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Bayesian Analysis of Current and Lifetime Comorbidity Rates of Mood and Anxiety Disorders In Individuals with Posttraumatic Stress Disorder

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Abstract

Although posttraumatic stress disorder (PTSD) is no longer considered an anxiety disorder in *DSM-5*, previous research has indicated high rates of comorbid anxiety and mood disorders in individuals with PTSD. The goal of the present study was to build upon previous examinations of diagnostic comorbidity by using Bayesian methods of estimating current and lifetime comorbidity rates to determine more precise estimates of the proportion of individuals in a clinical sample with PTSD that also meet criteria for various emotional disorders. Two hundred and fifty three individuals with a current or lifetime diagnosis of PTSD underwent a comprehensive assessment of current and lifetime emotional disorders. Bayesian statistical techniques were then used to calculate credibility intervals for the current and lifetime comorbidity rates of emotional disorders. The Bayesian analyses used informative priors based on previous comorbidity findings. The median number of current emotional disorders was two and the median number of lifetime comorbid emotional disorders was three. Credibility intervals indicated that social phobia and major depressive disorder were the most common current and lifetime comorbid emotional disorders. The proportion of individuals with lifetime comorbidity rates were very high for both any lifetime anxiety disorder (.91, 95% CI .88: .94) and any lifetime depressive disorder (.90, 95% CI .86: .93). Together these results indicate that despite the separation from the anxiety disorders in *DSM-5*, the vast majority of individuals with PTSD will present with one or more emotional disorders. Implications for the assessment and treatment of PTSD are discussed.

Keywords

PTSD; anxiety; depression; Assessment/Diagnosis; Bayesian analysis

With the publication of the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (*DSM-5*; APA, 2013), posttraumatic stress disorder (PTSD) is no longer considered to be an anxiety disorder and is now classified within the trauma and stressor

related disorders category. There were many valid reasons for separating PTSD from the anxiety disorders (Resick & Miller, 2009), but previous research nevertheless indicates that PTSD has strong associations with both mood and anxiety disorders (e.g., Kessler, Chiu, Demler, Merikangas, & Walters, 2005). The present study adopts a Bayesian statistical framework as a novel approach for examining comorbidity rates of mood and anxiety disorders in individuals with PTSD.

Although PTSD is distinct from other emotional disorders in DSM-5 in that a precipitating event is formally required for a diagnosis, there is extensive evidence that PTSD also shares common vulnerability factors with other emotional disorders, which may contribute to high levels of comorbidity. For example, Barlow's triple vulnerabilities model identifies neuroticism and perceived control as general vulnerability factors that are common across emotional disorders (Barlow, 2002). In this model, the two general vulnerabilities interact with disorder specific vulnerabilities (e.g., a traumatic event in PTSD; anxiety sensitivity in panic disorder) to result in the expression of specific emotional disorders. Meta-analytic reviews have been consistent with the triple vulnerabilities model and have demonstrated that neuroticism (Kotov, Gamez, Schmidt, & Watson, 2010) and perceived control (Gallagher, Bentley, & Barlow, 2014) have robust associations with a broad range of emotional disorders. There is also increasing evidence that maladaptive emotion regulation techniques such as emotional suppression contribute to the development and maintenance of PTSD and a range of emotional disorders (Amstadter, 2008).

Another reason to expect high levels of comorbid emotional disorders in individuals with PTSD is the overlap in symptoms among PTSD and emotional disorders. For example, persistent negative mood, anhedonia, sleep disturbances, and diminished concentration are all symptoms shared by PTSD and major depressive disorder. Similarly, diminished concentration, irritability, and sleep disturbances are all symptoms shared by PTSD and generalized anxiety disorder, and autonomic arousal is a core feature of both PTSD and panic disorder (Brown & McNiff, 2009). The common symptoms shared by PTSD and many emotional disorders provide another reason to expect high levels of comorbidity, although examinations of the shared symptoms of PTSD and MDD suggest that high levels of comorbidity are not an artifact that can be fully explained by the shared symptoms (Franklin & Zimmerman, 2001).

Previous examinations of comorbidity rates of anxiety and mood disorders in individuals with PTSD in both the United States (Brown, Campbell, Lehman, & Grisham, 2001; Kessler et al., 2005) and abroad (Creamer et al., 2001) have indicated that both anxiety and mood disorders are very common in individuals with PTSD. For example, the rates of lifetime comorbidity rates in a sample of male Vietnam veterans with a current diagnosis of PTSD were 84% for any lifetime mood disorder diagnosis and 52% for any lifetime anxiety disorder diagnosis (Orsillo et al., 1996). An examination of current emotional disorder comorbidities in adult outpatients with current PTSD also found high rates of comorbidity, with 88% of individuals with PTSD also meeting diagnostic criteria for another anxiety disorder and 80% meeting diagnostic criteria for a mood disorder (Brown et al., 2001). In fact, comparisons of the rates of comorbidity across emotional disorders have indicated that PTSD has the highest rates of comorbidity both when examining current and lifetime

comorbidity (Brown et al., 2001). Together, these previous findings and current conceptual models of the etiology of PTSD and emotional disorders provide compelling evidence that PTSD is very often accompanied by additional mood or anxiety disorders.

However, many of the previous examinations of emotional disorder comorbidity in PTSD have had methodological limitations that hinder our understanding of how likely it is that an individual with PTSD would also meet current or lifetime diagnostic criteria for particular mood or anxiety disorders. Specifically, previous examinations of emotional disorder comorbidity in PTSD have generally been limited by a reliance on a relatively small sample size of individuals diagnosed with PTSD (e.g., Brown et al., 2001), a reliance on lay interviews for determining diagnoses (e.g., Kessler et al., 2005), or a focus on comorbidity with just a few emotional disorders (e.g., Miller, Fogler, Wolf, Kaloupek, & Keane, 2008). Additional evidence is therefore needed to better understand the degree to which individuals with PTSD are likely to meet criteria for one or more emotional disorders.

The Present Study

The goal of present study was therefore to replicate and extend previous findings by examining current and lifetime emotional disorder comorbidities using a large clinical sample of individuals with a diagnosis of PTSD and to use a Bayesian statistical approach that allows for incorporation of prior knowledge when estimating proportions of comorbidity. Although the fundamental ideas of the Bayesian statistical paradigm have existed for centuries (Bayes, 1763), it is only in recent decades that they have begun to be applied in psychological research (Andrews & Baguley, 2013). The core idea behind Bayesian statistics is that a posterior distribution of a particular parameter can be generated as a function of both observed data and prior knowledge (see Kruschke, 2011 for a more thorough introduction to Bayesian statistics). In contrast with traditional frequentist statistics, a Bayesian approach therefore has the advantage of permitting researchers to incorporate prior knowledge into their data analysis. Bayesian data analysis also allows for the creation of 95% credible intervals, which indicate that the probability that a particular parameter lies within the specified interval is 95%. Confidence intervals are often mistakenly interpreted as representing this when in fact a 95% confidence interval in frequentist statistics actually indicates that for any sample we can obtain the mean of some parameter μ and form a 95% confidence interval of that mean, and that if this procedure were repeated in an infinite number of samples, then 95% of the confidence intervals constructed using this procedure would include the true parameter μ under the null hypothesis.

By adopting a Bayesian framework to examine emotional disorder comorbidity rates in PTSD we hoped to provide informative estimates of comorbidity rates of emotional disorders that would incorporate previous knowledge in the calculations of comorbidity rates. These Bayesian estimates of comorbidities could help clinicians better understand which comorbid disorders they are most likely to encounter when treating individuals with PTSD. The Bayesian estimates could also inform researchers about the diagnoses that it would be most important to examine in PTSD research if they are unable to conduct comprehensive diagnostic evaluations for some reason and need to focus on a select number

of potential comorbid emotional disorders. We hypothesized that comorbidity rates of the emotional disorders would be high and that the vast majority of individuals with a current or lifetime diagnosis of PTSD would also meet criteria for at least one additional emotional disorder diagnosis.

Method

Participants

Participants were 253 individuals who completed a comprehensive intake assessment at the Center for Anxiety and Related Disorders (CARD) and who received either a current ($n = 138$) or lifetime ($n = 253$) diagnosis of PTSD. CARD is a large outpatient clinic in Boston that specializes in providing comprehensive assessments of and cognitive-behavioral therapies for a broad range of emotional disorders. The diagnostic assessments were all conducted as part of a longstanding assessment grant focusing on the classification of depression and anxiety. All individuals who present to CARD are invited to participate in this assessment study and informed consent was obtained from all participants after an explanation of the purpose of the assessment was provided. The diagnosis of PTSD was the principal diagnosis for 45% of the individuals with a current diagnosis of PTSD. The majority (78.3%) of participants was female. The average age of participants was 35.71 years ($SD = 11.89$, range = 18 to 64). The majority of participants identified as Caucasian (79.1%), with the remaining identifying as African-American (11.9 %), Hispanic (4.7%), Asian (4.0%), or other (.4%). The most common criterion A events in this sample were physical abuse, sexual assault, and transportation accidents.

