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Elucidating Dimensions of Posttraumatic Stress Symptoms and their Functional Correlates in Disaster-Exposed Adolescents

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Abstract

The aim of this study was to elucidate the dimensional structure of posttraumatic stress disorder (PTSD) and potential moderators and functional correlates of this structure in disaster-affected adolescents. A population-based sample of 2,000 adolescents aged 12–17 years (*M*=14.5 years; 51% female) completed interviews on post-tornado PTSD symptoms, substance use, and parent-adolescent conflict between 4 and 13 months (*M*=8.8, *SD*=2.6) after tornado exposure. Confirmatory factor analyses revealed that all models fit well but a 5-factor dysphoric arousal model provided a statistically significantly better representation of adolescent PTSD symptoms compared to 4-factor dysphoria and emotional numbing models. There was evidence of

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Conflicts of Interest

Dr. Pietrzak is a scientific consultant to CogState Ltd. The remaining authors report no potential conflicts of interest related to this work.

Contributors

J.A. Sumner managed the literature searches, conducted the statistical analyses, and wrote the first draft of the manuscript. K.J. Ruggiero and C.K. Danielson designed the larger investigation and assisted with manuscript preparation. R.H. Pietrzak assisted with study design, statistical analysis, and manuscript preparation. Z.W. Adams assisted with manuscript preparation. All authors contributed to and have approved the final manuscript.

measurement invariance of the dysphoric arousal model across gender and age, although girls and older adolescents aged 15–17 years had higher mean scores than boys and younger adolescents aged 12–14 years, respectively, on some PTSD dimensions. Differential magnitudes of association between PTSD symptom dimensions and functional correlates were observed, with emotional numbing symptoms most strongly positively associated with problematic substance use since the tornado, and dysphoric arousal symptoms most strongly positively associated with parent-adolescent conflict; both correlations were significantly larger than the corresponding correlations with anxious arousal. Taken together, these results suggest that the dimensional structure of tornado-related PTSD symptomatology in adolescents is optimally characterized by five separate clusters of re-experiencing, avoidance, numbing, dysphoric arousal, and anxious arousal symptoms, which showed unique associations with functional correlates. Findings emphasize that PTSD in disaster-exposed adolescents is not best conceptualized as a homogeneous construct and highlight potential differential targets for post-disaster assessment and intervention.

Keywords

Posttraumatic stress disorder; disasters; adolescents; dysphoric arousal model; confirmatory factor analysis

Introduction

On average, a disaster occurs somewhere in the world every day (Norris et al., 2002), and most have effects beyond the immediate impact. Although many individuals are resilient or recover quickly after a disaster, a substantial percentage experiences adverse mental health outcomes, with posttraumatic stress disorder (PTSD) being the most common (Furr et al. 2010; Galea et al., 2005; Norris et al., 2002). Although PTSD is often considered a homogeneous diagnostic entity in epidemiologic studies, there is increasing interest in the nature of the underlying dimensional structure of this disorder (Elhai et al., 2013; Yufik and Simms, 2010), as well as how dimensional aspects of PTSD relate to clinical and functional outcomes in trauma-exposed populations (Boelen and Spuij, 2013; Pietrzak et al., 2010). This approach to classifying psychopathology aligns with contemporary scientific efforts in psychiatry, such as the National Institute of Mental Health Research Domain Criteria (NIMH RDoC) project, that aim to classify mental disorders based on dimensions of observable behavior (Cuthbert and Insel, 2013).

Although the *Diagnostic and Statistical Manual of Mental Disorders, 4th edition* (*DSM-IV;* American Psychiatric Association, 2000) characterizes PTSD using a 3-factor model with re-experiencing, avoidance/numbing, and hyperarousal factors, it is well established that this model is inferior to alternative 4- and 5-factor models of PTSD symptoms (Elhai and Palmieri, 2011; Yufik and Simms, 2010). The 4-factor dysphoria model has factors for re-experiencing, avoidance, hyperarousal, and dysphoria symptoms, with the dysphoria factor defined by symptoms reflecting nonspecific aspects of emotional disorders, such as insomnia and irritability (Simms et al., 2002). The numbing model separates avoidance and emotional numbing symptoms into distinct factors, resulting in re-experiencing, avoidance, numbing, and hyperarousal factors (King et al., 1998). The main distinction between the two

4-factor models is whether three hyperarousal items, namely *DSM-IV* Criterion D, item 1 (D1; difficulty falling/staying asleep), D2 (irritability/anger), and D3 (difficulty concentrating), are indicators of dysphoria (as in the dysphoria model) or hyperarousal (as in the numbing model). Meta-analytic evidence suggests that both 4-factor models characterize PTSD symptoms well, and one model has not received consistent support over the other (Yufik and Simms, 2010). Accordingly, the recently published *DSM-5* PTSD criteria include a 4-factor model of symptoms that is most similar to the numbing model (American Psychiatric Association, 2013). Recently, a 5-factor dysphoric arousal model has been developed that separates hyperarousal symptoms into those reflecting dysphoric arousal (i.e., symptoms of agitation and restlessness) and anxious arousal (i.e., fear-based arousal symptoms), resulting in re-experiencing, avoidance, numbing, dysphoric arousal, and anxious arousal factors (Elhai et al. 2011). The dysphoric arousal model has been found to be superior to the two 4-factor models across numerous adult samples, including veterans (Harpaz-Rotem et al., 2014; Pietrzak et al., 2012) and nationally representative samples (Armour et al., 2013).

