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Body Mistrust Bridges Interoceptive Awareness and Eating Disorder Symptoms

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Abstract

Interoceptive awareness (IA), or the awareness of internal body states, is known to be impaired in individuals with eating disorders (EDs); however, little is understood about how IA and ED symptoms are connected. Network analysis is a statistical approach useful for examining how symptoms interrelate and how comorbidities may be maintained. The present study used network analysis to: (1) test central symptoms within an IA-ED network, (2) identify symptoms that may bridge the association between IA and ED symptoms, and (3) explore whether central and bridge symptoms predict ED remission at discharge from intensive treatment. A regularized partial correlation network was estimated in a sample of 428 adolescent (*n*=187) and adult (*n*=241) ED patients in a partial hospital program. IA was assessed using items from the Multidimensional Assessment of Interoceptive Awareness, and ED symptoms were assessed using items from the Eating Disorder Examination-Questionnaire. Central symptoms within the network were strong desire to lose weight, feeling guilty, and listening for information from the body about emotional state. The most central symptom bridging IA and ED symptoms was (not) feeling safe in one's body. Of the central symptoms, greater desire to lose weight predicted lower likelihood of remission at treatment discharge. Bridge symptoms did not significantly predict remission. Body mistrust may be a mechanism by which associations between IA and EDs are maintained. Findings suggest targeting central and bridge symptoms may be helpful to improve IA and ED symptoms.

General Scientific Summary:

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This study suggests that desire to lose weight is central to eating disorder psychopathology and is associated with lower likelihood of remission. Feeling unsafe in one's body connects eating disorder symptoms with body awareness.

Keywords

network analysis; interoceptive awareness; eating disorder; comorbidity

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Deficits in interoceptive awareness (IA), the ability to recognize and process internal body states (e.g., hunger/satiety, taste, touch, pain, heartrate, breathlessness, arousal), have been implicated in the etiology and maintenance of mental health disorders including panic disorder, depression, somatic disorders, substance use disorders, posttraumatic stress, generalized anxiety disorder, autism spectrum disorder, and eating disorders (EDs; Khalsa et al., 2017). Indeed, deficits in IA have been implicated in the etiology of EDs since their initial conceptualization (Bruch, 1962), and these deficits are posited to contribute to ED symptoms including body image disturbance and inappropriate response to hunger/satiety (Kaye et al., 2009). Although IA deficits are not required for ED diagnoses, self-report, behavioral, and neurobiological studies have found deficits in IA in individuals with EDs compared to controls, and a recent meta-analysis of this literature reported large IA deficits (Jenkinson, Taylor, & Laws, 2018). Empirical evidence of altered activity in brain regions involved in perception of body states among individuals with EDs further supports the relevance of disturbed interoceptive processes in this population (Kaye, Fudge, & Paulus, 2009), as do findings showing that greater IA deficits are associated with worse ED treatment outcome (Bizeul, Sadowsky, & Rigaud, 2001; Carter, Blackmore, Sutandar-Pinnock, & Woodside, 2004).

Recent research outside the ED field has conceptualized IA as a multidimensional construct comprised of several facets including abilities to notice body sensations, attend to body sensations without distraction or worry, regulate attention and emotions by attending to body signals, be aware of the link between body signals and emotions, and listen to and trust in body sensations (Mehling et al., 2012). However, the majority of studies examining the connections between IA and EDs have neglected this multidimensional nature. A better understanding of which IA dimensions are most strongly linked with specific ED symptoms will provide insights necessary to inform the development of more effective treatments to target the co-occurrence of disturbances in IA dimensions and ED symptoms (see McNally, 2016).

Network analysis represents a useful analytic approach to characterize the complex links between IA dimensions and ED symptoms. This statistical method is rooted in the network theory of mental disorders, which proposes that disorders arise from and are defined by dynamic relations among symptoms, which may reinforce one another over time (Borsboom, 2017; Cramer, Waldorp, van der Maas, & Borsboom, 2010). Network theory contrasts with the traditional view of mental disorders as a set of symptoms arising from a latent syndrome. Network analytic studies of psychopathology allow for identification of *central symptoms* (or "nodes") that are core to and most influential within symptom networks (Borsboom & Cramer, 2013; McNally, 2016) which can inform targeted intervention selection (McNally, 2016). Supporting this concept, recent research has demonstrated that central nodes predict clinical outcomes (Elliot, Jones, & Schmidt, 2018; Olatunji, Christian, Brosof, Tolin, & Levinson, 2019; Olatunji, Levinson, & Calebs, 2018; Rodebaugh et al., 2018). Further, beyond deriving networks based on a single cluster of symptoms (e.g., ED symptoms), network analytic techniques can also be used to investigate relationships among interrelated or co-occurring symptom clusters (e.g., ED symptoms and IA dimensions). This is accomplished through the identification of *bridge pathways*, or symptoms in one cluster that are linked to symptoms in another (Borsboom & Cramer, 2013), which can provide insights into pathways underlying the co-occurrence of distinct symptom clusters. Of note, bridge symptoms are those that link the networks of distinct symptom clusters, whereas central symptoms are those that are at the core of the network. According to network theory, central symptoms should demonstrate predictive validity for disorder outcomes, while bridge symptoms should predict comorbidities between networks, rather than disorder outcomes (Borsboom & Cramer, 2013; Borsboom, 2017).

A number of studies have applied network analytic methods to EDs (DuBois, Rodgers, Franko, Eddy, & Thomas, 2017; Forbush, Siew, & Vitevitch, 2016; