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Evaluating the Construct Validity of Complex PTSD: A Latent Class Analysis

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Abstract

Both posttraumatic stress disorder (PTSD) and complex posttraumatic stress disorder (CPTSD) have been included in the eleventh edition of the International Classification of Diseases (ICD-11). However, the validity of CPTSD has been controversial based on overlapping symptomology with both PTSD and borderline personality disorder (BPD). Multiple studies have supported distinctions and further indicated higher rates of childhood trauma for CPTSD, but overlap with comorbid symptom profiles, quantitative distinctions in symptom severity, and the operationalisation of symptom criteria, have prolonged debate. This study thus aimed to assess whether latent classes that emerge from symptom endorsements are consistent with CPTSD as qualitatively distinct from PTSD and BPD. This study further aimed to investigate whether trauma history distinguishes CPTSD from PTSD. Latent class analysis (LCA) was performed on a sample of university undergraduates, and chi-squared tests and ANOVAs were used to asses between-class differences. The LCA identified four distinct classes: a PTSD-BPD class with elevated symptoms of PTSD and BPD, but low endorsement of disturbances-in-self-organisation (DSO) symptoms that define CPTSD; a CPTSD-BPD class with elevated symptoms of PTSD, DSO, and BPD; a DSO-BPD class with low symptoms of PTSD, but elevated symptoms of DSO and BPD; and a Low Symptom class with low endorsements on all symptoms. Findings were consistent with the distinction between PTSD and CPTSD symptom profiles in the ICD-11. The distinction between CPTSD and BPD was not supported, as three classes were comorbid with BPD symptoms. Trauma history was supported as a risk factor that distinguishes CPTSD from PTSD.

Keywords: posttraumatic stress, complex posttraumatic stress, borderline personality disorder, childhood trauma

The recently released eleventh edition of the International Classification of Diseases (ICD-11) includes simplified diagnostic criteria for posttraumatic stress disorder (PTSD) and a sibling diagnostic category, complex posttraumatic stress disorder (CPTSD). Although these conditions have been included as distinct diagnostic categories, there have also been concerns regarding the validity of the CPTSD construct, based on overlapping symptomology with both PTSD and borderline personality disorder (BPD). This controversy has been reflected in empirical studies and reviews (Resick et al., 2012; Wolf et al., 2015), but it is likely that these concerns have also been prolonged by unclear and inconsistent operationalisation of CPTSD. Robust measures of CPTSD have been under development and have contributed to its inclusion in the ICD-11, but further validity testing is still required in order for the construct validity of CPTSD to be established firmly.

ICD-11 revisions have placed emphasis on clinical utility to bring diagnoses more in line with mental health taxonomies as they are presented in clinical settings (Reed, 2010). In accordance with these organising principles, the ICD-11 formulation of PTSD is characterised by three clusters of symptoms: a) re-experiencing of trauma in the present, b) avoidance of trauma-related stimuli, and c) persistent sense of threat. The CPTSD symptom profile includes all core symptoms of PTSD but additionally specifies three symptom clusters that reflect disturbances in self-organisation (DSO): a) affective dysregulation, b) negative self-concept, and c) disturbances in relationships (Maercker et al., 2013).

Several latent profile analyses and latent class analyses have reported evidence that supports a distinction between PTSD and CPTSD consistent with these symptom profiles included in the ICD-11 (Cloitre, Garvert, Brewin, Bryant, & Maercker, 2013; Contractor et al., 2014; Elklit, Hyland, & Shevlin, 2014; Karatzias et al., 2016; Knefel, Garvert, Cloitre, & Lueger-Schuster, 2015; S. Murphy, Elklit, Dokkedahl, & Shevlin, 2016; Sachser, Keller, & Goldbeck, 2016). A comprehensive review of evidence for diagnosing PTSD and CPTSD reported several qualitative differential factors, including symptom complexity, symptom number, and symptom type, with different groups of individuals associated with each symptom profile (Brewin et al., 2017).

Studies have also indicated that significantly higher rates of prolonged, interpersonal trauma, especially if experienced during childhood, were reported for those who endorsed CPTSD symptoms as compared to those who endorsed PTSD (Karatzias et al., 2017; Roth, Newman, Pelcovitz, van der Kolk, & Mandel, 1997). These findings are consistent with a wide range of research that characterises the deleterious effects of childhood interpersonal

trauma, including DSO symptoms reported at significantly higher rates when compared to other forms of trauma.

For instance, significant associations have been reported between childhood emotional maltreatment and interpersonal difficulties in adulthood, dysfunctional views of self and others, and difficulties in emotion regulation (Bailey, Moran, & Pederson, 2007; Bradley et al., 2011; Crawford & Wright, 2007; Lassri, Luyten, Cohen, & Shahar, 2016). Samples with childhood sexual abuse and childhood physical abuse have been associated with self-directed perceptions of worthlessness and failure, and fearful attitudes towards relationships (Cloitre, Garvert, Weiss, Carlson, & Bryant, 2014; Karatzias et al., 2017; Kucharska, 2016). Traumatised controls in these studies included groups with little or no history of childhood emotional maltreatment, or those with less than moderate-to-severe levels of childhood abuse. These studies indicate that a history of early trauma is associated with increased levels of DSO symptomology and may be a risk factor for CPTSD rather than PTSD.

However, a study that tested the postulates of ICD-11 CPTSD in general population and veteran samples, found evidence for a two-dimensional four-class model in which classes differed quantitatively by their level of symptom severity, but not qualitatively as a function of PTSD versus CPTSD symptom profiles (Wolf et al., 2015). Individuals endorsing high levels of PTSD also endorsed high CPTSD symptoms, and individuals with low PTSD also reported low CPTSD. Trauma history was not significantly different between classes. A review of empirical CPTSD literature further reported significant overlap between CPTSD and PTSD symptomology, calling for further research on the discriminant validity of CPTSD (Resick et al., 2012).

Studies that have examined the discriminant validity between CPTSD and BPD constructs have reported findings that support a distinction (Cloitre et al., 2014; Knefel, Tran, & Lueger-Schuster, 2016). Cloitre et al. (2014) indicated that empirically valid phenomenological distinctions can be made between CPTSD and BPD symptomology despite overlap in some areas. For instance, self-concept and relationships are characteristically unstable in BPD, with vacillations between highly positive and highly negative evaluations of self and others, whereas CPTSD is marked by stable yet deeply negative perceptions in self and relational domains. These distinctions were recently upheld empirically (Frost, Hyland, Shevlin, & Murphy, 2018).

However, high rates of comorbidity between PTSD and BPD have supported speculation that CPTSD is merely the combination of both, rather than a distinct disorder. PTSD/BPD comorbidity rates have been reported as high as 30% in community samples

(Pagura et al., 2010) and 68% in clinical samples (Zlotnick, Franklin, & Zimmerman, 2002). A critical review of empirical support for the construct validity of CPTSD further reported significant overlap between CPTSD and BPD symptom profiles, concluding that there was insufficient evidence for CPTSD as a distinct diagnostic category (Resick et al., 2012).

The validity of CPTSD is thus subject to controversy on empirical grounds, but the lack of an established measure for CPTSD has also impeded validity testing. Operationalisations of CPTSD have undergone several transitions, from its initial conceptualisation by Herman (1992), to field trial investigations of 'Disorders of Extreme Stress Not Otherwise Specified' (DESNOS) for both the 4th (DSM-IV) and 5th (DSM-5) versions of the Diagnostic and Statistical Manual of Mental Disorders (Brewin et al., 2017). Recent studies (Cloitre et al., 2014; Karatzias et al., 2016; S. Murphy et al., 2016) have used measures that are consistent with the ICD-11 CPTSD symptom profile, most notably the International Trauma Questionnaire (ITQ). The ITQ is nonetheless under continuous development and as such a fully validated and standardised measure of CPTSD is still being established.

In summary, although there is empirical support to distinguish CPTSD from both PTSD and BPD, replication of validity testing is still needed to establish a firm distinction. Latent profile analyses and latent class analyses have supported these distinctions, and multiple studies also indicate higher rates of childhood trauma for CPTSD, but overlap with comorbid symptom profiles, merely quantitative distinctions in symptom severity, and the operationalisation of symptom criteria, have been some of the core concerns with the validity of CPTSD.

Research Aims and Hypotheses

Given the controversy surrounding the validity of CPTSD, this study sought to accomplish three main objectives using a sample of university undergraduates. This study aimed to determine whether latent classes that emerge from endorsed symptom profiles are consistent with a CPTSD construct that is qualitatively distinct from (a) PTSD, and (b) BPD. This study further aimed to investigate whether significant differences in history of childhood trauma distinguish CPTSD from PTSD. I therefore formulated three hypotheses:

1. Analyses will identify at least two distinct groups characterised by the following symptom profiles: (a) a CPTSD symptom profile with high endorsement of both PTSD and DSO symptoms, and (b) a PTSD symptom profile with high endorsement of PTSD symptoms and low endorsement of DSO symptoms.

2. Analyses will identify at least two distinct groups characterised by the following symptom profiles: (a) a CPTSD symptom profile with high endorsement of both PTSD and DSO symptoms, and low endorsement of BPD symptoms; and (b) a BPD symptom profile with low endorsement of both PTSD and DSO symptoms, and high endorsement of BPD symptoms.
3. Relative to a PTSD group, a CPTSD group will exhibit: (a) significantly higher rates of moderate-to-severe childhood trauma, (b) significantly more types of childhood trauma exposure, and (c) significantly higher mean scores for childhood trauma severity.

Method

Participants and Procedures

The data for this study were collected via online survey from undergraduate students registered at the University of Cape Town (UCT). This study thus relied on a cross-sectional survey design. Participants were recruited via the Student Research Participation Programme (SRPP), run by the UCT Department of Psychology. The SRPP encourages registered psychology undergraduates to take part in postgraduate psychological research, thus representing a platform for recruitment by convenience sampling. An advertisement inviting undergraduates to participate in this study was posted on the SRPP Vula website and emailed to students directly (Appendix A). Invitations to participate in this study were further broadcast in-person at the beginning of a UCT undergraduate psychology lecture. Proficiency in English and minimum age of 18 years were the only eligibility criteria. The advertisement provided a stable URL link to the online survey, ensuring that access to the study for prospective participants was easy and immediate.

Three main questionnaires (see Measures) regarding trauma symptoms, borderline personality, and history of childhood trauma were compiled into the online survey using the Google Forms platform. The survey began with an informed consent form (Appendix B) and requested an email address which was used to send proof of participation. Participants were thus advised that participation was voluntary, withdrawal would incur no penalty, responses would be stored securely and remain confidential, and that completion of the survey would be awarded with course credit in accordance with the SRPP guidelines. Given that the survey required participants to recall potentially traumatic experiences, a debrief form (Appendix C) provided contact details for local student support centres in case of distress. All procedures in

this study received ethical approval from the UCT Psychology Department's Research Ethics Committee (Appendix D).

A total of 625 response sets were recorded from the online survey, but the exclusion of responses due to multiple entries by the same participants reduced the final sample size to $N = 576$.

Measures

International Trauma Questionnaire (ITQ). The ITQ (Appendix E) is a brief 18-item self-report measure that focuses on the core features of PTSD and CPTSD, as they have been formulated for the ICD-11. The current ITQ measure is derived from an item response theory analysis of earlier versions measuring the same constructs, but development of the ITQ is ongoing (Cloitre, Roberts, Bisson, & Brewin, personal communication, April 25, 2018). Factor analyses have confirmed that the latent structure of the current ITQ is consistent with previous findings (Brewin et al., 2017; Hyland et al., 2017; Karatzias et al., 2017).

In the ITQ, participants are asked to give a brief description of the experience that most troubles them and to indicate approximately when it occurred, before responding to the rest of the questionnaire in reference to the experience. Six items measure three symptom clusters for PTSD: re-experiencing, avoidance, and sense of threat (see Table 1). Six further items measure three symptom clusters for DSO: affective dysregulation, negative self-concept, and disturbances in relationships (see Table 1). For each of the two sets of symptom clusters, three additional items measure functional impairment. All items are scored on a five-point scale, from 0 (not at all applicable) to 4 (extremely applicable), and endorsement of a symptom requires a score of at least 2. Diagnosis of PTSD requires at least one of two symptoms to be met for each of the three PTSD symptom clusters, as well as endorsement of associated functional impairment. Diagnosis of CPTSD requires all PTSD diagnostic criteria to be met, as well as at least one of two symptoms to be met for each of the three DSO symptom clusters, and endorsement of associated functional impairment (Cloitre et al., personal communication, April 25, 2018).

