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Adolescent Posttraumatic Stress Disorder: An Examination of Factor Structure Reliability in Two National Samples

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Abstract

A four-factor structure of posttraumatic stress disorder (PTSD) has been proposed for DSM-V based on empirical evidence that it is superior to the three-factor DSM-IV structure. However, most studies reveal multiple structures fit the data well in adolescent samples, and high factor correlations have been reported. Within two national samples of adolescents, we tested eight PTSD factor structures, which have never been compared in a single study. Confirmatory factor analyses (CFA) of PTSD symptoms were conducted in two national samples of adolescents: the National Survey of Adolescents (NSA; N=4,023) and the NSA-Replication (NSA-R; N=3,614). CFA revealed that all models provided very good fit to both samples (RMSEAs = .021–.039), though the one-factor model can be rejected, and correlations between factors were high ($r_s = .80$ – 1.0). Potential interpretations of these findings include: (1) the indicators (i.e., symptoms) need refinement; or (2) relevant symptoms have yet to be identified.

Keywords

posttraumatic stress disorder (PTSD); assessment; diagnosis; trauma; adolescents

1. Introduction

Significant revisions have been proposed for the diagnosis of posttraumatic stress disorder (PTSD) in the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-V), given research findings that the current structure of PTSD symptoms does not accurately describe the disorder in trauma-exposed samples (Elhai et al., 2009a; Simms, Watson, &

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Doebbling, 2002). Within the current DSM, DSM-IV-TR (American Psychiatric Association, 2000), a diagnosis of PTSD includes three clusters of symptoms: intrusive re-experiencing (Criterion B), avoidance and emotional numbing (Criterion C), and hyperarousal (Criterion D). Accordingly, the DSM-IV articulates a three-factor structure of PTSD; that is, PTSD is theorized to be comprised of three core, underlying constructs. Modifications proposed for the DSM-V PTSD diagnosis include adding three symptoms and a four-factor structure. Ongoing examination of the symptom content and structure of PTSD is important for many reasons, such as identifying variables that confer risk for PTSD onset, measuring treatment effects, and elucidating the genetic, cognitive, physiological, and neural underpinnings of PTSD.

The DSM-IV three-factor structure of PTSD was derived by expert consensus (APA, 2000). In recent years, researchers have attempted to use a more empirical approach to understand the structure of PTSD (e.g., Sack, Seeley, & Clarke, 1997; Saul, Grant, & Carter, 2008). Exploratory and confirmatory factor analyses are used to determine whether a number of observed variables (e.g., test items) can be explained by a smaller number of unobserved variables (“factors”). Confirmatory factor analytic (CFA) methods that have been employed to uncover the number of factors underlying the PTSD diagnosis have generally resulted in mixed findings. The CFA literature is summarized in Table 1, with a focus on the two most empirically supported adult models (Simms et al., 2002; King et al., 1998) and studies that have been employed with adolescent samples. One of the two most commonly supported factor structures in adult samples is a four-factor model of PTSD comprised of reexperiencing, effortful avoidance, emotional numbing, and hyperarousal (King et al., 1998) (see Table 2). The King (1998) model divided the C Criterion into two factors based on previous evidence that avoidance and numbing are distinct constructs (Foa, Riggs, & Gershuny, 1995; King & King, 1994; Litz, 1992; Litz, Schlenger, Weathers, Caddell, Fairbank, & LaVange, 1995). King and colleagues (1998) found initial support for their four-factor model with a sample of 524 treatment-seeking military veterans.

More recently, the King (1998) model has been compared to the DSM-IV three-factor and to an alternative four-factor model (Simms et al., 2002) which includes intrusions, avoidance, hyperarousal, and dysphoria factors. The addition of this ‘dysphoria’ factor in the Simms model is consistent with (1) observation that some of the initial DSM-IV symptoms (e.g., numbing, problems concentrating) are more consistent with dysphoria than the alternative factors, (2) findings that PTSD is often comorbid with depression (Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995), and (3) the presence of a negative affectivity component in many anxiety and mood disorders (Clark & Watson, 1991). Simms and colleagues (2002) reported that, among Gulf War veterans, this four-factor (intrusions, avoidance, hyperarousal, & dysphoria) model of PTSD (see Table 2) provided the best fit to the data via CFA.

Although research on adult samples has *not* typically supported the DSM-IV three-factor structure, most studies in adolescent samples report excellent fit indices for all models compared regardless of type of trauma or sample size (see Table 1). A “best-fitting” model is often selected based on rather small changes in fit indices. While we would expect some models to demonstrate similar fit due to only slight changes (e.g., the King and Simms models differ only with respect to which factor includes symptoms D1–D3), it is surprising that other models that include a different number of factors show excellent and comparable fit (e.g., Elhai et al., 2009a; Ford et al., 2009). The fact that multiple models fit well is perplexing: CFA is a theory-testing procedure (Floyd & Widaman, 1995), so the observation that many different models (i.e., theories of PTSD latent structure) fit well suggests that multiple underlying structures, or theories, of PTSD, all adequately explain variance in PTSD symptoms in various populations. Further complicating this literature is evidence that

these factors are highly correlated. Where available, factor correlations are reported in Table 1 and demonstrate that the “best-fitting” models identified in some studies typically include factors with high overlap. For example, Shevlin and colleagues (2009) recently examined modifications to the two leading four-factor models (King et al., 1998; Simms et al., 2002) in a sample of over 12,000 trauma-exposed adults. They reported that in their final, best-fitting model, factor correlations ranged from 0.69 to 0.85. King and colleagues (1998) identified a correlation of 0.92 between their Reexperiencing and Hyperarousal factors. In this context, parsimony would suggest that either the model with the fewest number of factors, or one with an overarching single “PTSD” factor be accepted (assuming these models reveal good fit to the data). However, no study to our knowledge has compared one- through four-factor, including hierarchical, models in adolescents.

