Received: 6 October 2020 | Revised: 6 December 2021 | Accepted: 11 January 2022

DOI: 10.1002/jts.22818

ISTSS International Society for Traumatic Stress Studies WILEY

RESEARCH ARTICLE

The nosographic structure of posttraumatic stress symptoms across trauma types: An exploratory network analysis approach

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The authors would like to thank the reviewers for their thoughtful comments that considerably improved the manuscript.

Abstract

The nosographic structure of posttraumatic stress disorder (PTSD) remains unclear, and attempts to determine its symptomatic organization have been unsatisfactory. Several explanations have been suggested, and the impact of trauma type is receiving increasing attention. As little is known about the differential impact trauma type in the nosographic structure of PTSD, we explored the nosology of PTSD and the effect of trauma type on its symptomatic organization. We reanalyzed five cross-sectional psychopathological networks involving different trauma types, encompassing a broad range of traumatic events in veterans, war-related trauma in veterans, sexual abuse, terrorist attacks, and various traumatic events in refugees. The weighted topological overlap was used to estimate the networks and attribute weights to their links. Coexpression differential network analysis was used to identify the common and specific network structures of the connections across different trauma types and to determine the importance of symptoms across the networks. We found a set of symptoms with more common connections with other symptoms, suggesting that these might constitute the prototypical nosographic structure of PTSD. We also found a set of symptoms that had a high number of specific connections with other symptoms; these connections varied according to trauma type. The importance of symptoms across the common and specific networks was ascertained. The present findings offer new insights into the symptomatic organization of PTSD and support previous research on the impact of trauma type on the nosology of this disorder.

Posttraumatic stress disorder (PTSD) is a complex, heterogeneous, and debilitating disorder (Birkeland et al., 2020). Its nosographic structure (i.e., symptomatic organization) has been exhaustively examined (Bryant, 2019) and associated with numerous symptomatic structures (Armour et al., 2016). The diversity of distinct conceptualizations led to changes in the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*) criteria between the fourth (*DSM-IV*; American Psychiatric Association [APA], 1994) and fifth editions (*DSM-5*; APA, 2013). However, these changes did not clarify the nosographic structure of PTSD as, according to the diagnostic requirements, there are a total of 636,120 possible clinical presentations of PTSD (Galatzer-Levy & Bryant, 2013). This number of possible clinical configurations makes it difficult to establish a clear nosology of PTSD (North et al., 2016), with proposals ranging from one to seven factors (Armour et al., 2016). Thus, the instability of PTSD symptoms across the distinct versions of the *DSM* leads to different proposed factor structures, which, in turn, impacts the prevalence rates of this condition

(Elhai et al., 2012). This can result in a significant number of individuals being excluded from a diagnosis of PTSD (Armour et al., 2016), and this obstacle influenced the development of the PTSD criteria in the *DSM-5* (North et al. 2016). Naturally, this has severe implications for research and clinical practice, as it hinders assessment (Elhai & Palmieri, 2011) and increases the potential of an incorrect diagnosis (Elhai et al., 2012). It also hampers the development and selection of personalized treatments (Armour et al., 2016). In this context, a more complete comprehension of the nosographic structure of PTSD would be valuable, as it would help ascertain the core symptoms while identifying the etiopathogenic and maintenance mechanisms of the disorder (Elhai et al., 2011) and contributing to the development and refinement of assessment instruments and treatment plans (Armour et al., 2016).

The clarification of the PTSD nosographic structure might be improved if trauma type is considered, with previous studies suggesting that specific symptoms may be associated with certain types of traumatic events (Kessler et al., 2017). However, previous studies have found mixed evidence for this hypothesis (Kelley et al., 2009; Smith et al., 2016; Graham et al., 2016). For example, Kelley and colleagues (2009) and Smith and colleagues (2016) found associations between avoidance symptoms and the experience of sexual trauma. Graham and colleagues (2016) found that symptoms of detachment and loss of interest were associated with war-related trauma, and Kelley and colleagues (2009) observed that physiological reactivity was related to experiencing a motor vehicle accident. However, these symptoms were also found to be associated with other traumatic events. For example, Ge and colleagues (2019) and Bryant and colleagues (2017) found that physiological reactivity was associated with both earthquake-related trauma and traumatic injury.

Researchers have proposed several factors to explain these discrepancies, including the use of nonrepresentative samples; the study of a single traumatic event (Smith et al., 2016); demographic features, such as age and sex (Lancaster et al., 2014); and trauma timing and recurrent exposure to a traumatic event (Fink et al., 2017; Shea et al., 2017). Additionally, the methods used to determine the associations between trauma type and specific symptoms (i.e., profile analysis [Kelley et al., 2009], confirmatory factor mixed modeling [Shevlin & Elkit, 2012], and logistic regressions [Graham et al., 2016]) have been insufficient to obtain an accurate view of the symptomatic organization across different types of traumatic events. Essentially, this is because these methods only acknowledge the presence of differences, not the identification of specificities and commonalities of one symptom at a time. The limitations of the current methods and the consequent variability of the results might inhibit a deeper understanding of the nosographic structure of specific trauma types, as the primary goal of these investigations is to identify the unique symptoms of PTSD.