Most research on the symptom structure of PTSD has been conducted in adults, although a small literature has explored this issue in youth, with a few investigations of disaster-exposed youth. Findings are consistent with the adult literature and have supported the dysphoria and numbing models over the *DSM-IV* model (Ayer et al., 2011; Bennett et al., 2014; Elhai et al., 2013). Of the studies comparing the 4- and 5-factor models in youth, all have supported the dysphoric arousal model as the best-fitting model (Bennett et al., 2014; Elhai et al., 2013; Wang et al., 2012; Wang, Armour et al., 2013; Wang, Li et al., 2011; Wang, Long et al., 2011; Wang, Wang et al., 2013).

Despite initial evidence that PTSD symptoms in youth manifest as separate re-experiencing, avoidance, numbing, dysphoric arousal, and anxious arousal dimensions, understanding of PTSD symptom structure in disaster-exposed youth is limited in three important ways. First, virtually all studies of the dysphoric arousal model in disaster-exposed youth have been conducted in Chinese adolescent earthquake survivors (e.g., Wang, Armour et al., 2013; Wang, Long et al., 2011). It is unknown whether extant findings apply to youth from other cultural backgrounds exposed to other types of natural disasters. Second, the extent to which gender and age moderate the latent structure of PTSD symptoms in disaster-exposed adolescents is unclear. PTSD is more prevalent in girls than boys after a disaster (Furr et al., 2010), and some studies have found that post-disaster PTSD prevalence in youth increases with age (Garrison et al., 1995). Examining mean differences in PTSD symptoms across gender and age groups assumes a common underlying symptom structure (Hukkelberg, 2014), but gender and age are understudied moderators of PTSD symptom structure, particularly in disaster-exposed youth. Although some age- and gender-related differences in the dysphoric arousal model were observed in a national clinical sample of trauma-exposed youth, overall neither age nor gender emerged as a robust moderator of PTSD symptom structure (Contractor et al., 2013). Furthermore, neither gender nor age significantly moderated PTSD symptom structure in Indian youth after a terrorist attack (Contractor et al., 2014). However, a recent study found evidence for some gender differences in factor loadings and factor variances/covariances of the dysphoric arousal model in a sample of

juvenile-justice-involved youth (Bennett et al., 2014). Only one study each has examined measurement invariance in PTSD symptom structure in disaster-exposed youth across gender (Wang, Armour et al., 2013) and age (Anthony et al., 1999), with evidence for at least some degree of invariance across these characteristics. Third, understanding of how different PTSD dimensions relate to measures of functioning is limited. A recent review highlighted the importance of validating distinct PTSD dimensions against functional correlates rather than solely relying on model fit statistics for understanding the nature of posttraumatic psychopathology (Elhai and Palmieri, 2011). Few studies of disaster-exposed youth have employed such validation approaches, and the handful that have primarily examined measures of depression and anxiety (e.g., Anthony et al., 1999; Wang, Long et al., 2011). Adolescence is a critical developmental period for the adoption of substance misuse behaviors (Viner et al., 2012), and it is characterized by increased parent-child conflict (Steinberg and Morris, 2001). However, little is known about how PTSD symptom dimensions relate to these outcomes.

We addressed these under-examined issues by investigating the dimensional structure of PTSD symptoms in a population-based sample of adolescents exposed to the tornadoes in Alabama and Joplin, MO in the spring of 2011. Based on evidence of the superiority of the 5-factor dysphoric arousal model in adolescent earthquake survivors (e.g., Wang, Long et al., 2011; Wang, Wang et al., 2013), we hypothesized that this model, rather than either 4-factor model, would provide the optimal representation of PTSD symptoms. We also investigated whether gender and age moderated the best-fitting model of PTSD symptom structure. Furthermore, given that disasters impact numerous domains of functioning (Galea et al., 2005), and PTSD in adolescents has been associated with psychosocial impairments, including substance use disorders and interpersonal difficulties (Giaconia et al., 1995), we assessed whether the underlying PTSD dimensions exhibited differential magnitudes of association with two developmentally-informed measures of functioning: 1) problematic substance use; and 2) parent-adolescent conflict.