Despite these problematic findings, there is agreement within the adult literature that the Simms et al. (2002) and King et al. (1998) models best describe PTSD symptomatology (Shevlin et al., 2009). In adolescent samples, however, there is little consensus. For example, Elhai and colleagues (2009a) tested the DSM-IV, King et al., and Simms et al. models in the National Survey of Adolescents (NSA; Kilpatrick et al., 2000). The NSA consists of a national probability sample of 4,023 adolescents aged 12–17 years. All three models evidenced very good fits to the data; however, the authors concluded that the Simms model had the best overall fit. Meanwhile, other PTSD factor structures also have been found to fit adolescent data well. Sack et al. (1997) identified a four factor model including (1) intrusions (emotional reactivity, intrusive thoughts, nightmares, flashbacks), (2) avoidance (physiological reactivity, exaggerated startle, avoidance of thoughts of trauma, no memory of trauma), (3) numbing (loss of interest, detachment, restricted affect), and (4) arousal (hypervigilance, sleep disturbance, irritability, concentration difficulties, sense of foreshortened future, and avoiding situational reminders). Anthony and colleagues (1999) selected a best-fitting three-factor model (different from the DSM-IV three-factor structure) in data yielded from over 6,000 hurricane-exposed adolescents. This model consisted of an overarching, hierarchical PTSD factor and three lower-order factors (1) intrusion/active avoidance, (2) arousal, and (3) numbing/passive avoidance. This Anthony model was recently tested within NSA data by Saul and colleagues (2008), who compared it to the DSM-IV three-factor model and to the four-factor model first identified by King et al. (1998). Saul et al (2008) concluded that the Anthony model provided superior fit to the data relative to the DSM-IV model, but that the four-factor King et al. (1998) model fit the NSA data best. However, when the King model was compared to the DSM-IV three-factor and a two-factor model (Spitzer, First, & Wakefield, 2007) by Ford and colleagues (2009), all three provided excellent fit to the same NSA data. The two-factor model (Spitzer et al., 2007) retains the reexperiencing (Criterion B) factor as in DSM-IV, but eliminates symptoms C3 and C4 (avoiding reminders and specific amnesia) as well as D1, D2, and D3 (difficulty sleeping, irritability, and difficulty concentrating) and combines the remaining symptoms from Criteria C and D into one avoidance/hyperarousal factor. Spitzer et al. (2007) proposed removing these symptoms due to their overlap with other mood and anxiety disorders (e.g., depression) and consequent lack of specificity to PTSD. While all three models fit the data very well, Ford et al. (2009) determined that the Spitzer two-factor model provided comparatively better fit to the NSA data. It is important to note, however, that the Spitzer model included five fewer symptoms than the other tested models, so it is possible that the removal of items contributed significantly to improved fit.

It is striking that within a single data set (i.e., the NSA) different investigators have reported a variety of “best-fitting” models. In sum, research using the same data to test competing theories yields conflicting results about which model, and therefore which theory of PTSD structure, best fits the data. There are a number of possible reasons for these inconsistencies, including (1) the tendency for most models to fit adolescent data well, (2) high inter-factor

correlations, (3) definition of trauma-exposure, (4) the selection of models to test, and (5) statistical tests chosen. Again, because there is often across-the-board good model fit, researchers have made conclusions based upon small changes in fit indices which could be influenced by a variety of factors such as sample characteristics (e.g., trauma type, gender and age distribution) and measures (e.g., continuous vs. categorical data). As discussed above, high inter-factor correlations also call previous results into question. It is notable, however, that to our knowledge, no adolescent studies have published inter-factor correlations and it is therefore not known whether the latent variable overlap identified in some adult studies is replicated in younger samples. Differences in inclusion criteria have also been shown to result in alterations in PTSD factor structure (Elhai et al., 2009b). For example, Saul et al. (2008) required that trauma-exposed participants endorse fear of death or injury, while Ford and colleagues (2009) did not. Consequently, Ford's sample consisted of over twice as many adolescents as Saul's. Further, model selection will impact findings. Lonigan, Shannon, Finch, Daugherty and Taylor (1991) found preliminary evidence for a one-factor structure of PTSD in 5,687 hurricane-exposed youth using exploratory factor analysis (EFA). To our knowledge, however, there has not yet been a rigorous comparison (i.e., using CFA) within an adolescent sample of a one-factor model to the two-, three-, and four-factor models most recently supported by the literature. Although the DSM-IV and theory imply that a single PTSD factor would logically overarch the two, three, or four PTSD components, hierarchical models have similarly only rarely been tested. Asmundson and colleagues (2000) found support for a hierarchical four- but not three-factor model of PTSD in adults, and Anthony et al.'s (1999) findings evidenced a hierarchical three-factor model in adolescents. It is also important to consider which competing models are tested in these different studies, as the best fitting is necessarily relative to the other models tested. Previous studies vary widely in the range of models tested, which makes determining the absolute best fitting model difficult.

In the current study, we aimed to rigorously test the latent structure of PTSD in adolescents, simultaneously address the aforementioned gaps in the literature, and inform revisions of the PTSD diagnosis for DSM-V and beyond. Given evidence that PTSD factors are highly correlated in adult populations (e.g., King et al., 1998; Shevlin et al., 2009), and multiple models typically fit adolescent data well, eight leading models, including hierarchical and one-factor models, were compared in two large national samples of adolescents. Unlike previous studies, particular attention was paid to correlations between factors and the extent to which symptoms loaded on factors within each model. The NSA, a sample utilized in previously published studies (e.g., Elhai et al., 2009a, Ford et al., 2009, Saul et al., 2008) was first subjected to these procedures, with a test of replication in the NSA Replication (NSA-R). Within these large, epidemiological samples of adolescents, participants were selected for trauma exposure based on the most DSM-IV consistent definition possible in order to be generalizable for clinical and research applications. The factor structure of PTSD has not yet been tested in the NSA-R, and this sample therefore affords the opportunity to replicate previous findings in a new nationally representative population of adolescents. We hypothesized that, similar to previous studies, all models would provide a good fit to the NSA and NSA-R data but that the hierarchical Simms et al. (2002) model would reveal the best overall fit. Results of the current study will help to foster stronger inferences regarding the latent structure of PTSD, with far-reaching implications for the assessment and diagnosis of PTSD.

2. Method

2.1 Overview

The current study employed data from the 1995 National Survey of Adolescents (NSA) and the 2005 National Survey of Adolescents-Replication (NSA-R). Both the NSA and NSA-R

are epidemiological studies of youth aged 12–17 residing in the U.S. The main purpose of these studies was to determine the prevalence of adolescents exposure to potentially traumatic events and the specific emotional and behavioral problems commonly associated with exposure to traumatic events (e.g., PTSD). The sampling and methodological procedures used in the NSA and NSA-R have been reported in detail elsewhere (see Kilpatrick et al., 2000, 2003; Wolitzky-Taylor et al., 2009) and are briefly summarized here.