In this context, psychopathological networks (Borsboom et al., 2019) are a promising alternative to the traditional "common cause" view that the previously mentioned methodologies reflect. The common cause conceptualization of mental disorders has long been discussed as problematic (Fried, 2015, 2017; Fried & Nesse, 2015). One of the primary assumptions of the common cause perspective is the interchangeability and equal validity of all symptoms of the diagnosis (Fried, 2015). This is problematic for the diagnosis of PTSD, as symptomatic presentations might differ according to the precipitating traumatic event (Kelley et al., 2009) as well as the fact that it is a highly comorbid disorder (Hyland et al., 2021) with distinctive responses to treatment (Asmundson et al., 2004). This suggests that the covariance between symptoms is not reflective of a common cause. In fact, as some scholars have argued (Armour et al., 2017; McNally et al., 2015), the assumption that PTSD symptoms do not interact with each other is highly implausible. Network theory conceptualizes mental disorders as complex systems of interacting symptoms (Borsboom & Cramer, 2013), where symptoms are seen as nodes and their interactions as edges. From this perspective, it is from the interactions between symptoms that mental disorders emerge (Borsboom, 2019). Focusing on the interactions between symptoms has already produced important insights into the nosographic and comorbidity structures of several mental disorders (e.g., Bekhuis et al., 2016; Bos et al., 2018a; Levinson et al., 2017; Ruzzano et al., 2015), including PTSD (e.g., Afzali et al., 2017; Armour et al., 2017; Birkeland & Heir, 2017; Bryant et al., 2017; Fried et al., 2018; McNally et al., 2015). Most of these advances were made by exploring central symptoms, which are the symptoms that display the highest number of connections with other symptoms (Epskamp et al., 2018 Fried et al., 2017). As higher numbers of connections in a network have been associated with more severe disorder (van Borkulo et al., 2015), central symptoms have been proposed to play an important role in the development and maintenance of psychopathological networks (Borsboom, 2017; Borsboom et al., 2019). Previous findings have also shown that deactivating these central symptoms promotes a faster change in the network properties (Castro et al., 2019). Thus, identifying these symptoms might be important to understand developmental processes of PTSD and, as has been suggested, particularly important for the identification of relevant treatment targets (Bekhuis et al., 2016; Borsboom & Cramer, 2013; Bryant et al., 2017; Knefel et al., 2016; McNally et al., 2015; Olatunji et al., 2018; Richetin et al., 2017; Robinaugh et al., 2016).

However, previous studies on the nosographic structure of PTSD have produced inconsistent results regarding the centrality of symptoms (Ross et al., 2018). For example, in a sample of individuals who experienced a terrorist attack, Birkeland and Heir (2017) found that emotional numbing was the symptom that displayed the highest strength (i.e., the sum of the weighted connections of a node to the other nodes in the network; Opsahl et al., 2010). In contrast, hypervigilance and concentration problems demonstrated the highest strength in a sample of individuals who had survived an earthquake (McNally et al., 2015), and Armour and colleagues (2017) found that negative trauma-related emotions and flashbacks had the highest strength in a sample of military veterans. Due to this lack of consistency regarding the most central symptoms across studies, the fused graphical lasso (FGL; Danaher et al., 2014) and network comparison test (NCT; van Borkulo et al., 2017) have been introduced to clarify the nosographic network structure of PTSD.

The FGL is a framework that allows for the joint estimation of a set of networks (Fried et al., 2018). This joint estimation explores identical aspects of the networks and approximates them (Constantini et al., 2017), allowing for more accurate and replicable network structures (Fried et al., 2018). In turn, the NCT is a framework used to compare the structure of two networks (van Borkulo et al., 2017). This method compares key aspects of network structure, namely how the network differs at the global and local levels. At a global level, NCT is used to compare the connectivity of the network (i.e., the number of connections in the network), and, at a local level, it enables researchers to identify connections between symptoms that are present in both networks. This allows for comparisons between pre- and posttreatment mental disorder severity (Pe et al., 2015; van Borkulo et al., 2015; Wichers & Groot, 2016) as well as between distinct types of traumatic events (Benfer et al., 2018).

Despite their contribution to the field, these methods are limited in their ability to capture the differences in networks in detail. For example, the FGL (Danaher et al., 2014) can inhibit observations of differences that might be of significant clinical relevance (Lyu et al., 2018). The NCT (van Borkulo et al., 2017) is unable to compare more than two networks simultaneously, making a comparison between various networks a daunting task, and it does not provide information about which connections are common and which are specific to each network. Moreover, the method used to assess differences between the strengths of the edges could generate Type I errors, and sample size can affect the statistical power (Fried et al., 2018).

In the context of PTSD, Fried and colleagues (2018) applied both methods to explore the differences and similarities across four datasets of individuals with *DSM-IV* PTSD symptoms. The authors' primary focus was to demonstrate the replicability of the network structure of PTSD and concluded that the networks were replicated, with moderate-to-high coefficients of similarity (i.e., 0.62–0.74) and centrality indices (i.e., 0.63–0.75) across the four networks. Despite the advances attained in this study, the problem underlying the nosographic structure of PTSD has not been completely eliminated, as there are variations in the central symptoms and network structures across several PTSD studies that remain unexplained (Birkeland et al., 2020; Contreras et al., 2019).