Method

Disaster Characteristics

The spring of 2011 was one of the most active and deadly tornado seasons in United States history. During April 2011, 758 tornadoes touched down, primarily in Mississippi, Alabama, and Georgia, breaking the record for the greatest number of tornadoes in one month (National Oceanic and Atmospheric Administration, 2011). Most tornado-related fatalities and injuries occurred between April 25–28 (321 fatalities), with damage estimated at $6 billion. On May 22, 2011, the deadliest single tornado in the United States since 1950 hit Joplin, Missouri. At least 160 people were killed, 750 were injured, and over 9,000 homes and businesses were destroyed.

Procedure

Two thousand families with adolescents aged 12–17 years were recruited from areas affected by the April 25–28 or May 22 tornadoes as part of a larger investigation of an Internet-based post-disaster intervention (see Adams et al., 2014). A targeted address-based

sampling strategy used information on tornado track coordinates to identify households in tornado-affected areas that did and did not have a matching landline telephone (matched and unmatched samples, respectively). Addresses without matching phone numbers (primarily cellphone-only households) were sent a letter explaining the study and a screening questionnaire that assessed inclusion criteria and requested landline/cellphone contacts. Respondents who returned the questionnaire received $5 regardless of eligibility. Households in the matched and unmatched samples were contacted via phone to determine eligibility. Eligibility criteria included a parent who: 1) resided in their address at the time of the tornado, 2) was the legal guardian of an adolescent aged 12–17 years, and 3) had reliable Internet access at home.

Eligible adolescent-parent dyads completed structured telephone interviews at baseline between September 2011 and June 2012, on average 8.8 months after tornado exposure (*SD*=2.6; range=4.0–13.5). This delay between the tornadoes and baseline permitted restoration of electricity and telephone and Internet access after the tornadoes. Trained interviewers obtained informed consent from parents and adolescents. Interviews were conducted first with the parent alone and then with the adolescent alone. Parents provided information regarding family demographic and tornado exposure and impact variables. Adolescent interviews assessed mental health variables and parent-adolescent conflict. Households received $15 for completing the baseline interview. Overall cooperation rate was 61%. The study was conducted in compliance with the principles of the Declaration of Helsinki and policies and procedures of the investigators' Institutional Review Board.

Participants

Sample demographics are summarized in Table 1. Data were weighted based on Census estimates of demographics to enhance the generalizability of the sample to the population of the communities from which they were recruited.

Measures

Tornado exposure and impact variables—Parents indicated whether they: 1) were present during the tornado; 2) sustained physical injuries; 3) were concerned about the safety of loved ones; 4) were displaced from the home for more than a week; 5) sustained tornado-related damage to their homes, land, vehicles, furniture, or personal items, or lost pets; and 6) were without basic services (water, electricity, clean clothing, food, shelter, transportation, and spending money) for more than a week. The first four variables were coded dichotomously. Property damage and loss of services count variables were created by summing the types of damages sustained or services lost (α=.75 and .69 for the property damage and loss of services variables, respectively).

PTSD symptoms—The National Survey of Adolescents-Replication PTSD module (Resnick et al., 1993) was used to assess the 17 *DSM-IV* PTSD symptoms among adolescents. This module has been found to be a reliable and valid measure of PTSD (Kilpatrick et al., 2003). Symptom criteria were scored dichotomously as present or absent since the tornado (α=.87).

Problematic substance use—Adolescent problematic substance use since the tornado was assessed using the CRAFFT, a standardized and valid 6-item self-report screen for adolescent substance-related problems and disorders (Knight et al., 2002). Higher scores indicate greater risk for problematic substance use (α=.68).

Parent-adolescent conflict—Adolescents completed the Conflict Behavior Questionnaire Short Form (CBQ; Prinz et al., 1979; Robin and Foster, 1984), a 20-item true/false measure of parent-adolescent conflict (e.g., “My mom/dad puts me down,” “My mom/dad screams a lot”). Higher scores indicate greater conflict (α=.90).

Data Analysis

Structural models of PTSD were compared using confirmatory factor analyses (CFAs) conducted with Mplus version 6.11 (Muthén and Muthén, 1998–2010); see Table 2 for item mappings. A robust (mean- and variance-adjusted) method of weighted least squares estimation (WLSMV; Muthén and Muthén, 1998–2010) was used given the presence of categorical indicators. Mplus can produce maximum likelihood estimations under missing at random conditions. Model fit was evaluated based on the χ^2, Comparative Fit Index (CFI), Tucker Lewis Index (TLI), and root mean square error of approximation (RMSEA). The following cutoffs were used as a guide for assessing model fit: CFI≥.95, TLI≥.95, and RMSEA≤.06 (Hu and Bentler, 1999). We also conducted χ^2 difference tests for nested models (using the DIFFTEST option in Mplus) to evaluate which model provided the best representation of PTSD symptom structure.

