit of a three-factor model to the training set, the fit was tested on the validation set (James et al., 2013; Gholamy et al., 2018) resulting in acceptable fit on all fit indices as well, which is illustrated in Tables 4 an 5.

4.2. Descriptives and correlation analyses

The TSC-26 and its subscales showed the expected significant, strong correlations with other scales measuring similar- or equivalent constructs. The results of the correlation analyses are presented in Table 6 together with means and SD's for all the scales. We have added the following: "The TSC skewness was 1.557 but we do not consider skewness problematic as the SD is not large."

4.3. Independent samples t-tests of exposure variables

The *t*-tests of differences in TSC-26 scores (two-tailed) between participants grouped by degree of trauma exposure all resulted in significant p-values. All *t*-tests pointed to the groups with higher degrees of exposure having the higher TSC-26 scores. These results are presented in Table 6.

4.4. Reliability analyses

The calculation of Cronbach's alpha values to describe the reliability, measured as internal consistency of the TSC-26 and its subscales, resulted in good reliability for all scales. These results are presented in Table 7. The analysis of the change in alpha values if individual items were removed indicated that the reliability of the total TSC-26 and subscales would not improve or change. The calculation of the test-retest reliability coefficient of the TSC-26 and its subscales resulted in overall high values (no (sub)scale $r < 0.690$), indicative of good temporal reliability (Charter, 2003). These results are also presented in Table 8.

5. Discussion

The primary aim of the study was to investigate the psychometric properties of TSC-26. Even though results from the CFA were supportive of construct validity of TSC-26 through convergent validation, showing acceptable fit of a three-factor model of the TSC-26, it must be considered that three changes to the model were necessary to achieve an acceptable fit. This could potentially indicate that items in the TSC-26 do not measure optimally on the three subscales. However, the three-factor model showed an acceptable fit on two of the four fit indices before modifications, and an acceptable fit was obtained across all four fit indices with a low degree of intervention. We argue that the modifications are not problematic to such an extent that it should hinder the future use of the total score of TSC-26 as a measure of associated

Table 3
Comparison of initial model fit of three different models of the TSC-26 training data.

Model	CFI	TLI	RMSEA	SRMR
First-order with three intercorrelated factors	***0.951***	0.946	0.068	***0.057***
First-order with one general factor	0.800	0.783	0.123	***0.067***
Second-order with three factors loading on a single higher order factor	0.840	0.825	0.110	***0.057***

Note: Values highlighted with a bold cursive font show acceptable fit of the model in accordance with the previously described cut-off values (CFI > 0.95, TLI > 0.95, RMSEA < 0.06, SRMR < 0.08).

Table 4
Progress in changes made to the three-factor model on the training set.

Modification index	Changes to the model	Reason for change	CFI	TLI	RMSEA	SRMR
None	None	N/A	***0.951***	0.946	0.068	***0.057***
TSC6~~TSC7 mi = 129.057	Allows for the residuals of item 6 and 7 to correlate in the model	Similar wording/ semantics	***0.956***	***0.951***	0.065	***0.055***
NeA=~TSC26 mi = 93.072	Allows for item 26 to load on both the somatization- and negative affectivity factors	Ambiguous wording	***0.960***	***0.956***	0.062	***0.054***
Dis =~TSC11 mi = 124.388	Allows for item 11 to load on both the somatization- and dissociation factors.	The symptom can theoretically be part of either factor.	***0.965***	***0.961***	***0.058***	***0.052***

Note: Values highlighted with a bold cursive font show acceptable fit of the model in accordance with the previously described cut-off values (CFI > 0.95, TLI > 0.95, RMSEA < 0.06, SRMR < 0.08).

Table 5
Validation of the modified three factor model of the TSC-26 on the validation set.

Modification index	Changes to the original	Reason for change	CFI	TLI	RMSEA	SRMR
TSC6~~TSC7 NeA=~TSC26 Dis =~TSC11	Allows for items 6 and 7 to correlate, item 26 to load on both somatization- and negative affectivity factors, and for item 11 to load on both somatization- and dissociation factors.	Development of the model on the training set	***0.966***	***0.963***	***0.056***	***0.057***

Note: Values highlighted with a bold italics show acceptable fit of the model in accordance with the previously described cut-off values (CFI > 0.95, TLI > 0.95, RMSEA < 0.06, SRMR < 0.08).

Table 6
Means, SD and correlations between total- and subscales.

	HTQ-17 total	HTQ-17 - hyperarousal	HTQ-17 - invasion	HTQ-17 – avoidance	NEO-PI-R - neuroticism	Means (SD)
TSC-26 total	***.864*****	.826**	.740**	.800**	.601**	37.987 (12.431)
TSC-26 - somatization	*.798***	***.798*****	.669**	.717**	.516**	16.960 (6.108)
TSC-26 - dissociation	.742**	.651**	.692**	.697**	.385**	6.523 (2.268)
TSC-26 - negative affectivity	.725**	.730**	.562**	.622**	***.647*****	14.514 (5.106)
Means (SD)	30.014 (10.970)	9.689 (4.130)	9.264 (3.588)	11.062 (4.262)	11.062 (4.262)	

Note: Correlations highlighted with bold and italics are the associations we expected to see. Correlations followed by ** were significant at the α < 0.001 level.

Table 7
Results of *t*-test of difference in TSC-26 scores in three exposure groups.

Exposure	*n*	*Mean TSC-26*	*SD*	*t(503)*	*p-value*	*Cohen's d*	*95 % CI*
Explosion disaster residents (n = 503)							
House damaged	***258***	***38.02***	9.74	3.97	***<0.001*****	9.19	[1.64, 4.85]
Minor damages	***247***	***34.78***	8.17				
Bereaved family members of cancer patients (n = 151)							
External help	***61***	***42.51***	12.84	−2.63	***.009****	11.56	[−8.76, −1.25]
No external help	***94***	***47.51***	9.23				
High School students witnessing stabbing (n = 318)							
In hall	***178***	***37.96***	10.20	2.04	***.042****	9.36	[.08, - 4.2]
Outside hall	***142***	***35.81***	8.17				

Note: Values highlighted with bold, and italics are p-values and groups means that correspond to our expectations. P-values followed by ** or * were significant at the α < 0.001 level or the α < 0.05 level, respectively.

symptoms of traumatization, but we would recommend a few individual changes in items to optimize fit (see later).

The failure to achieve an acceptable fit for the unmodified three-factor model of TSC-26 has practical implications for the ongoing analysis. As it was not possible to replicate the empirical investigations using a modified TSC-26, the subsequent analyses could not accurately reflect the factor structure with acceptable fit in the confirmatory factor analysis (CFA). Neglecting the modifications made to the model can pose validity concerns for subsequent analyses. However, the acceptable fit was achieved based on only three modifications, with several fit indices (CFI and SRMR) already pointing to acceptable fit of the three-factor model before modifications.

Results from the correlation analyses of the association between scores on the TSC-26, its subscales and scores on scales measuring related constructs were supportive of construct validity through convergent validation as well as criteria validity of the scale. Looking at

Table 8
Cronbach's alpha for the total TSC-26 total scale and its subscales plus correlation coefficient for T1-T2 plus CI.

Scale	Cronbach's alpha	Correlation coefficient T1-T2	95 % CI
Total TSC-26	***α = 0.94***	*r = 0.82*	*[.73,.88]*
Negative affectivity	***α = 0.90***	*r = 0.79*	*[.68,.87]*
Somatization	***α = 0.89***	*r = 0.81*	*[.70,.88]*
Dissociation	***α = 0.77***	*r = 0.69*	*[.54,.80]*

Note: Alpha values highlighted with bold and cursive meet our requirements for good reliability (α ≥.90 for scales of > 11 items and α ≥ 0.70 for scales 11 ≥ items > 7).

the correlation between total scores of TSC-26 and HTQ-17, a strong, but not perfect correlation is seen. This indicates that the TSC-26 measures a construct that is like the construct in the HTQ-17 but still distinctive. This result is desirable, since the TSC-26 should measure associated symptoms of traumatization and the HTQ-17 measure the symptoms included in the diagnostic criteria for PTSD. The correlation analysis between the TSC-26 and the HTQ-17 indicates that the TSC-26 measures symptoms of traumatization as intended.

The TSC-26 and subscales showed the expected significant, strong correlations (Abma et al., 2016) with other scales measuring similar- or equivalent constructs, indicative of construct validity of the subscales, as these show a strong correlation with another scale that measures a theoretically related construct. Evidence for construct validity indicates that the subscales of the TSC-26 measure the constructs they are intended to measure.