Previous network studies have shown that traumatic events are associated with specific symptoms (Ferreira et al., 2020; Isvoranu et al., 2016), suggesting that the trauma type might have a differential impact on the development of the network structure. This means that different types of traumatic events give rise to specific connections. Thus, it would be expected that changes in the structure of connections between PTSD symptoms should occur in relation to the traumatic event. This could help explain the different clinical presentations found in previous studies (Birkeland et al., 2020) and would shed light on the possible developmental paths of PTSD according to trauma type. The network perspective has only recently begun to be applied to explore this topic and, to our knowledge, only one network study has addressed it. Benfer and colleagues (2018) examined and compared the network structure of *DSM-5* PTSD symptoms in three trauma types: motor vehicle accidents, the sudden accidental or violent death of a loved one, and sexual assault. Using the NCT, the authors found differences in the network structure across the three trauma types, which they examined in pairs. Differences were observed in the global strength of the network that included sexual assault and motor vehicle accidents, as well as in the association between negative beliefs and anhedonia, which was not present in sexual assault trauma. The network that included the sudden accidental or violent death of a loved one revealed smaller global strength values than the other networks. There were also differences in the centrality of symptoms, where flashbacks and irritability were identified as central in the networks involving sexual assault and motor vehicle accidents, respectively.

This preliminary evidence suggests that different trauma types might give rise to different network structures and, thus, deserve further exploration. A more detailed view of which connections occur in PTSD regardless of trauma type and which connections are dependent on a certain traumatic experience might allow scholars to detect specific patterns in the development and the maintenance of PTSD after specific traumatic events and, consequently, improve treatment and prevention responses. In addition, identifying which development

paths are present regardless of trauma type would help to clarify the prototypical network structure of PTSD.

However, because the study of mental disorders as complex systems is a reasonably new field in psychology, methodologies that enable researchers to access this level of detail are not yet commonly available. In this context, it seems reasonable to use alternative approaches from other fields of network science that might help elucidate these issues. The coexpression differential network analysis (CoDiNA; Gysi et al., 2020) method was recently developed with the aim of providing a more fine-grained view of complex systems (e.g., biological, social, financial). Specifically, this framework allows the comparison of multiple weighted networks and the identification and classification of nodes and their connections among the networks (Gysi et al., 2020). There are three main categories of nodes and their connections: common (i.e., connections that are common to all the networks), different (i.e., connections that are common to all the networks but are present with a different sign), and specific (i.e., connections that are particular to a network or set of networks). This framework also estimates the importance of each symptom in each of the networks. These details are key steps to a more fine-grained comprehension of network structures. CoDiNA has been used in previous studies to ascertain the expression of HIV in children and adults with or without tuberculosis. Remarkably, this method helped researchers to identify the presence of specific genes and connections in the networks representing HIV in children and HIV in adults, as well as sets of genes associated with tuberculosis (Gysi et al., 2020). The same method has also been used to pinpoint signature genes in distinct types of cancer (Gysi et al., 2020).

The application of this framework might promote important advances regarding the nosographic structure of PTSD, such as the identification of connections that are specific to a certain trauma type and the identification of the prototypical network of interactions between PTSD symptoms. Identifying these specific and common connections between PTSD symptoms will help clarify the nosography of PTSD and the differential impact of each trauma type, consequently promoting the development of more personalized and effective treatments. With this in mind, the primary goals of this study were to (a) explore the nosographic structure of PTSD and (b) examine the impact of different types of traumatic events in the symptomatic organization of PTSD. A secondary goal of this study was to explore the commonalities and disparities between *DSM-IV* and *DSM-5*.

METHOD

Network collection

Three previous PTSD published networks were collected from three databases: PsychInfo, PsyArticles, and Academic Search Complete. To increase the variety of examined traumatic events, we requested and were provided with two additional PTSD networks from their original authors (Birkeland & Heir, 2017; Spiller et al., 2017). The stability of all networks was evaluated in the original studies. Overall, a convenience sample of five cross-sectional PTSD networks was collected and reanalyzed (see Table 1 for details of the original network studies). Two of these networks were estimated according to the 17 PTSD symptoms in the *DSM-IV*, and the remaining three networks were estimated according to the 20 *DSM-5* PTSD symptoms. The networks covered different types of traumatic events and populations, including childhood sexual abuse trauma in a clinical sample of adults (N = 179; McNally et al., 2017), a broad range of traumatic events in a clinical sample of veterans (N = 221; Armour et al., 2017), war-related trauma exposure in a community sample of veterans (N = 378; Moshier et al., 2018), a terrorist attack in a community sample of adults (N = 190; Birkeland and Heir, 2017), and a range of traumatic events in a community sample of refugees (N = 151; Spiller et al., 2017).

The sample representing childhood sexual abuse (McNally et al., 2017) had a total of 179 participants (M_{age} = 41.2 years, SD = 12.4); the inclusion criteria were a sexual abuse experience involving unwanted physical contact (e.g., fondling or anal, oral, or vaginal penetration) that occurred before 16 years of age. The sample of veterans who experienced a broad range of traumatic events (Armour et al., 2017) consisted of 221 participants (M_{age} = 60.4 years, SD = 15.3, range: 20–94 years) who were asked whether they were exposed to any of the 14 traumatic events included on the Trauma History Screen (Carlson et al., 2011; M = 5.95, SD = 3.21, range: 1–15). The sample of veterans who reported war-related trauma exposure (Moshier et al., 2018) consisted of 378 participants (M_{age} = 55 years, SD = 12; 93.6% male). In this sample, most participants were non-Hispanic (90.7%) and Caucasian (69.1%), and 72% had a current PTSD diagnosis, with a mean PTSD symptom duration of 301 months (SD = 199). The sample of victims of a terrorist attack (Birkeland et al., 2017) included 190 participants (M_{age} = 44.7 years, SD = 11.9; 61% female). All participants were survivors of the 2011 Oslo bombing attack and were employees of Norwegian ministers; 24% of the sample met the criteria for PTSD. In the community sample of refugees who