Table 1

PTSD, CPTSD, and BPD Symptom Profiles, and Items used in the Latent Class Analysis

Symptom profiles			
ICD-11 PTSD	ICD-11 CPTSD	DSM-IV BPD	Items
Re-experiencing	Re-experiencing		
Dreams	Dreams		ITQ 1: Have upsetting dreams.
Flashbacks	Flashbacks		ITQ 2: Have powerful memories.
Avoidance	Avoidance		
Thoughts	Thoughts		ITQ 3: Avoid internal reminders.
Behaviour	Behaviour		ITQ 4: Avoid external reminders.
Sense of threat	Sense of threat		
Hypervigilance	Hypervigilance		ITQ 5: Watchful, or on guard.
Startle	Startle		ITQ 6: Feel jumpy or easily startled.
	Affective dysregulation		
	Anger		ITQ 10: Take a long time to calm down.
	Sensitive		ITQ 11: Feel emotionally shut down.
	Negative self-concept		
	Worthless		ITQ 13: Feel worthless.
	Guilty		ITQ 12: Feel like a failure.
	Disturbances in relationships		
	Distant		ITQ 14: Feel cut off from people.
	Detached		ITQ 15: Struggle to stay emotionally close to people.
		Frantic	MSI-BPD 10: Desperate efforts to avoid feeling abandoned.
		Unstable relationships	MSI-BPD 1: Closest relationships troubled by many arguments.
		Unstable sense of self	MSI-BPD 9: Feel you have no identity.
		Impulsivity	MSI-BPD 3: At least two other problems with impulsivity.
		Self-harm	MSI-BPD 2: Deliberately hurt yourself physically.
		Mood changes	MSI-BPD 4: Extremely moody.
		Empty	MSI-BPD 8: Feel chronically empty.
		Temper	MSI-BPD 5: Very angry much of the time.
		Paranoid	MSI-BPD 6: Distrustful of others.
		Dissociation	MSI-BPD 7: Often feel unreal.

McLean Screening Instrument for Borderline Personality Disorder (MSI-BPD). Previous studies have relied on clinician-administered diagnostic measures to screen for BPD, such as using a subset of items from the DSM-5 Structured Clinical Interview (SCID-5) (Cloitre et al., 2014), but this study relied exclusively on self-report measures to accommodate time and resources that would have been required for training and data collection from interviews. The MSI-BPD (Appendix F) is a 10-item self-report measure for BPD symptoms (see Table 1), as operationalised in the DSM-IV (Zanarini et al., 2003). Items are scored dichotomously between 0 (symptom not present) and 1 (symptom present), and the diagnostic cut-off score is 7 out of a possible total score of 10. Psychometrically, the MSI-BPD performs satisfactorily, with an internal consistency of $\alpha = .77$ and test retest reliability of $r_s = .72$ (Melartin, Häkkinen, Koivisto, Suominen, & Isometsä, 2009).

Childhood Trauma Questionnaire (CTQ). The CTQ (Appendix G) is a 28-item self-report measure for identifying history of maltreatment in both clinical and non-clinical populations (Bernstein et al., 2003). Items are scored on a five-point scale reflecting the frequency that the respondent has experienced a given instance of maltreatment whilst growing up, ranging from 1 (never true), to 5 (very often true). Five subscales of maltreatment are measured, including emotional, physical, and sexual abuse, as well as emotional and physical neglect, with three additional items used to detect underreporting respondents. Cut-off scores specific to each subscale reflect levels of severity, ranging from ‘none’ to ‘severe’. Total scores reflect a quantitative index of childhood trauma severity. The CTQ has been assessed to support a five-factor model and show a satisfactory internal consistency of $\alpha = .90$ in community samples (Scher, Stein, Asmundson, McCreary, & Forde, 2001).

Sociodemographic questionnaire. A brief four-item questionnaire (Appendix H) constructed specifically for the purpose of this study measured age, sex, racial identity, and household income level, in order to provide sociodemographic data on the sample.

Statistical Analyses

Latent class analysis (LCA). LCA is a form of latent variable mixture modelling that reveals unobserved, distinct classes of individuals from observed categorical data (Oberski, 2016). A central assumption that underpins LCA is class-conditional independence of observed variables, which makes LCA useful to cluster observed symptoms into mutually exclusive groups. The endorsement patterns of observed symptoms are thus unrelated between latent classes and construct validity of diagnostic criteria can thus be assessed on the basis of this discrimination and the specific pattern of endorsement.

Items from the ITQ and the MSI-BPD representing symptom profiles for ICD-11 PTSD, ICD-11 CPTSD, and DSM-IV BPD (see Table 1), were coded as twenty-two dichotomous categorical variables in an LCA: six items representing PTSD symptoms, six items representing DSO symptoms, and ten items representing BPD symptoms. As general practice in LCA is to fit models with a successively increasing number of classes (Oberski, 2016), models with two through six classes were estimated using robust maximum likelihood method and assessed for optimal model fit. To ensure convergence on global rather than local maxima for the log-likelihood function, 400 initial random starting values and 50 final stage optimisations were used for the estimation of each model. These values are consistent with those used in previous LCA studies (Cloitre et al., 2014; S. Murphy et al., 2016). Selection of the best-fitting model was informed by a combination of parsimony and statistical fit criteria, including the Bayesian Information Criterion (BIC), the Sample-Size Adjusted BIC (SSA-BIC), and the Akaike Information Criterion (AIC), where lower values for each criterion indicate more optimal model fit. The Lo-Mendell-Rubin adjusted likelihood ratio test (LMR-A) and the bootstrap likelihood ratio test (BLRT) were further used to compare models with an increasing number of classes, where non-significant values at the $\alpha = .05$ level indicate more optimal fit for models with $k - 1$ classes compared to those with k classes (Asparouhov & Muthén, 2012). To ensure replication of global maxima for the log-likelihood function in each of the likelihood ratio tests, 400 initial random starting values, 50 final stage optimisations, and 50 bootstrap draws were used. Although no explicit standard exists for selecting the best-fitting model, evidence from a simulation study investigating the performance of the abovementioned fit indices in various sample sizes suggested that the BIC outperformed the other fit criteria (Nylund, Asparouhov, & Muthén, 2007), and as such the BIC was considered more definitive than alternative fit criteria for this study. Estimation and comparison of models with graphical representations were conducted in R version 3.5.1 (R Core Team, 2018) using the poLCA package (Linzer & Lewis, 2011) (see Appendix I for R code). Calculation of fit indices and likelihood ratio tests were conducted in MPLUS version 7 (L. K. Muthén & Muthén, 2012).

Previous LCA studies on CPTSD have not directly reported effect sizes, but a relatively recent study made extensive use of Monte Carlo data simulation methods specifically to examine effect size, statistical power, and sample size for use in the BLRT for LCA (Dziak, Lanza, & Tan, 2014). An effect size of approximately Cohen's $w = .297$ (Dziak et al., 2014, Table 5) was estimated to correspond to a sample size of approximately $N = 1208$ and power = .90 for testing the fit of a six-class model with fifteen items. Parameters for LCAs using more than fifteen items were not examined in the simulation study, but the trend

of the reported parameters suggested that in order to achieve power = .90 for testing the fit of a six-class model with twenty-two items, an effect size of approximately Cohen's w = .836 would be required, corresponding to an estimated N = 210 (Dziak et al., 2014, Formula 7). This conservative estimation suggests that N = 576 achieved acceptable power for the LCA in this study.

Descriptive statistics. Responses from the sociodemographic questionnaire, the ITQ, the MSI-BPD, and the CTQ were used in chi-squared tests of contingency and one-way ANOVAs to assess for significant differences in sociodemographic variables, diagnostic variables, symptom variables, trauma severity, trauma history, and number of types of trauma exposure between classes in the best-fitting model from the LCA. Where statistical assumptions for ANOVA were not satisfied, a Kruskal-Wallis test was performed. Where minimum expected frequencies of five were not satisfied for chi-squared tests, a Fisher's exact test was performed. Violations were mentioned only where they occurred. Where significant between-class differences warranted post-hoc comparisons, significant post-hoc results were reported at the α = .05 level using Bonferroni correction for multiple comparisons. Only observed data were used for these tests and SPSS version 25 (IBM Corp, 2017) was used for all analyses.

G*Power version 3.1.9.3 (Faul, Erdfelder, Buchner, & Lang, 2009) was used for a post-hoc power analysis to estimate power achieved for the chi-squared tests of contingency and one-way ANOVAs. A previous study that assessed between-class differences with the same measures for trauma history reported medium to large effect sizes (Karatzias et al., 2017). With sample size N = 576, df = 3, α = .05, and Cohen's w = .30, power achieved in chi-squared tests of contingency was calculated to be power = 1.0. With four groups and the same parameters for sample size and significance level, a medium effect size of Cohen's f^2 = .30 also achieved power = 1.0. Effect size estimates for Cramers' V were converted to Cohen's w according to the following formula: $w = V\sqrt{(r-1)}$, where r = the number of rows or columns, whichever is smaller, in the contingency table {Cohen:1988to, p. 223}.

Results

Sample Characteristics

Participants had a mean age of M = 20.46 years (SD = 2.76) and the majority of the sample was female (84.55%, n = 487). More than a third of the sample identified as White (37.85%, n = 218), followed by Coloured (30.38%, n = 175), Black (22.40%, n = 129), Indian (7.46%, n = 43), and other (1.91%, n = 11). More than half of the sample reported a

household income level in the middle category (54.51%, *n* = 314), followed by upper (27.26%, *n* = 157), and lower (18.23%, *n* = 105).

In total, 26.39% (*n* = 152) met diagnostic criteria for ICD-11 PTSD, 11.46% (*n* = 66) met diagnostic criteria for ICD-11 CPTSD, and 31.42% (*n* = 181) met diagnostic criteria for DSM-IV BPD. Participants who satisfied the diagnostic criteria for all three conditions constituted 7.99% (*n* = 46) of the sample, and 69.70% of those with CPTSD. Of those with PTSD, approximately two fifths (43.42%, *n* = 66) also met criteria for CPTSD, whereas approximately half (51.32%, *n* = 78) also met criteria for BPD. Females (28,10%, *n* = 137) were significantly more likely than males (16.90%, *n* = 15) to meet criteria for PTSD, χ^2 (1, *N* = 576) = 4.93, *p* = .026, *w* = .092. Females (33.3%, *n* = 162) were also significantly more likely than males (21.3%, *n* = 19) to meet criteria for BPD, χ^2 (1, *N* = 576) = 4.95, *p* = .026, *w* = .093. CPTSD diagnoses did not differ significantly by sex, χ^2 (1, *N* = 576) = 0.19, *p* = .665, *w* = .018.

Nearly one third of the sample (31.42%, *n* = 181) identified their most traumatic experience as occurring between 1 and 5 years ago, placing mean age of exposure between approximately 14.89 years (*SD* = 6.49) and 18.12 years (*SD* = 4.13). Of childhood traumas experienced with moderate-to-severe severity, the most frequent in the sample was emotional abuse (21.88%, *n* = 126), followed by sexual abuse (17.36%, *n* = 100), physical neglect (13.72%, *n* = 79), emotional neglect (13.54%, *n* = 78), and physical abuse (13.02%, *n* = 75). Comorbidity between emotional abuse and other types of trauma was high, with approximately over a third of participants with a history of emotional abuse also having experienced another type of childhood trauma. However, the majority of the sample (59.55%, n = 343) experienced either no types of childhood trauma or childhood traumas with minimal-to-low severity, with only 4.86% (*n* = 28) having experienced four or more types of trauma.

Latent Class Analysis

Table 2 shows the statistical fit indices calculated for the models estimated in the LCA. All models yielded significant BLRT values, and SSA-BIC and AIC fit criteria yielded increasingly lower values for models with successively more classes. These fit criteria therefore did not converge onto any reasonably interpretable number of latent classes. Models with three through six classes yielded non-significant LMR-A values, suggesting optimal fit for a two-class model. However, the BIC showed the clearest convergence of all fit criteria with the lowest value yielded for a four-class model. Overall consideration given to the interpretability and parsimony of the models, and that the BIC had been shown to outperform

the other fit criteria in a simulation study (Nylund et al., 2007), resulted in the four-class model being selected as the best-fitting model.

Table 2

Fit Indices for Latent Class Models

Model	Log-likelihood	BIC	SSA-BIC	AIC	LMR-A *p*	BLRT *p*	Entropy
2 classes	−7588.35	15462.73	15319.88	15266.71	< .001	< .001	.860
3 classes	−7440.24	15312.70	15096.83	15016.49	.093	< .001	.799
4 classes	**−7330.40**	**15239.21**	**14950.32**	**14842.81**	**.108**	**< .001**	**.800**
5 classes	−7267.22	15259.03	14897.13	14762.43	.640	< .001	.803
6 classes	−7218.64	15308.08	14873.16	14711.29	.244	< .001	.827

Note. Best-fitting model in bold. BIC = Bayesian Information Criterion. SSA-BIC = Sample-Size Adjusted BIC. AIC = Akaike Information Criterion. LMR-A = Lo-Mendell-Rubin adjusted likelihood ratio test. BLRT = bootstrap likelihood ratio test.

Symptom endorsement for the four classes are shown in Figure 1. Descriptive labels for each class were determined by assessing the patterns of endorsement for all twenty-two symptoms. Class 1 showed high endorsement of PTSD symptoms (except for the PTSD Dreams item, ‘having upsetting dreams’), low-to-moderate endorsement of DSO symptoms (except for the DSO anger item, ‘taking a long time to calm down’), and moderate-to-high endorsement of most of the BPD symptoms (except the BPD self-harm item, ‘deliberately hurting yourself physically’). Class 1 was thus labelled the ‘PTSD- BPD’ class. Class 2 showed high endorsement of all PTSD, DSO, and BPD symptoms. Class 2 was thus labelled the ‘CPTSD-BPD’ class. Class 3 showed low endorsement of PTSD symptoms and high endorsement of DSO and BPD symptoms. Class 3 was thus labelled the ‘DSO-BPD’ class. Class 4 showed low endorsement of all PTSD, DSO, and BPD symptoms. Class 4 was thus labelled the ‘Low Symptom’ class. showed high endorsement of all PTSD, DSO, and BPD symptoms. Class 2 was thus labelled the ‘CPTSD-BPD’ class. Class 3 showed low endorsement of PTSD symptoms and high endorsement of DSO and BPD symptoms. Class 3 was thus labelled the ‘DSO-BPD’ class. Class 4 showed low endorsement of all PTSD, DSO, and BPD symptoms. Class 4 was thus labelled the ‘Low Symptom’ class.

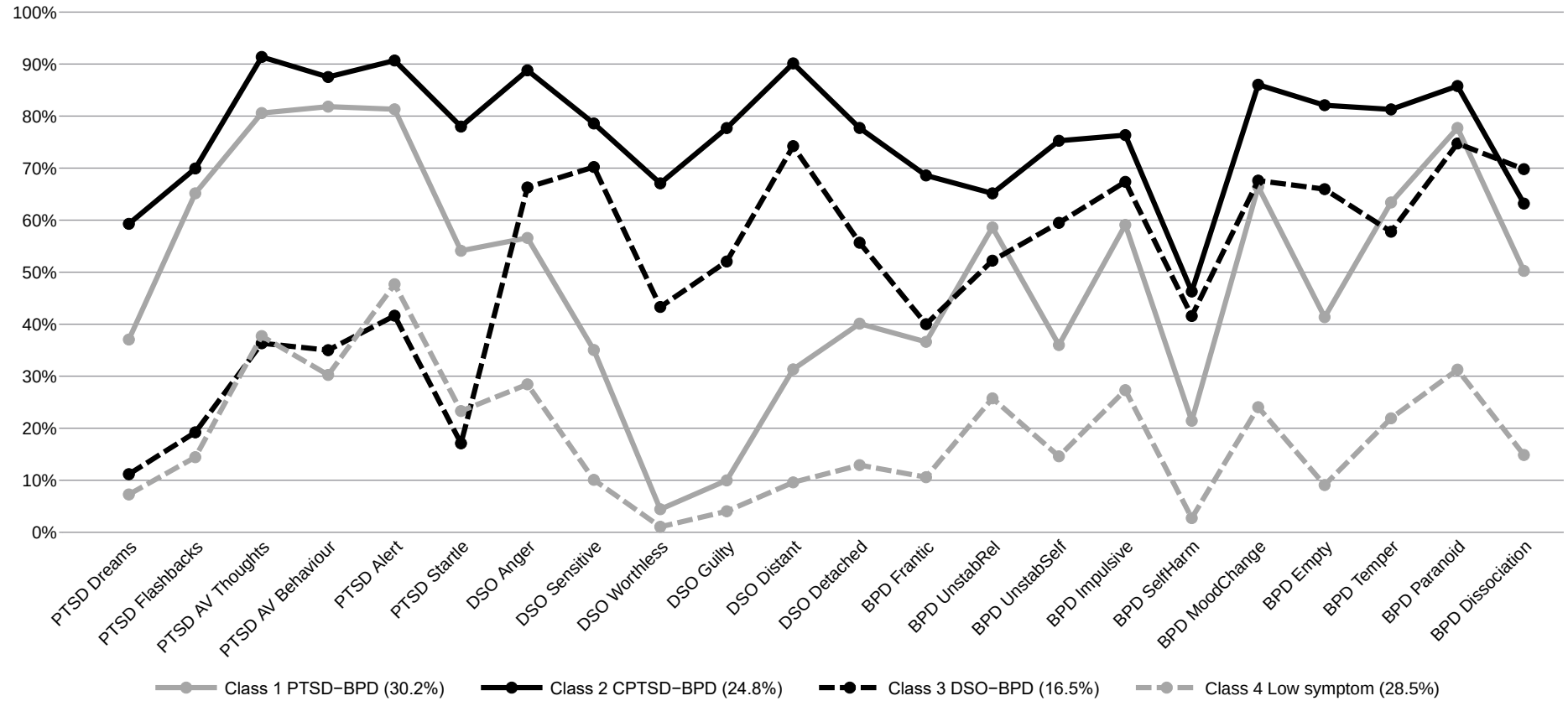

Figure 1. Symptom endorsement of PTSD, CPTSD, and BPD items by latent class. Sample proportions shown in parentheses.

Average probabilities of most likely latent class membership were acceptable, with 85.20% for the PTSD-BPD class, 90.10% for the CPTSD-BPD class, 85.70% for the DSO-BPD class, and 93.80% for the Low Symptom class. The scatterplots in Figure 2 indicate the class-conditional independence of the model, showing a clear distinction in the relationship between two example symptoms, before and after controlling for class membership. An entropy value of .80 (see Table 2) further indicated acceptable class separation. The sample proportions of the model were as follows: 30.21% (n = 174) for the PTSD-BPD class, 24.83% (n = 143) for the CPTSD-BPD class, 16.49% (n = 95) for the DSO-BPD class, and 28.47% (n = 164) for the Low Symptom class.

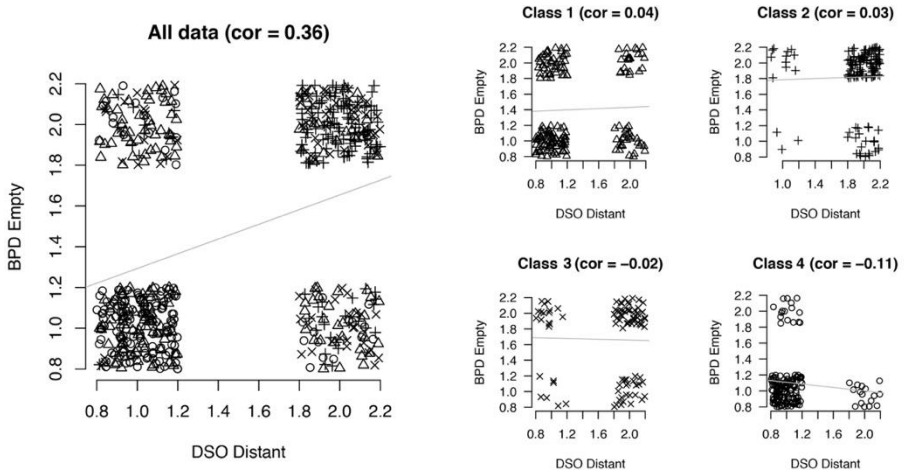

Figure 2. Scatter plots indicating correlations between items 'BPD Empty' and 'DSO Distant' for all observed data (left), and class-conditional correlations (right).

Between-Class Differences in Sociodemographic Characteristics

Chi-squared tests of contingency and one-way ANOVAs were conducted to assess potential between-class differences in sociodemographic variables, with results shown in Table 3. Positively skewed distributions for age were not sensitive to transformations, and Levene's test indicated significant differences in error variance (p = .005). A Kruskal-Wallis test was thus performed, which indicated that classes did not differ significantly by age. Although a significant result was detected for differences in sex, post-hoc comparisons detected no specific class with significantly different frequencies. Classes differed significantly by racial identity, where significantly more participants who identified as Black were found in the CPTSD-BPD and DSO-BPD classes relative to the Low Symptom class. There were also significantly more participants who identified as White in the Low Symptom class compared to the PTSD-BPD class. The four classes did not differ significantly by household income.

Table 3

Between-Class Differences in Sociodemographic Characteristics

Variable	Class 1 PTSD-BPD (*n* = 174)		Class 2 CPTSD-BPD (*n* = 143)		Class 3 DSO-BPD (*n* = 95)		Class 4 Low Symptom (*n* = 164)		χ^2	*p*	*w*
Age[a]	20.37	(2.30)	20.22	(2.21)	21.20	(3.94)	20.33	(2.72)	6.25	.100	.104
Sex									9.13	.028	.126
Female	155	(.89)	126	(.88)	76	(.80)	130	(.79)	9.13	.028	.126
Male	19	(.11)	17	(.12)	19	(.20)	34	(.21)	9.13	.028	.126
Racial identity									20.29	.016	.189
Black	40	(.23)	39	(.28)	27	(.30)	23	(.14)	11.56	.009	.143
Coloured	55	(.32)	43	(.31)	22	(.24)	55	(.34)	2.51	.474	.067
Indian	18	(.11)	11	(.08)	7	(.08)	7	(.04)	4.63	.201	.091
White	58	(.34)	48	(.34)	34	(.38)	78	(.48)	8.73	.033	.124
Household income level									9.35	.155	.127
Lower	39	(.22)	25	(.18)	17	(.18)	24	(.15)	3.53	.317	.078
Middle	99	(.57)	77	(.54)	54	(.57)	84	(.51)	1.35	.717	.048
Upper	36	(.21)	41	(.29)	24	(.25)	56	(.34)	8.05	.045	.118

Note. For *Age*, means are presented with standard deviations in parentheses. For *Sex*, *Racial Identity*, and *Household income*, raw numbers are presented with class percentages in parentheses.

[a]Kruskal-Wallis test results are displayed due to violations of normality and homogenous error variance.

Between-Class Differences in Diagnostic and Symptom Characteristics

Chi-squared tests of contingency were conducted to assess between-class differences in diagnostic and symptom characteristics, corresponding directly to symptom endorsement patterns shown in Figure 1. All tests were significant ($p < .001$). Results are shown in Table 4. Of participants in the PTSD-BPD class, 31.60% met diagnostic criteria for PTSD and 24.10% met diagnostic criteria for BPD, whereas only 1.70% met diagnostic criteria for CPTSD. BPD was the most common diagnosis for both the CPTSD-BPD (71.33%) and DSO- BPD classes (38.95%) Therefore, all classes except the Low Symptom class appeared to be comorbid with BPD. The proportion of participants in the CPTSD-BPD class who met diagnostic criteria for CPTSD was 43.36%, and there were minimal endorsements of PTSD (2.11%) and CPTSD (1.05%) diagnoses in the DSO-BPD class. Only three participants (1.83%) in the Low Symptom class met diagnostic criteria for PTSD and no one in this class met diagnostic criteria for either CPTSD or BPD.

The classes differed significantly on diagnostic endorsements for PTSD, CPTSD, and BPD. Post-hoc comparisons indicated that diagnosis of CPTSD was significantly more likely in the CPTSD-BPD class relative to all other classes, and diagnosis of PTSD was significantly more likely in the PTSD-BPD class relative to the DSO-BPD and Low Symptom classes. Diagnosis of BPD was significantly more likely in the CPTSD-BPD class, relative to all other classes, and also more likely in the DSO-BPD class relative to the Low Symptom class.

Testing the distinction between CPTSD and PTSD symptom profiles. Table 4 indicates that the classes differed significantly for all PTSD and DSO symptoms included in the LCA. Post-hoc comparisons indicated that the PTSD-BPD and CPTSD-BPD classes both showed significantly higher endorsements of all PTSD symptoms, relative to the other classes. There were also no significant differences in symptom endorsements between the CPTSD-BPD and PTSD-BPD classes for half of the PTSD symptoms. These symptoms were PTSD flashbacks, PTSD avoidance behaviour, and PTSD hypervigilance. Endorsements for all DSO symptoms were significantly higher in the CPTSD-BPD class relative to the PTSD-BPD class. These relative differences in symptom endorsements therefore indicate significantly higher PTSD symptomology for both the CPTSD-BPD and PTSD-BPD classes relative to the other classes, and significantly different DSO symptomology between each other: higher for the CPTSD-BPD class and lower for the PTSD-BPD class. These results therefore indicate a significant distinction between CPTSD and PTSD symptom profiles

Table 4

Between-Class Differences in Diagnostic and Symptom Characteristics

Variable	Class 1 PTSD-BPD (n = 174)	Class 2 CPTSD-BPD (n = 143)	Class 3 DSO-BPD (n = 95)	Class 4 Low Symptom (n = 164)	χ^2	w	Significant Post-hoc Comparisons
ICD-11 PTSD	55 (.32)	92 (.64)	2 (.02)	3 (.02)	188.21	.572	2 > 1, 3, 4 1 > 3, 4
Dreams	65 (.37)	86 (.60)	9 (.10)	10 (.06)	131.19	.477	2 > 1, 3, 4 1 > 3, 4
Flashbacks	114 (.66)	100 (.70)	17 (.18)	22 (.13)	160.31	.528	1, 2 > 3, 4
Thoughts	141 (.81)	131 (.92)	32 (.34)	61 (.37)	156.98	.522	2 > 1, 3, 4 1 > 3, 4
Behaviour	146 (.84)	125 (.87)	30 (.32)	47 (.29)	185.93	.568	1, 2 > 3, 4
Hypervigilance	141 (.81)	130 (.91)	38 (.40)	78 (.48)	112,14	.441	1, 2 > 3, 4
Startle	96 (.55)	112 (.78)	14 (.15)	36 (.22)	141.90	.496	2 > 1, 3, 4 1 > 3, 4
ICD-11 CPTSD	3 (.02)	62 (.43)	1 (.01)	0 (.00)	191.03	.576	2 > 1, 3, 4
Anger	98 (.56)	128 (.90)	61 (.64)	47 (.29)	117.94	.453	2 > 1, 3, 4 1, 3 > 4
Sensitive	61 (.35)	113 (.79)	68 (.72)	14 (.09)	189.42	.573	2, 3 > 1, 4 1 > 4
Worthless	6 (.03)	96 (.67)	42 (.44)	2 (.01)	244.37	.651	2 > 1, 3, 4 3 > 1, 4
Guilty	15 (.09)	113 (.79)	50 (.53)	6 (.04)	268.37	.683	2 > 1, 3, 4 3 > 1, 4 1 > 4
Distant	51 (.29)	129 (.90)	73 (.77)	16 (.10)	254.50	.665	2 > 1, 3, 4 3 > 1, 4 1 > 4
Detached	66 (.38)	112 (.78)	55 (.58)	21 (.13)	143.11	.498	2 > 1, 3, 4 3 > 1, 4 1 > 4
DSM-IV BPD	42 (.24)	102 (.71)	37 (.39)	0 (.00)	187.60	.571	2 > 1, 3, 4 1, 3 > 4
Frantic	63 (.36)	99 (.69)	37 (.39)	17 (.10)	113.16	.443	2 > 1, 3, 4 1, 3 > 4
Unstable relationships	102 (.59)	96 (.67)	47 (.50)	41 (.25)	62.95	.331	2 > 3, 4 1, 3 > 4
Unstable sense of self	64 (.37)	107 (.75)	57 (.60)	22 (.13)	131.28	.477	2, 3 > 1, 4 1 > 4
Impulsivity	104 (.60)	109 (.76)	65 (.68)	42 (.26)	91.92	.399	2 > 1, 4 1, 3 > 4
Self-harm	37 (.21)	67 (.47)	39 (.41)	4 (.02)	93.92	.404	2, 3 > 1, 4 1 > 4
Mood changes	116 (.67)	125 (.87)	62 (.65)	38 (.23)	140.73	.494	2 > 1, 3, 4 1, 3 > 4
Empty	70 (.40)	117 (.81)	63 (.66)	16 (.10)	178.59	.557	2 > 1, 3, 4 3 > 1, 4 1 > 4
Temper	107 (.62)	118 (.83)	56 (.59)	35 (.21)	122.31	.461	2 > 1, 3, 4 1, 3 > 4
Paranoid	133 (.76)	123 (.86)	72 (.76)	51 (.31)	126.67	.469	1, 2, 3 > 4
Dissociation	90 (.52)	86 (.60)	69 (.73)	23 (.14)	108.20	.433	1, 2 > 4 3 > 1, 4

Note. Raw numbers are presented with class percentages in parentheses. For all tests, df = 3, and p < .001. Bonferroni correction was used for multiple post-hoc comparisons.

Testing the distinction between CPTSD and BPD symptom profiles. Table 4 also indicates that the classes differed significantly for all BPD symptoms included in the LCA. Post-hoc comparison indicated that the CPTSD-BPD class consistently showed significantly higher endorsements of all PTSD symptoms and all DSO symptoms (except for the DSO sensitive item, 'feeling emotionally shut down'), relative to the DSO-BPD class. However, the CPTSD-BPD class also showed significantly higher endorsements for half of the BPD symptoms, relative to the DSO-BPD class. These symptoms were BPD frantic, BPD unstable relationships, BPD mood change, BPD empty, and BPD temper. There were no significant differences in endorsements of the remaining BPD symptoms between the CPTSD-BPD and DSO-BPD classes. These relative differences in symptom endorsements therefore indicate significantly higher PTSD and DSO symptomology in the CPTSD-BPD class relative to the DSO-BPD class, but also significantly higher BPD symptomology. These results therefore do not indicate a distinction between CPTSD and BPD symptom profiles

As demonstrated in testing the distinction between CPTSD and PTSD symptom profiles, although endorsements for all DSO symptoms were significantly higher in the CPTSD-BPD class relative to the PTSD-BPD class, there were no significant differences between these classes for half of the PTSD symptoms. These classes also endorsed PTSD symptoms significantly higher than the other classes. Furthermore, post-hoc comparisons indicated that seven of the ten BPD symptoms included in the LCA were significantly more likely to be endorsed by the CPTSD-BPD class relative to the PTSD-BPD class. These symptoms were BPD frantic, BPD unstable sense of self, BPD impulsivity, BPD self-harm, BPD mood change, BPD empty, and BPD temper. There were no significant differences in endorsements between the CPTSD-BPD and PTSD-BPD classes for the remaining BPD symptoms. These relative differences in symptom endorsements therefore indicate that the CPTSD-BPD and PTSD-BPD classes differ significantly in terms of DSO symptomology, where the CPTSD-BPD class was higher, but not PTSD symptomology, where both classes were higher than other classes. BPD symptomology was also significantly higher in the CPTSD-BPD class relative to the PTSD-BPD class. These results therefore also do not indicate a distinction between CPTSD and BPD symptom profiles.

Between-Class Differences in Childhood Trauma Characteristics

Chi-squared tests of contingency and one-way ANOVAs were conducted to assess between-class differences in trauma history, number of types of trauma exposure, and trauma severity. Results are shown in Table 5.

In terms of trauma history, the classes differed significantly for all types of moderate-to-severe trauma. Post-hoc comparisons indicated that the CPTSD-BPD class was significantly more likely than all other classes to report sexual abuse, and significantly more likely than the PTSD-BPD class to report either emotional abuse or emotional neglect. The only other significant relative between-class differences in trauma history were consistently lower frequencies of moderate-to-severe trauma exposure in the Low Symptom class.

The classes also differed significantly in terms of the number of types of trauma exposure. Post-hoc comparisons indicated that the CPTSD-BPD class was significantly more likely than the DSO-BPD class to report four or more types of trauma exposure. Compared to the PTSD-BPD class, the CPTSD-BPD class also contained significantly fewer participants who either had no trauma exposure or had minimal-to-low severity trauma exposure. The Low Symptom class consistently had significantly fewer types of trauma exposure than the other classes, with the exception of exposure to only one type of trauma, for which no classes differed significantly from each other. A Fisher's exact test was performed to obtain the chi-squared statistic for four-or-more types of trauma exposure, as an expected frequency was below minimum for one cell.

Trauma severity showed positively skewed distributions in some of the classes, and error variance was not homogenous ($p < .001$). A Kruskal-Wallis test was thus performed, indicating significant between-class differences. Post-hoc pairwise comparisons indicated that the CPTSD-BPD class had significantly higher mean trauma scores for all types of trauma, compared to both the PTSD-BPD and Low Symptom classes. The Low Symptom class had significantly lower trauma severity relative to all the other classes.

Table 5

Between-Class Differences in Childhood Trauma Characteristics

Variable	Class 1 PTSD-BPD (n = 174)		Class 2 CPTSD-BPD (n = 143)		Class 3 DSO-BPD (n = 95)		Class 4 Low Symptom (n = 164)		χ^2	p	w
Moderate-to-severe trauma											
Emotional abuse	39	(.22)	56	(.39)	24	(.25)	7	(.04)	55.42	< .001	.310
Physical abuse	27	(.16)	31	(.22)	12	(.13)	5	(.03)	24.83	< .001	.208
Sexual abuse	30	(.17)	45	(.32)	14	(.15)	11	(.07)	33.27	< .001	.240
Emotional neglect	19	(.11)	33	(.23)	20	(.21)	6	(.04)	30.39	< .001	.230
Physical neglect	26	(.15)	34	(.24)	11	(.12)	8	(.05)	23.64	< .001	.203
Number of types of trauma											
None	104	(.60)	53	(.37)	51	(.54)	135	(.82)	66.67	< .001	.340
1 type	29	(.17)	37	(.26)	18	(.19)	23	(.14)	7.71	.052	.116
2 types	22	(.13)	20	(.14)	16	(.17)	5	(.03)	15.76	.001	.165
3 types	11	(.06)	15	(.11)	9	(.10)	0	(.00)	17.42	.001	.174
≥ 4 types[a]	8	(.05)	18	(.13)	1	(.01)	1	(< .01)	25.16	< .001	.220
Trauma severity[b]	39.95	(13.11)	47.60	(15.46)	41.86	(11.28)	32.50	(7.17)	112.56	< .001	.441

Note. For M*oderate-to-severe trauma* and *Number of types of trauma*, raw numbers are presented with class percentages in parentheses. For *Trauma severity*, means are presented with standard deviations in parentheses.

[a]Fisher's exact test results are displayed due to an expected frequency lower than five for one cell.

[b]Kruskal-Wallis test results are displayed due to violations of normality and homogenous error variance.

Discussion

Using LCA, this study investigated the validity of ICD-11 CPTSD in terms of its distinction from both ICD-11 PTSD and DSM-IV BPD symptomology among a sample of university undergraduates. The LCA identified a best-fitting model with four distinct classes: a PTSD-BPD class with high PTSD symptoms, low DSO symptoms, and moderately high BPD symptoms; a CPTSD-BPD class that had high PTSD symptoms, high DSO symptoms, and high BPD symptoms; a DSO-BPD class with low PTSD symptoms, high DSO symptoms, and moderately high BPD symptoms; and a Low Symptom class that was relatively low in all symptoms. The class structure showed acceptable discrimination. The classes additionally did not differ significantly on sociodemographic characteristics, except for racial identity. Assessment of diagnostic and symptom characteristics of the classes showed that the endorsed symptom profiles were consistent with qualitatively distinct CPTSD and PTSD constructs. However, in contrast to the second hypothesis, the symptom characteristics of the classes were inconsistent with a qualitative distinction between CPTSD and BPD constructs. In fact, three of the four classes demonstrated comorbidity with BPD. Assessment of childhood trauma characteristics showed that, compared to the PTSD-BPD class, the CPTSD-BPD class had both higher rates of moderate-to-severe childhood trauma history, and higher childhood trauma severity.

I hypothesised that a latent class with a CPTSD symptom profile would be distinct from that with a PTSD symptom profile. High endorsement of PTSD symptoms and low endorsement of DSO symptoms were hypothesised to correspond to a PTSD class, whereas high endorsement of both PTSD and DSO symptoms were hypothesised to correspond to a CPTSD class. Significant relative differences in the patterns of symptom endorsement between the PTSD-BPD and CPTSD-BPD classes were thus consistent with the first research hypothesis that CPTSD and PTSD symptom profiles are qualitatively distinct. The results of the LCA thus support the symptom profiles for PTSD and CPTSD as they have been formulated in the ICD-11. These findings are also consistent with several previous studies that support this distinction (Cloitre et al., 2013; Contractor et al., 2014; Elklit et al., 2014; Karatzias et al., 2016; Knefel et al., 2015; S. Murphy et al., 2016; Sachser et al., 2016).

I also hypothesised that a latent class with a CPTSD symptom profile would be distinct from that with a BPD symptom profile. High endorsement of both PTSD and DSO symptoms, and low endorsement of BPD symptoms were hypothesised of a CPTSD class, whereas low endorsement of both PTSD and DSO symptoms, and high endorsement of BPD

symptoms were hypothesised to correspond to a BPD class. The relative differences in the patterns of symptom endorsement between the CPTSD-BPD class and both the DSO-BPD and PTSD-BPD classes were thus inconsistent with the second research hypothesis that CPTSD and BPD symptom profiles are qualitatively distinct. These results were more indicative of significant comorbidity between CPTSD and BPD symptom profiles in the CPTSD-BPD class than of a significant distinction between the CPTSD-BPD class and either of the other classes that endorsed BPD symptoms. Eight of the ten BPD symptoms included in the LCA were endorsed by more than two thirds of participants in the CPTSD-BPD class, and more than 70% met diagnostic criteria for BPD. These comorbidity rates are consistent with those that have been reported between PTSD and BPD in both community samples (Pagura et al., 2010) and clinical samples (Zlotnick et al., 2002).

It is notable that a recent LCA study that investigated the distinction between CPTSD and BPD reported a distinct CPTSD symptom profile that manifested in the absence of BPD symptomology, but also reported that BPD symptoms did not manifest in other classes independently of PTSD symptomology (Frost et al., 2018). Furthermore, the DSO-BPD class in this study shares similarities with the Low Symptom class revealed in the LCA study conducted by Cloitre et al. (2014). These recent findings are thus consistent with the emergence of classes with comorbid symptom profiles. The precise nature of these comorbid symptom profiles was not fully clarified in the results, but it is possible that these classes endorse subsyndromal levels of different disorders, such as bipolar disorder or major depressive disorder (Cloitre et al., 2014). Further validity research that accounts for subsyndromal symptomology will assist in disentangling the patterns of symptom endorsement in these classes.

This study's third hypothesis stated that significant differences in history of childhood trauma would distinguish CPTSD from PTSD. Specifically, a CPTSD class was hypothesized to demonstrate significantly higher rates of moderate-to-severe childhood trauma, significantly more types of childhood trauma exposure, and significantly higher mean scores for childhood trauma severity. Between-class differences in childhood trauma were thus consistent with the third research hypothesis that early childhood trauma distinguished between CPTSD and PTSD. Although there were no significant differences between the CPTSD-BPD and PTSD-BPD classes for two through four-or-more types of trauma exposure, the CPTSD-BPD class typically had higher rates and did nonetheless have significantly fewer participants who had no trauma exposure, compared to the PTSD-BPD class. These findings are thus consistent with early trauma being a risk factor for CPTSD, as suggested by a large

body of literature detailing the long-term harmful effects of prolonged interpersonal trauma in childhood (Karatzias et al., 2017; Roth et al., 1997).