The TSC-26 subscale for dissociation had a slightly stronger association with the avoidance subscale of the HTQ-17 which may contradict the evidence for the validity of the dissociation subscale. However, this is a very small difference of 0.005. In addition, the avoidance subscale does not reflect a construct that should be theoretically unrelated to dissociation, in fact we would argue that dissociation can be seen as an extreme form of avoidance, creating a distance between the traumatised person and their surroundings. Thus, although the slightly stronger correlation with the avoidance subscale does not match our expectations, the strong correlation between the dissociation subscale and related constructs can be interpreted as evidence for construct validity, even though this evidence had been stronger had the dissociation subscale showed a stronger correlation with the invasion subscale. It is to be expected that scores on the subscales generally exhibit strong correlations across the instruments, as scores on the combined TSC-26 and HTQ-17 scales correlate highly with each other.

The *t*-tests of differences in TSC-26 scores (two-tailed) between participants grouped by degree of trauma exposure all resulted in significant p-values. All *t*-tests pointed to the groups with higher degrees of exposure having the higher TSC-26 scores. Thus, the results of the *t*-tests of exposure groups can be seen as supportive of construct validity through discriminative validation, indicating that TSC-26 can differentiate meaningfully between groups with respectively high- and low trauma exposure.

Results from the reliability analyses were supportive of temporal and internal consistency. The reliability coefficients for the test-retest reliability showed moderate to strong correlations between T1 and T2, accordingly demonstrating high temporal stability. Cronbach's alpha for both the total scale, as well as all subscales exceeded Ponteretto and Ruckdeschel's (2007) cut offs, and thus showed excellent internal consistency. The analysis showed that omitting individual items from the scale would not increase Cronbach's alpha for the TSC-26 or its respective subscales. Both reliability analyses thus collectively point to strong reliability for both the total TSC-26 and its subscales.

The results of the reliability analyses offer evidence that the TSC-26 measures reliably in our sample, which further supports the construct validity of the TSC-26, following that reliability is a prerequisite for validity (Streiner & Norman, 2008). In summary, the analyses point to TSC-26 as a valid measure of traumatization, specifically symptoms of somatization, dissociation, and negative affectivity and in concordance with overall good psychometric properties.

6. Limitations

Findings of the current study must be considered in light of a number of limitations. First, the sample consists of Danish citizens, and it is unknown whether current results will generalize to other populations. The sample consists of participants from different populations of trauma-affected individuals, and although this contributes with many strengths (e.g., external generalisability), the trauma exposure in the sample varies in degree, as some responses included in the survey come from people who have not been directly involved in or witnesses to the traumatic event.

7. Future recommendations

Even though the Danish version contains direct translations of the same questions in the English version, further research should examine the psychometric properties of an English version of TSC-26. Furthermore, a validation study of TSC-26 should be carried out in a sample of English natives, considering potential cultural discrepancies. Based on the CFA, we propose a change to the Danish version on the wording of item 6 or 7, item 26 and item 11. These should be specified so that they are more unambiguously aimed at measuring their intended subscales. Such analysis at item level is an important part of the construct validity testing. Further research should also examine the psychometric properties of TSC-26 on additional populations of traumatized individuals, e.g. victims of sexual abuse and victims of war-trauma. Analyses of the correlations between the TSC-26 and scales that more specifically aim to measure symptoms similar to the TSC-26 could further contribute to criterion validity for the subscales of the TSC-26. It would also be beneficial to examine the treatment effects when using the TSC-26 as part of the assessment, to investigate the effect of targeting associated symptoms in treatment. In addition, we recommend that future studies determine a cut-off score, so that it is possible to determine whether a score on negative affectivity, somatization and dissociation is of clinical relevance. A cut off score could provide further relevance to the use of the TSC-26.

8. Conclusion

The total score of TSC-26 can validly be used as a measure of associated symptoms of traumatization in our samples of traumatized individuals. One must however be cautious of its limitations, especially in terms of which types of trauma-survivors it should be applied to. A few scale modifications are recommended in future studies, and the authors also recommend an investigation of the validity of an English version of the TSC-26 in an English-speaking population.

CRediT authorship contribution statement

Zoe Emilie Warburg de Chiffre: Writing – review & editing, Writing – original draft, Methodology, Formal analysis. **Johanne Esther Volkmann:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis. **Ask Elklit:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of competing interest

we have nothing to declare.