TABLE 1 Descriptive variables of the original studies

Network	Study	Population	Study location	Trauma type	Sample	Criteria	*N*	% male	Data type	PCL-5 score	
										M	*SD*
1	Armour et al., 2017	Veterans	United States	Broad range of traumatic events	Clinical	*DSM-5*	221	86.7	Continuous	31.0	13.4
2	Birkeland & Heir, 2017	Adults	Oslo	Terrorist attack	Community	*DSM-IV*	190	38	Continuous	34.1	14.9
3	McNally et al., 2017	Adults	Boston	Sexual abuse	Clinical	*DSM-IV*	179	16.2	Continuous	-	
4	Spiller et al., 2017	Adults	Turkey, Iran, Sri Lanka, Bosnia	Refugees	Community	*DSM-5*	151	70	Continuous	37.8	8.01
5	Moshier et al., 2018	Veterans	United States	War-related trauma	Community	*DSM-5*	378	93.6	Continuous	44.9	15.5

Note: All original analysis used Gaussian graphical models. *DSM* = *Diagnostic and Statistical Manual of Mental Disorders*; *DSM-IV* = *DSM* (4th ed.); *DSM-5* = *DSM* (5th ed.); PCL = Posttraumatic Stress Disorder Checklist.

experienced a variety of traumatic events (Spiller et al., 2017), trauma exposure was assessed using the Harvard Trauma Questionnaire (Mollica et al., 2017). Participants had experienced a mean of 14.7 (*SD* = 4.1) traumatic events. Most of the sample was male (70%), and the mean participant age was 41.9 years (*SD* = 9.8). Participants were from a variety of countries, including Turkey (54%), Iran (9%), Sri Lanka (9%), Afghanistan (7%), Bosnia (%), and others (21%). Overall, 51% of the participants fulfilled the criteria for probable PTSD. Comorbidity networks were excluded from the analyses.

Data analysis

The CoDiNA (Version 1.1.2; Gysi et al., 2020) R package (Version 4.0.2; R Core Team, 2020) was used to explore the general network structure of PTSD and the structure of specific connections across different trauma types. First, we used the *weighted topological overlap* (wTO; Version 1.6.3; Gysi et al., 2018) R package to estimate the networks. The wTO is derived from a topological overlap matrix, and a pair of nodes have their weight calculated using a normalized Pearson correlation (see the Supplementary Materials for an overview); thus, the node pair's correlation is normalized by the correlation of all its shared neighbors.

Next, we used CoDiNA to explore and characterize the common and specific structure of connections between the different types of traumatic events. CoDiNA considers the weight of the link, with values ranging between -1 and +1; if networks were derived from different experiments that did not follow the same procedure, then the networks must be reparametrized. A stretch parameter, performed using a min–max normalization, is used to permit this comparison, which allows all networks to be in the same range of values and, therefore, comparable. CoDiNA is based on the weight of the connections between the nodes included in the networks and uses a predefined threshold to remove spurious connections. In our case, we set the threshold to 0; this threshold identifies the minimum link weight to be considered for the comparison. When a link is under the absolute value of the defined threshold, it is set to 0; if the weight value is above the threshold, it is assigned a value of +1, and if it is under the threshold, the link is assigned a value of -1. If a link weight is 0 in all networks under evaluation, it is then removed from the analysis.

Next, CoDiNA classifies each of the connections (i.e., links) according to three types: common (α), different (*β*), and specific (γ). Common connections are present in all evaluated networks, different connections are present in all networks but have different weight signs depending on the network, and specific connections are present in at least one network but not all networks. As an example,

assume that a connection exists between Symptoms A and B in all trauma type networks; this connection is common to all networks under evaluation—with similar weight and the same weight sign—and, therefore, it is considered to be a common connection. However, there could be another connection that only exists for one trauma type, or a subset of trauma types, that CoDiNA will define as a specific connection. Once a connection has been identified, a score ratio is calculated to measure how well classified a link is and how strong that link is for a particular network. If the score ratio is over 1, the connection is selected (see the Supplementary Materials for more details). Strength centrality (i.e., the sum of the absolute weight of the connections between a node to all other nodes in the network; Opsahl et al., 2010) was used to characterize the common and specific structure of connections between the networks. The *igraph* package (Version 1.2.6; Csardi & Nepusz, 2006) for R was used to estimate this centrality measure.

As most of the symptoms were present in either the common network or the trauma-specific networks, we performed a subsequent analysis to determine which symptoms were more important for the common and specific networks. This analysis was intended to indicate in which network (i.e., common or specific) the symptom had a significantly higher strength. If a symptom had a significantly higher strength in the common network than in the specific network, this symptom was considered more important to this network. The importance of each symptom in each network was calculated based on their score ratios from CoDiNA. This allowed us to easily derive the strength of each symptom in each network and compare this value to the overall strength of all other symptoms, per category (i.e., the common network or a specific trauma-related network) by calculating its Z score and later correcting for multiple corrections. If a symptom was important overall in more than one network, we selected the one with the lower adjusted p value after applying the Benjamini–Hochberg test with the false rate discovery rate correction. The *igraph* package (Version 1.2.6; Csardi & Nepusz, 2006) for R was used to create the graphical representation of the common and specific network structure of connections according to trauma type.

RESULTS

Network structure of common connections

The common connections between PTSD symptoms across all networks are depicted in Figure 1. The symptoms with a higher number of common connections to the other symptoms in the network as well as higher levels of strength were physiological reactivity, emotional reactivity, negative beliefs, startle response, concentration problems, and loss of interest.

Network structure of specific connections across trauma types

The networks representing trauma exposure related to a broad range of traumatic events in veterans, war-related trauma in veterans, and a broad range of traumatic events in refugees revealed distinct structures of specific connections (Supplementary Figures S2, S3, and S4). The sexual abuse and terrorist attack networks revealed a similar structure of specific connections (Supplementary Figures S5 and S6). The networks that represented a broad range of traumatic events in veterans, war-related trauma in veterans, various traumatic events in refugees, a terrorist attack, and sexual abuse revealed 56, 45, 54, 38, and 38 specific connections, respectively (see Supplementary Table S1).

Regarding the network representing a broad range of traumatic events in veterans, 59% of the specific connections were also present in the war-related trauma network, 71% were present in the refugee sample network, and 46% appeared in the sexual abuse and terrorist attack networks. For example, the connection between flashbacks and sleep disturbance was present in the following networks: a broad range of traumatic events in veterans, various traumatic events in refugees, sexual abuse, and a terrorist attack; it was not present in the network representing war-related trauma in veterans. The connection between flashbacks and destructive behavior appeared only on the network representing a broad range of traumatic events in veterans.

In the network representing war-related trauma in veterans, 75% of the connections present were also found in the network encompassing a broad range of traumatic events in veterans, 71% were found in the refugee trauma network, and 42% appeared in the sexual abuse and terrorist attack networks. For example, the connection between avoidance of thoughts and loss of interest was present in the networks of symptoms representing war-related trauma, sexual abuse, a terrorist attack; however, it did not appear in either network that encompassed a sample exposed to a broad range of traumatic events (i.e., veterans or refugees).

Among the connections found in the network representing trauma exposure in refugees, 74% were also present in the network of broad trauma exposure in veterans, 57% in the war-related trauma network, and 41% in both the sexual abuse and terrorist attack networks. For example, the connection between concentration problems and avoidance of reminders was present in the refugee, sexual abuse, and terrorist attack networks, but it did not appear in the networks representing a broad range of traumatic events

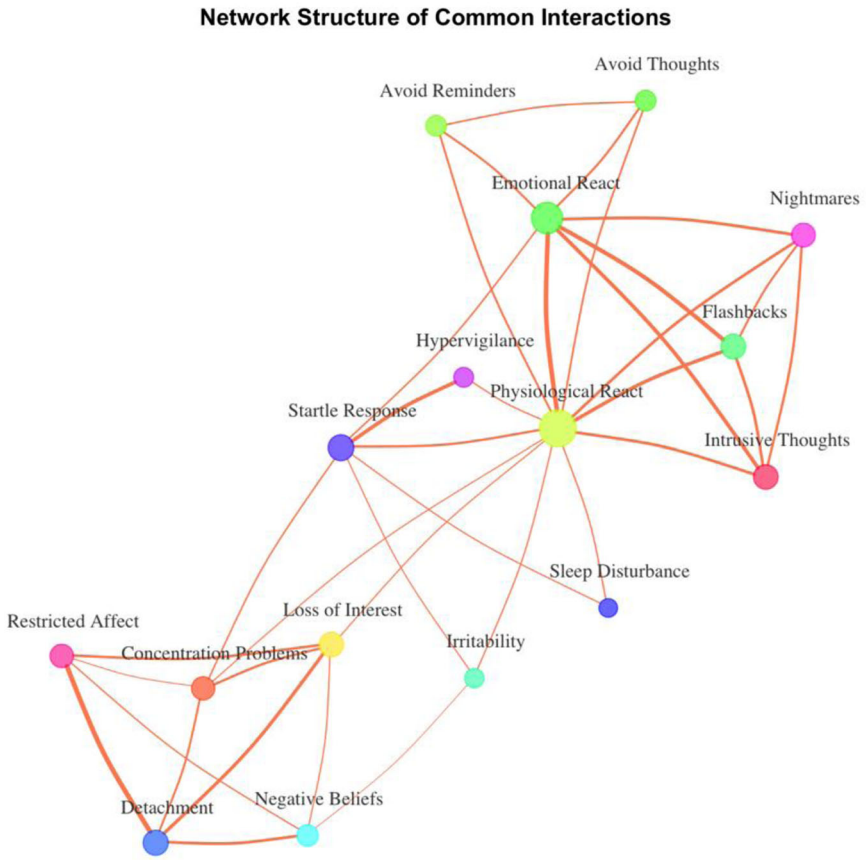

FIGURE 1 Network structure of common interactions. Note. The nodes represent symptoms of posttraumatic stress disorder, and the edges between the nodes represent the weighted topological overlap values between the symptoms, across trauma types. Node size represents the strength of centrality values. Thicker edges represent higher weighted topological overlap values between symptoms across the network

or war-related trauma in veterans. Two connections were exclusive to the network related to trauma exposure in refugees: blame and hypervigilance and blame and startle response.

The sexual abuse trauma and terrorist attack networks shared the same structure of specific interactions, with an identical 38 specific connections. Of these 38 connections, 68% were present in the network representing a broad range of traumatic events in veterans, 47% in the war-related trauma network, and 58% in the refugee trauma network. For example, the connection between irritability and sleep disturbance was present in the sexual abuse, terrorist attack, broad range of traumatic events in veterans, and war-related trauma networks but did not appear in the refugee trauma network. The connection between avoidance of thoughts and concentration problems as well as the connection between avoidance of thoughts and sleep disturbance were exclusive to the sexual abuse and terrorist attack networks.