One of the primary sources of utility in firmly establishing a distinction between PTSD and CPTSD is in terms of differential treatment methodologies for each. As a disorder characterised by trauma symptomology, CPTSD warrants modalities of treatment focussed on the amelioration of traumatic memory, the reduction of personal and social avoidance, and the development of more positive self-concept (Cloitre, Cohen, & Koenen, 2006). Although BPD severity may be related to stressful life events, trauma exposure is not a diagnostic requirement for BPD. By contrast, treatment modalities warranted for BPD, such as dialectical behaviour therapy, emphasise the reduction of life-interfering behaviours, reducing dependency on others, and promoting an internal, stable sense of self (Cloitre et al., 2014). Therefore, the significance of firmly establishing a distinction between PTSD and CPTSD extends to clinical practice.

Some limitations of this study's findings should be noted. Firstly, the sample consisted of university undergraduates recruited via convenience sampling. Replication of validity studies for CPTSD should ideally be more representative of clinical and community populations. Secondly, the MSI-BPD screening measure is typically used in clinical samples (Zanarini et al., 2003) whereas this study used it in a sample of university undergraduates. As a result, it is possible that the diagnostic cut-off score used in the MSI-BPD may not have discriminated in this study's sample as accurately as in a clinical sample. Thirdly, data was collected from UCT students at a time when stress levels may have been disproportionately high due to examinations and political unrest on campus. As a result, scores for some symptoms includes in the LCA may have been influenced, such as affective dysregulation or hypervigilance.

Conclusion

This study identified four distinct classes of university undergraduates, consistent with the distinction between PTSD and CPTSD symptom profiles in the ICD-11. The distinction between CPTSD and BPD was not supported, as most of the classes were comorbid with BPD symptoms. Trauma history was supported as a risk factor that distinguishes CPTSD from PTSD. The distinction between CPTSD and PTSD has significant consequences for informing clinical treatment modalities, but further validity testing in community and clinical samples of trauma-exposed individuals is needed in order for the distinction to be established firmly.

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Appendix A

Recruitment Email on SRPP Platform

From:	James Rink <rinkjames@gmail.com>
Subject:	20min Online Survey on Complex PTSD in UCT Students (earn 1 SRPP point for next semester)

Dear UCT psychology students!

You've been invited to take part in an online survey investigating a newly proposed mental disorder called complex posttraumatic stress disorder. I'm conducting this study to assess the extent to which this new diagnosis is actually useful.

To take part, you need to be 18 years or older and able to take the online survey in English. There are no other exclusion criteria.

The survey involves three main questionnaires that measure trauma symptoms, borderline symptoms, and childhood trauma. The entire survey should take you approximately 20 minutes to complete and you'll earn 1 SRPP point.

If you meet the above criteria, click here to access the survey and get started. It works fine on mobile.

Feel free to email me with any questions: rinkjames@gmail.com

Best regards,
James Rink

Appendix B

Informed Consent Form for SRPP Students

Consent to Participate in Research Study

ACSENT Laboratory

Department of Psychology

University of Cape Town

PTSD and Complex PTSD Amongst South African Students

Thank you for considering to take part in this study. This form serves to provide information about the study and to obtain your informed consent for participation. I am conducting this study as part of an Honours degree in the Department of Psychology at the University of Cape Town. Please read through this form carefully before you agree to take part.

What is the study about?

The purpose of this study is to test the validity of a newly proposed version of posttraumatic stress disorder (PTSD), called complex PTSD. I use data collected in this survey to look for distinct groups of responses and then I test for specific patterns across these groups to assess the usefulness of complex PTSD as a new category of mental illness.

What does participation involve?

Once you have agreed to take part in the study, you will be asked to complete three questionnaires that measure trauma symptoms, borderline symptoms, and childhood trauma. Finally, you will be asked to provide some sociodemographic details. The entire survey will take approximately 20 minutes.

What are the risks of participation?

It is possible that participating in the study may bring up some feelings of discomfort or anxiety, as some of the questions in the survey refer to traumatic experiences you may have had. Apart from potential discomfort arising from responding to the questionnaires, the study presents no foreseeable risks. Contact details for the UCT Wellness Centre and the UCT Student Careline will be made available should you feel concerned about your responses in the survey.

What are my rights during participation?

You may decline participation or withdraw at any time without penalty. This means that if you decide half way through taking the survey that you'd like to stop, you may do so. Responses are stored securely in a Google spreadsheet, accessible only with a 14-digit password that is known only to me. Responses are also kept strictly confidential so that individual responses are not identifiable in the study write up.

What are the benefits of participation?

Completion of the entire survey will grant you 1 SRPP point in course credit towards a second semester course of your choice. You will need to provide your name, surname, student number, email address, and specify the appropriate course code, in order for the course credit to be allocated successfully. Your personal details will not be used to identify your responses in the survey.

Where can I direct further questions?

Further information regarding the study can be obtained by contacting the researcher, James Rink (rinkjames@gmail.com), or my supervisor, Dr Gosia Lipinska (gosia.lipinska@uct.ac.za). Further questions regarding your rights as a participant, or issues related to the study, can be directed to the Research Ethics Committee, Department of Psychology, University of Cape Town by contacting Rosalind Adams (rosalind.adams@uct.ac.za, 021 650 3417).

- *I confirm that I have read and understand the above information*
- *I have had the opportunity to ask questions and had them answered*
- *I understand that all personal information will remain confidential and that all efforts will be made to ensure I cannot be identified (except as might be required by law)*
- *I agree that data gathered in this questionnaire may be stored anonymously*
- *I understand that my participation is voluntary and that I am free to withdraw at any time*
- *I agree to take part in this study*

Appendix C

Debrief Form

ACSENT Laboratory

Department of Psychology

University of Cape Town

PTSD and Complex PTSD Amongst South African Students

Dear study participant

Thank you for taking the time to participate in this study.

The point of this survey was to collect data that enables me assess the validity of complex PTSD as a new diagnosis. The responses you've contributed will help me to detect patterns in the data that may provide evidence for the usefulness of complex PTSD. Your responses will remain strictly confidential.

Some of the questions in this survey might've been uncomfortable to answer. If you left the survey midway, that's fine and there will be no penalty. If you feel concerned or anxious regarding your responses, please consider contacting either the UCT Student Careline or the Student Wellness Centre (details listed below).

- **The UCT Student Careline** offers 24/7 telephonic counselling, advice, referral facilities and general support to students facing any mental health challenges or emotional distress.

  Call **0800 24 25 26** (free from Telkom line)
  SMS **31393** for a call-me-back

- **The UCT Wellness Centre** offers predominantly short-term student counselling and psychotherapy, with the aim of ensuring that whatever personal, emotional or psychological problems students experience, the impact of these on their academic studies are kept to a minimum and their capacity for achievement is optimised.

  Call **021 650 1017**
  Email **Lerushda.cheddie@uct.ac.za**

Please feel free to contact me (rinkjames@gmail.com) directly with any other questions or feedback you may have. Alternatively, you're also welcome to direct queries and complaints to the Research Ethics Committee, Department of Psychology, University of Cape Town by contacting Rosalind Adams (rosalind.adams@uct.ac.za, 021 650 3417).

Best Regards,
James Rink

Appendix D

Ethics Approval

UNIVERSITY OF CAPE TOWN

Department of Psychology

University of Cape Town Rondebosch 7701 South Africa
Telephone (021) 650 3417
Fax No. (021) 650 4104

29 May 2018

James Rink
Department of Psychology
University of Cape Town
Rondebosch 7701

Dear James

I am pleased to inform you that ethical clearance has been given by an Ethics Review Committee of the Faculty of Humanities for your study, *PTSD and Complex PTSD Amongst South African Students: A Latent Class Analysis.* The reference number is PSY2018-022

I wish you all the best for your study.

Yours sincerely

University of Cape Town
PSYCHOLOGY DEPARTMENT
Upper Campus
Rondebosch

Lauren Wild (PhD)
Associate Professor
Chair: Ethics Review Committee

Appendix E

International Trauma Questionnaire (ITQ)

Please identify the experience that troubles you most and answer the questions in relation to this experience.

Brief description of the experience _____

When did the experience occur? (select one)

a. less than 6 months ago
b. 6 to 12 months ago
c. 1 to 5 years ago
d. 5 to 10 years ago
e. 10 to 20 years ago
f. more than 20 years ago

Below are a number of problems that people sometimes report in response to traumatic or stressful life events. Please read each item carefully, then select one of the numbers to the right to indicate how much you have been bothered by that problem in the past month.

	Not at all	A little bit	Moderately	Quite a bit	Extremely
In the past month, how much has this bothered you?					
1. Having upsetting dreams that replay part of the experience or are clearly related to the experience?	0	1	2	3	4
2. Having powerful images or memories that sometimes come into your mind in which you feel the experience is happening again in the here and now?	0	1	2	3	4
3. Avoiding internal reminders of the experience (for example, thoughts, feelings, or physical sensations)?	0	1	2	3	4
4. Avoiding external reminders of the experience (for example, people, places, conversations, objects, activities, or situations)?	0	1	2	3	4
5. Being “super-alert”, watchful, or on guard?	0	1	2	3	4
6. Feeling jumpy or easily startled?	0	1	2	3	4
In the past month have the above problems:					
7. Affected your relationships or social life?	0	1	2	3	4
8. Affected your work or ability to work?	0	1	2	3	4
9. Affected any other important part of your life such as parenting, or school or college work, or other important activities?	0	1	2	3	4

Below are problems that people who have had stressful or traumatic events sometimes experience. The questions refer to ways you typically feel, ways you typically think about yourself and ways you typically relate to others. Answer the following thinking about how true each statement is of you.

	Not at all	A little bit	Moderately	Quite a bit	Extremely
How true is this of you?					
1. When I am upset, it takes me a long time to calm down.	0	1	2	3	4
2. I feel numb or emotionally shut down.	0	1	2	3	4
3. I feel like a failure.	0	1	2	3	4
4. I feel worthless.	0	1	2	3	4
5. I feel distant or cut off from people.	0	1	2	3	4
6. I find it hard to stay emotionally close to people.	0	1	2	3	4
In the past month, have the above problems in emotions, in beliefs about yourself and in relationships:					
7. Created concern or distress about your relationships or social life?	0	1	2	3	4
8. Affected your work or ability to work?	0	1	2	3	4
9. Affected any other important parts of your life such as parenting, or school or college work, or other important activities?	0	1	2	3	4

Appendix F

McLean Screening Instrument for Borderline Personality Disorder (MSI-BPD)

	Yes	No
1. Have any of your closest relationships been troubled by a lot of arguments or repeated breakups?	1	0
2. Have you deliberately hurt yourself physically (e.g., punched yourself, cut yourself, burned yourself)? How about made a suicide attempt?	1	0
3. Have you had at least two other problems with impulsivity (e.g., eating binges and spending sprees, drinking too much and verbal outbursts)?	1	0
4. Have you been extremely moody?	1	0
5. Have you felt very angry a lot of the time? How about often acted in an angry or sarcastic manner?	1	0
6. Have you often been distrustful of other people?	1	0
7. Have you frequently felt unreal or as if things around you were unreal?	1	0
8. Have you chronically felt empty?	1	0
9. Have you often felt that you had no idea of who you are or that you have no identity?	1	0
10. Have you made desperate efforts to avoid feeling abandoned or being abandoned (e.g., repeatedly called someone to reassure yourself that he or she still cared, begged them not to leave you, clung to them physically)?	1	0

Appendix G

Childhood Trauma Questionnaire (CTQ)

For each of the questions below, please select the response that best represents how you feel about the statement, where 1 = never true, 2 = rarely true, 3 = sometimes true, 4 = often true, and 5 = very often true.