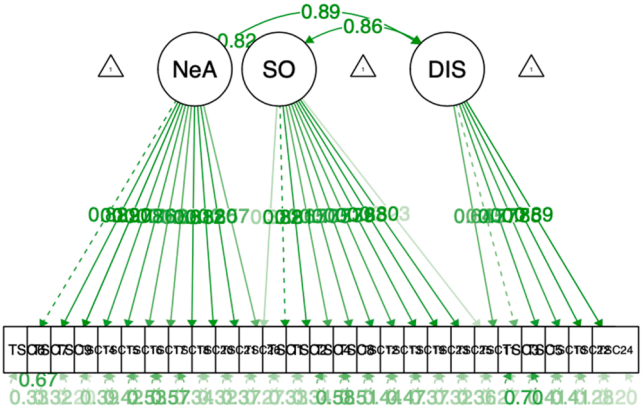
Appendix 1. The Trauma Symptom Checklist (TSC-26) Danish/English

Hvor tit har du oplevet følgende den sidste måned? / How often have you experienced each of the following in the last month?					
		Nej/ never	Ja, nogle gange/ occasionally	Ja, ofte/fairly often	Meget tit/ very often
1.	Har du problemer med at falde i søvn? /trouble getting to sleep	1	2	3	4
2.	Sover du uroligt? /restless sleep	1	2	3	4
3.	Hører du nogle gange stemmer inde i dit hoved? /hear voices inside your head	1	2	3	4
4.	Vågner du op tidligt om morgenen - og kan ikke falde i søvn igen? /waking up early in the morning and can't get back to sleep	1	2	3	4
5.	Oplever du nogle gange, at du har foretaget dig ting, som du overhovedet ikke kan huske, at du har gjort? /have done things you cannot remember you've done	1	2	3	4
6.	Føler du dig isoleret fra andre? /feeling isolated from others	1	2	3	4
7.	Føler du dig ensom? /loneliness	1	2	3	4
8.	Lider du af muskelsmerter? /muscle pains	1	2	3	4
9.	Har du følt dig trist? /sadness	1	2	3	4
10.	Har du forstyrrende tanker eller billeder om begivenheden? /"flashbacks" (sudden, vivid, distracting memories)	1	2	3	4
11.	Taber du tråden, forsvinder du i dine tanker? /losing the thread, going away in your mind	1	2	3	4
12.	Lider du af hovedpine? /headaches	1	2	3	4
13.	Har du problemer med maven? /stomach problems	1	2	3	4
14.	Græder du sommetider? /uncontrollable crying	1	2	3	4
15.	Føler du dig bange eller på vagt? / feel scared or on guard	1	2	3	4
16.	Har du svært ved styre dit temperament? /trouble controlling temper	1	2	3	4
17.	Har du svært ved at komme ud af det med andre? /trouble getting along with others	1	2	3	4
18.	Føler du dig vred eller irriteret? /feeling angry or irritated	1	2	3	4
19.	Lider du af svimmelhed? /dizziness	1	2	3	4
20.	Føler du dig underlegen? /feelings of inferiority	1	2	3	4
21.	Har du selvbebrejdelser? /feelings of guilt	1	2	3	4
22.	Har du en følelse af uvirkelighed? /feelings that things are "unreal"	1	2	3	4
23.	Har du problemer med at huske? /memory problems	1	2	3	4
24.	Føler du, at det nogle gange er, som om du er ude af din krop? /feelings that you are not always in your body	1	2	3	4
25.	Har du problemer med at trække vejret? / having trouble breathing	1	2	3	4
26.	Føler du dig uoplagt? /feeling unenergetic	1	2	3	4

Scoring key

Negativ affektivitet/ negative affectivity	tsc6 + tsc7 + tsc9 + tsc14 + tsc15 + tsc16 + tsc17 + tsc18 + tsc20 + tsc21.
Somatisering/somatization	tsc1 + tsc2 + tsc4 + tsc8 + tsc11+tsc12 + tsc13 + tsc19 + tsc23 + tsc25 + tsc26
Dissociation/dissociation	tsc3 + tsc5 + tsc10 + tsc22 + tsc24
TSC 26 total	Alle/all items

Appendix 2. CFA-diagram



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