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A network approach to understanding the structure of core symptoms of psychopathic personality disturbance in adolescent offenders

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Abstract

A central aim of research on psychopathic personality disturbance (PPD) involves identifying core features of the construct. Such aims have been addressed primarily through prototypicality studies and research using item-response theory. More recently, the logic of social network analysis was extended to psychopathology research to examine which symptoms are most central to PPD networks. Such studies identified affective symptoms of the disorder as especially central among adult offenders. To build upon this prior research, the current study used data on male offenders from the Incarcerated Serious and Violent Young Offender Study to examine the network structure of the Comprehensive Assessment of Psychopathic Personality – Institutional Rating Scale (CAPP-IRS; n = 224) and Psychopathy Checklist: Youth Version (PCL:YV; n = 445). Using multiple measures of PPD helped avoid equating measures with constructs. In both the CAPP-IRS and PCL:YV networks, in line with prior studies, attachment/affective features of the disorder were most central. Several recommendations are made for future research, including the need to study the longitudinal development of PPD using a network approach.

Keywords: CAPP-IRS; network analysis; PCL:YV; *qgraph*; symptom networks

Despite general agreement that psychopathic personality disturbance (PPD) includes, for both adults (Cleckley, 1976; Hare, 2003) and adolescents (Lynam, 1996; Forth, Kosson, & Hare, 2003), deficits in interpersonal, affective, and behavioral domains of functioning, there is debate regarding which of these features are core symptoms. This debate includes conceptual arguments (e.g., Hare & Neumann, 2010; Skeem & Cooke, 2010), prototypicality studies (e.g., Kreis, Cooke, Michie, Hoff, & Logan, 2012), and studies using item-response theory (IRT; Cooke & Michie, 1997; Tsang et al., 2015). A novel approach used to weigh in on this debate is the network-based perspective, which conceptualizes PPD as a system of symptoms that directly relate to one another, as opposed to a group of symptoms with one common cause (for reviews of the psychopathology network approach, see Borsboom, 2017; Fried & Cramer, 2017). The extension of network theory to psychological disorders includes using nodes to represent symptoms of a disorder and edges to represent a correlation coefficient that indicate that degree of association between symptoms. Unlike IRT, the relative importance of symptoms to the disorder is based on an individual symptom's connectivity to other symptoms in the network, rather than to an underlying latent construct. That said, the network approach and latent variable approach/common cause models are not necessarily diametrically opposed. The network approach can be used to help support or replicate findings from IRT-type approaches and cannot provide dispositive evidence against the presence of a latent construct (Fried & Cramer, 2017).

Overview of the Network Approach

There are several network theoretical perspectives (see Borgatti & Lopez-Kidwell, 2011; Schmittmann et al., 2013). Among these, the network architecture model is particularly relevant to psychopathology networks as it describes the interconnectivity and interdependency of nodes. From a network architecture model perspective, homophily among nodes (i.e., nodes that are

most alike in their characteristics) can help explain connectivity. Symptoms of similar type are expected to be well-connected to each other and are likely to share connections to other symptoms. Conceptually, this resembles item loadings in a factor analysis, except the network approach does not relate the structural properties of the network back to a common cause. Instead, the network approach is interested in the interplay between symptoms, such as bridge symptoms that help explain why two symptoms that appear conceptually distinct can exist within the network of a single disorder (Cramer, Waldorp, Van der Maas, & Borsboom, 2010).

In psychopathology networks, different centrality indices (see Opsahl, Agneesens, & Skvoretz, 2010) help identify which symptoms, represented by nodes, are potentially core features of a disorder. Strength centrality refers to the sum of the absolute weight of all edges (e.g., correlation coefficients) connected to a given node. Symptoms high in strength centrality typically have strong connections to other symptoms or are connected to a wide range of different symptoms, making them key components in the network. Betweenness centrality describes the number of instances in which a node falls on the shortest path (i.e., edge) between two other nodes. Removal of nodes high in betweenness centrality would create a sparser network by removing indirect connections between other nodes. Closeness centrality refers to the average distance of a particular node from all other nodes in the network; shorter edges represent greater closeness. In the context of PPD networks, nodes higher in closeness centrality might help establish how symptoms from different facets/domains come together to form the underlying construct. For betweenness and closeness centrality in weighted psychopathology networks, shortest paths are defined by a combination of the number of intermediary nodes and edgeweights, where the largest edgeweight represents the path of least resistance (see Opsahl et al., 2010 for a discussion). A related concept is small-worldness (Humphries & Gurney, 2008),

which describes transitivity (e.g., if A ←→ B and B ←→ C, then it is also likely that A ←→ C) and short average path length (Costantini et al., 2015). A network thus has small-world properties if symptoms are interconnected along short path lengths; symptoms can reach other symptoms in few paths (Borsboom & Cramer, 2013). Here, short path lengths are not sensitive to edgeweight size ((Epskamp, Cramer, Waldrop, Schmittmann, & Borsboom, 2012).

Extending the Network Approach to PPD

Overviews of the PPD literature have called for research examining statistical associations among different features of the construct (e.g., Lilienfeld, 2018). The network approach is especially suitable for addressing such questions. Verschuere et al. (2018) used three samples of adult offenders, two from the United States (US) and one from the Netherlands, to examine the network structure of the Psychopathy Checklist – Revised (PCL-R; Hare, 2003). Network analyses were performed separately across the three samples to examine the consistency of findings. Across both nations, callous-unemotional (CU) traits were a central feature within the PCL-R networks, although the importance of such traits was greater in the US samples. In the Dutch sample, items from the Lifestyle facet ("*Irresponsibility*" and "*Parasitic Orientation*") were most central. This may suggest cross-cultural differences in the importance of different symptoms of PPD. Of relevance to the debate about criminal behavior as symptoms of PPD and in line with findings from IRT studies (e.g., Tsang et al., 2015), Verschuere et al. (2018) found that "*Juvenile Delinquency*" and "*Revocation of Conditional Release*" were on the periphery of the PCL-R network and therefore possibly less relevant to the assessment of PPD. In a second study, Preszler, Marcus, Edens, and McDermott (2018) examined the centrality of PPD symptoms using a sample of adult forensic inpatients and patients with a history of civil commitment. The former was assessed using the PCL-R and the latter was assessed using the

Psychopathy Checklist: Screening Version (PCL:SV; Hart, Cox, & Hare, 1995). Like Verschuere et al. (2018), Preszler et al. (2018) found that affective symptoms were most central whereas items from the Antisocial facet tended to be on the periphery of the network.

Although the above studies focused on adults, the network approach can be used to also address clinically-relevant questions for adolescents, including debate regarding the *Diagnostic and Statistical Manual of Mental Disorders,* fifth edition's (*DSM*-5; American Psychiatric Association, 2013) inclusion of limited prosocial emotion (LPE) as a specifier when assessing conduct disorder (CD). The LPE specifier was selected because it resembled symptoms of childhood and adolescent PPD (Salekin, 2016). Items that define LPE include a lack of remorse, CU traits, shallow affect, and a lack of concern for performance. Several questions have been raised (see Salekin, 2016) regarding (1) whether other CD specifiers should be included, (2) whether there is sufficient empirical evidence for LPE as a core feature of PPD that justifies its inclusion as a specifier for CD, and (3) whether the abovementioned items appropriately capture the nature of LPE. Network analysis can address these questions by identifying which symptoms are most central to PPD and whether these symptoms are confined to a specific domain (e.g., LPE) or whether they are distributed across interpersonal, affective, and behavioral features of PPD.

The Current Study

The first aim of the current study was to examine whether the PPD symptom network structure identified for adults was similar for adolescents. This aim helped address questions about whether PPD symptom manifestations vary across developmental stages (e.g., Edens & Vincent, 2008; Seagrave & Grisso, 2002). Some instruments, such as the Psychopathy Checklist: Youth Version (PCL:YV; Forth et al., 2003), have partially addressed this issue by adapting

items from adult instruments to be more developmentally appropriate for youth. However, doing so does not address questions regarding whether the importance of certain symptoms varies by developmental stage. For example, putative symptoms like empathy deficits may be more central than superficial charm because youth lack the interpersonal sophistication that allows for expressions of superficial charm to be advantageous.