	Never true	Rarely true	Sometimes true	Often true	Very often true
When I was growing up…					
1. I didn't have enough to eat.	1	2	3	4	5
2. I knew that there was someone to take care of me and protect me.	1	2	3	4	5
3. People in my family called me things like 'stupid', 'lazy', or 'ugly'.	1	2	3	4	5
4. My parents were too drunk or high to take care of the family.	1	2	3	4	5
5. There was someone in my family who helped me feel that I was important or special.	1	2	3	4	5
6. I had to wear dirty clothes.	1	2	3	4	5
7. I felt loved.	1	2	3	4	5
8. I thought my parents wished I had never been born.	1	2	3	4	5
9. I got hit so hard by someone in my family that I had to see a doctor or go to the hospital.	1	2	3	4	5
10. There was nothing I wanted to change about my family.	1	2	3	4	5
11. People in my family hit me so hard that it left me with bruises or marks.	1	2	3	4	5

12. I was punished with a belt, a board, a cord, or some other hard object.	1	2	3	4	5
13. People in my family looked out for each other.	1	2	3	4	5
14. People in my family said hurtful or insulting things to me.	1	2	3	4	5
15. I believe that I was physically abused.	1	2	3	4	5
16. I had the perfect childhood.	1	2	3	4	5
17. I got hit or beaten so badly that it was noticed by someone like a teacher, neighbour, or doctor.	1	2	3	4	5
18. I felt that someone in my family hated me.	1	2	3	4	5
19. People in my family felt close to each other.	1	2	3	4	5
20. Someone tried to touch me in a sexual way or tried to make me touch them.	1	2	3	4	5
21. Someone threatened to hurt me or tell lies about me unless I did something sexual for them.	1	2	3	4	5
22. I had the best family in the world.	1	2	3	4	5
23. Someone made me try to do sexual things or watch sexual things.	1	2	3	4	5
24. Someone molested me.	1	2	3	4	5
25. I believe that I was emotionally abused.	1	2	3	4	5
26. There was someone to take me to the doctor if I needed it.	1	2	3	4	5
27. I believe that I was sexually abused.	1	2	3	4	5
28. My family was a source of strength and support.	1	2	3	4	5

Appendix H

Sociodemographic Questionnaire

Please indicate your,

- age: _____
- sex: _____
- race: _____

Please indicate the category of household income level that best applies to you:

- Lower income (R1–R19 200)
- Middle income (R19 201–R307 200)
- Upper income (R307 201 and above)

