**Symptom-Level Networks of Youth- and Parent-Reported Depression and Anxiety in a
Transdiagnostic Clinical Sample**

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Background: Depression and anxiety disorders confer a significant public health concern for youth and their co-occurrence places youth at a higher risk for poorer psychosocial outcomes. In the present study, we use network analysis to investigate the role of and interactions among individual depression and anxiety symptoms in a treatment-seeking clinical sample.

Methods: We estimate regularized partial correlation networks for youth- and parent reported symptoms in a transdiagnostic sample of youth (N= 417, ages 8-18). We examined features of the symptom-level networks such as network stability, centrality, bridge symptoms, and communities in both youth- and parent-reported networks.

Results: Results indicate stable networks with disorder-specific clustering, such that symptoms were more interconnected within compared to between disorders. Symptoms related to self-comparison to peers and negative views of the future were most central in both networks. Symptoms of depression and anxiety were connected by worries for the future and hopelessness in the youth-reported network, whereas self-comparison to peers and low self-efficacy were bridge symptoms in the parent network. Distinct symptom clusters emerged in the parent- and youth-reported networks.

Conclusions: Our findings indicate that negative self-evaluation, negative views of the future, and repetitive negative thinking more generally are influential symptoms in the presentation and co-occurrence of depression and anxiety and as such may be promising targets in the treatment and prevention of depression and anxiety in youth.

Anxiety and depression are the most common mental health concerns for children and adolescents worldwide and recent evidence suggests that the prevalence of these disorders in youth has been growing over the past two decades (Beesdo et al., 2009; Ghandour et al., 2019; Twenge et al., 2019). Depression and anxiety are associated with poorer psychosocial outcomes and increased suicide risk and, as such, confer a significant public health concern (Garber & Weersing, 2016). Moreover, these disorders commonly co-occur in youth and this comorbidity is associated with greater severity and impairment and lower levels of global functioning (Cummings et al., 2014; Garber & Weersing, 2016). Despite the prevalence of and impairment associated with such comorbidity, the etiology and maintaining factors of this co-occurrence are still largely uncertain. Limited progress on this front may be explained by the overreliance on diagnostic categories, which may obscure important symptom-level relationships both within and between disorders (Fried, 2015). Furthermore, the role of specific symptoms is often neglected by a common cause approach to comorbidity research, which purports a shared latent variable among co-occurring disorders and assumes that all symptoms are equivalent as they are caused by the same underlying syndrome (Cramer et al., 2010). These are considerable limitations of the current state of comorbidity research, as specific symptoms are differentially associated with risk, impairment, and treatment outcomes (Fried & Nesse, 2014; Bringmann et al., 2014). As such, myriad questions remain regarding the differential and influential roles of individual depression and anxiety symptoms in initiating and maintaining comorbidity in youth.

Clinical network theory can account for symptom-level interactions both within and between disorders (Cramer et al., 2010). Per this approach, symptoms meaningfully interact with one another to form a network of bidirectionally-related symptoms that constitute a given psychiatric disorder or network of multiple disorders (Borsboom & Cramer, 2013; Cramer et al.,

2010; Brosboom, 2017). Symptoms play differential roles in networks, as certain symptoms (termed *central symptoms*) may be more interconnected or may have a stronger causal influence, as compared to other symptoms (Borsboom & Cramer, 2013). Furthermore, the network approach poses that comorbidity arises due to bridge symptoms, which are symptoms that are shared by and connect the networks of two disorders (Cramer et al., 2010; Jones et al., 2019). The activation of a bridge symptom is thought to have a cascading effect, in turn activating the symptom network of another disorder (Borsboom, 2017; Cramer et al., 2010). This perspective on comorbidity deviates from the traditional common cause view, as it emphasizes the interactions among symptoms (Cramer et al., 2010).