The second aim was to address calls for research on the network structure of PPD using measurement tools beyond the PCL family (Preszler et al., 2018; Verschuere et al., 2018). The current study compared the network structure of PPD symptoms across the PCL:YV and the Comprehensive Assessment of Psychopathic Personality – Institutional Rating Scale (CAPP-IRS; Cooke, Hart, Logan, & Michie, 2004). Whereas the PCL family have been criticized for relying on a limited range of items and failing to measure potentially important PPD symptoms such as boldness and a lack of anxiety (e.g., Skeem & Cooke, 2010), the CAPP-IRS was developed with symptom over-inclusiveness in mind (Cooke et al., 2004). The developers of the CAPP believed that it was better to identify through statistical analysis whether certain symptoms are not part of the construct, as opposed to possibly excluding relevant symptoms that could not be added later (Cooke et al., 2012). Network analysis is suited to addressing this question. As well, the over-inclusiveness of the CAPP helped to avoid omitted variable bias, which is a specific concern in network science because the exclusion of relevant symptoms can alter the structure of a network (e.g., Box-Steffensmeier, Christenson, & Morgan, 2018). Lastly, the third aim of the current study involved identifying central features of PPD among adolescents to address discussion concerning whether LPE is sufficient as the only CD specifier, or whether additional specifiers may be needed (see Salekin, 2016).

Method

Participants and Procedures

The Incarcerated Serious and Violent Young Offender Study (ISVYOS) is a longitudinal study of males and females interviewed in youth custody facilities throughout British Columbia (BC), Canada. The study received ethics approval from the Simon Fraser University Research Ethics Board. Participants were recruited between 1998 and 2011 with a data collection hiatus between 2003-2005. Participants are thus divided into Cohort 1 (1998-2003) and Cohort 2 (2005-2011). PCL:YV ratings were available for both cohorts whereas CAPP-IRS ratings were completed for Cohort 2 only. Given concerns about the measurement of PPD within female populations (see Forouzan & Cooke, 2005), the current study focused on males only. Of this subsample, 445 participants were rated on the PCL:YV and 224 participants were rated on the CAPP-IRS. Within both subsamples, approximately 30% were Indigenous, approximately 55% were White, and approximately 15% were from a non-Indigenous ethnic minority (e.g., Chinese, Indian, Black). The proportion of Indigenous participants was in line with the overrepresentation of Indigenous youth in custody in Canada (Malakieh, 2017). The average age of recruitment was similar across the two subsamples (PCL:YV = 16.24 (*SD* = 1.27); CAPP-IRS = 15.95 (*SD* = 1.30)) and reflected the modal age of incarcerated youth (Malakieh, 2017).

The BC Ministry of Child and Family Development is the caregiver to all incarcerated youth and consented to the ISVYOS' recruitment of participants from custody centers throughout the province. Research assistants (RAs) approached youth while on their custody center unit and invited them to participate in the study. Approximately five percent of youth declined to participate. If youth wished to participate, RAs brought them to a private interview room to ensure confidentiality. To obtain assent, participants were read and given a copy of an information sheet explaining the purpose of the study, how information would be collected (e.g.

interview and file information), and that all information would be kept confidential unless the participant made a direct threat against themselves or someone else. Participants signed a form signifying that they understood the details of the study.

Materials

Comprehensive Assessment of Psychopathic Personality-Institutional Rating Scale (Cooke et al., 2004). To develop the CAPP, Cooke et al. (2004) reviewed research literature and surveyed the perspectives of clinical experts to develop a 33-symptom concept map of PPD. The 33 symptoms were rationally allocated into six domains (Table 1) reflecting basic functions of personality: Attachment, Behavioral, Cognitive, Dominance, Emotion, and Self. The 33 symptoms of the CAPP are mapped onto the CAPP-IRS and scored on a seven-point scale (0 = *not present*, 6 = *very severe*). With CAPP-IRS total scores ranging from 0-198, greater test score variance is possible, which addresses concerns regarding the lack of symptom variation among individuals scoring 'high' on other measures such as the PCL family (Skeem, Andershed, Kerr, & Louden, 2007). The CAPP-IRS was adapted for use with adolescents (see Dawson, McCuish, Hart, & Corrado, 2012), which primarily involved reconstructing questions to be age-appropriate.

CAPP-IRS ratings were based on interview and file information. All raters (n = 18) were graduate and undergraduate students that underwent training conducted by one of the CAPP-IRS developers. Interrater reliability was evaluated by assigning six RAs to three pairs. Each pair rated 10 participants, resulting in a total of 30 participants. Pairs remained the same across the 30 ratings (McCormick, 2007). Per Cicchetti and Sparrow's (1981) ranking of intraclass correlation coefficient (ICC) values, interrater reliability was excellent for total scores (ICC = 0.91) and adequate to excellent for domain scores (ICC 0.69-0.86). Cronbach's alpha values ranged from

0.74 to 0.89 for the six domains. The averages CAPP-IRS score for the sample was 69.83 (*SD* = 36.52; range = 0 to 181). This was approximately ten points lower than the average score found for male psychiatric patients with a criminal history (Pedersen, Kunz, Rasmussen, & Elsass, 2010). The difference is unsurprising given the latter is likely a narrower, more serious subsample of offenders. To the best of our knowledge, there is no other study of offenders rated using the CAPP-IRS. The average symptom rating across the six domains ranged from 1.74 (*SD* = 1.27; Self domain) to 2.67 (*SD* = 1.25; Behavioral domain).

--Insert Table 1 about Here--

Psychopathy Checklist: Youth Version (Forth et al., 2003). The PCL:YV is a symptom rating scale coded using information from a 60-90-minute semi-structured interview and a review of file-based collateral information. The 20 items comprising the PCL:YV (see Table 1) were identified as traits important to the construct of PPD in adolescence (Forth et al., 2003) and are rated on a scale that ranges from 0-2 (0 = *item does not apply*; 1 = *item applies somewhat*; 2 = *item definitely applies*). Confirmatory factor analysis of the PCL:YV using these same data (McCuish, Mathesius, Lussier, & Corrado, 2018) supported a four-factor model defined by Interpersonal (4 items), Affective (four items), Lifestyle (five items), and Antisocial (five items) facets. Two items related to short-term relationships and sexual promiscuity do not load onto any facet. However, both items were retained because of concerns about omitting relevant variables that may impact not only how other items relate to these two, but how the other 18 items relate to one another in a network defined by partial correlations.

Twenty-eight graduate and undergraduate RAs were involved in scoring the PCL:YV. Thirteen of these RAs also scored the CAPP-IRS. Training and interrater reliability were conducted using the same procedures used for the CAPP-IRS (see Vincent, 2002). The ICC

value for PCL:YV total scores was excellent (0.92). ICC values for each of the four facets were not available, but ICC values were excellent for the combination of Interpersonal and Affective facets (ICC = 0.82) and the combination of Lifestyle and Antisocial facets (ICC = .89). Cronbach's alpha values ranged from 0.55 to 0.74 for the four facets. Lower reliability values were unsurprising given the limited scale and number of items (Cortina, 1993). The average PCL:YV test score was 21.73 (*SD* = 6.62; range = 4 to 37), which resembled the average (20.50; *SD* not reported) noted by Edens, Campbell, and Weir (2006) in their meta-analysis of 21 studies using the PCL:YV. The average score on the Interpersonal facet was 3.19 (*SD* = 2.17). The average score on the Affective facet was 4.62 (*SD* = 2.15). The average score on the Lifestyle facet was 5.12 (*SD* = 2.02). The average score on the Antisocial facet was 7.24 (*SD* = 2.12).