We examined whether the best-fitting model was invariant across adolescent gender and younger (12–14 years) and older (15–17 years) age using a comprehensive invariance testing approach (Meredith and Teresi, 2006; Wang, Armour et al., 2013). We tested a series of models that imposed increasingly stringent restrictions across groups: 1) Configural invariance model (same factor structure across groups but all parameters allowed to vary); 2) Weak factorial/metric invariance model (factor loadings constrained to be equal across groups); 3) Strong factorial/scalar invariance model (observed variable thresholds constrained to be equal across groups to assess equivalence in item severity); 4) Strict factorial invariance model (residual error variances constrained to be equal across groups to assess equivalence in measurement error across groups); 5) Invariance of factor variances and covariances (factor variances and covariances constrained to be equal across groups); and 6) Invariance of factor means (factor means constrained to be equal across groups). We investigated whether each of the progressively more restricted models was associated with a statistically significant decrement in model fit using χ^2 difference tests (using the DIFFTEST option in Mplus).

Using a latent variable framework, we also examined functional correlates of the PTSD symptom dimensions by correlating PTSD dimensions with factors representing 1) problematic substance use since the tornado (defined by the 6 CRAFFT items), and 2) parent-adolescent conflict (defined by the 20 CBQ items). We assessed differences in the magnitude of these correlations by computing Wald chi-square tests of parameter constraints (Múthen and Múthen, 1998–2010). The Wald tests assessed whether the difference between

each pair of correlations was statistically significantly different than zero. Alpha was set at .01 to control for Type I error.

Results

Descriptive Statistics

Descriptive statistics are presented in Table 1. Most families were present for the tornado. Tornado-related parental injury was rare, but approximately three-quarters of parents reported concern for loved ones during or after the tornado. PTSD severity scores were calculated by summing the number of symptom criteria endorsed; most adolescents reported low symptom levels since the tornado (see Adams et al., 2014, for prevalence of PTSD diagnosis in this sample). Girls had higher PTSD symptoms (n=1019; M=2.73, SD=3.52) than boys (n=980; M=2.07, SD=3.02), t(1970.52)=4.50, p<.0001. Older adolescents aged 15–17 years (n=1020) reported higher PTSD symptoms (M=2.62, SD=3.42) than younger adolescents aged 12–14 years (n=975; M=2.17, SD=3.15), t(1989.63)=3.09, p=.002. Mean differences in PTSD symptoms across gender and age corresponded to small effect sizes (Cohen's d=0.20 for gender and d=0.14 for age).

Model Fit Comparison

Fit statistics for the 4- and 5-factor models are presented in Table 3; all three models provided an excellent fit to the data. Chi-square difference tests revealed that the dysphoric arousal model fit the data significantly better than the dysphoria [χ^2 (4)=9.73, p=.045] and numbing [χ^2 (4)=10.70, p=.030] models.

Measurement Invariance across Gender and Age

Factorial invariance testing results are presented in Table 4. Fit statistics for models with constraints at the different levels tested indicated very good fit to the data. There was evidence for measurement invariance in factor loadings, item thresholds, residual error variances, and factor variances and covariances for the dysphoric arousal model across both boys and girls and younger and older adolescents. Chi-square difference tests comparing nested models suggested that constraining these different parameters to be equal across gender and age groups was not associated with statistically significant decrements in model fit. When testing for strict factorial invariance across younger and older adolescents, the model that allowed the residual variances to vary across groups did not converge; thus, a χ^2 difference test could not be computed for this comparison. However, the model that constrained residual variances to be equal across younger and older adolescents had a good fit, thereby providing support for strict factorial invariance across age. Together, these results supported invariance in the meaning of the PTSD factors, item severity, residual error, factor score variation, and correlations between the PTSD factors across both boys and girls and younger and older adolescents.

However, significant differences in factor means emerged as a function of gender and age (Table 5). Girls had significantly higher latent scores than boys on re-experiencing, avoidance, dysphoric arousal, and anxious arousal. Older adolescents had significantly higher latent scores than younger adolescents on re-experiencing, avoidance, numbing, and

dysphoric arousal. Gender and age differences in factor means corresponded to small effect sizes based on Cohen's *d*.

We examined whether differences in PTSD factor means between boys and girls and younger and older adolescents could be explained by differences in tornado exposure and impact characteristics (caregiver present for tornado, caregiver injured during tornado, caregiver concerned about the safety of loved ones, displacement for more than one week, property damage, loss of services). Boys and girls did not differ significantly on most tornado exposure and impact variables (*p*s>.28), although slightly more girls (77%) had caregivers who reported being concerned about the safety of loved ones during or after the tornadoes than boys (72%), $\chi^2(1)=7.13$, $p=.01$. Younger and older adolescents did not differ significantly on these measures, *p*s>.05.