Network analysis is a statistical and graphical methodology that quantifies and facilitates the operationalization of central and bridge symptoms. Past studies have used network analysis to examine depression and anxiety comorbidity in adult samples and have broadly found disorder-specific clustering with bridge symptoms of sleep disturbances, fatigue, motor disturbances, excessive worry, and sad mood connecting the disorder-specific clusters (e.g., Beard et al., 2016; Cramer et al., 2010). Such findings have improved our understanding of the interrelation of depression and anxiety symptoms underpinning comorbidity in adults; however, few studies have investigated symptom-level anxiety and depression networks in youth (McElroy et al., 2018; Osborn et al., 2020; Dobson et al., 2020). Broadly, network analyses of youth depression and anxiety symptoms have yielded results indicating that worry, low self-esteem, and physical symptoms of depression bridge depression and anxiety symptoms (e.g., McElroy et al., 2018; Dobson et al., 2020). Importantly, existing studies examining this comorbidity with network analysis have been limited by non-clinical samples, insufficient sample sizes, and/or samples consisting of singular disorders. Thus, it is imperative to examine

these symptom-level interrelations in a sufficiently powered sample of youth with transdiagnostic clinical presentations, particularly if the eventual goal of such research is to leverage network targets to augment clinical intervention.

In the current study, we used network analysis to investigate the interconnection among symptoms of depression and anxiety in a large, transdiagnostic sample of treatment-seeking youth. To do so, we used both youth self-reported and parent-reported data to fully capture the relationship between symptoms and to examine possible informant discrepancies in networks. Here, we explore features of parent- and youth-reported symptom networks, such as topology, communities, centrality, and bridge symptoms to better understand the relative importance and interrelation of each symptom in the network(s). To our knowledge, this is the first study to examine the symptom-level network of depression and anxiety in a sizeable, transdiagnostic clinical sample of youth using both parent- and self-report, thus the analyses presented herein are largely exploratory in nature.

Methods

Participants

Participants included 417 youth aged 8-18 ($M = 12.14$, $SD = 3.04$) who presented at a University-based research clinic in a large, urban area that provides assessment and outpatient treatment of emotional disorders. Participants included youth who met diagnostic criteria for any mood, anxiety, or obsessive-compulsive spectrum disorder according to the Anxiety Disorder Interview Schedule for DSM-5, Child Version (ADIS-5-C; Silverman & Albano, in press). Inclusion criteria for the present study included being between the ages of 8 and 18 years, having a principal diagnosis of an anxiety, mood, or obsessive-compulsive spectrum disorder, and being sufficiently proficient in English to complete study questionnaires. Exclusion criteria included

the presence of a cognitive or developmental disorder that would preclude questionnaire completion. Demographic and diagnostic information for participants is presented in Table 1.

Procedure

All procedures were approved by the University's institutional review board, and informed consent was obtained from all participants before beginning any study procedures. All participants in the study were youth and their caregiver(s) who presented for an initial diagnostic evaluation through a naturalistic study examining youth outcomes and mechanisms of transdiagnostic treatment. Diagnoses were established by a trained evaluator based on youth/parent interview using the ADIS-5-C (Silverman & Albano, in press). Youth and caregiver(s) were asked to complete a battery of questionnaires as part of the initial diagnostic evaluation process. Eligible youth and their caregiver(s) were referred for the treatment component of this study. No compensation was provided for completing the initial diagnostic interview or questionnaires.

Measures

The Screen for Anxiety Related Emotional Disorders-Child and Parent Report (SCARED-C/P; Birmaher et al., 1997) is a 41-item measure of anxiety symptoms in youth. Items are rated on 3-point Likert scale ranging from 0 (*not true or hardly true*) to 2 (*very true or often true*). Total scores range from 0-82, with higher scores indicating more anxiety symptoms. The SCARED-C/P has demonstrated adequate validity and reliability (Birmaher et al., 1999). In the current sample, the SCARED-C/P demonstrated excellent internal consistency for the total score (parent and child $\alpha = .92$). Items used as nodes are outlined in *Table 2*.