2.2 Participants

2.2.1 NSA—The 1995 NSA included 4,023 youth aged 12–17 years, with an oversample of urban-dwelling adolescents. Sample selection procedures produced a representative sample of adolescents based on U.S. Bureau of the Census estimates of the 1995 adolescent population. Parental permission was obtained to interview a randomly selected adolescent. For inclusion in the current study, participants had to have experienced at least one Criterion A traumatic event (N=1,527).

2.2.2 NSA-R—The 2005 NSA included 3,614 youth aged 12–17 years. The full sample included a national household probability sample as well as an oversample of urban-dwelling adolescents. Parental permission was obtained to interview a randomly selected adolescent. Again, only the trauma-exposed subsample (N=1,119) of participants was included in the analyses. Additional participant demographic information for the NSA and NSA-R (e.g., mean age, ethnicity) is described below.

2.2.3 Weighting procedures—The 1995 and 2005 samples were each weighted to maximize representativeness to the U.S. adolescent populations in each survey year. Because adolescents were over-sampled in urban areas, a weight was created to restore the urban cases back to their true proportion of the urban/suburban/rural variable, based on 1995 and 2005 Census estimates. Next, weights were created to adjust each case based on age and gender. We generated sample frequencies by age cohort and gender and compared this distribution to the Census estimates. Weightings were assigned to each gender-by-age cell within the sample. This procedure resulted in weighted sample distributions that closely approximated Census estimates for 1995 and 2005, respectively.

2.3 Measures

A structured telephone interview was used to collect information across several domains, including demographic characteristics, traumatic event history, and mental health history. With few exceptions, identical questions were used to assess these key domains in the NSA and NSA-R interviews.

2.3.1 Demographic variables—Age was categorized as 12–14 year olds (“younger adolescents”) and 15–17 year olds (“older adolescents”). Racial/ethnic group was assessed using standard questions employed by the U.S. Bureau of the Census. For ANOVAs, dummy-coded variables refer to African-American/non-Hispanic and Hispanic. Caucasian, non-Hispanic participants served as the reference group.

2.3.2 Potentially Traumatic Event Assessment—Participants were assessed for experiencing a number of potentially traumatic events using behaviorally specific close-ended questions. If exposure to a potentially traumatic event was endorsed, a follow-up question (also close-ended) was asked to assess level of fear (0=not at all; 1=very or extremely afraid), fear of dying, and fear of severe injury. As stated above, to be included in the present analyses, participants must have experienced at least one of the following potentially traumatic events, with a positive endorsement to at least one of the subjective response items (i.e., extreme fear, fear of dying, fear of injury).

2.3.2.1 Sexual assault: Lifetime history of sexual assault was measured using contextually orienting prefatory statements followed by behaviorally specific closed-ended questions. Sexual assault items asked about experiences involving forced (a) vaginal or anal penetration by an object, finger, or penis; (b) oral-genital contact; (c) touching of the respondents breasts or genitalia; and (d) respondent s touching of another person s genitalia. In the NSA-R substance facilitated rape was also assessed.

2.3.2.2: Physical assault/abuse was defined as having been: (a) attacked or threatened with a gun, knife, or some other weapon; (b) attacked by another person with perceived intent to kill or seriously injure; (c) beaten and injured (i.e., “hurt pretty badly”) by another person; (d) spanked so forcefully that the respondent sustained welts or bruises, or required medical care; or, (e) cut, burned, or tied up by a caregiver as a punitive consequence. In the NSA physical assault and abuse were not differentiated, but they were in the NSA-R.

2.3.2.3 Witnessed Violence: Participants were assessed to determine whether they had ever witnessed community or parental violence. Witnessed violence included having personally observed someone: (a) shoot someone with a gun; (b) cut or stab someone with a knife; (c) threaten someone with a gun, a knife, or other weapon; (d) mug or rob someone; or (e) rape or sexually assault someone. In the NSA community and parental witnessed violence were entered as a single variable, and in the NSA-R they were differentiated.

2.3.2.4 Other Potentially Traumatic Events: Participants were also asked in a yes/no format if they had been exposed to a dog attack, motor vehicle accident, fire, and/or a natural disaster.

2.3.3 Posttraumatic Stress Disorder (PTSD)—Lifetime PTSD was assessed using the PTSD module of the NSA survey (Kilpatrick et al., 1989)¹, a structured diagnostic interview that assessed each *DSM-IV* symptom with a yes/no response indicating the presence of a symptom for at least two weeks. All participants were administered the entire PTSD assessment module. The symptoms were not anchored to any specific index traumatic event. In order to meet criteria for each model of PTSD (described below), consistent with the DSM, functional impairment was required. This was met by endorsement of impairment in at least one of three domains regarding problems with school, work, or family/friends. Research on this measure has provided support for concurrent validity and several forms of reliability (e.g., temporal stability, internal consistency, diagnostic reliability; Resnick et al., 1993; Ruggiero et al., 2006). The measure was validated against the PTSD module of the Structured Clinical Interview for the *DSM* (SCID; Spitzer, Williams, & Gibbon, 1987) administered by mental health professionals (Kilpatrick et al, 1998). The inter-rater kappa coefficient was 0.85 for the diagnosis of PTSD, and comparisons

2.4 Procedure

Procedures for both the NSA 1995 and NSA 2005 were similar. A highly structured telephone interview was designed to collect information across several domains. Participants were selected using a multi-stage, stratified, random-digit dial procedure within each region of the country. The interview was administered by trained interviewers employed by Shulman, Ronca, and Bucuvalas, Inc., a survey research firm with significant experience managing survey studies. A computer-assisted telephone interview system aided this process by prompting interviewers with each question consecutively on a computer screen, and

¹Past 6 months PTSD symptoms were also assessed and examined in the current study. Results were consistent with lifetime PTSD analyses and thus were not described in detail here. Please contact the first author for more information. between the PTSD module used here and SCID yielded a kappa coefficient of 0.77.

supervisors conducted random checks of data entry accuracy and interviewers adherence to assessment procedures.