Analytic Strategy

In line with analyses of PPD networks by Preszler et al. (2018), partial correlations were calculated to elucidate the association between two symptoms while conditioning on all other variables. Association matrices based on polychoric correlation coefficients are available in the supplemental materials (Figures S1 and S2). The CAPP-IRS and PCL:YV networks were measured separately. Both networks were produced using the *qgraph* package (Version 1.5; Epskamp et al., 2012) in R (version 3.5.1; R Core Team, 2018). The *qgraph* package includes the *EBICglasso* function to estimate network structure. This package uses the graphical least absolute shrinkage and selection operator (LASSO) function to produce a gaussian graphical model. The LASSO creates a sparser network by favoring the removal of true edges over the inclusion of spurious ones (Epskamp & Fried, 2018). This helped avoid false positives by penalizing models so that small correlations are reduced to zero. Small-worldness properties of each network assessed the extent of local clustering relative to the average shortest path length

between nodes. A network has small-world properties "if the small-worldness is greater than 1" (Humphries & Gurney, 2008, e0002051). Betweenness, closeness, and strength centrality were used to identify core nodes in the CAPP-IRS and PCL:YV networks. One-step expected influence (EI) values were also examined using *networktools* for R (Version 1.2.0; Jones, 2018). EI is valuable for interpreting the centrality of nodes in networks with negative edges because it treats negative edges as evidence against the centrality of a node, which contrasts from strength centrality, which treats negative edges as absolute values; Robinaugh, Millner, & McNally, 2016).

Finally, additional analyses were performed using the *bootnet* package (Version 1.1.0; Epskamp, 2018) to address concerns about the reproducibility of psychopathology networks (Epskamp et al., 2017). Like prior PPD network studies (e.g., Verschuere et al., 2018), these analyses were generated using 2,500 bootstrap samples and included (a) the case-dropping subset bootstrap, which examines the stability of centrality indices over random subsamples of decreasingly smaller sample size, (b) the correlation stability (CS) coefficient, which represents the maximum proportion of the sample that can be dropped while maintaining a 95% probability that the correlation between the baseline centrality index and bootstrapped subsamples is 0.70 or higher, and (c) the bootstrapped difference test, which evaluates whether two nodes significantly differ on a given measure of centrality. The bootstrapped difference tests should be interpreted cautiously because the multiple significance tests increase the possibility of Type I error. Epskamp et al. (2017) noted that Bonferroni and other types of corrections would severely reduce statistical power given the number of tests. At this time, it is best simply to be cautious when interpreting differences between nodes. Findings were significant at $p < .05$.

Missing Data

For the CAPP-IRS, 98.2% of the sample had complete data, 1.3% had missing data for one symptom, and one participant had missing data for three symptoms. For the PCL:YV, 61% of the sample had complete data, 24% had missing data on one item, and the remainder of the sample (15%) had missing data on two or more items. For both instruments, the mi command for Stata was used to impute 10 datasets. For each instrument, missingness was imputed with all symptoms/items included in the analysis. The average imputed value across the 10 datasets was used for the construction of the symptom network.

Results

Network Structure of the CAPP-IRS

The network structure for the CAPP-IRS is shown in Figure 1 (for each numbered node in the network, see Table 1 for the corresponding symptom). The small-worldness value of the CAPP-IRS network (1.20) suggests that it can be considered a small-world network (Humphries & Gurney, 2008). The strongest edgeweight was negative and was between lacks anxiety (E22) and sense of entitlement (S30). The strongest positive edgeweight was between lacks anxiety and lacks emotional depth (E24). In terms of node centrality (see Figure 2), for strength centrality, the symptoms detached (A1), unreliable (B6), self-aggrandizing (S28), and sense of entitlement were greater than one standard deviation above the mean value for the network. For closeness centrality, uncommitted (A2), aggressive (B10), lacks anxiety, lacks emotional depth, and sense of entitlement were greater than one standard deviation above the mean value for the network. For betweenness centrality, uncommitted, unempathic (A3), unreliable, lacks anxiety, lacks emotional depth, and sense of entitlement were greater than one standard deviation above the mean value for the network. Sense of entitlement was the only symptom that was above one standard deviation from the mean for all centrality measures, which illustrates the value of

examining different centrality indices. That said, this symptom, as well as others, were associated with negative edges, which justified examining EI (see Figure S3 of the supplementary materials). Lacks anxiety, despite having a high closeness and betweenness centrality value, was the least central node according to its EI value. Although sense of entitlement also had negative edges between lacks anxiety and lacks planfulness (C15), it was still moderately central per its EI value. Uncaring (A4) and aggressive (B9) were the only nodes to have an EI value greater than one standard deviation above the mean value for the network.

--Insert Figure 1 about Here--
--Insert Figure 2 about Here--

Bootstrapping analyses were performed to interpret the stability and reliability of network findings. The case-dropping subset bootstrap, which examines the stability of centrality indices over random subsamples of decreasingly smaller sample size, revealed that betweenness centrality was prone to varying from the observed data when smaller subsamples were drawn (see S4 of the supplementary materials). CS-coefficients for betweenness, closeness, and strength centrality were 0.13, 0.28, and 0.52, respectively. This means that (a) interpreting differences in nodes based on betweenness centrality values cannot be done reliably, (b) differences between nodes based on closeness centrality should be interpreted with caution, and (c) differences between nodes according to strength centrality can be interpreted reliably (see Epskamp et al., 2017).

Bootstrapped difference tests were calculated for strength, closeness, betweenness, and EI centrality (Figures 3a-3d). However, because the CS-coefficient for betweenness centrality was below 0.25, in line with previous research (e.g., Verschuere et al., 2017), the current study did not interpret differences in node centrality across according to this index. As shown in Figure 3a, the strength centrality values for symptoms that were greater than one standard deviation

above the mean (detached, unreliable, self-aggrandizing, and sense of entitlement; see Figure 2) were significantly ($p < .05$) larger compared to a wide range of other symptoms, especially suspicious (C11), intolerant (C13), manipulative (D19), and self-centered (S27). As shown in Figure 3b, the closeness centrality values of symptoms that were greater than one standard deviation above the mean (uncommitted, aggressive, lacks anxiety, lacks emotional depth, and sense of entitlement; see Figure 2) were significantly larger compared to suspicious. The closeness value for sense of entitlement was significantly larger compared to several symptoms from the Cognitive, Dominance, and Emotion domains. However, the centrality of this symptom as well as lacks anxiety should be interpreted cautiously due to their negative edges. Indeed, the EI values in Figure 3d indicate that lacks anxiety had a significantly lower EI value compared to all other nodes. The bootstrapped difference test for EI showed that unempathic (A3), unreliable, antagonistic, domineering, and deceitful (D16-D18), lacks emotional depth, and self-aggrandizing were significantly larger compared to a wide range of symptoms, including reckless (B7), restless (B8), C11, lacks planfulness (C15), and garrulous (D21).

--Insert Figures 3a-3d about Here--

Network Structure of the PCL:YV

The network structure of the PCL:YV is shown in Figure 4. The small-worldness value of the PCL:YV network (1.12) was above Humphries and Gurney's (2008) threshold for identifying a network with small-world properties. All edgeweights in the network were positive. The strongest edgeweight was between "*Shallow Affect*" (Aff6) and "*Callous / Lack of Empathy*" (Aff7). "*Promiscuous Sexual Relationships*" (Unc19 and "*Short-term Relationships*" (Unc20) were located on the periphery of the network, as were the three criminal behavior items from the Antisocial facet (Ant16-Ant18). To better understand which symptoms were most central,

centrality values for each node were plotted across three centrality indices (strength, closeness, and betweenness; see Figure 5). For strength centrality, "*Lacks Remorse or Guilt*" (Aff5), "*Callous/Lack of Empathy*", "*Poor Behavioral Control*" (Ant14), and "*Criminal Versatility*" (Ant18) were greater than one standard deviation above the network's mean value. For closeness centrality, three of the four items from the Affective facet (Aff5-Aff7), and "*Poor Behavioral Control*" were greater than one standard deviation above the network's mean value. For betweenness centrality, "*Callous/Lack of Empathy*", "*Poor Behavioral Control*", and "*Criminal Versatility*" were greater than one standard deviation above the network's mean value. EI values were not examined because there were no negative edges in the PCL:YV network, meaning that EI values and strength values were equivalent.

--Insert Figure 4 about Here--
--Insert Figure 5 about Here--

For the bootstrapping, like the CAPP-IRS network, the case-dropping subset bootstrap revealed that betweenness centrality was especially prone to varying from the observed data when smaller subsamples were drawn (see S5 of the supplementary materials). This was confirmed by the inspection of the betweenness centrality CS-coefficient, which was 0.20. For closeness and strength centrality, CS-coefficients were 0.28, and 0.52, respectively. It was a coincidence that these values were identical (after rounding) to those in the CAPP-IRS network. Like the CAPP-IRS network, the CS-coefficients imply that (a) interpreting differences in nodes based on betweenness centrality values cannot be done reliably, (b) differences between nodes based on closeness centrality should be interpreted with caution, and (c) the differences between nodes according to strength centrality can be reliably interpreted. Third, bootstrapped difference tests were calculated across strength, closeness, and betweenness centrality (see Figures 6a-6c), though difference tests for the latter were not interpreted because of the low CS-coefficient

associated with betweenness centrality (see Epskamp et al. 2017; Verschuere et al., 2018). As shown in Figure 6a, the strength centrality values for items that were greater than one standard deviation above the mean ("*Lack of Remorse or Guilt*", "*Callous/Lack of Empathy*", "*Poor Behavioral Control*", and "*Criminal Versatility*"; see Figure 5) were associated with values that were significantly ($p < .05$) larger when compared to a wide range of other items, especially those from the Lifestyle facet, including "*Stimulation Seeking*" (L9), "*Parasitic Lifestyle*" (L10), "*Lacks Long Term Goals*" (L11), and "*Impulsivity*" (L12). The centrality value for "*Revocation of Conditional Release*" (Ant17) was significantly lower compared to seven of the remaining 19 PCL:YV items. As shown in Figure 6b, the closeness centrality values for items that were greater than one standard deviation above the mean (*Lack of Remorse or Guilt*", "*Shallow Affect*", "*Callous/Lack of Empathy*", "*Poor Behavioral Control*", and "*Criminal Versatility*"; see Figure 5) were all associated with significantly larger values compared to "*Stimulation Seeking*", "*Impulsivity*", and "*Revocation of Conditional Release*".

--Insert Figures 6a-6c about Here--

Discussion

Whereas prior research using a network approach focused on adults and only used instruments from the PCL family (Preszler et al., 2018; Verschuere et al., 2018), the current study focused on adolescent incarcerated male offenders assessed using the PCL:YV ($n = 445$) and the CAPP-IRS ($n = 224$). This allowed for an examination of whether the most central symptoms of PPD in adults overlapped with those identified for youth. It also addressed concerns about mono-measurement bias in the study of PPD networks. Like the adult literature (e.g., Preszler et al., 2018; Verschuere et al., 2018), the CAPP-IRS and PCL:YV networks

showed that affective/emotional features of the disorder were especially central. Key results from both networks are described and contextualized within the broader PPD literature.

CAPP-IRS Results

An advantage of the CAPP-IRS is its inclusion of a greater range of symptoms that are not captured by the PCL:YV, which helps avoid concerns about omitted variable bias in network research (Box-Steffensmeier et al., 2018). For example, a lack of anxiety is not included in the PCL:YV but has been implicated as a potentially important feature of PPD (e.g., Skeem et al., 2007). However, at least in the CAPP-IRS network identified in the current study, lacks anxiety (E22) was the least central node according to EI values. This may be interpreted as evidence for performing the types of culling procedures Cooke et al. (2012) recommended for instances in which inclusivity results in the measurement of personality traits irrelevant to PPD. However, the symptom from the network that was most strongly and positively associated with a lack of anxiety was detached, which also happened to be among the most central nodes in the network. It may be the case that a lack of anxiety is implicated in specific subtypes of PPD (e.g., primary versus secondary psychopathy) as opposed to a key feature of the disorder. On the other hand, boldness, which was measured by a sense of invulnerability, has also been implicated as a key feature of PPD not captured by the PCL:YV (Skeem et al., 2007) but was not particularly central in the CAPP-IRS network, nor was it strongly connected to more central symptoms.

In terms of the properties of the CAPP-IRS network, in line with conceptualizations of PPD as a multi-dimensional construct (Cooke et al., 2004), the small-worldness value implied local clusters; symptoms that were direct neighbors of a third symptom were likely to share an edge (Borsboom et al., 2011). In terms of the centrality of individual nodes, like previous literature (Verschuere et al., 2018), the stability of betweenness centrality values was low per

bootstrapping analyses; consequently, less weight was given to betweenness centrality. However, the bootstrapping analyses indicated that strength and closeness centrality could be interpreted reliably. For strength centrality, detached, unreliable (B6), self-aggrandizing (S28), and sense of entitlement (S30) were greater than one standard deviation above the mean value for strength centrality and were significantly larger when compared to a wide range of other symptoms, especially suspicious (C11), intolerant (C13), manipulative (D19), and self-centered (S27). For closeness centrality, uncommitted (A2), aggressive (B10), lacks anxiety, lacks emotional depth (E24), and sense of entitlement were significantly larger compared to suspicious. The centrality of lacks anxiety and sense of entitlement were at least partially due to negative edges. When inspecting EI values, lacks anxiety was the least central node in the network and sense of entitlement was only moderately central. EI values indicated that the most central symptoms were unempathic (A3), unreliable, antagonistic, domineering, and deceitful (D16-D18), lacks emotional depth, and self-aggrandizing. These nodes had EI values that were significantly larger compared to at least one symptom from every domain except for the Attachment domain.

There was some overlap between the CAPP-IRS symptoms that were most central in the network and the symptoms of PPD that practitioners identified as being prototypical of the construct (e.g., Kreis et al., 2012). That unempathic, detached, uncommitted, and lacks emotional depth were especially central reflected findings from Preszler et al. (2018) and Verschuere et al. (2018) that indicated that Affective items from the PCL-R were particularly central in North American samples. That the unreliable symptom from the CAPP-IRS had a high strength and EI value was in line with Verschuere et al.'s (2018) observation that the irresponsibility feature of the Lifestyle facet from the PCL-R was central among Dutch offenders. Thus, despite using an adolescent sample and a different instrument, observations about the core symptoms of PPD

were similar when compared to adults examined using the PCL-R and PCL:SV. Such findings may reflect that key differences between adolescent and adult features of PPD are principally related to differences in symptom manifestations as opposed to different kinds of symptoms.

PCL:YV Results

Items in the PCL:YV network tended to cluster within their respective Interpersonal, Affective, and Lifestyle facets. The small-worldness value for the network affirmed this observation, indicating that nodes were characterized by local clustering, suggesting interconnectivity within certain clusters. The two unclassified items and the three items measuring criminal behavior were on the network's periphery. For most of these five nodes, their location on the periphery was reflected in their centrality value. For strength centrality, "*Revocation of Conditional Release*" (Ant17) was among the least central nodes in the network, which aligned with prior work using network analysis (Verschuere et al., 2018) and IRT (Tsang et al., 2015). In terms of the most central nodes, because all edges were positive and because betweenness centrality differences could not be interpreted reliably, interpretations focused on the bootstrapped difference tests regarding strength and closeness centrality. "*Lacks Remorse or Guilt*" (Aff5), "*Shallow Affect*" (Aff6), and "*Poor Behavioral Control*" (Ant14) had strength and closeness centrality values that were significantly ($p < .05$) larger compared to a wide range of other items, especially those from the Lifestyle facet. These items share conceptual overlap with symptoms from the CAPP-IRS that were also identified as core aspects of PPD. Specifically, "*Lacks Remorse or Guilt*" and "*Shallow Affect*" resemble the CAPP-IRS symptoms detached, unempathic, and lacks emotional depth. As well, "*Poor Behavioral Control*" resembles the unreliable symptom from the CAPP-IRS, which was also central in its respective network.

The PCL:YV was developed as a downward extension of the PCL-R, which allows for more direct comparisons with the adult studies on PPD networks. The current study more closely resembled Preszler et al. (2018) than Verschuere et al. (2018) because only the former examined partial correlations between items. Like Preszler et al.'s (2018) study, items from the Affective facet were especially central. Criminal behavior items from the Antisocial facet were on the periphery of the networks from all three studies. However, somewhat contrary to the adult studies, based on strength centrality, "*Criminal Versatility*" was among the most central PCL:YV items and significantly differed from a wide range of other items according to the bootstrapped difference test. This may be because of the tendency for criminal behavior to be more frequent/versatile in adolescence compared to adulthood; as such, core features of PPD may share a more proximal relationship to offending at this developmental stage.

Implications for Assessment

Findings from the current study have implications for at least three concerns regarding PPD specifiers as part of the assessment of CD. First, Salekin (2016) noted that there was debate about whether LPE was a core feature of PPD and therefore whether it was appropriate to include it as a CD specifier in the *DSM*-5. However, the current study found that nodes that shared conceptual overlap with LPE (e.g., uncommitted and lacks emotional depth from the CAPP-IRS and lack of remorse from the PCL:YV) were also core features of the networks to which they belonged. In effect, results from the current study supported the inclusion of LPE as a CD specifier. Second, concern regarding the *DSM-5*'s failure to include more than one CD specifier (see Salekin, 2016) appeared justified given that other features of PPD, especially views of the self (e.g., self-aggrandizing, sense of entitlement) and negative interactions with others (e.g., antagonistic, domineering, and deceitful) also figured prominently in the CAPP-IRS

network, especially based on EI values. Third, although shallow affect's utility as an indicator of LPE was questioned (Lahey, 2014), the "*Shallow Affect*" item from the PCL:YV and the lack of emotional depth symptom from the CAPP-IRS were both central in their networks.

Limitations and Future Research

Much of the meaningfulness of assessing PPD is tied to the construct's utility in predicting future offending. The current study did not address whether the core features of PPD, at least according to the CAPP-IRS and PCL:YV networks, were also important for offending. Such information has become a critical part of the conversation about the value of CD specifiers (Salekin, Andershed, Batky, & Bontemps, 2018). The current study also lacked measures of general personality traits that could be used in network analyses to better understand whether symptoms of PPD are features of a specific disorder, or whether symptoms are part of the nomological network of general personality traits (see Lilienfeld, 2018). Due to concerns about the invariance of PPD instruments across gender (e.g., Forouzan & Cooke, 2005), the current study excluded females and thus did not evaluate whether core features of PPD varied across sex. Finally, the CS-coefficient for betweenness centrality was below 0.25 in both the CAPP-IRS and PCL:YV networks. As such, we avoided interpreting the meaningfulness of nodes that were higher or lower in betweenness centrality. That said, Verschuere et al. (2018) questioned whether betweenness centrality values were valuable to being with in terms of interpreting PPD networks.

Although network analysis and IRT both examine core features of a construct, the criteria they use are markedly different. The latter examines how increases in a latent trait are related to increases in the probability of the presence of a particular symptom whereas the former provides specific information on the inter-relationship between symptoms. As such, network analysis should not be viewed as a replacement or alternative to IRT; indeed, for every network model

there is, at least conceptually, an equivalent model that can be produced using IRT (see Epskamp, Maris, Waldrop, & Borsboom, 2018). Future research should perform both analyses on the same dataset to more precisely identify core features of PPD. Network analysis could be used to identify the PPD symptoms that are most central within a network and item characteristic curves from an IRT analysis could be used to interpret whether these symptoms are both discriminating (i.e., helps differentiate between individuals at slightly different levels of the latent trait) and difficult (i.e., endorsement occurs at higher levels of the latent trait).

Conclusion

The current study assessed whether prior research on the network structure of PPD could be reproduced within a sample of adolescents and across different measures of the construct. We do not consider this an example of true replication given that the analytic strategies used between the current study and the studies by Verschuere et al. (2018) and Preszler et al. (2018) were slightly different. Nevertheless, there is some justification for optimism regarding the future of network analysis as part of PPD research given that findings from the current study were similar to these earlier studies. Regardless of whether the CAPP-IRS or PCL:YV network were interpreted, affective deficits appeared to be the most central feature of PPD, whereas certain criminal behavior indicators (e.g., "*Revocation of Conditional Release*") were peripheral to the construct. These observations aligned with previous research using different analytic strategies (e.g., IRT, prototypicality analysis; Tsang et al., 2015). Finally, findings from the current study supported the inclusion of LPE as a CD specifier. However, the findings also implied that additional CD specifiers may be warranted given that features of PPD defined by grandiose/narcissistic self-perceptions and negative interpersonal interactions with others (e.g., domineering) were also central in the CAPP-IRS network.

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Tables and Figures

Table 1. Description of nodes from the CAPP-IRS and PCL:YV networks

Node	CAPP-IRS Description (Figure 1)	Node	PCL Description (Figure 4)
A1	Detached	I1	Glib/Superficial Charm
A2	Uncommitted	I2	Grandiose Sense of Self Worth
A3	Unempathic	I3	Pathological Lying
A4	Uncaring	I4	Conning/Manipulative
B5	Lacks Perseverance	Aff5	Lack of Remorse or Guilt
B6	Unreliable	Aff6	Shallow Affect
B7	Reckless	Aff7	Callous/Lack of Empathy
B8	Restless	Aff8	Failure to Accept Responsibility
B9	Disruptive	L9	Stimulation Seeking
B10	Aggressive	L10	Parasitic Lifestyle
C11	Suspicious	L11	Lacks Long-term Goals
C12	Lacks Concentration	L12	Impulsivity
C13	Intolerant	L13	Irresponsibility
C14	Inflexible	Ant14	Poor Behavioural Control
C15	Lacks Planfulness	Ant15	Early Behavioural Problems
D16	Antagonistic	Ant16	Juvenile Delinquency
D17	Domineering	Ant17	Revocation of Conditional Release
D18	Deceitful	Ant18	Criminal Versatility
D19	Manipulative	Unc19	Promiscuous Sexual Behavior
D20	Insincere	Unc20	Short-term Relationships
D21	Garrulous		-
E22	Lacks Anxiety		-
E23	Lacks Pleasure		-
E24	Lacks Emotional Depth		-
E25	Lacks Emotional Stability		-
E26	Lacks Remorse		-
S27	Self Centered		-
S28	Self Aggrandizing		-
S29	Sense of Uniqueness		-
S30	Sense of Entitlement		-
S31	Sense of Invulnerability		-
S32	Self-Justifying		-
S33	Unstable Self Concept		-

Notes. For CAPP-IRS, "A" = Attachment domain, "B" = Behavioral domain, "C" = Cognitive domain, "D" = Dominance domain, "E" = Emotion domain, "S" = Self domain. For PCL:YV, "I" = Interpersonal facet, "Aff" = Affective facet, "L" = Lifestyle facet, "Ant" = Antisocial facet, and "Unc" = Unclassified.