Symptom centrality in the common and specific networks

Regarding symptom centrality, we found differences between the trauma type–specific networks (Figure 2). The network representing a broad range of traumatic events in veterans revealed that the symptoms of negative emotions, flashbacks, irritability, and loss of interest demonstrated the highest centrality; the network representing war-related trauma in veterans included the same highly central symptoms with the exception of flashbacks. In the refugee trauma network, the symptoms that displayed the highest strength were negative emotions, blame, and flashbacks. In the sexual abuse and terrorist attack networks, the symptoms with the highest strength were flashbacks, concentration problems, irritability, and avoidance of trauma-related thoughts.

Symptom importance in the structure of common and specific networks

Eleven symptoms were more important in the common network than in the specific networks: intrusive thoughts, nightmares, emotional reactivity, physiological reactivity, avoidance of reminders, negative beliefs, loss of interest, detachment, restricted affect, hypervigilance, and startle response (see Supplementary Table S2). The remaining symptoms were found to be more important for specific trauma networks than for the common network. Sleep disturbance emerged as an important symptom in all trauma

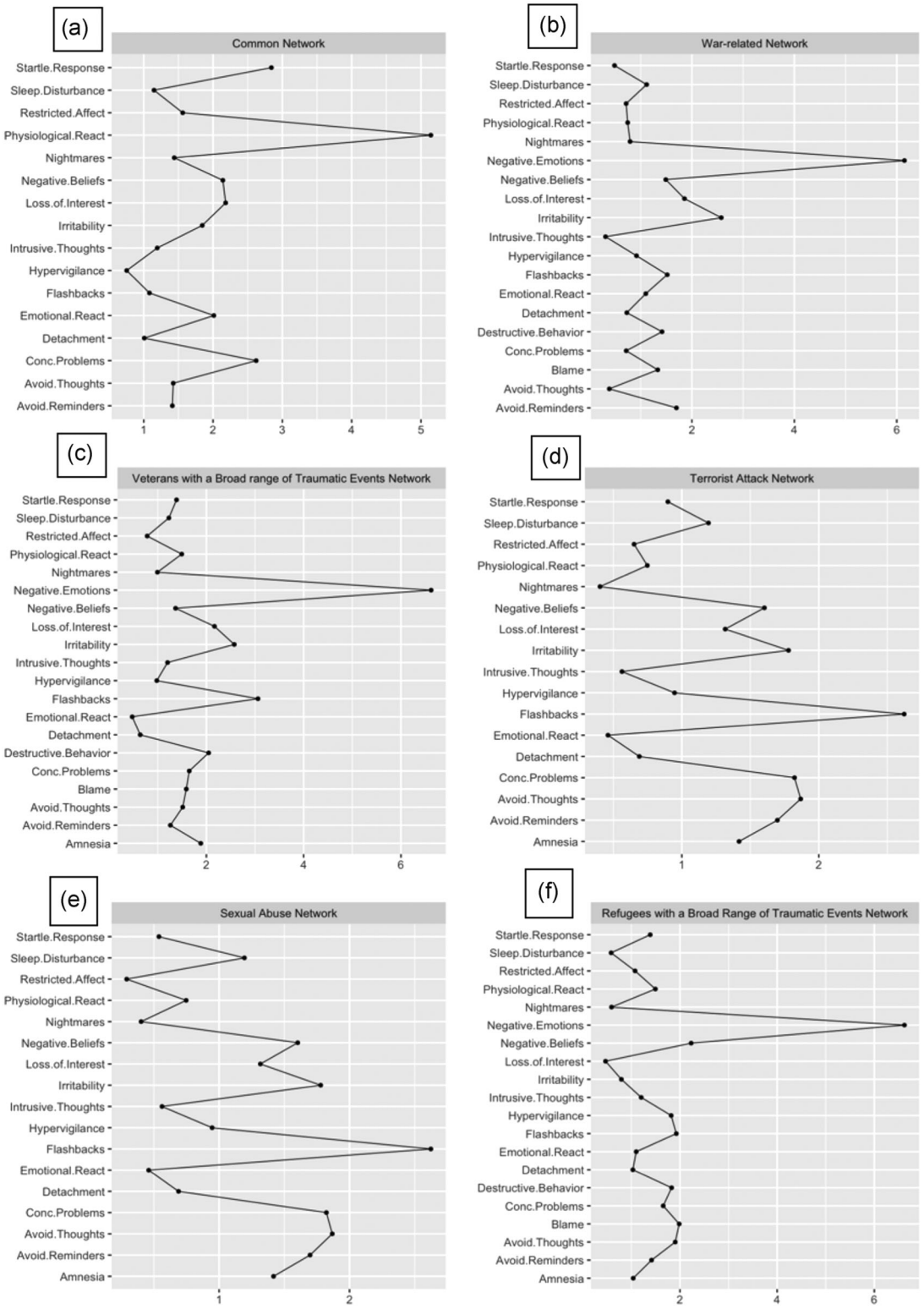

FIGURE 2 Strength centrality values across networks. Note. The figure depicts strength centrality values found in symptom networks related to (a) common connections, (b) war-related trauma in veterans, (c) a broad range of traumatic events in veterans, (d) a terrorist attack, (e) sexual abuse, and (f) refugee-related trauma

networks except for war-related trauma in the veterans. Irritability was important for every network except the refugee trauma network. Blame, destructive behavior, and negative emotions were more important symptoms in the networks representing refugee trauma, a broad range of trauma in veterans, and war-related trauma in veterans. Amnesia was identified as an important symptom in the networks of symptoms related to a broad range of traumatic events in veterans, sexual abuse, and a terrorist attack.