Functional Correlates of PTSD Symptom Dimensions

Table 6 presents intercorrelations between factors of the dysphoric arousal model and Table 7 presents results of the Wald tests of parameter constraints for pairs of correlations between the dysphoric arousal model factors and factors indicating problematic substance use and parent-adolescent conflict. The numbing-problematic substance use correlation and the dysphoric arousal-parent-adolescent conflict correlation were the largest in magnitude for these two functional correlates. Results of the Wald tests indicated that these two correlations were significantly larger than the corresponding correlations with anxious arousal. The anxious arousal-parent-adolescent conflict correlation was also significantly smaller than the re-experiencing-parent-adolescent conflict correlation.

Discussion

The United States experiences the most tornadoes worldwide, with over 1,000 tornadoes recorded each year (Evans and Oehler-Stinnett, 2006), but little research has studied how posttraumatic psychopathology manifests in youth exposed to these disasters. To our knowledge, this study is the first to examine the structure of PTSD symptoms in tornado-exposed adolescents and investigate potential moderators of this structure and associations between underlying dimensions of PTSD with developmentally-informed functional correlates that have been understudied in the youth disaster mental health literature. Results revealed that: 1) the 5-factor dysphoric arousal model provided the best representation of PTSD symptom dimensions; 2) there was measurement invariance of the dysphoric arousal model across gender and age; 3) numbing was most strongly positively associated with post-tornado problematic substance use and significantly more strongly related than anxious arousal; and 4) dysphoric arousal was most strongly positively associated with parent-adolescent conflict and significantly more strongly related than anxious arousal.

Our findings add to a growing body of evidence supporting a dysphoric arousal model of PTSD symptoms. This model has provided an optimal representation of PTSD symptoms in trauma-exposed adults (Harpaz-Rotem et al., 2014; Pietrzak et al., 2012) and youth (Elhai et al., 2013). To date, virtually all research on the dysphoric arousal model in disaster-exposed youth has been conducted in Chinese adolescent earthquake survivors (e.g., Wang, Armour et al., 2013; Wang, Long et al., 2011). Our results extend work on the dysphoric arousal

model in disaster-exposed youth to both a new cultural context and natural disaster. Earthquakes and tornadoes are similar in that they strike quickly with little warning, although tornadoes occur more frequently than other natural disasters (Evans and Oehler-Stinnett, 2006).

We found that the dysphoric arousal model fit well in boys and girls and younger and older adolescents, and this is consistent with preliminary results of invariance in PTSD factor structure across gender and age in disaster-exposed adolescents (Anthony et al., 1999; Wang, Armour et al., 2013). Furthermore, results suggested that boys and girls and younger and older adolescents did not differ significantly in PTSD factor meaning, item severity, residual error, factor score variance, and factor intercorrelations. In contrast, we found significant differences in factor means as a function of gender and age, although effect sizes were small. Girls and older adolescents had higher latent scores than boys and younger adolescents, respectively, across most PTSD symptom dimensions. These findings are consistent with research on differences in PTSD symptoms as a function of gender and age in youth (Furr et al., 2010; Garrison et al., 1995). Importantly, we observed these latent mean differences after demonstrating measurement invariance in PTSD factor structure across gender and age. Researchers have emphasized the importance of establishing that the PTSD construct has the same meaning across groups before conducting tests of mean differences (Hukkelberg, 2014), although this is rarely done. Despite consistency between our findings and those of prior research, including work conducted in non-disaster-exposed samples (e.g., Contractor et al., 2013, , 2014), our results diverge somewhat from those of a recent study of juvenile-justice-involved youth. In this sample of delinquent youth, the factor loadings for most of the dysphoric arousal model factors were stronger for girls than boys, and there was some evidence that the dysphoric arousal model accounted for more variance for boys than girls (Bennett et al., 2014). Differences in the nature of our sample (disaster-exposed adolescents with approximately equal percentages of boys and girls) and that of Bennett et al. (2014; highly-traumatized, predominantly male juvenile delinquents exposed to various traumas) may account for the discrepant findings.

Although we found greatest support for the dysphoric arousal model, the dysphoria and numbing models examined also provided good fit to the data. Although statistically significant, differences in model fit for the 5-factor model compared to both 4-factor models were minor. This result is consistent with the larger literature on the dimensional structure of PTSD; numerous studies support 4- and 5-factor models, with evidence for superior model fit using CFA often based on minimal differences in model fit statistics (Ayer et al., 2011). Our findings thus suggest that the dysphoria and numbing 4-factor models also provide a good representation of PTSD symptom dimensions. Nevertheless, the support for the dysphoric arousal model is consistent with current theories that suggest hyperarousal symptoms characterized by agitation and restlessness may be distinct from emotional numbing and hyperarousal symptoms characterized by fear-based physiological arousal (Watson, 2005). This distinction is also aligned with the NIMH RDoC framework, which differentiates between various negative valence systems (e.g., loss vs. acute threat/fear systems; Cuthbert and Insel, 2013). Like other investigators (e.g., Wang, Armour et al., 2013), we observed high intercorrelations among the factors of the dysphoric arousal model. For example, the re-experiencing and anxious arousal factors correlated at 0.929, and other