Interviews began with parental consent and a brief parent interview consisting primarily of demographic questions, several of which were later corroborated by the adolescent. The majority of the interview was conducted with the adolescent. The data used in this study were obtained directly from the adolescent interview. See Kilpatrick et al. (2000, 2003) and Wolitzky-Taylor et al. (2008) for more details about the samples and procedures for the NSA and NSA-R, respectively.

3. Data Analyses

3.1 Descriptive Analyses

The Statistical Package for the Social Sciences (SPSS) version 17.0 was used to compute descriptive analyses. We opted to test the Spitzer et al. (2007), King et al. (1998), and Simms et al. (2002) models based on their support in one of the two data sets used in our study (i.e., the NSA). While previous support for the one-factor (Lonigan et al., 1991) model in adolescents relative to other models has been limited, the dearth of empirical examination of this model led us to test it as well. Finally, we chose to examine hierarchical versions of the DSM-IV, Simms, and King models due to their theoretical relevance. A two-factor hierarchical model is statistically unreliable, and therefore the Spitzer et al. (2007) model could not be tested in this way.

3.2 Confirmatory Factor Analyses

CFAs were conducted in Mplus version 5.1 (Muthén & Muthén, 1998–2008). The weighted least squares mean and variance adjusted (WLSMV) estimation method was used in all Mplus analyses due to categorical item scores. Fit criteria were based on the recommendations of Hu and Bentler (1999), where a Root Mean Square Error of Approximation (RMSEA) of less than .08 indicates reasonable model fit, and .06 good model fit. The RMSEA indicates ‘badness of fit’, where a higher RMSEA implies worse fit, and zero would indicate the best fit (Kline, 2005). The Comparative Fit Index (CFI) and Tucker–Lewis Index (TLI) are also reported, but RMSEA is considered a more reliable index of fit, especially using the WLSMV estimation method (Yu, 2002). CFI and TLI range from 0 to 1, with higher values indicating better fit (Kline, 2005). A CFI or TLI above .95 is considered very good (Hu & Bentler, 1999). However, a CFI or TLI equal to 1.0 means that the χ^2 value is less than the degrees of freedom for the model rather than that the model fits the data perfectly (Kline, 2005). Missing data were estimated in order to use all available data in Mplus with full information maximum likelihood (FIML) procedures as described by Asparouhov & Muthén (2010). For each sample, eight models were tested using the 17 lifetime PTSD symptoms coded 0 = ‘no symptom’ and 1 = ‘symptom endorsed’ as observed variables. The first five models are described in Table 2. The last three models were hierarchical versions of the three- and four- factor models (i.e., DSM-IV, King et al., & Simms et al.), where a higher-order “PTSD” factor identified by the three or four (depending on model) lower-order latent factors was also entered into the model. It is important to note that the estimation of the four-factor and hierarchical four-factor models requires at least one latent variable (i.e., King avoidance, Simms avoidance & hyperarousal) to be identified by only two observed variables. Accepted standards for structural equation modeling have recommended that at least three observed variables per latent variable be included in order to adequately identify the intended latent construct (Kline, 2005). The King and DSM-IV models were nested and therefore could be compared via a χ^2 difference test. Differences between the one-factor and the three- and four-factor models were also tested using the χ^2 difference test. These difference tests were conducted with the DIFFTEST feature in Mplus.

Comparisons between other models could not be tested in this way, however, because they were not nested.

4. Results

4.1 Results of Descriptive Analyses

In the trauma-exposed NSA (1995) sample ($N=1,527$), the mean age of participants was 14.70 years ($SD=1.70$, range=12.00–17.00), and the sample was 46% female. Sixty-five percent of these participants identified themselves as Caucasian Non-Hispanic, 19% African-American, 11% Hispanic, and 6% other race/ethnicity. The NSA-R (2005) data revealed similar demographics. The mean age for trauma-exposed NSA-R ($N=1,119$) youth was 14.91 ($SD=1.67$, range=11–18), and females represented 49% of the sample. Sixty-two percent of participants identified as Caucasian Non-Hispanic, 16% African-American, 12% Hispanic, and 6% other race/ethnicity. Rates of traumatic events within each trauma-exposed sample are listed in Table 3.

In the NSA, univariate analyses of variance (ANOVA) revealed that age ($F(1)=22.03$, $p<.001$, $\eta^2=.02$), and sex ($F(1)=16.51$, $p<.001$, $\eta^2=.01$) predicted differences in number of PTSD symptoms. Specifically, girls and older adolescents reported higher numbers of PTSD symptoms. Compared to Caucasian youth, African Americans reported significantly more PTSD symptoms ($F(1)=9.52$, $p<.01$, $\eta^2=.01$), while Hispanics did not differ from Caucasians in number of PTSD symptoms ($F(1)=0.06$, ns, $\eta^2=.00$). In the NSA-R, number of PTSD symptoms similarly differed by age ($F(1)=10.28$, $p<.01$, $\eta^2=.01$) and sex ($F(1)=49.46$, $p<.001$, $\eta^2=.05$), where females and older adolescents endorsed more PTSD symptoms than males and younger youth. In the NSA-R, African Americans did not differ from Caucasians in number of PTSD symptoms reported ($F(1)=2.25$, ns, $\eta^2=.003$), and Hispanics reported significantly fewer PTSD symptoms compared to Caucasian youth ($F(1)=1.79$, ns, $\eta^2=.003$).

4.2 Results of Confirmatory Factor Analyses

According to the fit indices and model acceptability criteria described above, all models demonstrated a good fit to the data in both samples, with three exceptions (see Table 4). Specifically, in the NSA-R, the King et al., 1998, Simms et al., 2002, and Simms hierarchical four-factor models latent variable covariance matrix were not positive definite, suggesting that the model fit indices should not be interpreted. Examination of residuals, latent variable covariances and correlations suggested that this was due to the extensive overlap between the hyperarousal and numbing latent variables in the King model ($r=0.96$). Within the Simms model, latent variable correlations were also extremely high. For example, hyperarousal and dysphoria were correlated at $r=1.0$, as was the correlation between hyperarousal and avoidance in the Simms hierarchical model. Indeed, correlations between latent variables in the two-, three-, and four-factor models were consistently high, suggesting that these variables may be measuring the same underlying construct (see Table 5).