DISCUSSION

The nosographic structure of PTSD remains uncertain (Bryant, 2019), and attempts to uncover the symptomatic structure of the disorder have turned out to be unsatisfactory (Birkeland et al., 2020). This is amplified by the reported association between trauma type and distinctive clinical configurations (Kessler et al., 2017). The present study took a novel approach to clarify these topics, which allowed for the identification of specificities in the network structure of particular trauma types as well as a set of interactions between the symptoms that might characterize the general structure of PTSD independent of trauma type.

The identification of these characteristics not only contributes to clarifying the nosological structure of PTSD but also to untangling the differential impact of each of the traumatic events explored in this study. Regarding the common structure of PTSD, the results showed that symptoms of physiological and emotional reactivity, startle response, negative beliefs, concentration problems, and loss of interest had the highest number of common interactions with other symptoms. Moreover, these symptoms were identified as being more important to the common structure of PTSD than to any of the specific trauma networks. This suggests that individuals with PTSD may commonly experience these symptoms regardless of the traumatic event they experienced and that these symptoms may characterize the prototypical structure of PTSD.

Moreover, the high centrality of these symptoms might suggest that they are responsible for the emergence of the disorder (Borsboom, 2019). Except for startle response, these symptoms have previously been suggested as nonspecific symptoms of PTSD (Gros et al., 2010; Walton, 2017), and they often overlap with symptoms of other mental conditions, such as major depression or generalized anxiety disorder (i.e., concentration problems and loss of interest; Gros et al., 2012; Price & Stolke-Cooke, 2015) or panic disorder or a specific phobia (i.e., physiological and emotional reactivity; Walton, 2017). In fact, previous research has suggested that these nonspecific symptoms are responsible for the high levels of comorbidity between these disorders and PTSD (Spinhoven et al., 2014) or constitute a general component of distress that is typical of several mental disorders (Watson, 2009). The present results point in this direction, suggesting that these symptoms constitute the common structure of PTSD rather than being specifically related to any of the traumatic events analyzed in the present study.

It is also worth noting that symptoms identified as important for the common network are present both in the *DSM-IV* and *DSM-5* diagnostic criteria, suggesting that both diagnostic manuals capture the common structure of PTSD. In turn, the symptoms found to be the most important for trauma-specific networks, might also be valuable diagnostic criteria, as they might be potential markers of specific trauma types. For example, we found that amnesia was more important in the networks that covered a variety of traumatic events in veterans, sexual abuse, and a terrorist attack than in the networks pertaining to other trauma types or the common network. In previous studies (e.g., Birkeland et al., 2020; Fried et al., 2018;), amnesia has revealed low centrality values, leading some authors to suggest that amnesia be removed from the *DSM* criteria for PTSD. The present results suggest that this might not be adequate due to amnesia's specificity to some trauma types, which might be of clinical relevance for diagnosis as well as for the development of treatment and prevention strategies.

Other connections and symptoms were found to be specific to some trauma types. In most cases, these specific connections and symptoms were associated with a subgroup of traumatic events, which might be due to the common characteristics of the traumatic events (Jakob et al., 2017; Li et al., 2016) and/or other confounding factors associated with the development of the disorder (Betts et al., 2013, Olff et al., 2007; Ryan et al., 2016).

Traumatic events appear to share common characteristics. For example, veterans and refugees have in common a continuous exposure to unstable and stressful environments (Jakob et al., 2017; Li et al., 2016), which might explain the similarities we found in these types of traumas. Negative emotions, blame, and destructive behavior were found to be more important in both these networks than in the other trauma-specific networks and the common network. The networks associated with sexual abuse and a terrorist attack also revealed a similar structure, which may also be related to the common contextual characteristics of these types of traumatic events, such as their unpredictability (Pereda, 2013) and the perpetrators' deliberate intention to cause harm (Santiago et al., 2013).

Despite this, some connections were exclusive to specific networks. For example, avoidance of thoughts and loss of interest had a connection in the networks representing war-related trauma, sexual abuse, and a terrorist attack;

however, this connection did not appear in either of the networks representing a broad range of traumatic events. Moreover, connections between avoidance of thoughts and concentration problems as well as avoidance of thoughts and sleep disturbance were exclusive to the sexual abuse and terrorist attack networks. This suggests that there might be connections that emerge only for particular traumatic events. However, several connections were common to both networks that represented a broad range of traumatic events (i.e., among veterans and refugees). In this case, due to the myriad traumatic events in each network, the specific connections that emerged might be related to sample characteristics other than trauma type. Although this might be the case, the ability of network analysis to identify these specific connections is a promising avenue for future research. As several factors have been associated with the development of different clinical presentations (Kelley et al., 2009), with varying effect sizes, network analysis might provide a fruitful path for clarifying the differential impact of these factors.