researchers have reported correlations as high as 0.86 between factors of the dysphoric arousal model (Wang, Long et al., 2011). High factor intercorrelations may suggest that factors should be combined for the sake of parsimony (Ayer et al., 2011). Investigations of associations between the different PTSD dimensions with clinically relevant functional correlates may thus be important for informing whether PTSD factors have differential explanatory utility.

Indeed, despite the high positive correlations among the factors of the dysphoric arousal model, differences in the relative strength of associations between these dimensions with two measures of functioning emerged, suggesting some degree of distinctiveness among PTSD dimensions. Emotional numbing was most strongly positively associated with problematic substance use since the tornado, whereas dysphoric arousal was most strongly positively associated with parent-adolescent conflict. Both of these correlations were statistically significantly larger than the corresponding correlations with anxious arousal, which had the weakest positive correlation with both problematic substance use and parent-adolescent conflict. Fear-based physiological hyperreactivity, as indicated by anxious arousal, may not be as strong a marker of posttraumatic symptoms that contribute to substance use or interpersonal conflict. Our findings also provide preliminary evidence that adolescents with numbing symptoms might use substances to self-medicate or alleviate their symptoms. Moreover, the agitated, irritable, and restless nature of the dysphoric arousal symptoms might contribute to increased conflict between adolescents and parents. Our finding of differential strength of associations between parent-adolescent conflict with dysphoric and anxious arousal is consistent with recent research indicating that dysphoric, but not anxious, arousal in delinquent youth was related to particular mental health problems (Bennett et al., 2014), and it provides further support for differentiating between dysphoric and anxious arousal symptoms of PTSD. The cross-sectional nature of our data precludes conclusions regarding causality, however, and research is needed to ascertain the directional nature of these associations. Nevertheless, by highlighting key dimensions of PTSD that are associated with particular negative outcomes after a disaster, these results can help inform post-disaster assessment and intervention efforts for disaster-affected adolescents. Our findings suggest the importance of distinguishing between dysphoric and anxious arousal symptoms when assessing PTSD in disaster-exposed adolescents; monitoring dysphoric arousal symptoms in particular may help inform risk prediction models for functional recovery in youth after a disaster.

The current investigation is characterized by several strengths, including the use of a novel address-based, rather than convenience, sampling approach that allowed us to study a large population-based sample of tornado-exposed youth. Nevertheless, methodological limitations must be noted. First, our measures of PTSD symptoms, problematic substance use, and parent-adolescent conflict were limited to adolescent self-report. Although adolescents have been shown to be valid reporters of PTSD and substance use, our understanding of adolescent post-tornado functioning may have been enhanced by including supplemental parent reports (Cantwell et al., 1997). Second, baseline assessments were conducted several months after the tornadoes. Thus, this study cannot address functioning immediately after a tornado. Third, the lack of data on pre-disaster functioning precludes an examination of change in PTSD symptoms due to tornado exposure. Fourth, as in other

studies of PTSD factor structure, some of the factors examined were defined by only two indicators. Ideally, more indicators are used to define a latent construct to produce more stable parameter estimates and more reliable factors (Marsh et al., 1998). It is also of interest to expand the assessment of these dimensions of PTSD to include other units of analysis, such as neural, psychophysiological, and behavioral assessments. Fifth, because this study was conducted before *DSM-5* was published, our findings reflect the underlying dimensions of PTSD as defined by *DSM-IV-TR*. Nevertheless, emerging data suggest that the dysphoric arousal model factors provide good fit to relevant *DSM-5* PTSD symptoms (Tsai et al., in press). Further research is needed to investigate whether the dysphoric arousal model provides a good fit to the *DSM-5* PTSD symptoms in disaster-exposed adolescents.

Despite these limitations, our results suggest that investigating underlying dimensions of PTSD, rather than considering PTSD as a single, homogeneous entity, may help inform assessment and prevention strategies for posttraumatic psychopathology in disaster-exposed adolescents. Additional research is needed to increasingly characterize these symptom dimensions at multiple units of analysis. Furthermore, longitudinal studies are needed to delineate the course of these dimensions and to investigate how symptom dimension trajectories relate to aspects of adolescent post-disaster functioning (Pietrzak et al., 2013). As we learn more about the key dimensions underlying disaster-related PTSD in youth and their functional correlates, this knowledge has the potential to be used to tailor post-disaster intervention efforts based on PTSD symptom dimension profiles.

