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Disentangling the Symptom-Level Nuances in Comorbid Posttraumatic Stress Disorder and Problematic Alcohol Use in Northern Irish Military Veterans: A Network Analysis

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Posttraumatic stress disorder (PTSD) and alcohol use are highly prevalent among military veteran populations. Several theories have been proposed to account for the comorbidity between PTSD and problematic alcohol use, but research examining the symptom-level associations between the two is limited. The current study used network analysis to examine the associations between PTSD and problematic alcohol use. Data were collected through a cross-sectional survey of veterans of the United Kingdom Armed Forces living in Northern Ireland. The sample comprised 511 (91.2% male) veterans with a history of trauma exposure and current alcohol use. A network consisting of PTSD symptoms from the PTSD Checklist for *DSM-5* (PCL-5) and items from the Alcohol Use Disorders Identification Test (AUDIT) was constructed, and the bridge centrality of all items was estimated to identify items with the highest number of associations and the strongest associations between the two constructs. The PTSD symptom "reckless behavior" (2.43) had the highest bridge centrality values and thus the strongest connections and most connections to the alcohol use items. For the alcohol use items, "not being able to stop drinking" (2.31) and "number of drinks" (1.24) demonstrated the strongest bridge connections to the PTSD items. These results highlight the role of specific PTSD symptoms involved in the interaction between PTSD and problematic alcohol use.

Posttraumatic stress disorder (PTSD) and problematic alcohol use are highly prevalent among military veteran populations (Black et al., 2018; Hines et al., 2014; Stevelink et al., 2018), and they frequently co-occur (Banducci et al., 2019; Norman et al., 2018; Simons et al., 2018). A recent review by Fuehrlein and colleagues (2016) that examined a nationally representative sample of over 3,000 U.S. military veterans found that individuals who had an alcohol use disorder were 4 times more likely to also have a PTSD diagnosis compared to those with no alcohol use disorder. The prevalence of this comorbidity has been reported to be as high as 63% in U.S. veterans (Black et al., 2018; Seal et al., 2011). In the United Kingdom, military veterans are more likely to have comorbid PTSD and problematic alcohol use than individuals in the general population (Rhead et al., 2020). Co-occurring PTSD and problematic alcohol use can lead to significantly higher levels of impairment than when either disorder occurs in isolation, with individuals who experience both carrying a higher risk for a range of psychosocial issues and future psychopathology than those with alcohol use disorder or PTSD alone (Blanco et al., 2013; Straus et al., 2018).

Several theories have been put forth to explain this comorbid relationship. First, problematic alcohol use and PTSD may co-occur because they share common risk factors, such as trauma exposure, adverse childhood experiences, and common mental health problems (Banducci et al., 2019; Head et al., 2016; Nichter et al., 2019). Second, according to the risk-taking hypothesis, alcohol use leads to a high degree of impulsivity and risk-taking behavior, which, in turn, puts an individual at risk for experiencing a traumatic event and subsequent PTSD (Chilcoat & Breslau, 1998). In addition, given that alcohol use is frequently associated with emotional dysregulation and the use of maladaptive coping strategies, this particular vulnerability may increase the likelihood an individual will develop PTSD following a traumatic event (Haller & Chassin, 2014; Taylor et al., 2017).

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However, one of the most frequently cited theoretical models is the self-medication hypothesis (Khantzian, 1997). This model maintains that individuals who engage in substance use may do so to alleviate distressing negative affect states (Black et al., 2018; Khantzian, 1997). In the context of the veteran population, alcohol use could be considered a maladaptive coping strategy used to help relieve PTSD symptoms. Khantzian (1997) suggested that alcohol consumption could play different roles in relieving the distress of PTSD symptomatology depending on the quantity consumed; this idea was outlined in a recent review by Lane and colleagues (2019). Briefly, alcohol consumed in small quantities could help lessen feelings of detachment and emotional numbness, whereas the consumption of larger quantities could alleviate the distress of intense emotions, such as those associated with the reexperiencing of traumatic events (Khantzian, 1997; Lane et al., 2019). The existing literature contains a wealth of empirical evidence supporting the self-medication hypothesis (Alexander & Ward, 2018; Leeies et al., 2010).

To date, most studies that have examined the complex overlap between problematic alcohol use and PTSD have employed a latent variable modeling approach, which adopts a common cause perspective to the conceptualization of psychopathology. Although this approach has advanced the field's understanding of the association between PTSD and problematic alcohol use, the common cause perspective treats all symptoms as interchangeable indicators of the same underlying disorder and ignores the relevance of specific symptom-level associations (Fried, 2015). However, despite this perspective, there is an evidence base that suggests these symptom-level associations (i.e., between symptoms of PTSD and problematic alcohol use) may play an integral role in this comorbidity (Afzali et al., 2017).

Considering this criticism, researchers have recently employed network theory and network analysis (NA) to understand symptom-level interactions among many co-occurring disorders. The network approach acknowledges the importance of individual symptoms and symptom-level associations (Fried, 2015). As McElroy and Patalay (2019) outlined, the exploration of specific symptom-level associations between co-occurring disorders, in turn, can offer a more comprehensive investigation of comorbid associations among disorders. Network theory recognizes psychological conditions as systems of complex symptom networks that dynamically interact and mutually reinforce one another (Cramer et al., 2010). Comorbidity is proposed to occur when symptoms of one condition, known as "bridge" symptoms, activate symptoms of a second condition (Fried & Cramer, 2017).

In recent years, network analytic techniques have been more widely applied to examine comorbidity across a range of psychological conditions. However, to our knowledge, only one previous study has used NA to examine co-occurring PTSD and problematic alcohol use (Afzali et al., 2017). Afzali and colleagues (2017) examined the network structure of PTSD and problematic alcohol use symptoms among over 3,000 adults in the general population. Symptoms of PTSD and problematic alcohol use were assessed via self-report and gathered using a diagnostic structured assessment designed for the study. The study results indicated that four symptoms (i.e., using alcohol in risky situations, physical or mental ill health as a result of alcohol use, anhedonia, and self-destructive behavior) bridged the gap between the two disorders and, thus, may play a key role in their co-occurrence (Afzali et al., 2017). The authors concluded that their findings supported both the self-medication hypothesis and the risk-taking hypothesis. Afzali et al. (2017) were the first researchers to study alcohol misuse and PTSD using network analysis; however, it is important to conduct further replication studies aimed at gathering an evidence base for understanding the complexity of this relation. Moreover, as the authors used a general population sample, further studies are needed to determine whether the findings replicate to other populations. This may, in turn, aid the development of new prevention or intervention strategies or ensure existing strategies are optimally efficacious. If future results are different across studies with different populations, interventions and preventative strategies may have to be tailored to specific populations. One such population may be military veterans, as there are several contextual factors within these individuals that may make their experiences unique compared with the general population. Such factors include moral injury, combat exposure, and difficulties transitioning into civilian life, among others. Further, military veterans have frequently been cited as an at-risk population for both PTSD and problematic alcohol use, which merits the investigation of their comorbidity in this population. Indeed, recent research has suggested that the lifetime prevalence of PTSD among veterans is high, ranging from 7.1% to 22% (Blanco et al., 2013; Goldberg et al., 2016; Nichter et al., 2019), and they tend to have higher levels of alcohol problems than the active military personnel (Stevelink et al., 2018) or the general population (Henderson et al., 2009).

In the context of the three outlined theories, several specific hypotheses can be made regarding what would typically be expected of a network of PTSD and alcohol-related symptoms based on each theory. First, regarding the risk-taking hypothesis, alcohol items that reflect high levels of alcohol consumption would be expected to show possible links with PTSD symptoms related to impulsivity and risk-taking behavior (e.g., reckless behavior). Second, regarding theories that argue that emotional dysregulation or maladaptive coping strategies may play a complex role in the link between alcohol use and PTSD symptoms, PTSD symptoms that reflect negative affective states would be expected to act as strong bridging symptoms to the alcohol use disorder symptom network. Finally, regarding the self-medication hypothesis, alcohol use disorder items that reflect high levels of alcohol consumption or the need to drink first thing in the morning may be expected to be linked with PTSD symptoms related to the reexperiencing of traumatic events, distress, or avoidance-based PTSD symptoms (Lane et al., 2019). Given the lack of studies that have used network analytic techniques to investigate such hypotheses within veteran populations, it is important to state that these predictions are more

general in nature and, therefore, are not specific to a veteran population.

To our knowledge, no previous studies have used a network analytic approach to examine the co-occurrence of PTSD and problematic alcohol use in the veteran population. Moreover, what is currently understood about the complex interplay by which PTSD and problematic alcohol use co-occur remains in its infancy. The current study, therefore, aimed to investigate the complex interplay between PTSD and problematic alcohol use by (a) examining the symptom-level structure of these constructs, (b) examining which symptoms may play a bridging role between both constructs, and (c) focusing on a specific at-risk population (i.e., military veterans).

Method

Participants and Procedure

The data for the current study were collected as part of a larger cross-sectional self-report survey of the United Kingdom Armed Forces veterans living in Northern Ireland (NI). The questionnaire was available online and in pen-and-paper format between December 2017 and June 2019. It was advertised through social media and NI organizations that work with veterans. Participants were also directly approached through emails and text messages if they had previously left their contact details with the research team and agreed to be contacted about future research activities. The initial sample size was 1,329 participants, who provided informed consent and started completing the questionnaire. Participants were only included in the current study if they had a history of trauma exposure and completed the PTSD Checklist (PCL) for the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*-5; i.e., the PCL-5) and Alcohol Use Disorders Identification Test (AUDIT) measures. Individuals who were missing 20% or more data across the measures of interest were excluded. In addition, participants were only included if they indicated that they currently consume alcohol at least "monthly or less;" those who indicated that they "never" consume alcohol were removed. Ethical approval was provided by the Ulster University Research Ethics Committee and Queen's University Belfast's Engineering and Physical Sciences Faculty Research Ethics Committee (EPS 19_156). All participants provided written consent.

The effective sample size was 511 participants; further information regarding the data quality control procedure can be found in the Supplementary Materials. Upon reaching this effective sample size, certain criteria were applied to ensure this was adequate for network analysis. The number of possible parameters was calculated using the following calculation: number of parameters = number of nodes in the network * number of nodes – 1 / 2 (Epskamp et al., 2018). In the context of the present study, this was 29*28/2, equalling 406 possible parameters. The number of participants needed should ideally exceed the number of parameters; therefore, the sample size was deemed acceptable.

Most participants were male (n = 466, 91.2%) and married or living with a partner (n = 382, 74.8%; separated or divorced: n = 85, 16.6%; single or never married: n = 26, 5.1%; widowed: n = 17, 3.3%; other: n = 1, 0.2%). The mean participant age was 55.4 years (SD = 10.83). A total of 440 (86.1%) participants were Army veterans, 58 (11.4%) were Navy veterans, 40 (7.8%) were Royal Air Force veterans, and 10 (2.0%) were veterans of the Marines, with some participants reporting having served in multiple branches. The most commonly endorsed index traumatic events were the death of a family member or very close friend (16.6%), a fire or explosion (16.2%), being present when someone was killed, injured, or assaulted (15.2%), and "other" traumatic event (12.6%). Participants experienced on average 6.32 (SD = 3.05) different trauma types. Scores on the PCL-5 ranged from 0 to 80, with a mean score of 28.23 (SD = 23.09). Overall, 38.9% (n = 199) of the sample met the caseness criteria for probable PTSD (i.e., a score of 34 or higher on the PCL-5). Regarding alcohol use disorders, AUDIT scores ranged from 1 to 35, with a mean score of 8.75 (SD = 6.90). When using a cutoff score of 8 or higher, 229 (44.8%) participants met the caseness criteria for problematic alcohol use, whereas 85 participants (16.2%) met the caseness criteria when a more conservative cutoff score of 16 was used. In total, 115 (22.5%) participants had probable PTSD and, at the same time, used alcohol in at least a problematic way. There was a significant positive correlation between total PCL-5 and AUDIT scores, r_s = .27, p < .001. The amount of missing data on key variables was 0.1%.

Measures

Lifetime Trauma Exposure

Trauma exposure was assessed using 17 items: 13 items comprising the Stressful Life Events Screening Questionnaire adapted for *DSM-5* (SLESQ; Elhai et al., 2012) and four items from the Life Events Checklist for *DSM-5* (LEC-5; Weathers, Blake, et al., 2013). The additional items from the LEC-5 were included to ensure a fully comprehensive trauma screening within this population; see the Supplementary material for more details. Both measures are widely used and have been well validated. Participants endorsed whether they had experienced any of the 17 listed stressful life events, responding "yes" or "no" to each, and asked to indicate which of their endorsed events they regarded as being the "worst" they had experienced.

PTSD Symptoms

Symptoms of PTSD were assessed using the PCL-5 (Weathers, Litz, et al., 2013), which contains 20 items that map directly onto the *DSM-5* symptom criteria for PTSD. Respondents were asked to use a 5-point Likert scale ranging from *0* (*not at all*) to 4 (*extremely*) to indicate how much each symptom has bothered them over the past month, scoring their answers in relation to symptoms stemming from their previously nominated worst event. Higher PCL-5 scores indicate more severe PTSD symptomatology. All 20 items were used in the estimation of the

network. A previously validated cutoff score of 34 was used to established caseness for probable PTSD, which is in line with the cutoff criteria established by Murphy et al. (2017). The PCL-5 is a widely used instrument and has demonstrated excellent psychometric properties in various populations. In the present sample, Cronbach's alpha for the PCL-5 total score was .98.

Problematic Alcohol Use

To assess problematic alcohol use, we used the AUDIT (Babor et al., 2001), which contains 10 items, scored on a Likert-type scale ranging from 0 to 4, that inquire about participants' alcohol consumption and alcohol-related problems. Babor and colleagues (2001) defined problematic or hazardous drinking as a "pattern of alcohol consumption that increases the risk of harmful consequences for the user or others" (Babor et al., 2001, p. 19). We adopted this definition in the current study. Higher AUDIT scores indicate higher levels of consumption and drinking problems, with a cutoff score of 8 recommended as an indicator of hazardous and harmful alcohol use as well as potential alcohol dependence. A cutoff score of 16 can also be used to indicate higher levels of problematic drinking and dependence. The first item (i.e., "How often do you have a drink containing alcohol?") was used as an inclusion criterion in the current study because the survey utilized a "skip function, whereby participants who answered *never* on this item skipped seven questions related to problematic alcohol. Because the use of skip functions in network analysis can be problematic (Boschloo et al., 2015), only Items 2−10 were used in the estimation of the network. The AUDIT has demonstrated excellent psychometric properties across various contexts. In the present sample, Cronbach's alpha for the AUDIT was .87.

Data Analysis

Network Estimation

A network consists of nodes and edges. Nodes represent variables, and edges represent associations between these variables. The network was estimated using the R package *bootnet* (Epskamp et al., 2018). The 20 PCL-5 items and nine AUDIT items were used as nodes in the network. All items were treated as ordinal, and a Gaussian graphical model was estimated based on a polychoric correlation matrix. The edges were weighted and, therefore, could be interpreted as partial correlations. In line with Afzali et al. (2017), graphical lasso regularization methods, specifically extended Bayesian information criterion (EBIC) graphical lasso (glasso), were employed during network estimation (Friedman et al., 2008) to reduce the possibility of spurious edges. This method works by shrinking all the edges and setting the very small edge values to 0, thus resulting in a more parsimonious network. The EBIC procedure uses a hypertuning parameter gamma (γ), which helps determine the extent to which EBIC prefers sparser models (Hevey, 2018). The value of the hyperparameter gamma typically ranges from 0 (i.e., high sensitivity) to 0.5 (i.e., high specificity; Epskamp et al., 2018). Therefore, if the hyperparameter gamma is set to 0.5, the EBIC will favor a network containing fewer edges, in turn increasing confidence that the edges are genuine. However, if the hyperparameter gamma value is closer to zero, the EBIC will favor a network model with more edges (McNally et al., 2017). In the current study, the value of the hyperparameter gamma was set to 0.5 in line with previous research (Beard et al., 2016; McNally et al., 2017). Further rationale for the estimation parameters is provided in the Supplementary Materials. Regarding visualization, we used the Fruchterman and Reingold (1991) algorithm via the R-package *qgraph* (Epskamp et al., 2012). In *qgraph*, blue solid lines depict positive edges, and red dashed lines depict negative edges. The thicker and more saturated the line, the stronger the connection. The network was estimated using complete pairwise observations.

There was a nonsignificant correlation between bridge expected influence (BEI) and the standard deviation of the nodes, $r(27) = -.25$, $p = .177$. An examination of the data revealed that several items were positively skewed, and there was a significant correlation between skew and BEI, $r = -0.44$, $p = < .016$. Therefore, during the network estimation, a nonparanormal transformation was conducted to address this, which is in line with recent research recommendations (see Epskamp et al., 2018; Liu et al., 2009).

Bridge Centrality

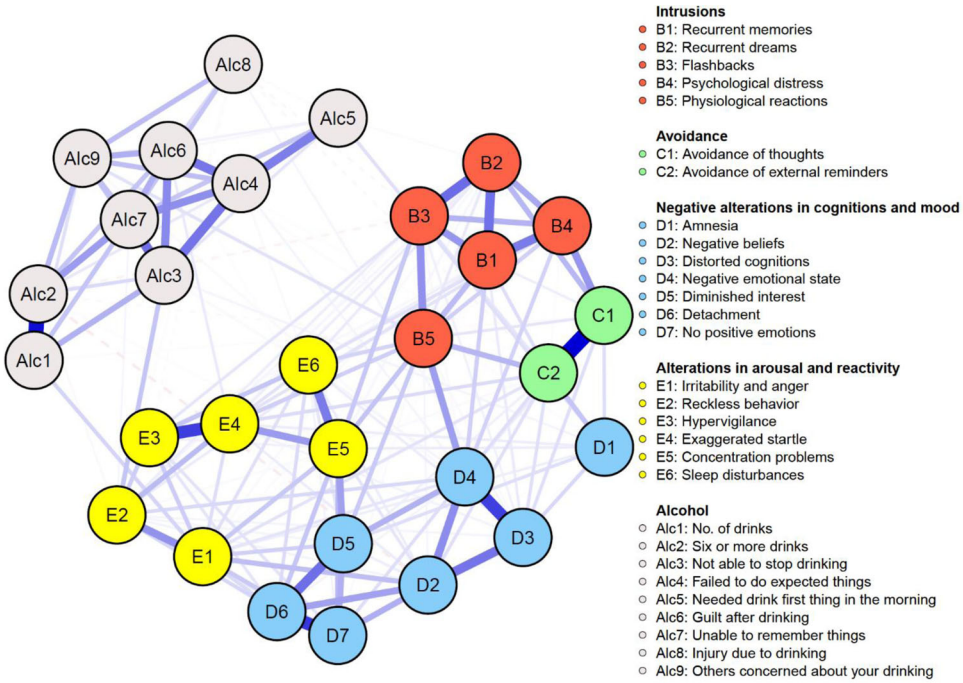
To examine the associations between the PTSD alcohol use items, bridge centrality was estimated using the R package *networktools* (Jones, 2018). We focused on the BEI centrality, which is the sum of all direct edges that a specific node from one construct (i.e., PTSD) has with all other nodes from the second construct (i.e., problematic alcohol use). As BEI centrality considers whether the associations between nodes are positive or negative, a high value indicates a strong positive connection.

Network Accuracy, Stability, and Significance Tests

The R package *bootnet* was used to examine network accuracy and stability as well as to conduct tests of significance. First, we bootstrapped (2,000 iterations) the 95% confidence intervals around the edge weights in the network. Smaller confidence intervals indicate higher accuracy. Second, we calculated the correlation stability coefficient (CS-coefficient) for expected influence (EI) and BEI centrality, using 2,000 bootstraps with progressively smaller subsets of the sample. The CS-coefficient indicates the proportion of the original sample that can be dropped to retain a correlation of above .70 between the order of the centrality indices in the original sample and the reduced subsample. Based on a recent simulation study, the CS-coefficient should be at least .25, but preferably above .50 (Epskamp et al., 2018), for the estimates to be considered stable. Finally, tests of significance were computed to examine the differences between the edge weights of the individual nodes.

Figure 1

Regularized Partial Correlation Network of Posttraumatic Stress Disorder (PTSD) Symptoms and Problematic Alcohol Use in Northern Ireland Veterans



Note. $N = 511$.

Results

Mean values and standard deviations for all items used in network analysis are presented in the Supplementary Materials. The resulting network is depicted in Figure 1. The strongest edges were found within each construct rather than between the two constructs and included the edges between the PTSD symptoms "avoidance of thoughts" and "avoidance of external reminders," regularized partial correlation (RPC) = .43; "detachment" and "no positive emotions," RPC = .33; "hypervigilance" and "exaggerated startle," RPC = .32; and "distorted cognitions" and "negative emotional state," RPC = .32; and the problematic alcohol use symptoms "six or more drinks" and "number of drinks consumed," RPC = .40. There was a high degree of overlap in the confidence intervals of the edge weights (see Supplementary Materials), but the tests of significant differences showed that the edges listed herein were significantly stronger than the vast majority of the other edges in the network.

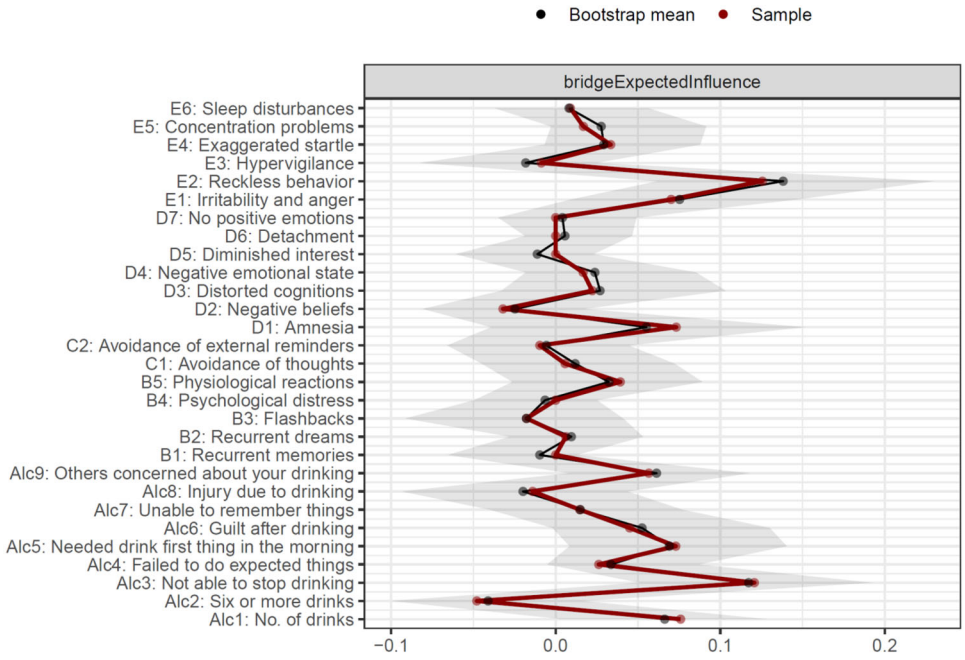
As shown in Figure 2, the PTSD symptom "reckless behavior," standardized BEI = 2.43, had the highest BEI centrality. This was followed by the alcohol items "not being able to stop drinking," standardized BEI = 2.31, and "number of drinks," standardized BEI = 1.24. Stability analyses indicated a stable order of EI, with a CS-coefficient of .75. Further analyses revealed a CS-coefficient of .44 for BEI (see Supplementary Materials). Because CS-coefficients should be at least .25 but preferably above .50 (Epskamp et al., 2018), as previously noted, interpretations based on the BEI should be made with caution.

Discussion

The present network analysis indicated that three symptoms had relatively high BEI centrality and, therefore, played an important "bridging role" connecting PTSD and alcohol use. The PTSD symptom "reckless behavior" had the highest BEI centrality, followed closely by the alcohol items "not being able to stop drinking" and "number of drinks." This suggests that these symptoms contribute the most to the co-occurrence of problematic alcohol use and PTSD symptomatology in the current sample of NI veterans.

The bridging role of the PTSD symptom "reckless behavior" is in line with findings reported by Afzali et al. (2017), who used a general population sample. Given the context of the present sample (i.e., veterans with a history of trauma exposure) and the theoretical rationale underlying the risk-taking hypothesis, this finding could be contextualized in relation to the risk-taking hypothesis (Chilcoat & Breslau, 1998; Haller & Chassin, 2014; Taylor et al., 2017), whereby alcohol use may lead some individuals to become involved in dangerous situations, which can carry a high risk of trauma exposure that subsequently leads to PTSD. However, this interpretation is difficult to definitively conclude given the limitations of the way in which we employed bridge analysis in the current study. Specifically, the present results indicate that reckless behavior was the PTSD symptom that was most strongly related to the alcohol items. Therefore, this finding provides insight into how PTSD symptoms relate to problematic alcohol use items and not vice versa. Nonetheless, given that reckless behavior the highest number

Figure 2
Standardized Bridge Expected Influence Centrality.



of direct connections with the alcohol use items in the current study, it could be argued that this PTSD symptom plays a key role in the co-occurrence of PTSD and problematic alcohol use.

However, the alcohol use item "not being able to stop drinking" and the item related to drinking a high volume of alcohol were the AUDIT items most strongly related to the PTSD items. This finding can be considered as less speculative support for the risk-taking hypothesis given that not being able to stop drinking and drinking a high volume of alcohol could themselves be considered reckless behavior, as they may increase the likelihood an individual will act more impulsively and engage in other forms self-destructive behavior, thus increasing the likelihood of retraumatization (Reed et al., 2012).

Overall, the associations or mechanisms between reckless behavior as a symptom of PTSD and problematic alcohol use are challenging to understand and interpret for several reasons. For example, there may be considerable nosological and item overlap between the two constructs, whereby alcohol misuse is, in fact, the reckless behavior endorsed within the PTSD measure as opposed to alcohol misuse leading to the engagement of reckless behavior. This, in turn, raises challenges regarding how these constructs are measured and studied, an important consideration for future research. Furthermore, given the nature of the sample (i.e., a veteran population) and the types of traumatic events that were most frequently endorsed (e.g., fires and explosions), it is possible that a portion of the traumatic events participants in this sample experienced may have predated their current levels of alcohol use, thus limiting support for the risk-taking hypothesis within this context. However, given the cross-sectional nature of the data, we could not empirically test whether this was the case. Without further context regarding the sample studied and further investigation of the nosological and item overlap of these constructs, these issues cannot be definitively resolved. Therefore, there remains much to be understood given the highlighted conceptual and measurement issues regarding reckless behavior.

The bridging roles of "not being able to stop drinking" and "number of drinks" could also lend support to the self-medication hypothesis (Khantzian, 1997). In the context of the veteran population, which comprises individuals who generally have a prior history of trauma and/or combat exposure, this theory would posit that alcohol use is a maladaptive strategy used to help relieve the negative emotions that are common characteristics of PTSD. This has been well-documented in the literature. For example, Hien et al. (2010) found that women who engaged in problematic alcohol use also reported significantly higher overall PTSD symptom severity and experienced significantly more PTSD-related avoidance and numbing and hyperarousal symptoms than those who did not use alcohol (Hien et al., 2010).

Afzali et al. (2017) also posited that further hypotheses can be considered. Specifically, they noted that there may be variation among certain populations that leads particular subgroups to be at an increased risk, or that key elements of both major theories (i.e. the risk-taking and self-medication theories) have a combined impact at the individual level. Considering the latter, emotional dysregulation arguably plays an important role in both theories. Afzali et al. (2017) stressed that both problematic alcohol use and reckless behavior have strong links to deficits in emotional regulation. In the context of the self-medication