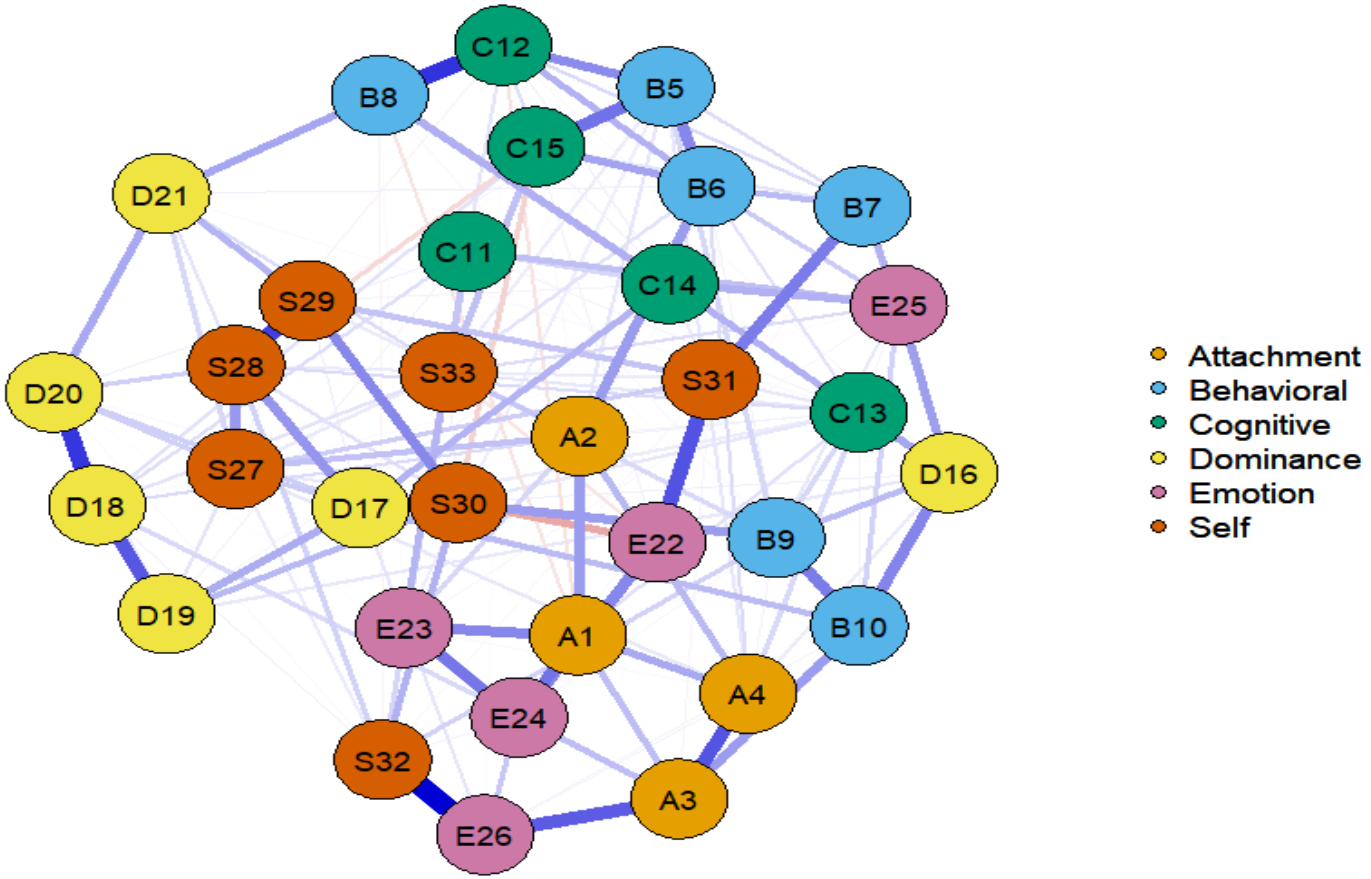


Figure 1. graphicalLASSO network graph of the CAPP-IRS. Attachment domain = nodes A1-A4; Behavioral domain = nodes B5-B10; Cognitive domain = nodes C11-C15; Dominance domain = nodes D16-D21; Emotion domain = nodes E22-E26; Self domain = nodes S27-S33. Nodes represent the 33 symptoms of the CAPP-IRS and the edges represent the partial correlations between symptoms. Thicker edges denote stronger associations. Blue ties indicate positive associations whereas red ties indicate negative associations. The Fruchterman-Reingold layout is used to display the results. See the online article for the color version of this figure.

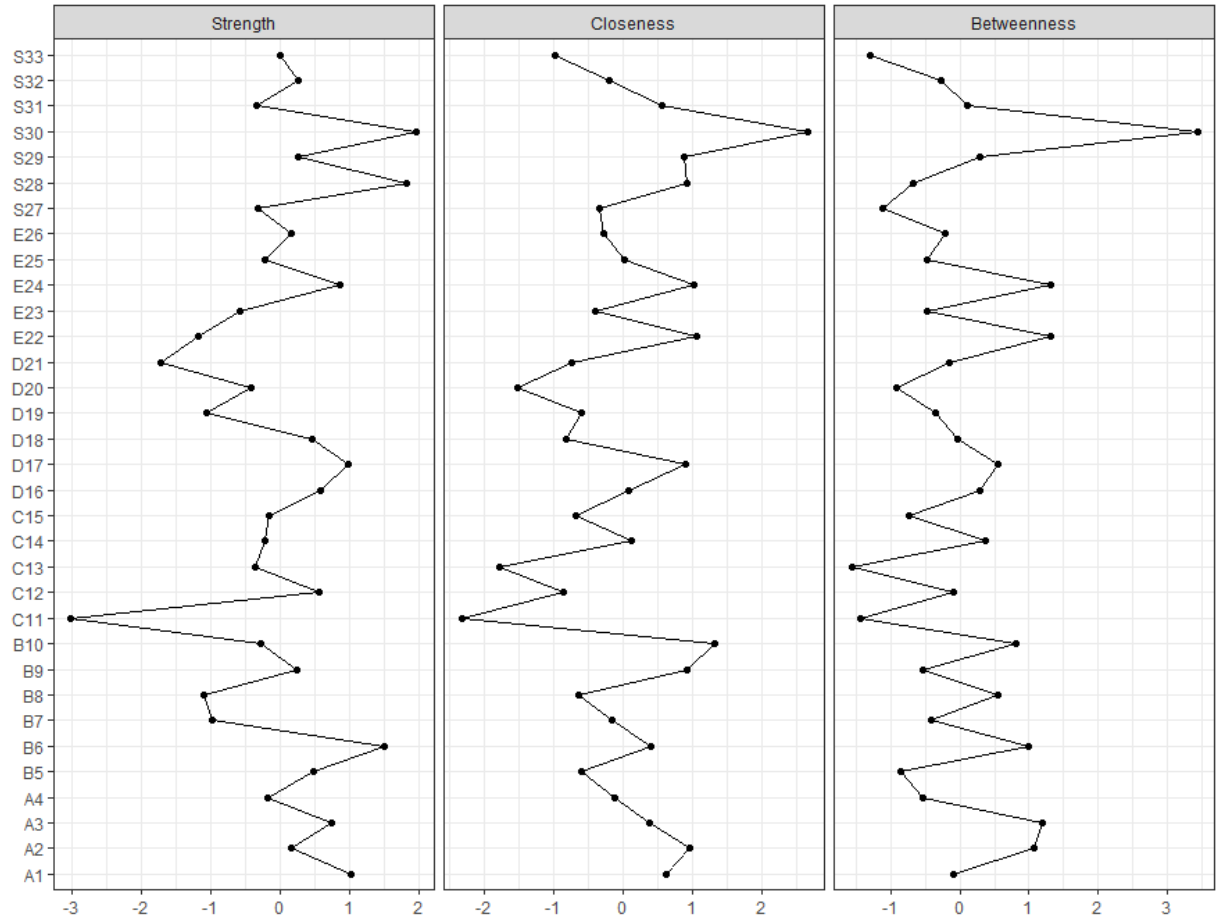


Figure 2. Indicators of node centrality within the CAPP-IRS symptom network. Nodes are plotted on the y-axis and z-scores representing the centrality indices are plotted on the x-axis. See Table 1 for legend detailing CAPP-IRS symptoms and corresponding node number.

Note. Average values are represented by z-score values of zero, which are not always located in the center of each graph.

Figure 3a. Bootstrapped differences in strength centrality (CAPP-IRS)

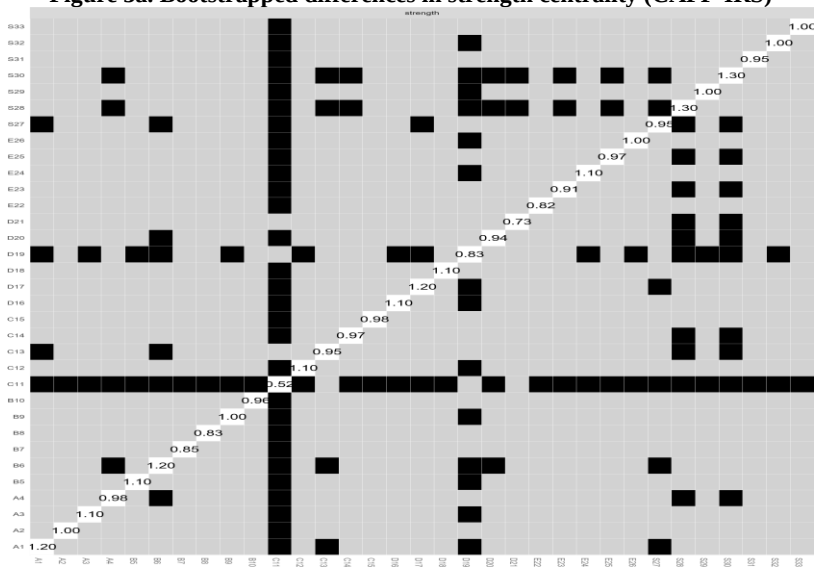


Figure 3b. Bootstrapped differences in closeness centrality (CAPP-IRS)