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Highlights

- We examined the symptom structure of PTSD in tornado-exposed adolescents.
- The 5-factor dysphoric arousal model best represented post-tornado PTSD symptoms.
- There was measurement invariance of the 5-factor model across gender and age.
- PTSD symptom dimensions were differentially related to functional correlates.
- PTSD in disaster-exposed adolescents is not a homogeneous entity.

Table 1

Descriptive statistics.

Variable	Mean (SD)	Percent	Range
Age	14.5 (1.7)		12–17
Gender (% Female)		51.0	
Race			
White		70.4	
Black		25.4	
Other		4.2	
Household annual income <$20,000		22.1	
Tornado Exposure and Impact Variables			
Parent present for tornado		90.6	
Parent injured during tornado		2.7	
Parent concerned for loved ones during/after tornado		74.8	
Displaced for >1 week		8.6	
Property damage count	1.4 (1.6)		0–6
Loss of services count	0.6 (1.1)		0–7
Months between tornado and baseline assessment	8.8 (2.6)		4.0–13.5
Number of PTSD symptoms endorsed since tornado	2.4 (3.3)		0–17
Prevalence of probable PTSD diagnosis since the tornado			
Full sample		6.7%	
Girls		7.7%	
Boys		5.6%	
CRAFFT total for problematic substance use since tornado	0.2 (0.6)		0–6
CBQ total at baseline[a]	2.8 (4.0)		0–20

Note. SD=standard deviation. PTSD=posttraumatic stress disorder. CBQ=Conflict Behavior Questionnaire.

[a]Higher CBQ scores indicate greater conflict.

Table 2

Item mappings of the dysphoria, numbing, and dysphoric arousal models of posttraumatic stress disorder (PTSD) symptom dimensionality

DSM-IV PTSD Symptom	Item Mappings		
	Dysphoria	Numbing	Dysphoric Arousal
B1. Intrusive thoughts of trauma	R	R	R
B2. Recurrent dreams of trauma	R	R	R
B3. Flashbacks	R	R	R
B4. Emotional reactivity to trauma cues	R	R	R
B5. Physiological reactivity to trauma cues	R	R	R
C1. Avoiding thoughts of trauma	A	A	A
C2. Avoiding reminders of trauma	A	A	A
C3. Inability to recall aspects of trauma	D	N	N
C4. Loss of interest	D	N	N
C5. Detachment	D	N	N
C6. Restricted affect	D	N	N
C7. Sense of foreshortened future	D	N	N
D1. Sleep disturbance	D	H	DA
D2. Irritability	D	H	DA
D3. Difficulty concentrating	D	H	DA
D4. Hypervigilance	H	H	AA
D5. Exaggerated startle response	H	H	AA

Note. DSM-IV=Diagnostic and Statistical Manual of Mental Disorders, 4th edition. R=Re-experiencing; A=Avoidance; H=Hyperarousal; D=Dysphoria; N=Numbing; DA=Dysphoric Arousal; AA=Anxious Arousal.

Table 3

Fit statistics for confirmatory factor analyses.

Model	χ^2	df	CFI	TLI	RMSEA [90% CI]
Dysphoria	165.15***	113	.995.	.994	.015 [.010, .020]
Numbing	166.35***	113	.995	.994	.015 [.010, .020]
Dysphoric Arousal	156.18**	109	.996	.994	.015 [.009, .020]

Note. df = degrees of freedom; CFI = Comparative Fit Index; TLI = Tucker-Lewis index; RMSEA = root mean square error of approximation. CI = confidence interval.

* $p < .05$,

** $p < .01$,

*** $p \leq .001$

Table 4

Results of factorial invariance testing for the dysphoric arousal model across gender and age.

	Type of invariance	χ^2	df	CFI	TLI	RMSEA [90% CI]	χ^2 difference test[a]	df	*p*
Gender	Configural	264.49*	220	.996	.994	.014 [.006, .020]	--	--	--
	Weak factorial/metric	271.62*	232	.996	.995	.013 [.003, .019]	15.14	12	.23
	Strong factorial/scalar	285.51*	244	.996	.995	.013 [.004, .019]	15.23	12	.23
	Strict factorial[b]	285.51*	244	.996	.995	.013 [.004, .019]	20.92	17	.23
	Factor variance	282.83+	249	.997	.996	.012 [.000, .018]	2.46	5	.78
	Factor covariance	275.48	258	.998	.998	.008 [.000, .015]	6.57	9	.68
Age	Configural	258.44*	218	.996	.995	.014 [.004, .020]	--	--	--
	Weak factorial/metric	270.40*	230	.996	.995	.013 [.004, .019]	15.65	12	.21
	Strong factorial/scalar	287.92*	242	.995	.995	.014 [.006, .020]	20.67	12	.06
	Strict factorial	287.92*	242	.995	.995	.014 [.006, .020]	--	--	--
	Factor variance	288.56*	247	.996	.995	.013 [.004, .019]	4.44	5	.49
	Factor covariance	280.50	257	.998	.998	.010 [.000, .016]	8.46	10	.58

Note. df=degrees of freedom; CFI=Comparative Fit Index; TLI=Tucker-Lewis index; RMSEA=root mean square error of approximation. CI=confidence interval.