Interestingly, the specific connections identified were also associated with local structural network properties, namely symptom centrality. In the network that encompassed a broad range of traumatic events in veterans, flashbacks were one of the most central symptoms. In turn, in the network representing a broad range of traumatic events in refugees, blame, which was involved in two specific connections (i.e., with both hypervigilance and startle response), was also one of the most central symptoms in that network. As central symptoms have been suggested to be key treatment targets (Borsboom, 2017), the fact that these symptoms have further specific connections suggests that treatment targets might change according to specific factors.

Moreover, the present results show that differences in symptom centrality occurred across the networks of specific traumatic events. Depressive symptoms (i.e., irritability and loss of interest) were more central for the two veteran networks than for any of the other specific networks. This is in accordance with previous studies showing that veterans usually experience depressive symptoms along with PTSD symptoms (Rytwinski et al., 2013). This might be because the impact of war-related trauma tends to promote a negative view of one's self, others, and the future (Benner et al., 2018), which makes veterans and military personnel more susceptible to an elevated number of depressive symptoms (Armenta et al., 2019). In turn, previous studies have suggested that victims of sexual abuse gain awareness of their experience through flashbacks (Schröder et al., 2018), which was the most central symptom in the sexual abuse network but not in any other network. Hypervigilance was also a more central symptom in the network representing refugee trauma than in the other networks. This might be related to refugees living in continuous fear of being persecuted, tortured, sexually assaulted, murdered, or subjected to witnessing the murder of their loved ones (Li et al., 2016; Liddell et al., 2019), leaving them in a constant state of uncertainty about their future (Liddell et al., 2019). In this context, these results point to the need for attending to trauma type when choosing treatment strategies to address the specificities that might originate from the type of traumatic event an individual has experienced.

The present results should be read bearing in mind some of the limitations of this study. First, it should be noted that although we explored the differences in the networks according to the trauma type, several confounding factors have been associated with the development of specific clinical presentations. For example, gender (Betts et al., 2013), age (Olff et al., 2007), genetic factors (Chitrala et al., 2016), social support, and previous trauma history (Alipour & Ahmadi, 2020) have been shown to impact the clinical presentation of PTSD. Women are twice as likely to develop PTSD compared with men (Betts et al., 2013), and certain genetic factors have been shown to increase the risk of developing PTSD by 30% (Ryan et al., 2016). These factors, which we did not take into account in the present analysis, might also explain why several connections were specific to more than one traumatic event. For example, the terrorist attack network and the sexual abuse network, which had similar structures, were the only two samples in our study that were mostly composed of women.

In addition, in some samples, namely those in the studies of general trauma exposure among veterans and refugees (i.e., Armour et al., 2017; Spiller et al., 2017), the types of reported traumatic events were heterogeneous. For example, among veterans exposed to a high variety of traumatic events, some reported being abandoned by a spouse, partner, parent, or their family. This might have had an impact on the identification of the specific connections in each trauma type. Thus, solely attributing the differences between networks to the traumatic events represented might exemplify only one possible explanation for the results. This key limitation should be addressed in future studies by using large samples of individual patient data representing exposure to different traumatic events and comparing the networks by trauma type.

This leads to the second limitation of our study, which was our use of cross-sectional data. It has been acknowledged that the use of cross-sectional data hampers the comprehension of symptom development because the evaluation of symptoms is made at a single point in time. To overcome this limitation, we suggest the replication of these analyses in longitudinal networks, which are intended to identify possible fluctuations in findings across the course of a mental disorder. Second, we

analyzed a small number of samples. The inclusion of more networks associated with other types of traumatic events might promote a more refined view of which symptoms could be more important to specific trauma-type networks and possible markers for each traumatic event. In addition to including and comparing more trauma types, future research should include traumatic events that are not perpetrated by humans (i.e., natural disasters) to clarify the specific network structure of connections in this trauma type.

Finally, the sexual abuse network (McNally et al., 2017) showed low reliability, and although the remaining networks displayed moderate-to-high reliability values, this might have affected the precision of the results by adding to the networks' spurious connections. Fourth, the networks analyzed were assessed using different versions of the DSM (i.e., *DSM-IV* and *DSM-5*). These versions include different numbers of symptoms, which might constrain the analysis of possible between-symptom connections. Future research should, therefore, replicate this study in larger samples with the same number of symptoms. Fifth, most of the central symptoms found were symptoms present in *DSM-IV* and *DSM-5*, and their presence in both versions of the *DSM* increases the possibility of a higher number of connections with the other symptoms. The centrality of these symptoms should, therefore, be interpreted carefully, as this might be a result of method variance. Similarly, to our knowledge, this was the first study in the psychopathological network field to use the wTO and the CoDiNA frameworks; thus, it makes sense to interpret the present results with caution, as the strengths of the connections reported do not represent the traditional partial correlations estimated in psychopathological networks but rather the wTO.

In conclusion, despite these limitations, we believe the use of these frameworks needs to be improved and examined to accommodate the particularities of psychological symptomatic networks, as they contribute to revealing new insights about the nosographic structure of PTSD and its specificities in different types of traumatic events.

OPEN PRACTICES STATEMENT

We analyzed open-access data that are freely available online and data that are not under our direct control; Our complete analysis scripts and code book could be available upon request to the authors.

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SUPPORTING INFORMATION

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How to cite this article: Ferreira, F., Gysi, D., Castro, D., & Ferreira, T. B. (2022). The nosographic structure of posttraumatic stress symptoms across trauma types: An exploratory network analysis approach. *Journal of Traumatic Stress*, *35,* 1115–1128. https://doi.org/10.1002/jts.22818