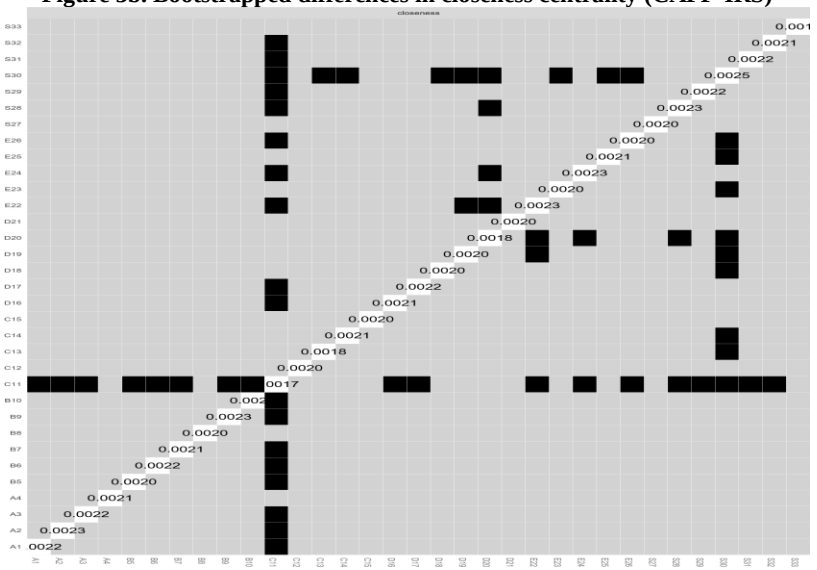


Figure 3c. Bootstrapped differences in betweenness centrality (CAPP-IRS)

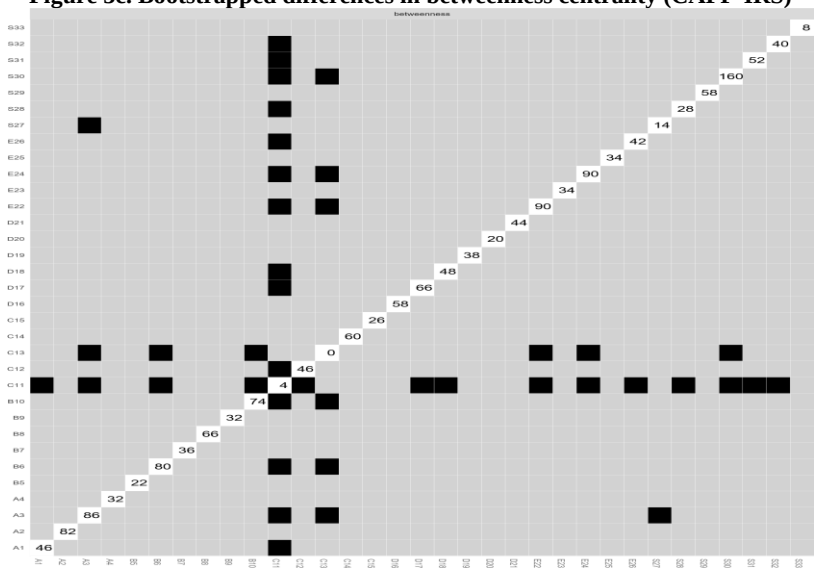
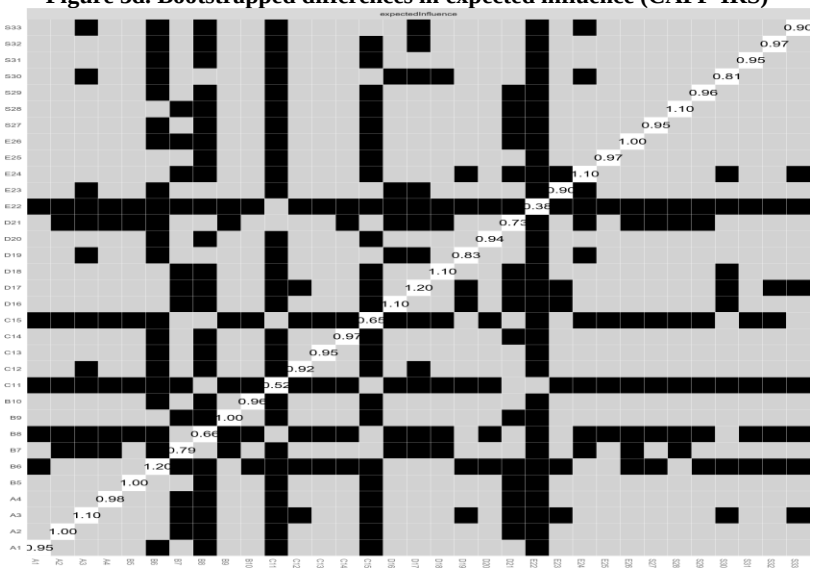


Figure 3d. Bootstrapped differences in expected influence (CAPP-IRS)



Figures 3a-3d. Bootstrapped differences in centrality measures from the CAPP-IRS network. Grey boxes indicate non-significant differences, black boxes indicate significant differences. Centrality values plotted on the diagonal.

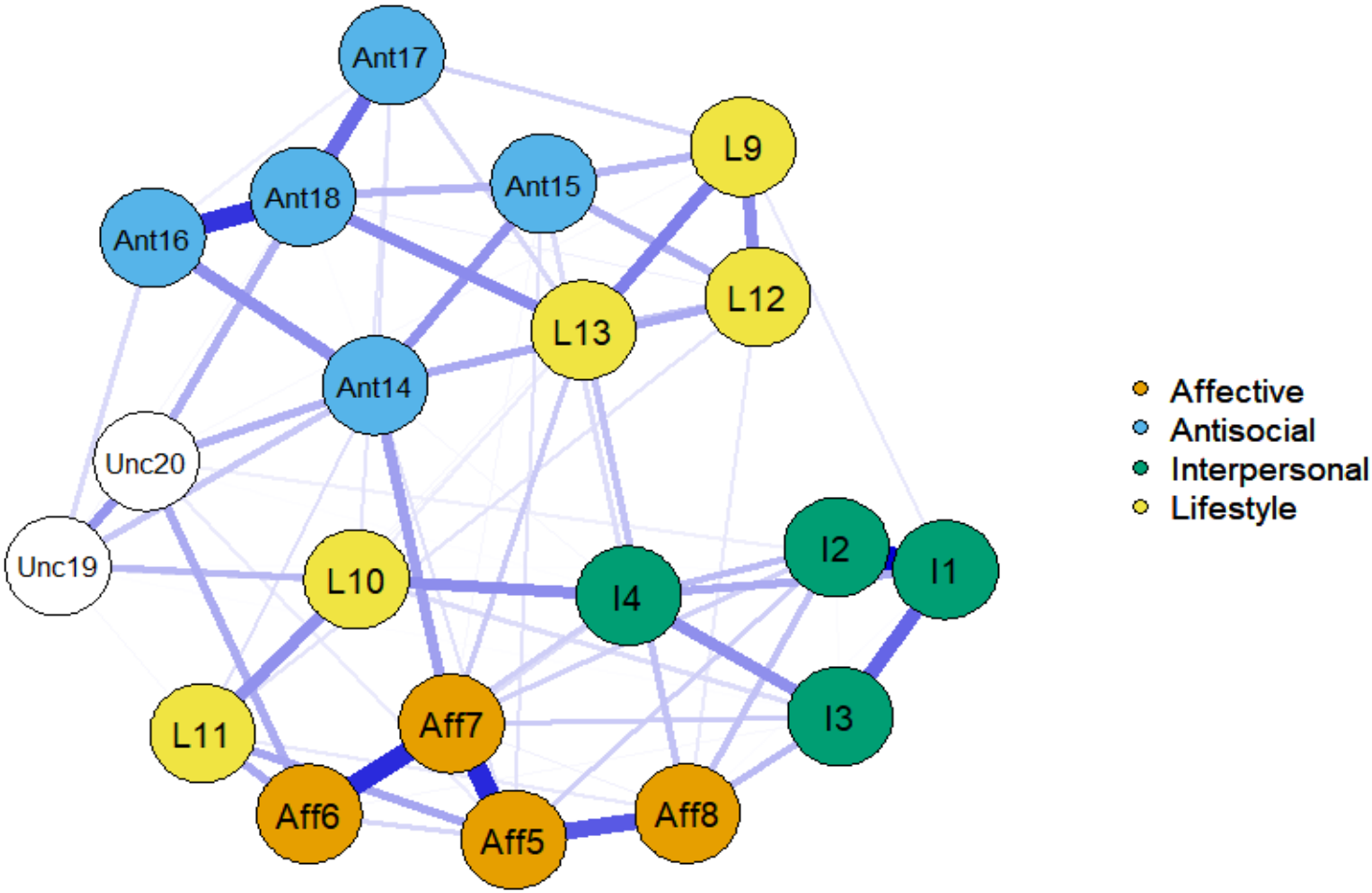


Figure 4. graphicalLASSO network graph of the PCL:YV. Interpersonal facet = nodes I1-I4; Affective facet = nodes Aff5-Aff8; Lifestyle facet = nodes L9-L13; Antisocial facet = nodes Ant14-Ant18. Nodes represent the 20 items of the PCL:YV and the edges represent the partial correlations between items. Thicker edges denote stronger associations. Blue edges indicate positive associations whereas red edges indicate negative associations. The Fruchterman-Reingold layout is used to display the results. See the online article for the color version of this figure.