Appendix I

R Code

```
## packages ----
library(poLCA)
library(tidyverse)
library(caret)
library(magrittr)
library(broom)
library(ztable)
library(e1071)
library(reshape2)
library(readxl)
library(plyr)
library(dplyr)
library(ggplot2)
library(directlabels)
library(gridExtra)
library(grid)
library(scales)

## import data ----
CPTSD <- read_excel("CPTSD20180816.xlsx")

## cleaning vars ----
colnames(CPTSD) <- c('time','email','consent','itq.trauma','itq.trauma.time',
                     'itq.re.1','itq.re.2','itq.av.1','itq.av.2','itq.th.1',
                     'itq.th.2','itq.imp.ptsd.1','itq.imp.ptsd.2','itq.imp.ptsd.3',
                     'itq.ad.1','itq.ad.2','itq.nsc.1','itq.nsc.2','itq.dr.1',
                     'itq.dr.2','itq.imp.dso.1','itq.imp.dso.2','itq.imp.dso.3',
                     'bpd.1','bpd.2','bpd.3','bpd.4','bpd.5','bpd.6','bpd.7',
                     'bpd.8','bpd.9','bpd.10','ctq.1','ctq.2','ctq.3','ctq.4',
                     'ctq.5','ctq.6','ctq.7','ctq.8','ctq.9','ctq.10','ctq.11',
                     'ctq.12','ctq.13','ctq.14','ctq.15','ctq.16','ctq.17',
                     'ctq.18','ctq.19','ctq.20','ctq.21','ctq.22','ctq.23',
                     'ctq.24','ctq.25','ctq.26','ctq.27','ctq.28','age','sex',
                     'race','income','fname','sname','dup.id','course')
colnames(CPTSD)

# removing rows based on duplicate id
CPTSD <- CPTSD[unique(CPTSD$dup.id), ]

# itq vars
CPTSD[,6:23] <- lapply(CPTSD[,6:23],
  factor,
  levels=c('Not at all','A little bit','Moderately','Quite a bit','Extremely'),
  labels = 1:5)
CPTSD[,6:23] <- lapply(CPTSD[,6:23],
  function(x) as.numeric(levels(x))[as.integer(x)])

# bpd vars
CPTSD[,24:33] <- lapply(CPTSD[,24:33],
  factor,
  levels=c('No','Yes'),
  labels = 1:2)
CPTSD[,24:33] <- lapply(CPTSD[,24:33],
  function(x) as.numeric(levels(x))[as.integer(x)])

# ctq vars
CPTSD[,34:61] <- lapply(CPTSD[,34:61],
  factor,
  levels=c('Never true','Rarely true','Sometimes true','Often true','Very often true'),
  labels = 1:5)
CPTSD[,34:61] <- lapply(CPTSD[,34:61],
  function(x) as.numeric(levels(x))[as.integer(x)])

str(CPTSD)
summary(CPTSD)
colnames(CPTSD)
glimpse(CPTSD)

# sex var
CPTSD$sex <- tolower(CPTSD$sex)
CPTSD$sex <- str_replace_all(CPTSD$sex,
  c('female|femsle'),
  'f')
CPTSD$sex <- str_replace_all(CPTSD$sex,
  c('male|make'),
  'm')
CPTSD$sex <- as.factor(CPTSD$sex)

# race var
CPTSD$race <- tolower(CPTSD$race)
CPTSD$race <- gsub("\\s*\\([^\\)]+\\)","",as.character(CPTSD$race))
CPTSD$race <- str_replace_all(CPTSD$race,
  c('white/european|white/medeteranian|white/caucasian|caucasian|whiteish'),
  'white')
CPTSD$race <- str_replace_all(CPTSD$race,
  c('asian|biracial- black and white|biracial|hispanic|white/coloured'),
```

```
  'other')
CPTSD$race <- str_replace_all(CPTSD$race,
  c('cape malay/coloured|mixed race|colored|coloured'),
  'mixed')
CPTSD$race <- str_replace_all(CPTSD$race,
  c('black south african|black african|african black|black/african|black'),
  'african')
CPTSD$race <- str_replace_all(CPTSD$race,
  c('indian/arab|indian'),
  'indian')

CPTSD$race <- as.factor(CPTSD$race)
levels(CPTSD$race)
summary(CPTSD$race)

# household-income var
CPTSD$income <- gsub("\\s*\\([^\\)]+\\)","",as.character(CPTSD$income))
CPTSD$income <- as.factor(CPTSD$income)

par(mfrow=c(1, 2))
barplot(summary(CPTSD$race))
barplot(summary(CPTSD$sex))

## calculating vars ----
itq.cutoff <- 3 #given range 1 to 5

## PTSD symptom diagnostic cut-offs (binary); no = 1; yes = 2

# re-experiencing
CPTSD$re1 <- case_when(
  CPTSD$itq.re.1 >= itq.cutoff ~ 2, TRUE ~ 1)
CPTSD$re2 <- case_when(
  CPTSD$itq.re.2 >= itq.cutoff ~ 2, TRUE ~ 1)
# avoidance
CPTSD$av1 <- case_when(
  CPTSD$itq.av.1 >= itq.cutoff ~ 2, TRUE ~ 1)
CPTSD$av2 <- case_when(
  CPTSD$itq.av.2 >= itq.cutoff ~ 2, TRUE ~ 1)
# threat
CPTSD$th1 <- case_when(
  CPTSD$itq.th.1 >= itq.cutoff ~ 2, TRUE ~ 1)
CPTSD$th2 <- case_when(
  CPTSD$itq.th.2 >= itq.cutoff ~ 2, TRUE ~ 1)

## DSO symptom diagnostic cut-offs (binary); no = 1; yes = 2

# affective dysregulation
CPTSD$ad1 <- case_when(
  CPTSD$itq.ad.1 >= itq.cutoff ~ 2, TRUE ~ 1)
CPTSD$ad2 <- case_when(
  CPTSD$itq.ad.2 >= itq.cutoff ~ 2, TRUE ~ 1)
# negative self concept
CPTSD$nsc1 <- case_when(
  CPTSD$itq.nsc.1 >= itq.cutoff ~ 2, TRUE ~ 1)
CPTSD$nsc2 <- case_when(
  CPTSD$itq.nsc.2 >= itq.cutoff ~ 2, TRUE ~ 1)
# disturbances in relationships
CPTSD$dr1 <- case_when(
  CPTSD$itq.dr.1 >= itq.cutoff ~ 2, TRUE ~ 1)
CPTSD$dr2 <- case_when(
  CPTSD$itq.dr.2 >= itq.cutoff ~ 2, TRUE ~ 1)

## PTSD symptom cluster diagnostic cut-offs (binary); no = 1; yes = 2

# re-experiencing
CPTSD$re <- case_when(
  CPTSD$re1 == 2 |
  CPTSD$re2 == 2 ~ 2, TRUE ~ 1)
# avoidance
CPTSD$av <- case_when(
  CPTSD$av1 == 2 |
  CPTSD$av2 == 2 ~ 2, TRUE ~ 1)
# threat
CPTSD$th <- case_when(
  CPTSD$th1 == 2 |
  CPTSD$th2 == 2 ~ 2, TRUE ~ 1)

## DSO symptom cluster diagnostic cut-offs (binary); no = 1; yes = 2

# affective dysregulation
CPTSD$ad <- case_when(
  CPTSD$ad1 == 2 |
  CPTSD$ad2 == 2 ~ 2, TRUE ~ 1)
# negative self concept
CPTSD$nsc <- case_when(
  CPTSD$nsc1 == 2 |
  CPTSD$nsc2 == 2 ~ 2, TRUE ~ 1)
# disturbances in relationships
CPTSD$dr <- case_when(
  CPTSD$dr1 == 2 |
  CPTSD$dr2 == 2 ~ 2, TRUE ~ 1)

## functional impairment

# PTSD (binary); no = 1; yes = 2
CPTSD$imp.ptsd = case_when(
```

```
  CPTSD$itq.imp.ptsd.1 >= itq.cutoff |
  CPTSD$itq.imp.ptsd.2 >= itq.cutoff |
  CPTSD$itq.imp.ptsd.3 >= itq.cutoff ~ 2, TRUE ~ 1)
# DSO (binary); no = 1; yes = 2
CPTSD$imp.dso <- case_when(
  CPTSD$itq.imp.dso.1 >= itq.cutoff |
  CPTSD$itq.imp.dso.2 >= itq.cutoff |
  CPTSD$itq.imp.dso.3 >= itq.cutoff ~ 2, TRUE ~ 1)

## diagnoses

#PTSD (binary); no = 1; yes = 2
CPTSD$ptsd <- case_when(
  CPTSD$re == 2 &
  CPTSD$av == 2 &
  CPTSD$th == 2 &
  CPTSD$imp.ptsd == 2 ~ 2, TRUE ~ 1)
#CPTSD (binary); no = 1; yes = 2
CPTSD$cptsd <- case_when(
  CPTSD$ptsd == 2 &
  CPTSD$ad == 2 &
  CPTSD$nsc == 2 &
  CPTSD$dr == 2 &
  CPTSD$imp.dso == 2 ~ 2, TRUE ~ 1)
# BPD (binary); no = 1; yes = 2
CPTSD$bpd.b <- case_when(rowSums(
  CPTSD[,(
    which(colnames(CPTSD)=='bpd.1'):
    which(colnames(CPTSD)=='bpd.10'))]-1) >= 7 ~ 2, TRUE ~ 1)
# BPD (continuous); 1 through 11
CPTSD$bpd.c <- rowSums(
  CPTSD[,(
    which(colnames(CPTSD)=='bpd.1'):
    which(colnames(CPTSD)=='bpd.10'))]-1) + 1

## CTQ scales (continuous); 5 through 25

# emotional abuse
CPTSD$ea <- rowSums(
  CPTSD[,c('ctq.3','ctq.8','ctq.14','ctq.18','ctq.25')])
# physical abuse
CPTSD$pa <- rowSums(
  CPTSD[,c('ctq.9','ctq.11','ctq.12','ctq.15','ctq.17')])
# sexual abuse
CPTSD$sa <- rowSums(
  CPTSD[,c('ctq.20','ctq.21','ctq.23','ctq.24','ctq.27')])
# emotional neglect
CPTSD$en <- (5*6) -
  rowSums(CPTSD[,c('ctq.5','ctq.7','ctq.13','ctq.19','ctq.28')])
# physical neglect
CPTSD$pn <- (2*6) -
  rowSums(CPTSD[,c('ctq.2','ctq.26')]) +
  rowSums(CPTSD[,c('ctq.1','ctq.4','ctq.6')])
# minimisation / denial (continuous); 1 through 4
CPTSD$md <- rowSums(
  CPTSD[,c('ctq.10','ctq.16','ctq.22')] == 5) + 1

## CTQ scale severity cut-offs

## minimal severity (binary); no = 1; yes = 2

# emotional abuse
CPTSD$ea.min <- case_when(
  CPTSD$ea <= 8 ~ 2, TRUE ~ 1)
# physical abuse
CPTSD$pa.min <- case_when(
  CPTSD$pa <= 7 ~ 2, TRUE ~ 1)
# sexual abuse
CPTSD$sa.min <- case_when(
  CPTSD$sa <= 5 ~ 2, TRUE ~ 1)
# emotional neglect
CPTSD$en.min <- case_when(
  CPTSD$en <= 9 ~ 2, TRUE ~ 1)
# physical neglect
CPTSD$pn.min <- case_when(
  CPTSD$pn <= 7 ~ 2, TRUE ~ 1)

## low severity (binary); no = 1; yes = 2

# emotional abuse
CPTSD$ea.low <- case_when(
  CPTSD$ea >= 9 &
  CPTSD$ea <= 12 ~ 2, TRUE ~ 1)
# physical abuse
CPTSD$pa.low <- case_when(
  CPTSD$pa >= 8 &
  CPTSD$pa <= 9 ~ 2, TRUE ~ 1)
# sexual abuse
CPTSD$sa.low <- case_when(
  CPTSD$sa >= 6 &
  CPTSD$sa <= 7 ~ 2, TRUE ~ 1)
# emotional neglect
CPTSD$en.low <- case_when(
  CPTSD$en >= 10 &
  CPTSD$en <= 14 ~ 2, TRUE ~ 1)
# physical neglect
```

```
CPTSD$pn.low <- case_when(
  CPTSD$pn >= 8 &
  CPTSD$pn <= 9 ~ 2, TRUE ~ 1)

## moderate severity (binary); no = 1; yes = 2

# emotional abuse
CPTSD$ea.mod <- case_when(
  CPTSD$ea >= 13 &
   CPTSD$ea <= 15 ~ 2, TRUE ~ 1)
# physical abuse
CPTSD$pa.mod <- case_when(
  CPTSD$pa >= 10 &
  CPTSD$pa <= 12 ~ 2, TRUE ~ 1)
# sexual abuse
CPTSD$sa.mod <- case_when(
  CPTSD$sa >= 8 &
  CPTSD$sa <= 12 ~ 2, TRUE ~ 1)
# emotional neglect
CPTSD$en.mod <- case_when(
  CPTSD$en >= 15 &
  CPTSD$en <= 17 ~ 2, TRUE ~ 1)
# physical neglect
CPTSD$pn.mod <- case_when(
  CPTSD$pn >= 10 &
  CPTSD$pn <= 12 ~ 2, TRUE ~ 1)

## severe severity (binary); no = 1; yes = 2

# emotional abuse
CPTSD$ea.sev <- case_when(
  CPTSD$ea >= 16 ~ 2, TRUE ~ 1)
# physical abuse
CPTSD$pa.sev <- case_when(
  CPTSD$pa >= 13 ~ 2, TRUE ~ 1)
# sexual abuse
CPTSD$sa.sev <- case_when(
  CPTSD$sa >= 13 ~ 2, TRUE ~ 1)
# emotional neglect
CPTSD$en.sev <- case_when(
  CPTSD$en >= 18 ~ 2, TRUE ~ 1)
# physical neglect
CPTSD$pn.sev <- case_when(
  CPTSD$pn >= 13 ~ 2, TRUE ~ 1)

## moderate-to-severe trauma (binary); no = 1; yes = 2
# emotional abuse
CPTSD$ea.modsev <- case_when(
  CPTSD$ea.mod == 2 |
  CPTSD$ea.sev == 2 ~ 2, TRUE ~ 1)
# physical abuse
CPTSD$pa.modsev <- case_when(
  CPTSD$pa.mod == 2 |
    CPTSD$pa.sev == 2 ~ 2, TRUE ~ 1)
# sexual abuse
CPTSD$sa.modsev <- case_when(
  CPTSD$sa.mod == 2 |
    CPTSD$sa.sev == 2 ~ 2, TRUE ~ 1)
# emotional neglect
CPTSD$en.modsev <- case_when(
  CPTSD$en.mod == 2 |
    CPTSD$en.sev == 2 ~ 2, TRUE ~ 1)
# physical neglect
CPTSD$pn.modsev <- case_when(
  CPTSD$pn.mod == 2 |
    CPTSD$pn.sev == 2 ~ 2, TRUE ~ 1)

## total abuse score (continuous); 15 through 75
CPTSD$abuse.total <- CPTSD$ea + CPTSD$pa + CPTSD$sa
## total neglect score (continuous); 10 though 50
CPTSD$neglect.total <- CPTSD$en + CPTSD$pn
## total CTQ trauma score
CPTSD$trauma.total <- CPTSD$abuse.total + CPTSD$neglect.total

## abuse-exposure-types for moderate-to-severe abuse (continuous); 1 through 4
CPTSD$abuse.types <- rowSums(
  CPTSD[,c('ea.modsev','pa.modsev','sa.modsev')] == 2) + 1
## neglect-exposure-types for moderate-to-severe neglect (continuous); 1 through 3
CPTSD$neglect.types <- rowSums(
  CPTSD[,c('en.modsev','pn.modsev')] == 2) + 1
## total trauma-exposure-types (continuous); 1 through 6
CPTSD$trauma.types <- rowSums(
  CPTSD[,c('ea.modsev','pa.modsev','sa.modsev','en.modsev','pn.modsev')] == 2) + 1

glimpse(CPTSD)

## filtering dataframe by relevant vars  ----

# moderate to severe abuse
CPTSD.modsev.a <- filter(CPTSD,CPTSD$abuse.types >= 2)
CPTSD.ea <- filter(CPTSD,CPTSD$ea >= 13)
CPTSD.pa <- filter(CPTSD,CPTSD$pa >= 10)
CPTSD.sa <- filter(CPTSD,CPTSD$sa >= 8)

# moderate to severe neglect
CPTSD.modsev.n <- filter(CPTSD,CPTSD$neglect.types >= 2)
```

```
CPTSD.en <- filter(CPTSD,CPTSD$en >= 15)
CPTSD.pn <- filter(CPTSD,CPTSD$pn >= 10)

# sex
CPTSD.f <- filter(CPTSD,CPTSD$sex == 'f')
CPTSD.m <- filter(CPTSD,CPTSD$sex == 'm')

# race
CPTSD.african <- filter(CPTSD,CPTSD$race == 'african')
CPTSD.asianindian <- filter(CPTSD,CPTSD$race == 'asian/indian')
CPTSD.mixed <- filter(CPTSD,CPTSD$race == 'mixed')
CPTSD.white <- filter(CPTSD,CPTSD$race == 'white')

## randomly splitting dataframe for cross validation ----
set.seed(321)
a <- createDataPartition(CPTSD$age, groups=2, p = 0.6, list=FALSE)

CPTSD.1 <- CPTSD[a,]
CPTSD.2 <- CPTSD[-a,]

remove(a)

## ----
## entering manifest vars ----

# dataframe
df <- CPTSD

# manifest vars to correlate for scatter plots
cvar1 <- 'dr1'
cvar2 <- 'bpd.8'

# manifest vars
lca.vars <- names(
  df[,c(
    which(colnames(CPTSD)=='re1'):which(colnames(CPTSD)=='dr2'),
    which(colnames(CPTSD)=='bpd.1'):which(colnames(CPTSD)=='bpd.10'))])

# LCA formula
f <- cbind(re1,re2,av1,av2,th1,th2,ad1,ad2,nsc1,nsc2,dr1,dr2,
           bpd.1,bpd.2,bpd.3,bpd.4,bpd.5,bpd.6,bpd.7,bpd.8,bpd.9,bpd.10)~1

## manifest vars

# dx-clusters + bpd: re, av, th, ad, nsc, dr, bpd1, ... bpd9, bpd10
#lca.vars <- names(df[,c(82:87,24:33)])
# dx-clusters: re, av, th, ad, nsc, dr
#lca.vars <- names(df[,c(82:87)])
# dx-symptoms + bpd: re1, re2, ... d1, d2, bpd1, ... bpd9, bpd10
#lca.vars <- names(df[,c(70:81,24:33)])
# dx-symptoms: re1, re2, ... d1, d2
#lca.vars <- names(df[,c(70:81)])
# ITQ items: itq.re1, itq.re2, ... itq.dr1, itq.dr2
#lca.vars <- names(df[,c(6:11,15:20)])

## covariate vars

# bpd
#lca.covars <- "bpd.c"
# bpd.1 ... bpd.10
#lca.covars <- names(df[,c(24:33)])
# abuse total
#lca.covars <- "abuse.total"

## LCA formula

#f <- as.formula(paste("cbind(",paste(lca.vars, collapse = ","), ")~",paste(lca.covars, collapse = "+") ))
#f <- as.formula(paste("cbind(", paste(lca.vars, collapse = ","), ")~1"))

## generate 1-4 models of classes x-y ----
classes <- 1:4

#set.seed(203987)
#M0 <- llply(classes, function(k)
#  poLCA(f,df,nclass=k,probs.start=M0.reorder[k],maxiter=3000,tol=1e-10,nrep=1,calc.se=TRUE))

for(i in classes[1]:classes[4]) {
  set.seed(45634)
  lc <- poLCA(f,df,nclass=i,maxiter=3000,tol=1e-10,nrep=100,verbose=FALSE)
  lc.reorder <- poLCA.reorder(lc$probs.start,
                              if(i==4) {
                                c(3,4,1,2)}
                                else {order(lc$P,decreasing=TRUE)})
  assign(paste('lc',i,sep=''),
         poLCA(f,df,nclass=i,probs.start=lc.reorder,maxiter=3000,tol=1e-10,nrep=100,calc.se=TRUE))
  }

#set.seed(45634)
#lc4 <- poLCA(f,df,nclass=4,maxiter=3000,tol=1e-10,nrep=100)
#probs.start <- lc4$probs.start
#lc4.reorder <- poLCA.reorder(probs.start,c(2,4,3,1))
#lc4 <- poLCA(f,df,nclass=4,maxiter=3000,tol=1e-10,nrep=100,probs.start=lc4.reorder)

M0 <- list(get(paste('lc',classes[1],sep='')),
           get(paste('lc',classes[2],sep='')),
           get(paste('lc',classes[3],sep='')),
```

```
        get(paste('lc',classes[4],sep="")))

## model fit criteria ----
M0_fit <- data.frame(model=paste(nrow(as.data.frame(M0[[1]]$probs[1])),"-class", sep=""),
                     loglik=M0[[1]]$llik,
                     #df=M0[[1]]$resid.df,
                     bic=M0[[1]]$bic,
                     abic=(-2*M0[[1]]$llik) + ((log((M0[[1]]$N + 2)/24)) * M0[[1]]$npar),
                     aic=M0[[1]]$aic,