Assessment

Diagnoses of PTSD and comorbid emotional disorders were established using the Anxiety Disorders Interview Schedule for *DSM-IV*: Lifetime Version (ADIS-IV-L; Di Nardo, Brown, & Barlow, 1994), a semistructured interview designed to ascertain reliable diagnosis of the *DSM-IV* (APA, 2000) anxiety, mood, somatoform, and substance use disorders and to screen for the presence of other conditions (e.g., psychotic disorders). Assessments were conducted by doctoral-level clinical psychologists and advanced clinical doctoral students who underwent an extensive training process (Brown, Di Nardo, Lehman, & Campbell, 2001). A previous reliability study of the ADIS-IV-L ($n = 362$), which had two independent administrations of the ADIS-IV-L, indicated good to excellent interrater agreement for lifetime diagnoses of PTSD ($\kappa = .61$), social phobia ($\kappa = .73$), panic disorder with or without agoraphobia ($\kappa = .79$), generalized anxiety disorder ($\kappa = .65$), obsessive-compulsive disorder ($\kappa = .75$), specific phobia ($\kappa = .70$), and major depressive disorder ($\kappa = .68$; Brown, Di Nardo, Lehman, & Campbell, 2001).

Data Analysis

All Bayesian analyses for the present study were conducted using Mplus 7.0 (Muthén & Muthén, 1998–2013) using Markov Chain Monte Carlo simulation procedures with a Gibbs sampler, two chains, 10,000 iterations, and every fifth iteration used for thinning. Informative priors for current and lifetime comorbidity rates for emotional disorders were specified based on previous findings regarding the comorbidity rates (Brown, Campbell et

al., 2001). This previous study also used the ADIS-IV-L to examine comorbidity rates in an adult outpatient sample of individuals at CARD and used a sample with a mean age of 33.94 years ($SD=10.89$, range 18 to 64) that was 62% female and 88% Caucasian.

Priors were specified as normally distributed with means corresponding to the respective comorbidity rates, and the prior variances being calculated using the formula $(p * (1 - p) / n)$, where p represented the proportion of individuals with a particular comorbid diagnosis and n represented the relevant sample size in the study from which priors were generated. These procedures were used to generate credibility intervals (with median point estimates) for both current and lifetime comorbidity proportions for the following diagnoses: social phobia, panic disorder with or without agoraphobia, generalized anxiety disorder, obsessive-compulsive disorder, specific phobia, other *DSM-IV* anxiety disorder, any *DSM-IV* anxiety disorder, major depressive disorder, dysthymic disorder, other depressive disorder, any depressive disorder. Sensitivity analyses were then conducted in which more disperse priors were specified by multiplying the prior variance by ten. Results of these sensitivity analyses did not significantly differ from the primary findings substantively or statistically.

Results

We began by examining the overall frequency of comorbid emotional disorders for individuals with either a current or lifetime diagnosis of PTSD (Table 1). As expected, results indicated that the vast majority of both individuals with a current diagnosis of PTSD (92.8%) or lifetime diagnosis of PTSD (98.8%) had at least one current or lifetime comorbid emotional disorder. For individuals with a current diagnosis of PTSD, the mean number of current comorbid emotional disorder diagnoses was 2.04 (Median = 2, Mode = 2, $SD = 1.21$). For individuals with a lifetime diagnosis of PTSD, the mean number of lifetime comorbid emotional disorder diagnoses was 2.81 (Median = 3, Mode = 3, $SD = 1.31$).

We next conducted the Bayesian analysis of current comorbidity rates. Table 2 presents the comorbidity rates from the Brown, Campbell et al., (2001) study that were used to generate priors, the observed current comorbidity rates in the current sample, and the Bayesian median estimates and credibility intervals for current comorbidity rates. As seen in Table 2, the median estimate for any comorbid anxiety disorder was very high (.90), with the estimated proportion of comorbidity for particular anxiety disorders ranging from .15 (specific phobia) to .47 (social phobia). The estimated proportions of comorbid MDD (.57) or any depressive disorder (.70) were also very high. Although still quite high, the credibility intervals indicated lower proportions of current comorbidity for PDA, specific phobia, and depressive disorders than previous findings (Brown, Campbell et al., 2001).

Finally, we conducted the Bayesian analysis of lifetime comorbidity rates. Table 3 presents the comorbidity rates from the Brown, Campbell et al., (2001) study that were used to generate priors, the observed lifetime comorbidity rates in the current sample, and the Bayesian median estimates and credibility intervals for lifetime comorbidity rates. As seen in Table 3, the median estimate for any lifetime comorbid anxiety disorder was very high (.91), with the estimated proportion of lifetime comorbidity for particular anxiety disorders ranging from .24 (OCD) to .50 (social phobia). The estimated proportions of lifetime

comorbid MDD (.81) or any depressive disorder (.90) were also very high. The credibility intervals indicated higher proportions of lifetime comorbidity with social phobia, and lower proportions of lifetime comorbidity for PDA, specific phobia, and dysthymia than previous findings (Brown, Campbell et al., 2001).

Discussion

Consistent with past research (e.g., Brown et al., 2001), our findings provide strong evidence that PTSD is associated with very high rates of both current and lifetime comorbid anxiety and depressive disorders. The distributions of the number of current or lifetime comorbid anxiety and depressive disorders indicated that it is very rare for an individual with a diagnosis of PTSD to not meet diagnostic criteria for an anxiety or depressive disorder, and that the majority of individuals with PTSD actually meet diagnostic criteria for two or more anxiety or depressive disorders. Furthermore, the results of the Bayesian estimates of the proportion of current and lifetime comorbidity rates were significantly higher than those reported in previous examinations of comorbidity in individuals with PTSD (Creamer et al., 2001; Orsillo et al., 1996).

Strengths of the current study include the use of the ADIS-IV-L to provide a comprehensive assessment of emotional disorder comorbidities that was conducted by clinicians that underwent a rigorous training process and the use of a relatively large clinical sample. The use of Bayesian statistical methods that allowed for the incorporation of prior knowledge is perhaps the most novel feature of the present study as Bayesian statistics remain underutilized in psychological research. Until recently Bayesian statistics were difficult to implement due to the intensive computational requirements of these analyses and the limited software options available for conducting these analyses. There are now multiple statistical packages available for conducting Bayesian analyses (e.g., Mplus) as well as introductory textbooks that explain how Bayesian statistics can be applied in psychological research (e.g., Kaplan, 2014). We hope that the present study provides a useful introduction and example of how these methods can be used to study psychopathology as the ability to incorporate prior knowledge into data analyses is a major strength of the Bayesian approach.

Limitations of the present study include the use of data from a non-representative clinical sample collected at an outpatient specialty clinic, which may have inflated comorbidity rates for certain disorders, that individuals with severe substance use or bipolar disorders were screened out prior to completing the interview, which may have deflated comorbidity rates for mood disorders and other disorders, and that the ADIS-IV did not evaluate the full range of potential comorbidity (e.g., personality disorders). We are also unable to examine trauma type as a potential moderator of comorbidity rates. It is also important to note that our results were obtained from a clinical sample of individuals with PTSD rather than an epidemiological sample.

Conclusions

Our findings provide useful information for practicing clinicians regarding the particular comorbid disorders they are most likely to encounter when treating individuals with PTSD.

It is not all together surprising that our results indicated that MDD is the disorder that most commonly co-occurs with PTSD given the overlap in symptoms as well evidence that traumatic events are also a risk factor for depression (Shalev, Freedman, Peri, Brandes, Sahar, et al., 1998). The credibility intervals nevertheless provide guidance regarding which disorders clinicians may want to prioritize the assessment of if practical constraints prevent a comprehensive diagnostic assessment. Our results also suggest that dimensional diagnostic systems that emphasize the underlying features (e.g., neuroticism) of the emotional disorders (Brown & Barlow, 2009) may provide a useful framework for conceptualizing and interpreting comorbidity when assessing PTSD, given the very high levels of comorbidity.

The findings of high levels of comorbidity also have implications for research examining treatments for PTSD. It is relatively common for PTSD treatment outcome studies to report the impact of treatment of symptoms of depression (e.g., Foa, Hembree, Cahill, Rauch, Riggs et al., 2005; Resick, Nishith, Weaver, Astin, & Feuer, 2002), but much less common for treatment outcome studies to also report the impact of PTSD treatments on the full range of emotional disorder comorbidities that our results suggest are very common in PTSD. The two most widely studied empirically supported treatments for PTSD (Prolonged Exposure Therapy, Foa et al., 2005; Cognitive Processing Therapy; Resick et al., 2002) contain treatment components (e.g., cognitive restructuring, exposure) that are essential elements of cognitive behavioral treatment protocols for the emotional disorders we found to be highly comorbid with PTSD. It would therefore be reasonable to expect that these treatments might also have a beneficial effect on comorbid disorders, but more data is needed to explicitly test this hypothesis. Transdiagnostic treatment protocols such as the Unified Protocol (Barlow et al., 2011) that are intended to efficiently treat a range of emotional disorders by targeting the shared features of emotional disorders may also provide a promising approach for efficiently treating PTSD and the full range of emotional comorbidities found in PTSD, but to date only very limited data exists examining the impact of the Unified Protocol on PTSD.

Finally, our results provide additional evidence of the benefits that novel analytic approaches can bring to improving our understanding of complex issues such as diagnostic comorbidity. Recent examinations of comorbidity patterns in PTSD have demonstrated how advanced analytic techniques such as latent class analysis allow for a more sophisticated understanding of potentially distinct classes of individuals with PTSD that exhibit different comorbidity profiles (Galatzer-Levy, Nickerson, Litz, & Marmar, 2013; Müller, Vandeleur, Rodgers, Rössler, Castelao, et al., 2014). Our application of Bayesian statistics allowed us to incorporate existing knowledge of comorbidity rates to provide more informative credible intervals for current and lifetime rates of comorbidity for a range of emotional disorders. Our findings provide clear evidence that, although PTSD is no longer considered an anxiety disorder in *DSM-5*, there are very strong associations between PTSD and the anxiety disorders.

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Table 1

Distribution of Current and Lifetime Comorbid Emotional Disorders

# Comorbid Emotional Disorders	Current PTSD (<i>n</i> = 138)	Lifetime PTSD (<i>n</i> = 253)
0	7.2 %	1.2 %
1	29.0 %	13.0 %
2	31.2 %	30.8 %
3	21.0 %	29.2 %
4	8.7 %	15.0 %
5	2.2 %	6.3 %
6	0.7 %	4.0 %
7	0.0 %	0.4 %

Note: PTSD = Posttraumatic stress disorder.

Table 2

Bayesian Estimates of Current Comorbidity Rates of Emotional Disorders

	Observed Proportions		Bayesian Results	
	2001 Estimate (<i>n</i> = 49)	Current data (<i>n</i> = 138)	Median Estimate	Credible Interval
Anxiety				
PDA	.55	.304	0.364	.295 : .434
Social Phobia	.41	.493	0.469	.396 : .541
GAD	.22	.167	0.179	.124 : .235
OCD	.22	.232	0.234	.172 : .294
Specific Phobia	.27	.123	0.148	.097 : .199
Other anxiety	.02	.029	0.026	.003 : .049
Any anxiety	.88	.906	0.900	.856 : .944
Depression				
MDD	.65	.543	0.573	.502 : .644
Dysthymia	.20	.058	0.074	.037 : .112
Other mood	.06	.051	0.053	.021 : .085
Any mood	.80	.645	0.698	.632 : .765

Note: PDA = Panic Disorder with or without agoraphobia; GAD = Generalized Anxiety Disorder; OCD = Obsessive Compulsive Disorder; MDD = Major Depressive Disorder.

Table 3

Bayesian Estimates of Lifetime Comorbidity Rates of Emotional Disorders

	Observed Proportions		Bayesian Results	
	2001 Estimate (<i>n</i> = 82)	Current data (<i>n</i> = 253)	Median Estimate	Credible Interval
Anxiety				
PDA	0.60	.364	0.421	.368 : .474
Social Phobia	0.43	.518	0.496	.442 : .550
GAD	0.30	.261	0.270	.221 : .317
OCD	0.24	.237	0.238	.192 : .284
Specific Phobia	0.33	.257	0.273	.225 : .321
Other anxiety	0.02	.059	0.056	.028 : .084
Any anxiety	0.94	.889	0.906	.875 : .938
Depression				
MDD	0.82	.802	0.807	.764 : .850
Dysthymia	0.18	.123	0.134	.097 : .172
Other mood	0.11	.111	0.110	.077 : .145
Any mood	0.91	.889	0.895	.863 : .928

Note: PDA = Panic Disorder with or without agoraphobia; GAD = Generalized Anxiety Disorder; OCD = Obsessive Compulsive Disorder; MDD = Major Depressive Disorder.