The Mood and Feelings Questionnaire-Child and Parent Report (MFQ-C/P; Angold et al., 1987) is a 33-item measure for the child-report and a 34-item measure for the parent-report of

youth depression symptoms over the past two weeks. Items are rated using a 3-point Likert scale ranging from 0 (*not true*) to 2 (*true*) with total scores ranging from 0-66 and higher scores indicating more depression symptom. Past work has demonstrated the reliability and validity of the MFQ-C/P (Burleson Daviss et al., 2006; Wood et al., 1995). In the current sample, the MFQ-C/P demonstrated excellent internal consistency for the total score (parent $\alpha = .92$; child $\alpha = .93$). Items used as nodes are outlined in *Table 2*.

Node Selection

A total of 22 nodes (12 items from the MFQ-C/P and 10 items from the SCARED-C/P measures) were included. Parent- and youth-reported nodes corresponded to the same items to facilitate comparisons. Items were used as nodes if they corresponded to DSM-5 diagnostic criteria for MDD or GAD or represented common anxious or depressive symptoms in youth. We focused on symptoms of MDD and GAD due to the high comorbidity rates between these two disorders (compared to other anxiety disorders), their representativeness of core anxiety and depressogenic symptoms clusters, and the commonality of these two diagnoses in the sample used for subsequent analyses (Cummings et al., 2014; Garber & Weersing, 2016). The number of nodes was guided by results of a simulation study by Constantin and Cramer (2020), which found that Gaussian Graphical Model (GGM) with 20 nodes can be estimated in a sample of 200 participants or more with sufficient sensitivity and specificity. Moreover, we assessed for redundant nodes using the *goldbricker* function, which compares the similarity in correlations of two nodes with all other nodes in the network to identify pairs that may underlie the same construct (Jones, 2017; Levinson et al., 2018).

Analyses

All analyses were performed in R 4.0.2 and R Studio 1.3.1056 using the R *bootnet* package (Epskamp, et al., 2017). Separate networks for parent- and child-reported symptoms were estimated using identical procedures outlined by Epskamp and Fried (2018). We estimated association networks that depict partial polychoric correlations between symptoms using the GGM and regularized the network using the Graphical Least Absolute Shrinkage and Selection Operator (gLASSO) with an Extended Bayesian Information Criterion hyperparameter of 0.5 (EBIC; $\gamma = 0.5$). This hyperparameter was selected to return a sparse network with fewer edges given the relatively small sample size (Epskamp et al., 2017; Foygel & Drton, 2010).

To better understand the relative importance of individual symptoms in the network, we assessed several commonly used measures of centrality: strength, closeness, and betweenness. Though we report all three centrality metrics, the present study focusses on strength centrality, or the size of the relationships between a node and all other nodes in the network, as betweenness and closeness indices may be influenced by spurious covariance among symptoms and tend to be less stable than the strength centrality index (Hallquist et al., 2019; Epskamp & Fried, 2018). Bridge symptoms were identified using the *bridge* function in the *networktools* R package. We used the bridge strength centrality metric, which refers to the absolute sum of all edge values between a given node and all other nodes that are not in the same pre-specified community (here, there were two communities composed of either depression or anxiety symptoms). To assess the variability, accuracy, and significance of edge-weights, we used non-parametric bootstrapping with 5000 samples to assess the 95% confidence intervals for the edges. We investigated the stability of the centrality indices by computing correlation stability coefficients (CS-coefficient) using parametric case-dropping bootstrapping with 5000 samples.

To investigate the presence of communities in the networks, which are clusters of nodes with particularly dense interconnections, we used the *spin glass* function in the *igraph* R-package ($y = 1$, start temperature = 1, stop temperature = .01, cooling factor = .99, spins = 23; Jones et al., 2018; Csardi & Nepusz, 2006; Robinaugh et al., 2014). This function identifies sets (communities) of nodes that have more connecting edges within the community than outside of the community (e.g., other nodes in the network). Lastly, we examined differences in the parent- and youth-reported networks using a permutation-based hypothesis test, *NetworkComparisonTest*, that assesses invariances between two networks (van Borkulo et al., 2017). We examined global structure and strength invariance and performed this comparison with 5000 permutations.

Results

Item and measure-level descriptive statistics are presented in Table 2. Plots of the regularized partial correlation network of parent- and youth-reported symptoms are presented in Figure 1 and 2, respectively. Centrality indices for both networks were examined and are shown in Figure 3 and 4. Stability coefficients of the parent-reported and youth-reported centrality measures indicate that strength index was moderately stable (both networks CS-coefficient = 0.44). In the parent-reported network, nodes *bad future* and *good as others* had the highest strength centrality index, indicating that they were the most strongly connected to all other nodes in the parent network. In comparison, nodes *good as others* and *things working out* had the highest strength centrality for the youth-reported network. Centrality metrics for the bridge symptoms indicated that parent network nodes *good as others* and *did wrong* had the greatest bridge strength. On the other hand, bridge nodes *past worry*, *things working*, *bad future*, and *heart* had the highest strength centrality index in the youth-reported network.

Five distinct communities emerged in the parent-reported network and are plotted in Figure 1. The following clusters emerged in the parent-reported network: Low positive affect; Depressive agitation; Evaluative worries; Anxious hyperarousal; Generalized worries. In comparison, four distinct communities emerged in the youth-reported network (Figure 2): Low positive affect; Depressive agitation; Evaluative worries; Generalized worries. The Network Comparison test indicated significant differences in the structure of the two networks, as demonstrated by a significant network invariance test ($M = 0.34, p < .01$). Global strength was slightly higher in the parent-reported network (10.66) compared to the youth-reported network (10.79); however, this difference was not significant ($S = 0.13, p = .89$).

Discussion

To our knowledge, the present study is the first to examine parent- and youth-reported symptom-level networks of depression and anxiety in a transdiagnostic clinical sample of youth. Here, we sought to elucidate the symptom-to-symptom interactions that underpin frequently co-occurring symptoms of depression and anxiety in youth. We found that, regardless of informant, symptoms of depression and anxiety were highly interconnected. Consistent with past work, analyses indicated disorder-specific clustering, such that most symptom-to-symptom relationships were stronger within as opposed to between disorders (e.g., Dobson et al., 2010; Beard et al., 2016). Analyses of centrality indicated that certain symptoms had more connections in the network compared to others. *Good as others* was one of the most central symptoms in both parent- and youth-reported networks. Given the important role of peers to social-emotional development during childhood and adolescence, it is not surprising that distress surrounding self-comparison to peers is a highly influential and interconnected node in networks of youth symptomology. Other nodes that were central in both the youth-reported and parent-reported

networks encompassed other cognitive symptoms (e.g., negative view of the future), which is consistent with centrality findings from other network analyses of youth internalizing disorders (e.g., McElroy et al., 2018) and inconsistent with centrality findings in adult networks that have found affective symptoms to be the most central (e.g., sad mood; Beard et al., 2016; Cramer et al. 2010). These discrepant results suggest that cognitive symptoms may be more closely connected to other symptoms in youth versus adults and may be particularly important to target through intervention.

Despite these similarities between the parent- and youth-reported network, there were differences in the bridge symptoms and node clustering of the networks. In the parent-reported network, anxiety and depression clusters were connected via symptoms constituting negative self-evaluation related worries and low self-efficacy (*good as others – did wrong*), whereas in the youth-reported network, the two disorders were connected via symptoms of worry about things working out and a pessimistic view of the future (*things working – bad future*). This difference in bridge symptoms suggests an informant discrepancy in the domains connecting depression and anxiety symptoms; such that parents may view symptoms of negative self-evaluation as an important link, whereas youth may view negative views of their future as the connecting link between symptoms of depression and anxiety. While the existing literature regarding parent-child discrepancies in youth internalizing networks is limited, there is a sizeable literature on informant discrepancies in psychology more broadly (De Los Reyes et al., 2015). Past work has found low-to-moderate rates of correspondence between informants when rating internalizing symptoms in youth (De Los Reyes et al., 2015). Factors such as symptom saliency to each informant and the observability of symptoms play crucial roles in rates of agreement between parents and children (Karver, 2006; Comer & Kendall, 2004). It is possible that youth

may vocalize, and in turn parents may observe, negative statements about themselves compared to peers (e.g., “Timmy is smarter than me”) and their actions (e.g., “I always do my homework wrong”) more readily than concerns for the future (e.g., “I worry nothing will work out for me”). As such, it follows negative self-evaluative symptoms may be more observable and thus salient to parents compared to worries for the future, causing them to be perceived as more crucial agents in connecting depression and anxiety symptoms (Karver, 2006). Although the specific content of the bridge nodes varied in the parent- and youth-reported networks, both sets of bridge symptoms constitute repetitive negative thinking (RNT), a cognitive process involving perseverative focus on negative emotional content (whether it be negative self-evaluation or negative appraisal of the future). RNT has been conceptualized as a transdiagnostic risk and maintaining factor for anxiety and depression encompassing both rumination and worry, and empirical research has borne this out (McEvoy et al., 2013; Spinhoven et al., 2015). Our results support RNT as a transdiagnostic process connecting anxiety and depression in children and adolescents that is a central feature of both disorders and thus may represent a highly relevant transdiagnostic treatment target.

Informant discrepancies in networks extended beyond bridge symptoms, as the network community structures differed. The parent-reported network included five distinct communities; however, the distinct community representing anxious hyperarousal was not detected in the youth-reported network, as the hyperarousal symptoms clustered with generalized worries. Thus, in the current sample, youth reported that their general symptoms of worry are more closely associated with physiological feelings of worry compared to their parents, who reported that such physiological symptoms are less associated with cognitive symptoms but rather stand alone as a unique cluster. The youth-reported association between cognitive and physiological symptoms is

not surprising given past research indicating that the majority of youth experience at least one somatic complaint alongside anxiety (Beidel et al., 1991) and that somatic complaints are more common with comorbid depression and anxiety disorders compared to singular anxiety disorders (Hofflich et al., 2006).

Symptoms with high centrality (e.g., *good as others*) may be fruitful therapeutic targets, as decreasing or deactivating a central node may have a domino effect whereby other connected nodes may also decrease (Cramer et al., 2010). Based on the current results, it may be promising to target repetitive negative thinking in treatment via intervention techniques such as cognitive reappraisal or mindfulness strategies, as targeting this mechanism could decrease the frequency or severity of related symptoms in the network. Moreover, the results of this study may inform the development of brief interventions for youth, such that central symptoms or processes may be the focus of said treatments. Given that the peer component of most youth CBT protocols is under-developed, the relevant process, cognitive, and behavioral elements associated with social comparison should be explored as it relates to further innovation to follow from these findings. Although such possibilities for intervention-related outputs of this network analysis are exciting, it should be noted that there are mixed findings thus far regarding the effectiveness of targeting central and bridge symptoms in treatment (Castro et al., 2019).

Despite the novelty and potential treatment implications of the study, there are several important considerations. First, although our sample was elevated in terms of both depression and anxiety symptoms, the majority of the sample had a primary anxiety disorder. While this may limit the generalizability of these findings, the disproportionate number of anxious to depressed participants may in fact represent lower base rates of depression in self-referred clinical samples of youth. Similarly, there was a high proportion of White, Hispanic youth and

low proportion of Black and Asian/Pacific Islander youth in the sample. Future work should replicate these analyses in a more ethnically and racially representative sample. Lastly, while cross-sectional association networks are useful in understanding general interrelations among symptoms, they do not offer insight into the directionality of associations and therefore the temporal associations between symptoms are precluded from the present study. With these considerations in mind, there are many fruitful avenues for future work, such as elucidating temporal relations among these symptoms using timeseries data, examining demographic differences in the networks, and investigating the change in symptom networks pre- and post-treatment.