                     caic=(-2*M0[[1]]$llik) + M0[[1]]$npar * (1 + log(M0[[1]]$N)),
                     #loglikratio=M0[[1]]$Gsq,
                     entropy=NA)

# model
M0_fit$model <- as.character(M0_fit$model)
M0_fit[2,1] <- paste(nrow(as.data.frame(M0[[2]]$probs[1])),"-class", sep="")
M0_fit[3,1] <- paste(nrow(as.data.frame(M0[[3]]$probs[1])),"-class", sep="")
M0_fit[4,1] <- paste(nrow(as.data.frame(M0[[4]]$probs[1])),"-class", sep="")

# log-likelihood
M0_fit[2,2] <- M0[[2]]$llik
M0_fit[3,2] <- M0[[3]]$llik
M0_fit[4,2] <- M0[[4]]$llik

# resid. df
#M0_fit[2,3] <- M0[[2]]$resid.df
#M0_fit[3,3] <- M0[[3]]$resid.df
#M0_fit[4,3] <- M0[[4]]$resid.df

# BIC
M0_fit[2,3] <- M0[[2]]$bic
M0_fit[3,3] <- M0[[3]]$bic
M0_fit[4,3] <- M0[[4]]$bic

# aBIC
M0_fit[2,4] <- (-2*M0[[2]]$llik) + ((log((M0[[2]]$N + 2)/24)) * M0[[2]]$npar)
M0_fit[3,4] <- (-2*M0[[3]]$llik) + ((log((M0[[3]]$N + 2)/24)) * M0[[3]]$npar)
M0_fit[4,4] <- (-2*M0[[4]]$llik) + ((log((M0[[4]]$N + 2)/24)) * M0[[4]]$npar)

# AIC
M0_fit[2,5] <- M0[[2]]$aic
M0_fit[3,5] <- M0[[3]]$aic
M0_fit[4,5] <- M0[[4]]$aic

# cAIC
M0_fit[2,6] <- (-2*M0[[2]]$llik) + M0[[2]]$npar * (1 + log(M0[[2]]$N))
M0_fit[3,6] <- (-2*M0[[3]]$llik) + M0[[3]]$npar * (1 + log(M0[[3]]$N))
M0_fit[4,6] <- (-2*M0[[4]]$llik) + M0[[4]]$npar * (1 + log(M0[[4]]$N))

# likelihood-ratio
#M0_fit[2,7] <- M0[[2]]$Gsq
#M0_fit[3,7] <- M0[[3]]$Gsq
#M0_fit[4,7] <- M0[[4]]$Gsq

# Entropy
entropy <- function (p) sum(-p*log(p))

error_prior <- entropy(M0[[1]]$P)
error_post <- mean(apply(M0[[1]]$posterior,1, entropy),na.rm = TRUE)
M0[[1]]$entropy <- round(((error_prior-error_post) / error_prior),3)

error_prior <- entropy(M0[[2]]$P)
error_post <- mean(apply(M0[[2]]$posterior,1, entropy),na.rm = TRUE)
M0[[2]]$entropy <- round(((error_prior-error_post) / error_prior),3)

error_prior <- entropy(M0[[3]]$P)
error_post <- mean(apply(M0[[3]]$posterior,1, entropy),na.rm = TRUE)
M0[[3]]$entropy <- round(((error_prior-error_post) / error_prior),3)

error_prior <- entropy(M0[[4]]$P)
error_post <- mean(apply(M0[[4]]$posterior,1, entropy),na.rm = TRUE)
M0[[4]]$entropy <- round(((error_prior-error_post) / error_prior),3)

M0_fit[1,7] <- M0[[1]]$entropy
M0_fit[2,7] <- M0[[2]]$entropy
M0_fit[3,7] <- M0[[3]]$entropy
M0_fit[4,7] <- M0[[4]]$entropy

M0_fit

ztable(M0_fit) %>%
  makeHeatmap(mycolor=gradientColor(
    low="#57bb8a",
    mid="#ffffff",
    high="#e67c73",n=8),cols=c(3,4,5,6),margin=2) %>%
  print(caption="model fit criteria")

# export to csv for use in MPLUS for LMRA and BLRT p-values
#write.csv(df[,lca.vars], file="cptsdlca.csv",row.names=FALSE,col.names=FALSE)
#write.table(df[,lca.vars], file="cptsdlca.dat",row.names = FALSE, col.names = FALSE, sep=',')


## specify best model: lowest BIC ----
bestmodel <- which(M0_fit$bic==min(M0_fit$bic))
```

```
## profile plots ----

# manifest var levels
item.l <- nrow(unique(df[,lca.vars[1]]))

# class-conditional probabilities
M0_classmeans <- ldply(M0,
   function(M) ldply(M$probs,
   function(p) colSums((1:ncol(p))*t(p))-1))

# standard errors
M0_classmeans.se <- ldply(M0,
   function(M) ldply(M$probs.se,
   function(p) colSums((1:ncol(p))*t(p))))

# confidence intervals from standard errors
#lower bounds
M0_classmeans_lower <- data.frame(
  .id=M0_classmeans$.id,
  M0_classmeans[,2:ncol(M0_classmeans)]-
  M0_classmeans.se[,2:ncol(M0_classmeans)])
#upper bounds
M0_classmeans_upper <- data.frame(
  .id=M0_classmeans$.id,
  M0_classmeans[,2:ncol(M0_classmeans)]+
  M0_classmeans.se[,2:ncol(M0_classmeans)])

# if manifest vars = ITQ items, then average the class-cond probs per symptom
if(item.l > 2) {

  M0_classmeans_list <- lapply(
    list(M0_classmeans,
         M0_classmeans_lower,
         M0_classmeans_upper),

    function(w) {
      cbind(.id = c('re','av','th','ad','nsc','dr'),
            aggregate(w[,2:(classes[4]+1)],
                      list(rep(1:(nrow(w[,2:(classes[4]+1)])%/%2+1),
                               each=2,
                               len=nrow(w[,2:(classes[4]+1)]))),
                      mean)[-1]) })

  M0_classmeans <- M0_classmeans_list[1]
  M0_classmeans_lower <- M0_classmeans_list[2]
  M0_classmeans_upper <- M0_classmeans_list[3]
}
M0_classmeans_list
```

```
# tabulating class-condiitonal probabilities
expected_value <- melt(M0_classmeans)[,1:3]
expected_value$lower <- melt(M0_classmeans_lower)[,3]
expected_value$upper <- melt(M0_classmeans_upper)[,3]

solution_names <- c(paste(classes[1],"-class", sep=""),
                    paste(classes[2],"-class", sep=""),
                    paste(classes[3],"-class", sep=""),
                    paste(classes[4],"-class", sep=""))

expected_value$solution <- solution_names[
  rep(rep(1:4, each=
          if(item.l > 2) {
            length(lca.vars)/2}
          else {length(lca.vars)}),classes[4])]

names(expected_value) <- c("Variable","Class", "Expected value",
                           "Lower bound", "Upper bound", "Solution")
levels(expected_value$Class) <- as.character(seq_along(levels(expected_value$Class)))
expected_value$Variable <- factor(expected_value$Variable,levels =
                                  if(item.l > 2) {
                                    c('re','av','th','ad','nsc','dr')}
                                  else {lca.vars})

x.order <- c('re1','re2','av1','av2','th1','th2','ad1','ad2','nsc2','nsc1','dr1','dr2',
             'bpd.10','bpd.1','bpd.9','bpd.3','bpd.2','bpd.4','bpd.8','bpd.5','bpd.6','bpd.7')

x.labels <- c('PTSD Dreams','PTSD Flashbacks','PTSD AV Thoughts',
              'PTSD AV Behaviour','PTSD Alert','PTSD Startle',
              'DSO Anger','DSO Sensitive','DSO Worthless',
              'DSO Guilty','DSO Distant','DSO Detached',
              'BPD Frantic','BPD UnstabRel','BPD UnstabSelf',
              'BPD Impulsive','BPD SelfHarm','BPD MoodChange',
              'BPD Empty','BPD Temper','BPD Paranoid','BPD Dissociation')

x.order.orig <- c('re1','re2','av1','av2','th1','th2','ad1','ad2','nsc1','nsc2','dr1','dr2',
                  'bpd.1','bpd.2','bpd.3','bpd.4','bpd.5','bpd.6','bpd.7','bpd.8','bpd.9','bpd.10')

x.labels.orig <- c('PTSD Dreams','PTSD Flashbacks','PTSD AV Thoughts',
              'PTSD AV Behaviour','PTSD Alert','PTSD Startle',
              'DSO Anger','DSO Sensitive','DSO Guilty',
              'DSO Worthless','DSO Distant','DSO Detached',
              'BPD UnstabRel','BPD SelfHarm','BPD Impulsive',
              'BPD MoodChange','BPD Temper','BPD Para',
              'BPD Diss','BPD Empty','BPD UnstabSelf','BPD Frantic')

# profiles plots of models 1-4 of classes x-y
```

```
pl1 <- ggplot(expected_value, aes(x=Variable, y=`Expected value`, shape=Class))
pl1 + facet_wrap(~Solution) +
  geom_point() +
  annotate("rect",
           xmin=-Inf, xmax=(which(is.element(lca.vars,c('th','th2')))+0.5),
           ymin=-Inf, ymax=Inf, alpha=0.65, fill="#dce6f2") +
  annotate("rect",
           xmin=(which(is.element(lca.vars,c('th','th2')))+0.5),
           xmax=(which(is.element(lca.vars,c('dr','dr2')))+0.5),
           ymin=-Inf, ymax=Inf, alpha=0.65, fill="#ecf0df") +
  annotate("rect",
           xmin=(which(is.element(lca.vars,c('dr','dr2')))+0.5),
           xmax=Inf, ymin=-Inf, ymax=Inf, alpha=0.65, fill="#f1dcdb") +
  geom_point(aes(colour=Class)) +
  geom_line(aes(colour = Class, group = Class)) +
  geom_ribbon(aes(
    ymin=`Lower bound`,
    ymax=`Upper bound`,
    fill=Class,group=Class), alpha=0.1) +
  theme_bw() +
  guides(colour=FALSE, shape=FALSE, fill=FALSE) +
  geom_dl(aes(colour=Class,label=Class),
          method= list(dl.trans(x=x+0.2), "last.qp", cex=1)) +
  scale_y_continuous(breaks=seq(0,1,.1)) +
  scale_x_discrete(limits=x.order) +
  theme(axis.text.x = element_text(angle=45,vjust=1,hjust=1),
        panel.grid.minor.x=element_blank(),
        panel.grid.major.x=element_blank(),
        panel.grid.minor.y=element_blank(),
        axis.title.x = element_blank(),
        axis.title.y = element_blank(),
        axis.ticks = element_blank(),
        panel.border = element_blank()
)

## best model profile plot ----

# re-naming classes to reorder for plots
#M0[[bestmodel]]$predclass[M0[[bestmodel]]$predclass==1] <- 1
#M0[[bestmodel]]$predclass[M0[[bestmodel]]$predclass==3] <- 99
#M0[[bestmodel]]$predclass[M0[[bestmodel]]$predclass==4] <- 3
#M0[[bestmodel]]$predclass[M0[[bestmodel]]$predclass==2] <- 98
#M0[[bestmodel]]$predclass[M0[[bestmodel]]$predclass==98] <- 4
#M0[[bestmodel]]$predclass[M0[[bestmodel]]$predclass==99] <- 2

#class.breaks <- c(1,3,4,2,5)
class.labels <- c(paste("Class 1 PTSD-BPD (",
                        percent(length(M0[[bestmodel]]$predclass[M0[[bestmodel]]$predclass==1])
                                /M0[[bestmodel]]$N),")",sep=""),
                  paste("Class 2 CPTSD-BPD (",
                        percent(length(M0[[bestmodel]]$predclass[M0[[bestmodel]]$predclass==2])
                                /M0[[bestmodel]]$N),")",sep=""),
                  paste("Class 3 DSO-BPD (",
                        percent(length(M0[[bestmodel]]$predclass[M0[[bestmodel]]$predclass==3])
                                /M0[[bestmodel]]$N),")",sep=""),
                  paste("Class 4 Low symptom (",
                        percent(length(M0[[bestmodel]]$predclass[M0[[bestmodel]]$predclass==4])
                                /M0[[bestmodel]]$N),")",sep=""),
                  "class 5")

pl2 <- ggplot(expected_value[
  expected_value$Solution==paste(c(classes[bestmodel],"-class"),collapse=""),],
              aes(x=Variable, y=`Expected value`))
pl2 + facet_wrap(~Solution) +
  #geom_point() +
  annotate("rect",
           xmin=-Inf, xmax=(which(is.element(lca.vars,c('th','th2')))+0.5),
           ymin=-Inf, ymax=Inf, alpha=.4, fill="#a4c2f4") +
  annotate("rect",
           xmin=(which(is.element(lca.vars,c('th','th2')))+0.5),
           xmax=(which(is.element(lca.vars,c('dr','dr2')))+0.5),
           ymin=-Inf, ymax=Inf, alpha=.4, fill="#b6d7a8") +
  annotate("rect",
           xmin=(which(is.element(lca.vars,c('dr','dr2')))+0.5),
           xmax=Inf, ymin=-Inf, ymax=Inf, alpha=.4, fill="#ea9999") +
  #geom_ribbon(aes(
  #  ymin=`Lower bound`,
  #  ymax=`Upper bound`,
  #  group=Class), alpha=0.3) +
  #geom_point(aes(colour=Class) +
  geom_hline(yintercept = seq(0,1,.1), color="#939398") +
  geom_point(aes(color=Class,shape=Class,group=Class),size=4.5) +
  scale_shape_manual(values=c(19,19,19,19,19),
                     #breaks=class.breaks,
                     labels = class.labels) +
  scale_color_manual(values=c('#A6A6A6','#000000','#000000','#A6A6A6','#000000'),
                     #breaks=class.breaks,
                     labels = class.labels) +
  geom_line(aes(linetype = Class, group = Class, size=Class, color=Class),size=2.25) +
  scale_linetype_manual(values=c("solid","solid","31","31","solid"),
                     #breaks=class.breaks,
                     labels = class.labels) +
  theme_bw() +
  guides(fill=FALSE, size=FALSE) +
  #geom_dl(aes(colour=Class,label=Class),
```

```
 #       method= list(dl.trans(x=x+0.2), "last.qp", cex=1)) +
 scale_y_continuous(labels=percent,breaks=seq(0,1,.1),expand=expand_scale(mult = c(.0025,.0025))) +
 #scale_y_continuous(expand=expand_scale(mult = c(.0025,.0025))) +
 scale_x_discrete(limits=x.order,labels=x.labels) +
 #scale_x_discrete(limits=x.order.orig,labels=x.labels.orig) +
 expand_limits(x = 0, y = 0) +
 theme(axis.text.x = element_text(angle=45,vjust=1,hjust=1,size=16,color='black'),
       axis.text.y = element_text(size=16,color='black'),
       panel.grid.minor.x=element_blank(),
       panel.grid.major.x=element_blank(),
       panel.grid.minor.y=element_blank(),
       panel.grid.major.y=element_blank(),
       axis.title.x = element_blank(),
       axis.title.y = element_blank(),
       axis.ticks = element_blank(),
       axis.ticks.y = element_line(color="#939398",size=.5),
       strip.background = element_blank(),
       strip.text = element_blank(),
       panel.border = element_blank(),
       legend.title = element_blank(),
       legend.key.width = unit(2.5, 'cm'),
       legend.text=element_text(size=16,margin = margin(r = 30, unit = "pt")),
       legend.margin = margin(c(5, 5, 5, 0)),
       legend.position="bottom"
 )



## ----
## correlation matrices ----

# list of correlation matrices of manifest vars in best model
M0_cor <- dlply(df, .(M0[[bestmodel]]$predclass),
                function(x) signif(cor(x[,lca.vars]),2))

# per class correlation matrices of manifest vars in best model
for(i in 1:classes[bestmodel]) {
  assign(paste('cm',i,sep=''),as.data.frame(M0_cor[i]))
}
remove(i)
names(cm1) <- substring(names(cm1),4)
names(cm2) <- substring(names(cm2),4)
names(cm3) <- substring(names(cm3),4)
names(cm4) <- substring(names(cm4),4)
names(cm5) <- substring(names(cm5),4)

# specify vars
#lca.var1 <- noquote(lca.vars[which(lca.vars==cvar1)])
#lca.var2 <- noquote(lca.vars[which(lca.vars==cvar2)])

## scatter plots for best model ----

# correlation
with(df, cor(get(cvar1), get(cvar2)))
# class-conditional correlation
with(subset(df, M0[[bestmodel]]$predclass==bestmodel), cor(get(cvar1), get(cvar2)))

# scatter plot for all data
par(mfrow=c(1,1),pin=c(3,3))
with(df, {
  plot(jitter(get(cvar1)), jitter(get(cvar2)), axes=FALSE, xlab=cvar1, ylab=cvar2,
       main=sprintf("All data (cor = %1.2f)", cor(get(cvar1), get(cvar2))),
       pch=M0[[bestmodel]]$predclass)
  axis(1); axis(2)
  abline(lm(get(cvar2) ~ get(cvar1)), col="gray")
})

# scatter plots for class-condiitonal data
if (classes[bestmodel]/2 > 2) {
  par(mfrow=c(2,3),pin=c(1.1,1.1))
  } else if (classes[bestmodel]/2 > 1) {
  par(mfrow=c(2,2),pin=c(1.3,1.3))
  } else par(mfrow=c(1,2),pin=c(1.6,1.6))
for(i in 1:classes[bestmodel]) {
  with(subset(df, M0[[bestmodel]]$predclass==i), {
    plot(jitter(get(cvar1)), jitter(get(cvar2)), axes=FALSE, xlab=cvar1, ylab=cvar2,
         main=sprintf("Class %d (cor = %1.2f)", i, cor(get(cvar1), get(cvar2))), pch=i)
    abline(lm(get(cvar2) ~ get(cvar1)), col="gray")
    axis(1); axis(2, las=2)
  })
}
remove(i)
```