In order to better determine the cause of these model errors and the impact of such high factor correlations, the King, Simms, and Simms hierarchical models were re-run in the NSA-R but with the most problematic, highest factor correlations constrained to equal zero or 0.5. While the models converged, the same error occurred in each of these post hoc analyses. Therefore, as in the originally tested models, fit indices cannot be interpreted with any level of confidence and do not provide any valuable additional information.

Another potential explanation for these model errors could be that the Simms and King models require at least one factor to be defined by only two items. As noted above, this is counter to recommendations for this type of analysis (Kline, 2005). Because CFA

necessitates constraining one factor loading of an indicator (i.e., symptom) on a factor to equal 1.0 in order to allow model identification, a factor with only two items then would be solely defined by the variance of the one other non-constrained item. If this item is also highly correlated with other items on other factors, its factor will also be highly correlated with those other factors. To further explore whether the errors could be remedied without changing the entire model structure, we selected a different item to be constrained for each factor that included only two items in the King and Simms models in the NSA-R. For example, we re-ran the Simms model with symptom D5 (exaggerated startle) constrained to a loading of 1.0 on the hyperarousal factor, whereas the other symptom in this factor (D4, hypervigilance) was constrained in the original model (scaling of items on other factors (i.e., ones with more than 2 items) were not altered, such that the same (first) item remained constrained to 1.0). This did not change model fits, factor correlations, or model errors, however.

All models provided good and similar fits to each data set, so it was difficult to select a single best-fitting model. The King model fit better than the DSM-IV model via χ^2 difference testing in the NSA ($p<.001$) and NSA-R ($p<.001$). Because the one-factor model was nested within the DSM, Simms, and King models, it could be compared via χ^2 difference testing to these three models as well. Within both the NSA and NSA-R, the one-factor model provided significantly worse fit to the data compared to the DSM (NSA ($p<.001$); NSA-R ($p<.001$)), Simms (NSA ($p<.001$); NSA-R ($p<.001$)), and King (NSA ($p<.001$); NSA-R ($p<.001$)). It was not possible to conduct χ^2 difference tests to compare other models (e.g., Simms vs. King) because they were not nested. In addition, the WLSMV estimator precluded the use of Bayesian Information Criterion (BIC) or Akaike's Information Criterion (AIC) to compare models. Based on small changes in RMSEA, which is the most reliable fit index for the WLSMV estimator used in these analyses (Yu, 2002), the four-factor models *may* fit the NSA and NSA-R data slightly better than the other models. The 17 PTSD symptom variables probit factor loadings by model are listed in Table 6 below. Flashbacks (B3) and specific amnesia (C3) consistently exhibited low loadings relative to other items; all loadings were significant at the $p<.001$ level.

Comparing RMSEA visually is not a sufficient means to determine fit, however. We therefore repeated the aforementioned analyses using the less preferred (for categorical outcomes) maximum likelihood (ML) estimation procedure to obtain BIC. A 10-point decrease in BIC is indicative of 150:1 odds that the lower-BIC model fits the data better (Raftery, 1995). This is a more computationally intensive procedure and is therefore not recommended for CFA with categorical outcomes and more than three factors. Therefore, despite modifications to the analyses (e.g., increasing number of iterations), the hierarchical models did not converge. Results were the consistent with the aforementioned WLSMV findings, where most models fit equally well (with the exception of the one-factor). The two-factor model's BIC is difficult to compare to the other models, as it included fewer items. Table 4 lists BIC for each model.

Because PTSD symptoms have been shown to differ by sex (Nemeroff et al., 2006), we also tested every model within samples of trauma-exposed males and females for both the NSA and NSA-R. These analyses revealed a good fit for all models regardless of sex, consistent with the findings discussed above for the models tested across sex.²

²Due to space constraints, model fit indices by sex are not discussed in this paper. Please contact the first author for further details.

5. Discussion

The present study conducted CFA of data collected from the NSA and NSA-R for the purpose of providing more thorough psychometric testing of the latent structure of PTSD. The NSA and NSA-R are particularly useful to examine the latent factor structure of PTSD because they employed (1) large nationally representative samples, and (2) a reliable structured interview to measure PTSD. Moreover, the current PTSD measure assessed symptoms dichotomously, which makes the data correspond well with how a clinician would inquire about symptoms during an interview; thus, results may be generalizable to routine clinical practice. The fact that the methodology is quite similar across the two 1,000-plus participant studies also provides a unique and stringent means of testing the robustness of results from any one model. Finally, the present study tested the leading models previously supported in the literature, which allows for an exhaustive test of comparative model fit. Accordingly, findings from these data sets have a high probability of being robust and meaningful.

Results from the CFAs suggested that all previous models provide adequate fit to the data in both the NSA and NSA-R and in both sexes. The King model demonstrated significantly better fit than the DSM-IV model in both samples, and the one-factor model did not fit as well as the other models. However, due to the non-nested nature of the other models, we could not determine whether differences in model fit were significantly different.

Our analyses also suggested significant problems with the models in which a latent construct is defined by only two indicators (i.e., the Simms and King models). These models produced non-positive definite results in the NSA-R due to collinearity between latent constructs (i.e., factor correlations above .94), and while the models produced reliable estimates in the NSA, the factor correlations still suggested collinearity. It is widely recommended that latent constructs be defined by a minimum of three indicators (Kline, 2005); thus, it is not surprising that these models produced problematic estimates. Interestingly, the current model proposed for DSM-V includes an avoidance symptom cluster with only two items. The current results suggest that this approach is statistically problematic.

It is difficult to compare the current factor correlations to prior research because factor correlations have been inconsistently reported in prior CFA research, particularly among adolescents (see Table 1). One prior study among adults reported high correlations between factors (range .6 – .92; King et al., 1998), while another study among adults reported correlations within an acceptable range (range .43 – .61; Simms et al., 2002). It is possible that the current high correlations are due to the use of an adolescent sample, which may suggest that PTSD latent structures differ between adult and adolescent populations for developmental reasons. One recent study reported that among an adult sample, the Simms et al. (2002) four-factor model provided good fit to the data, while the King et al. (1998) and DSM-IV model did not provide good fit; by contrast, among an adolescent sample, the Simms et al., King et al., and DSM-IV models each provided excellent fit to the data (Elhai et al., 2009a). Unfortunately, however, this study did not report factor correlations. Future research is necessary to examine more carefully the complete psychometric properties of the competing latent structures of PTSD in both adults and adolescents.