Conclusion

This study is the first to examine the youth- and parent-reported symptom-level networks of depression and anxiety symptoms in a large, transdiagnostic clinical sample of youth. Here, we demonstrated that while depression and anxiety symptoms are strongly interconnected, the symptom-to-symptom association is generally stronger within as opposed to between disorders. We further demonstrated that cognitive symptoms are more important in the networks, both in terms of connections to other symptoms within the same disorder and in terms of cross-disorder connections. Lastly, we revealed key differences in the youth- and parent-reported network, providing additional insight into the study of emotional disorder symptom informant discrepancies in youth clinical samples.

*The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Table 1*Demographic Information*

	Mean (SD) or N (%)
Age	12.21 (3.05)
Sex; Female	232 (49.89%)
Race	
White	427 (91.43%)
American Indian	1 (0.2%)
Black	12 (2.57%)
Asian	10 (2.15%)
Other	17 (3.7%)
Ethnicity	
Hispanic	305 (65.53%)
Non-Hispanic	161 (34.47%)
Principle Diagnosis	
Depressive disorder	36 (7.71%)
Anxiety disorder	350 (74.95%)
Anxiety and depression	11 (2.35%)
Obsessive compulsive disorder	61 (13.06%)

Table 2*Nodes Used in Parent- and Youth-Reported Networks*

Node	Item	Parent M (SD)	Youth M (SD)
unhappy	I felt miserable or unhappy	0.85 (0.62)	0.84 (0.64)
enjoy	I didn't enjoy anything at all	0.38 (0.55)	0.39 (0.58)
less hungry	I was less hungry than usual	0.39 (0.63)	0.58 (0.73)
hungrier	I ate more than usual	0.32 (0.59)	0.5 (0.69)
restless	I was very restless	0.64 (0.67)	0.75 (0.75)
no good	I felt I was no good anymore	0.5 (0.63)	0.51 (0.7)
grumpy	I felt grumpy and cross with my parents	1.1 (0.67)	0.91 (0.76)
bad future	I thought there was nothing good for me in the future	0.38 (0.62)	0.49 (0.72)
concentrate	I found it hard to think properly or concentrate	0.86 (0.74)	1 (0.74)
did wrong	I did everything wrong	0.53 (0.64)	0.45 (0.68)
sleep prob	I didn't sleep as well as I usually sleep	0.67 (0.75)	0.86 (0.82)
more sleep	I slept a lot more than usual	0.32 (0.61)	0.49 (0.7)
breathe	When I feel frightened, it is hard for me to breathe	0.62 (0.73)	0.46 (0.66)
liking me	I worry about other people liking me	1.09 (0.76)	0.78 (0.82)
good as others	I worry about being as good as other kids	0.9 (0.79)	0.64 (0.79)
heart	When I get frightened, my heart beats fast	0.9 (0.79)	1.14 (0.81)
things working	I worry about things working out for me	1 (0.76)	0.75 (0.76)
worrier	I am a worrier	1.42 (0.72)	1.16 (1.31)
worry too much	People tell me that I worry too much	0.51 (0.72)	0.52 (0.73)
throw up	When I get frightened, I feel like throwing up	0.43 (0.7)	0.4 (0.65)
performance	I worry about how well I do things	1.19 (0.77)	0.94 (0.78)
past worry	I worry about things that have already happened	0.73 (0.74)	0.87 (0.78)

Parent-Reported Regularized Partial Correlation Network with Color-Coded Communities

Figure 2

Youth-Reported Regularized Partial Correlation Network with Color-Coded Communities

Figure 3*Standardized Strength Centrality Index for the Parent-Reported Network*

Note. Strength centrality index for nodes in parent-reported network. X-axis corresponds to standardized values for centrality indexes.

Figure 4*Standardized Strength Centrality Index for the Youth-Reported Network*

Note. Strength centrality index for nodes in parent-reported network. X-axis corresponds to standardized values for centrality indexes.