*$p<.05$,

+$p<.10$

[a] χ^2 difference test computed using the DIFFTEST option in Mplus.

[b] Fit statistics for the strict factorial invariance model are the same as the strong factorial/scalar invariance model but the model was compared to one that allowed residual variances to be freely estimated across groups, as indicated with results for the χ^2 difference test.

Table 5

Factor means for the dysphoric arousal model as a function of gender and age.

PTSD Dimension	Factor Mean (SE)		*p*	Cohen's *d*
	Girls	Boys		
Re-experiencing	0	−0.27 (0.07)	< .0001	.17
Avoidance	0	−0.37 (0.08)	< .0001	.21
Numbing	0	−0.10 (0.16)	.16	.03
Dysphoric Arousal	0	−0.28 (0.07)	< .0001	.17
Anxious Arousal	0	−0.18 (0.08)	.03	.10
	12–14 year olds	15–17 year olds		
Re-experiencing	0	0.19 (0.07)	.01	.12
Avoidance	0	0.20 (0.08)	.01	.12
Numbing	0	0.25 (0.08)	.01	.15
Dysphoric Arousal	0	0.13 (0.07)	.06	.08
Anxious Arousal	0	−0.06 (0.08)	.48	−.03

Note. SE=standard error. Factor means were set to zero for the reference group for model identification.

Table 6

Correlations between the factors of the dysphoric arousal model.

	1.	2.	3.	4.	5.
1. Re-experiencing	--				
2. Avoidance	.898	--			
3. Numbing	.896	.914	--		
4. Dysphoric arousal	.910	.889	.923	--	
5. Anxious arousal	.929	.845	.847	.888	--

Note. All correlations significant at $p<.001$.

Table 7

Results of Wald tests of parameter constraints for correlations between the factors of the dysphoric arousal model with problematic substance use since tornado and parent-adolescent conflict.

Correlation	*r*	Correlation	*r*	Wald test	*p*
Re-exp with Substance Use	.526	Avoid with Substance Use	.559	0.386	.535
Re-exp with Substance Use	.526	Numb with Substance Use	.591	2.679	.102
Re-exp with Substance Use	.526	Dys Arous with Substance Use	.567	0.723	.395
Re-exp with Substance Use	.526	Anx Arous with Substance Use	.383	3.418	.065
Avoid with Substance Use	.559	Numb with Substance Use	.591	0.423	.515
Avoid with Substance Use	.559	Dys Arous with Substance Use	.567	0.018	.893
Avoid with Substance Use	.559	Anx Arous with Substance Use	.383	4.666	.031
Numb with Substance Use	.591	Dys Arous with Substance Use	.567	0.018	.893
Numb with Substance Use	.591	Anx Arous with Substance Use	.383	6.793	.009
Dys Arous with Substance Use	.567	Anx Arous with Substance Use	.383	5.550	.019
Re-exp with Parent-Adol Conflict	.415	Avoid with Parent-Adol Conflict	.398	0.121	.728
Re-exp with Parent-Adol Conflict	.415	Numb with Parent-Adol Conflict	.429	0.086	.770
Re-exp with Parent-Adol Conflict	.415	Dys Arous with Parent-Adol Conflict	.487	2.585	.108
Re-exp with Parent-Adol Conflict	.415	Anx Arous with Parent-Adol Conflict	.255	7.109	.008
Avoid with Parent-Adol Conflict	.398	Numb with Parent-Adol Conflict	.429	0.377	.539
Avoid with Parent-Adol Conflict	.398	Dys Arous with Parent-Adol Conflict	.487	2.752	.097
Avoid with Parent-Adol Conflict	.398	Anx Arous with Parent-Adol Conflict	.255	4.025	.045
Numb with Parent-Adol Conflict	.429	Dys Arous with Parent-Adol Conflict	.487	1.402	.236
Numb with Parent-Adol Conflict	.429	Anx Arous with Parent-Adol Conflict	.255	6.563	.010
Dys Arous with Parent-Adol Conflict	.487	Anx Arous with Parent-Adol Conflict	.255	12.910	.0003

Note. Re-exp=Re-experiencing. Avoid=Avoidance. Numb=Numbing. Dys Arous=Dysphoric arousal. Anx Arous=Anxious arousal. Substance Use=Problematic substance use based on the CRAFFT. Parent-Adol Conflict=Parent-adolescent conflict based on the CBQ. All correlations significant at $p<.001$. Alpha was set at .01 to control for Type I error.