One parsimonious way to interpret the overall findings regarding nearly equivalent fit between several models is that the model with the least number of factors provides the simplest explanation of the data. Because the one-factor structure demonstrated worse fit compared to the three- and four-factor structures, this would suggest that a model with two or more factors is most acceptable. Consistent with this finding, a wealth of empirical evidence on PTSD collected since the diagnosis construction in 1981 suggests that

dysfunction in *multiple* physiological mechanisms is implicated in PTSD, including the hypothalamic-pituitary-adrenal axis system (which itself is not unitary; Yehuda, Giller, Southwick, Lowy, & Mason, 1991; Yehuda et al., 1993), and sympathetic and parasympathetic nervous systems (Blechert, Michael, Grossman, Lajtman, & Wilhelm, 2007; Pole, 2007). Dysfunction in multiple neuropsychological mechanisms is implicated in PTSD, including in working memory, attention, and initial learning (Vasterling, Brailey, Constans, & Sutker, 1998; Vasterling et al., 2002). At the neural level of analyses, hippocampal volume, amygdala hyperactivity, and prefrontal-regulatory structures recruitment (e.g., ventrolateral prefrontal cortex, anterior cingulate cortex) are all implicated in PTSD (Falconer et al., 2008; Gilbertson et al., 2002; Shin et al., 2004, 2005). At the genetic level of analysis, multiple genetic loci within varying neurobiologic systems, such as the monoamine transporters, have been associated with PTSD (Amstadter et al., 2009; Koenen et al., 2008). The sheer number of mechanisms that have been found to operate in concert in each of these subsystems provide evidence for the hypothesis that variability in each of the 17 phenomenological (i.e., overt/observable) PTSD symptoms are representative of multiple mechanisms operating in concert (i.e., correlated latent constructs).

Although the current findings suggest that the one-factor model can be rejected, and that the King model is preferable to the DSM model, the question of why other multidimensional models (e.g., hierarchical models, Simms and DSM, King models) demonstrated relatively equivalent fit in both samples still remains. Given that this research area has many inconsistencies and no model has been uniformly supported as the “best model” across studies, it may not be surprising that one model did not fit best in both samples. However, it is rather striking, given the previous inconsistencies, that *all* models demonstrated good to excellent fit in these samples. Of course, limitations of statistical tests prevented us from being able to directly compare some (e.g., hierarchical) models. However, assuming that the ‘right’ model has been tested in this study, it remains puzzling that each of the current ‘wrong’ latent models of PTSD also yielded good fit indices. Beyond simply identifying a model with best fit, it is also important to explain why competing models all fit well.

One explanation for why all competing models demonstrated comparatively good fit is that the indicators are suboptimal for accurate modeling of the latent PTSD constructs. That is, it is difficult to discriminate between models if the indicators of the hypothesized latent constructs are in some way weak. In the present context, the indicators of the hypothesized latent constructs are the currently accepted DSM-IV PTSD symptoms. This interpretation is consistent with growing concern over the definition of the PTSD construct (e.g., Rosen & Lilienfeld, 2008), and in this study, symptoms B3 (flashbacks) and C3 (specific amnesia) revealed relatively low, unacceptable factor loadings across most models tested. The Spitzer model was developed to correct for the non-specific PTSD symptoms (e.g., trouble concentrating) and was intended to include only ‘face valid’ PTSD symptoms. While the Spitzer model did provide a good fit in the NSA and NSA-R samples, its fit was not necessarily meaningfully better than other models. Thus, the problem of all models fitting well may not be due solely to the inclusion of non-specific symptoms. This leaves the possibility that the problem is due to the inclusion of poorly performing indicators (e.g., flashbacks), or to the *exclusion* of relevant symptoms. That is, if other key symptoms were assessed, and these symptoms were then used to identify the latent constructs, then poorly specified latent PTSD models would not fit well and only the ‘right’ latent PTSD model would fit well. While this is a possibility, it is not readily clear what these key missing PTSD symptoms are.

Moreover, it will be important to determine whether an observed correlate of PTSD is a symptom versus a pre-morbid risk factor. Data from discordant twin studies can help elucidate these questions. For example, based on identical twin veterans discordant for

combat exposure and PTSD, Gilbertson and colleagues (2006) found that neurocognitive deficits among veterans with PTSD were also found in their identical twin without PTSD, regardless of combat exposure (also see Kremen et al., 2007). These data suggest that the neurocognitive deficits are not associated signs of PTSD but are instead premorbid risk factors for PTSD development following trauma exposure. By contrast, Orr and colleagues (2003) found that among identical twin veterans discordant for PTSD and combat exposure, only veterans with PTSD displayed elevated heart rate in response to sudden loud tones, whereas their non-PTSD twin brothers did not display this heart rate responding regardless of combat exposure. These data demonstrate that the startle response to loud tones is a bona-fide symptom of PTSD and not a premorbid risk factor. As can be seen, some alleged symptoms of PTSD may actually be pre-morbid risk factors, in which case the same 'symptom' would be endorsed by individuals with and without PTSD. The call for new symptoms of PTSD is timely, given the on-going refinement of the PTSD diagnosis for DSM-V and the current debate about the validity of the PTSD construct (Rosen & Lilienfeld, 2008). Indeed, the proposed revision of PTSD for DSM-V includes additional symptoms, such as two indicators of trauma-related cognitive distortions (e.g., guilt, shame). Future research should evaluate whether these extra symptoms help to elucidate the PTSD factor structure.

Overall, the current study demonstrates 1) multiple models appear to explain the same data close to equivalently, and 2) factor correlations among models typically reported as best fitting are unacceptably high. These results call for more research investigating the psychometric properties of the competing latent models of PTSD, particularly comparing adults to adolescents. However, this study is not without limitations. The study is limited to a single measure of PTSD, which calls into question whether the present results extend to other measures. This limitation also highlights the need for more multimodal investigations. Due to the use of random digit dialing methodology, this study is also limited by its exclusion of adolescents residing in households without phones. In any case, future research is clearly needed to tease apart the apparent equivocal results. As mentioned above, new important avenues that may foster advances in this area are (1) the development and testing of new symptoms of PTSD, (2) reexamination of the utility of existing symptoms, and (3) further examination of developmental differences to improve understanding of PTSD's factor structure and most valid symptom indicators in adolescents.