hypothesis, individuals with PTSD are more likely to use alcohol in an attempt to manage distressing negative emotions, and in the context of the risk-taking hypothesis, reckless behavior is frequently associated with impulsivity, which is also a core aspect of emotional dysregulation (Gratz & Roemer, 2004; Leeies et al., 2010). Previous research has highlighted the crucial role that the key characteristics of emotional dysregulation, such as impulsivity or avoidance (Gratz & Roemer, 2004), play in the relation between PTSD and alcohol use. For example, a recent study that used time-series data in a veteran sample demonstrated that the positive association between day-to-day PTSD symptom change and the number of drinks consumed was significantly moderated by impulsivity (Black et al., 2018). Another recent time-series data study demonstrated that day-to-day PTSD symptom change was associated with an increased risk of problematic alcohol use due to deficits in emotional regulation ability (Simons et al., 2018). In addition, there is evidence that emotional dysregulation following exposure to traumatic events significantly predicts alcohol use (Radomski & Read, 2016). Therefore, it is possible that an individual who experiences distressing PTSD symptoms would seek to regulate these emotions, and individuals with lower impulse control may seek out more immediate strategies for emotion regulation, such as alcohol and substance use, with less regard for the potential longer-term detrimental effects (Black et al., 2018). However, given the cross-sectional nature of the current study and lack of temporal ordering, such interpretations are tentative.

From a network perspective, the idea that emotional dysregulation plays a role in the co-occurrence of PTSD and problematic alcohol use can be seen as problematic, as it is more akin to the common cause framework. However, recent literature has begun to discuss latent variable modeling and network analysis as two complementary rather than opposing approaches, as they were once considered to be, and has proposed the idea of hybrid models wherein both approaches could be combined to best explain aspects of psychopathology (Epskamp et al., 2017; Fried & Cramer, 2017). Given that the current study demonstrates evidence to support both major theories, both of which have a strong self-regulatory component, the idea that a higher-order dimension (e.g., emotional regulation) that may influence the onset and maintenance of symptoms, while tentative, is not out of place. However, formal testing of this hypothesis is required.

In sum, although the present findings lend support to both the self-medication hypothesis and the risk-taking hypothesis, with caution, emotional dysregulation is another plausible mechanism that offers a possible explanation as to how components of both theories may each play a key role in explaining the co-occurrence of problematic alcohol use and PTSD symptomatology (Tripp et al., 2015).

Several recommendations for future research are suggested. First, there remains a marked lack of understanding surrounding the trajectory of PTSD and problematic alcohol use co-occurrence over time (Black et al., 2018). This is even more challenging in the context of a veteran sample in which a significant portion of trauma exposure could be combat-related and could potentially have predated current reported alcohol use. Future network analysis studies should therefore employ time-series data to help explain how comorbid PTSD and problematic alcohol use fluctuate over time. Given the challenge of temporal ordering in relation to PTSD and alcohol use, prospective studies are greatly needed to shed light on this complex association. Such research will be vital to inform how clinical treatment for PTSD and interventions for substance use disorders could potentially be integrated to have a maximum impact (Black et al., 2018).

In addition, we have discussed the role of emotional regulation in the context of the current study as a plausible mechanism that may play a role in PTSD and problematic alcohol use comorbidity. Existing research has highlighted that individuals with comorbid PTSD and substance use disorders often display significant deficits in emotional regulation; however, the evidence remains scarce (Radomski & Read, 2016; Tull et al., 2018). Future research could employ moderated network analysis to help explain the association between the two constructs (Haslbeck et al., 2019).

Moreover, the scope of the current study was limited to the examination of PTSD and alcohol use; however, there may be important distinctions surrounding the type and/or frequency of the substances consumed (i.e., drugs vs. alcohol vs. both). For example, previous research has highlighted important distinctions among individuals with co-occurring PTSD and cocaine use versus those with comorbid PTSD and alcohol use. Specifically, individuals who use cocaine have been shown to demonstrate higher levels of occupational and social impairment and more legal problems, such as arrests, whereas those who use alcohol are significantly more likely to be involved in serious accidents, have higher rates of exposure to such situations, and are more likely to experience other mental health disorders, such as depression or anxiety (Back et al., 2003). Therefore, future studies should seek to investigate the distinction between different types of substance abuse in relation to co-occurring PTSD. Finally, the relation between PTSD and alcohol use may be more complex; recent research posits that the role of additional factors, such as trauma type and depression, may put veterans at risk for engaging in problematic substance use. Future network analysis studies could examine the complex interplay between PTSD, depression, and substance use (Kelley et al., 2013).

Several clinical implications are apparent from the current findings. First, if replicated in other studies, the nodes identified as playing a bridging role in connecting both constructs should be considered important parts of both clinical case conceptualization and risk assessment for clinicians working with the veteran population. In addition, there is a temptation to suggest that targeting the symptom with the highest bridge centrality across the two constructs may be the most useful starting point for any clinical intervention to either prevent the development of co-occurring PTSD and alcohol use or to sever the connection between the two constructs. However, any interpretations based on the most influential bridging symptoms as targets for intervention should be taken with caution, as they would

first need to be tested empirically. Future studies would need to examine the network structure of comorbid PTSD and problematic alcohol use before, during, and after the intervention, to understand the potential effects and benefits of intervening with regard to the most central bridging symptoms (Afzali et al., 2017).