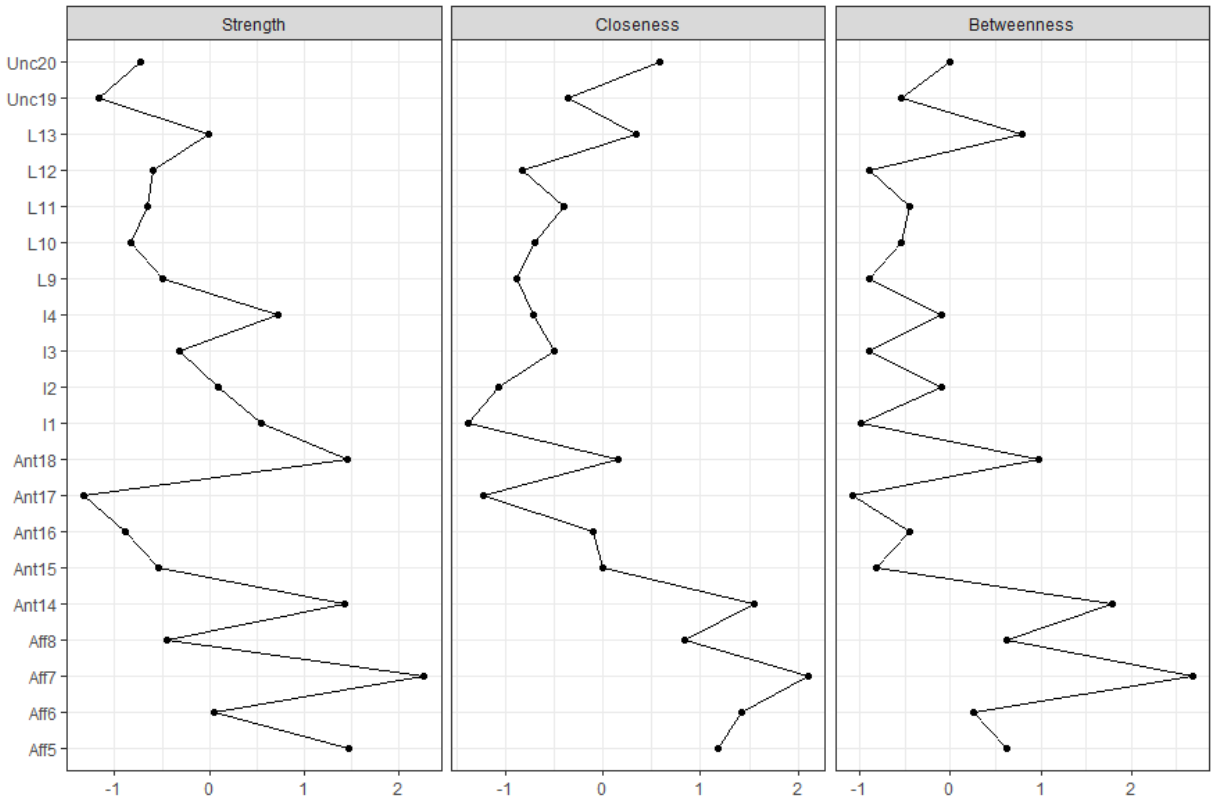


Figure 5. Indicators of node centrality within the PCL:YV symptom network. Nodes are plotted on the y-axis and z-scores representing the centrality indices are plotted on the x-axis. See Table 1 for legend detailing PCL:YV items and corresponding node number.

Note. Average values are represented by z-score values of zero, which are not always located in the centre of each graph.

Figure 6a. Bootstrapped differences in strength centrality (PCL:YV)

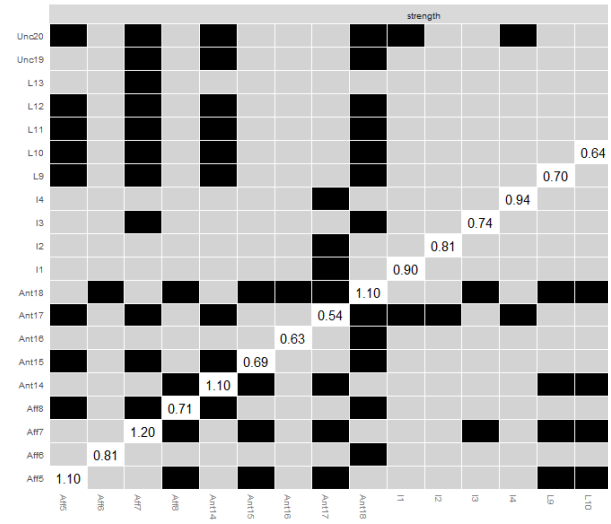


Figure 6b. Bootstrapped differences in closeness centrality (PCL:YV)

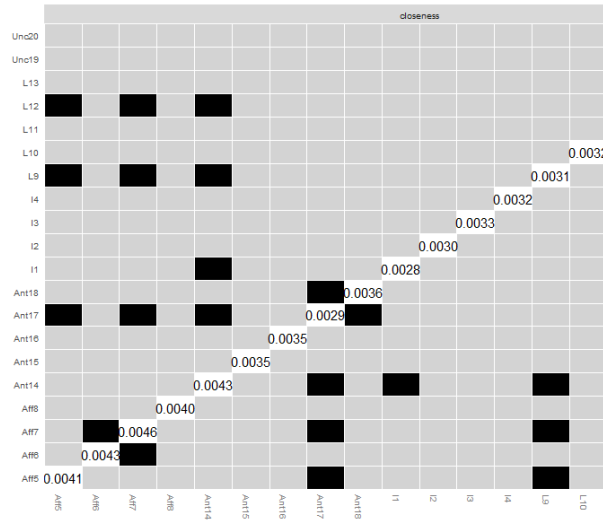
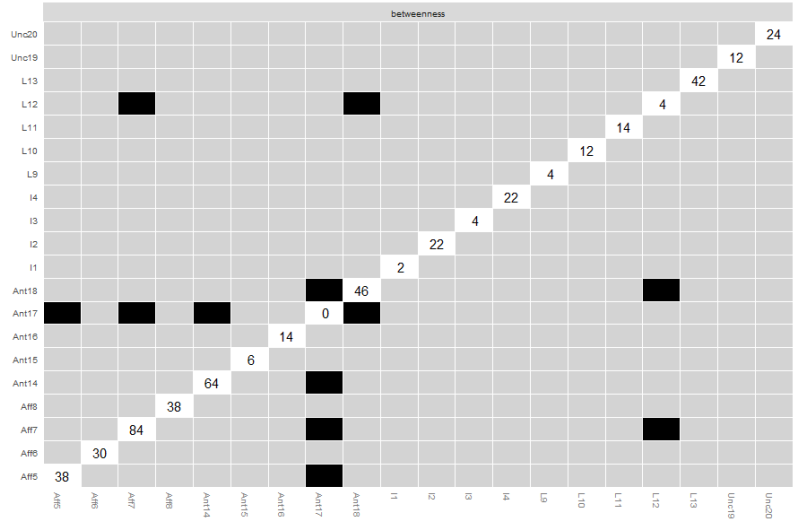


Figure 6c. Bootstrapped differences in betweenness centrality (PCL:YV)



Figures 6a-6c. Bootstrapped differences in centrality measures from the PCL:YV network. Grey boxes indicate non-significant differences, black boxes indicate significant differences. Centrality values plotted on the diagonal.