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Table 1

Summary of previous PTSD CFA results, focused on adolescent samples along with the King et al. 1998 and Simms et al., 2002 adult studies

Study	Model	N	PTSD Measure	Sample	CFI	RMSEA	Factor Correlations	Data type
Elhai et al., 2009a	Intrusions, Avoidance, Arousal	3351	PTSD Interview	Child and Adolescent	.98	.03	n/r	Binary
	Intrusions, Avoidance, Numbing, Arousal				.98	.02	n/r	
	Intrusions, Avoidance, Dysphoria, Arousal				.99	.02	n/r	
Ford et al., 2009	Intrusions, Avoidance/Arousal	3351	PTSD Interview	Child and Adolescent	.98	.03	n/r	Binary
	Intrusions, Avoidance, Arousal				.98	.03	n/r	
	Intrusions, Avoidance, Numbing, Arousal				.98	.02	n/r	
King et al., 1998	Reexperiencing, Effortful avoidance, Numbing, Arousal	524	CAPS	Adult	n/r	.044	R/E A=.81 R/N=.60 R/H=.92 EA/N=.58 EA/H=.74 EN/H=.73	5-pt Likert
	Reexperiencing and Effortful avoidance as indicators of a higher-order construct, Numbing and Arousal as indicators of another higher-order construct				n/r	.045	n/r	
	Reexperiencing, Effortful avoidance, Numbing, Arousal all underneath one higher-order construct				n/r	.046	n/r	
	Single factor				n/r	.075	n/r	
Sack et al., 1997	Intrusion, Avoidance, Numbing, Arousal	209	DICA	Adolescent	.968	n/r	n/r	Binary
Saul et al., 2008	Intrusion, Avoidance, Numbing, Arousal	1581	PTSD Interview	Child and Adolescent	.92	.03	n/r	Binary
	Intrusions, Avoidance, Arousal				.94	.04	n/r	
	Intrusion/Avoidance, Arousal, Numbing				.94	.04	n/r	
Shevlin et al., 2009	DSM-IV three-factor	12,467	AUDADI S-IV	Adult	.95	.04	n/r	Binary
	King et al. (1998) four factor				.96	.03	n/r	
	Simms et al. (2002) four factor				.96	.03	n/r	
	Simms model, symptoms D1-D3 load equally onto Dysphoria and Hyperarousal				.96	.03	n/r	
	D2 unconstrained, D1 and D3 constrained to load equally on Dysphoria and Hyperarousal				.96	.03	n/r	

Study	Model	N	PTSD Measure	Sample	CFI	RMSEA	Factor Correlations	Data type
	D2 and D3 unconstrained, D1 retains equal loadings on Dysphoria and Hyperarousal				.96	.03	I/A=.85 I/D=.72 I/H=.77 A/D=.84 A/H=.70 D/H=.69	
	D1-D3 unconstrained				.96	.03	n/r	
Simms et al., 2002	Single Factor	948	PCL-M	Adult	.79	.11		5-pt Likert
	Intrusion/Avoidance, Arousal/Numbing				.85	.095	n/r	
	Intrusions, Avoidance/numbing, Arousal				.85	.095	n/r	
	Intrusions/Avoidance, Numbing, Arousal				.86	.091	n/r	
	Intrusions, Avoidance, Numbing, Arousal				.89	.081	n/r	
	Intrusions, Avoidance, Dysphoria, Hyperarousal				.92	.071	I/A=.58 I/D=.61 I/H=.58 A/D=.51 A/H=.43 D/H=.60	

Note. Studies in bold font used data from the NSA also used in this study. AUDADIS-IV=Alcohol Use Disorder and Associated Disabilities Interview Schedule-DSM-IV version (Grant, Dawson, & Hasin, 2001), CAPS = Clinician Administered PTSD Scale (Blake et al., 1990), DICA = Diagnostic Interview for Children and Adolescents (Wehner et al., 1987), PCL-M = Posttraumatic Checklist-Military Version (Weathers et al., 1993), PTSD Interview = PTSD structured interview used in NSA (e.g., Kilpatrick et al., 2000). 'n/r' = not reported, 'R' = reexperiencing, 'EA' = effortful avoidance, 'N' = numbing, 'H' = hyperarousal, 'I' = intrusions, 'A' = avoidance, 'D' = dysphoria.

Table 2

Confirmatory Factor Analytic Models Tested

PTSD Symptom Items	1 Factor	2 Factors (Spitzer et al.)	3 Factors (DSM-IV)	4 Factors (Simms et al.)	4 Factors (King et al.)
B1. Intrusive thoughts	PTSD	Reexperiencing	Reexperiencing	Intrusions	Reexperiencing
B2. Nightmares	PTSD	Reexperiencing	Reexperiencing	Intrusions	Reexperiencing
B3. Flashbacks	PTSD	Reexperiencing	Reexperiencing	Intrusions	Reexperiencing
B4. Cued emotional reactivity	PTSD	Reexperiencing	Reexperiencing	Intrusions	Reexperiencing
B5. Cued physical reactivity	PTSD	Reexperiencing	Reexperiencing	Intrusions	Reexperiencing
C1. Avoids thoughts	PTSD	Avoidance/hyperarousal	Avoidance/numbing	Avoidance	Avoidance
C2. Avoids reminders	PTSD	Avoidance/hyperarousal	Avoidance/numbing	Avoidance	Avoidance
C3. Specific amnesia	PTSD	--	Avoidance/numbing	Dysphoria	Numbing
C4. Loss of interest	PTSD	--	Avoidance/numbing	Dysphoria	Numbing
C5. Feeling distant	PTSD	Avoidance/hyperarousal	Avoidance/numbing	Dysphoria	Numbing
C6. Feeling numb	PTSD	Avoidance/hyperarousal	Avoidance/numbing	Dysphoria	Numbing
C7. Sense of a foreshortened future	PTSD	Avoidance/hyperarousal	Avoidance/numbing	Dysphoria	Numbing
D1. Sleep problems	PTSD	--	Hyperarousal	Dysphoria	Hyperarousal
D2. Anger/Irritability	PTSD	--	Hyperarousal	Dysphoria	Hyperarousal
D3. Trouble concentrating	PTSD	--	Hyperarousal	Dysphoria	Hyperarousal
D4. Hypervigilance	PTSD	Avoidance/hyperarousal	Hyperarousal	Hyperarousal	Hyperarousal
D5. Exaggerated startle response	PTSD	Avoidance/hyperarousal	Hyperarousal	Hyperarousal	Hyperarousal