Finally, the results of the current study tentatively suggest that interventions that target aspects of emotion dysregulation, specifically impulsiveness and the overall regulation of negative affect, as well as those aimed at replacing the maladaptive emotion regulation strategies, may be particularly important in the veteran population (Radomski & Read, 2016). Again, however, this would first need to be tested empirically. Nonetheless, given that emotional regulation has been frequently identified as an important transdiagnostic factor that increases the risk of a wide range of co-occurring psychological disorders, the current findings bolster previous research and suggest that transdiagnostic therapeutic interventions that focus on shared underlying factors (e.g., emotional dysregulation) may be a fruitful avenue of exploration (Radomski & Read, 2016).

The current findings should be interpreted within the context of several limitations. First, the current sample consisted of NI veterans, most of whom were male, which reduces the generalizability to female samples and across other populations. Although this is comparable with the current military demographics of the United Kingdom veteran population (Stevelink et al., 2018), important symptom-level differences may exist in the context of gender. Previous research has suggested that important gender differences may emerge in relation to how individuals perceive and/or respond to traumatic events, which may directly impact the relation between PTSD and alcohol use (Kelley et al., 2013; Smith & Cottler, 2018). Second, it must be noted that our effective sample was much smaller ($n = 511$) than the initial sample of respondents ($N = 1{,}329$). This was primarily due to large amounts of missing data and the inclusion criteria for the current study (see the Supplementary Materials for further information regarding the data quality control procedure). Due to the missing data, it was not possible to reliably compare the included and excluded participants. Third, the data collected as part of this study were cross-sectional in nature and, therefore, assumptions regarding causality and the temporal ordering of symptoms cannot be made. This may be particularly relevant for future study in the context of veterans and military personnel who have experienced traumatic events earlier in life (i.e., childhood trauma), during deployment, or postdeployment. This also means that we were unable to determine whether a specific PTSD symptom triggered a specific alcohol symptom and vice versa in the present study.

Fourth, the data were collected via self-report measures; therefore, the results may have been different if clinical interviews had been conducted. However, previous studies have found concordance rates between PTSD self-report measures and clinical interviews have been found to be acceptable (e.g., Macdonald et al., 2013). It is also important to note that the PCL-5 and AUDIT are screening tools rather than clinical measures and can therefore not determine the presence of a clinical diagnosis. More broadly, self-report measures are also limited as they can be affected by a participant's willingness to respond to the questionnaire and/or rely on accurate recall of past events. Therefore, the potential impact of issues such as age and difficulty with recall or memory could potentially affect the results. However, stressful or traumatic events have a high degree of salience and are often remembered well regardless of age. The present study also relied on self-reported veteran status. To ensure the anonymity of participants, which is particularly important within the context of Northern Ireland as a postconflict society, the survey was available online and could be accessed by anyone. However, due to the length of the questionnaire (1−1.5 hr) and the fact that it was advertised through veteran organizations and at armed forces events, it is unlikely that it was completed by individuals other than veterans. In relation to the analysis, the edge weight bootstrapped stability test revealed wide confidence intervals, so the results should be interpreted with caution. Furthermore, it is important to consider the low stability of the network in relation to BEI as a limitation. This could be linked to the modest sample size. Therefore, it is important to assert that interpretations were tentatively made, and further research using more adequately powered data is necessary. In addition, we did not control for the potential influence of cumulative trauma exposure. The impact of cumulative trauma exposure may influence symptom-level associations within the network and must be noted as a limitation given that, on average, participants experienced 6.32 different trauma types. Finally, 12.6% of the sample reported "other situation" as their index trauma; given the lack of context for this type of event, this is a notable limitation. However, the high level of endorsement may be related to how this was phrased—participants were asked, "Have you ever been in any other situation where you were seriously injured or your life was in danger (e.g., involved in military combat or living in a war zone)?" Therefore, given the examples offered within this question, it is highly likely participants in a veteran sample will frequently endorse such an item.

To our knowledge, this was the first study to examine the network structure of co-occurring PTSD and problematic alcohol use in NI military veterans. The findings yield support for both the self-medication hypothesis and the risk-taking hypothesis as explanations for the comorbidity between these two constructs. If replicated, the results of the current study will be informative for individuals working clinically with veteran populations, such as those in NI, and will also inform future intervention research in the area of PTSD and alcohol use.

Open Practices Statement

The current study was not formally preregistered. The participants did not give consent for their data to be made publicly available. Derived data supporting the findings of this study

will be made available from the corresponding author upon reasonable request. However, all R code related to the current study is available within the Supplementary Materials.

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