Table 3
Rates of Traumatic Events within Trauma-Exposed NSA and NSA-R Samples

Sample	Sexual Assault	Drug/Alcohol Facilitated Rape	Physical Assault [*]	Physical Abuse [*]	Witnessing Parental Violence ⁺	Witnessing Community Violence ⁺	Other Traumatic Event [^]
NSA (N=1,527)	6%	N/A	31%	31%	83%		80%
NSA-R (N=1,119)	11%	1%	31%	13%	20%	42%	70%

Note. NSA: National Survey of Adolescents; NSA-R: National Survey of Adolescents-Replication; N/A: Not Assessed

^{*} In the NSA, physical assault and abuse were not differentiated

⁺ In the NSA, witnessing parental and community violence were entered as a single "witnessing violence" variable

[^] Other Traumatic Event includes: dog attack, car accident, fire, and/or natural disaster

Table 4

Confirmatory Factor Analysis Model Fit Indices by Sample

Sample	Model	CFI	TLI	RMSEA	BIC ^b
NSA (N=1,527)	1-Factor	0.979	0.988	0.029	18186.56
	2-Factor	0.989	0.992	0.023	12121.03
	3-Factor	0.984	0.990	0.025	18174.65
	King et al 4-Factor	0.989	0.993	0.021	18168.23
	Simms et al 4-Factor	0.989	0.993	0.021	18171.18
	Hierarchical 3-Factor ^c	0.984	0.990	0.025	N/A
	Hierarchical King et al 4-Factor ^c	0.986	0.992	0.024	N/A
	Hierarchical Simms et al 4-Factor ^c	0.988	0.993	0.022	N/A
	1-Factor	0.954	0.981	0.038	13553.59
	2-Factor	0.957	0.977	0.039	8998.12
NSA-R (N=1,119)	3-Factor	0.962	0.984	0.035	13541.96
	King et al 4-Factor ^a	.969	.987	.032	13534.44
	Simms et al 4-Factor ^a	.968	.986	.032	13541.55
	Hierarchical 3-Factor ^c	0.962	0.984	0.035	N/A
	Hierarchical King et al 4-Factor ^c	0.964	0.984	0.034	N/A
	Hierarchical Simms et al 4-Factor ^{a, c}	.967	.986	.033	N/A

^aNote. Model converged but was non-positive definite due to high factor correlations that seriously limits interpretability of results;^bComputed using maximum likelihood estimation;^cModel did not converge due to computational intensity

Table 5

Latent Variable Correlation

Sample	2-Factor			3-Factor			King et al 4-Factor				Simms et al 4-Factor			
	R with A/H	R with A/N	R with H	A/N with H	R with A	R with N	R with H	A with N	A with H	N with H	I with A	I with H	A with D	H with D
NSA (N=1,527)	0.97	0.96	0.93	0.94	0.94	0.90	0.93	0.85	0.85	0.92	0.94	0.88	0.85	0.84
NSA-R (N=1,119)	0.91	0.86	0.86	0.95	0.95	0.80	0.86	0.92	0.86	0.96	0.95	0.96	0.91	1.00

Note. NSA: National Survey of Adolescents; NSA-R: National Survey of Adolescents-Replication; R: Reexperiencing; A/H: Avoidance/Hyperarousal; A/N: Avoidance/Numbing; H: Hyperarousal; A: Avoidance; N: Numbing.

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Table 6

Probit Factor Loadings by Model

	NSA (N=1,527)					NSA-R (N=1,119)				
	1- Factor	2- Factor	3- Factor	King et al 4- Factor	Simms et al 4- Factor	1- Factor	2- Factor	3- Factor	King et al 4- Factor	Simms et al 4- Factor
PTSD Symptoms										
B1. Intrusive thoughts	0.78	0.81	0.80	0.80	0.80	0.71	0.78	0.77	0.77	0.77
B2. Nightmares	0.61	0.58	0.63	0.63	0.63	0.55	0.58	0.59	0.59	0.59
B3. Flashbacks	0.44	0.45	0.45	0.45	0.45	0.54	0.60	0.58	0.58	0.58
B4. Cued emotional reactivity	0.69	0.73	0.71	0.71	0.71	0.74	0.80	0.81	0.81	0.81
B5. Cued physical reactivity	0.67	0.71	0.68	0.68	0.68	0.61	0.64	0.65	0.65	0.65
C1. Avoids thoughts	0.78	0.80	0.79	0.84	0.84	0.69	0.69	0.70	0.72	0.72
C2. Avoids reminders	0.66	0.68	0.67	0.71	0.71	0.65	0.69	0.66	0.68	0.68
C3. Specific amnesia	0.45	--	0.46	0.47	0.46	0.52	--	0.53	0.54	0.53
C4. Loss of interest	0.68	--	0.69	0.71	0.70	0.74	--	0.75	0.76	0.76
C5. Feeling distant	0.71	0.70	0.72	0.74	0.72	0.77	0.74	0.78	0.79	0.78
C6. Feeling numb	0.76	0.75	0.77	0.79	0.78	0.72	0.71	0.73	0.74	0.73
C7. Sense of a foreshortened future	0.57	0.57	0.58	0.60	0.58	0.72	0.72	0.73	0.74	0.73
D1. Sleep problems	0.65	--	0.67	0.67	0.66	0.68	--	0.69	0.69	0.69
D2. Anger/Irritability	0.68	--	0.70	0.70	0.69	0.72	--	0.74	0.74	0.73
D3. Trouble concentrating	0.70	--	0.73	0.73	0.72	0.62	--	0.64	0.64	0.64
D4. Hypervigilance	0.64	0.66	0.66	0.66	0.72	0.65	0.63	0.67	0.67	0.64
D5. Exaggerated startle response	0.59	0.60	0.61	0.61	0.66	0.65	0.63	0.66	0.66	0.63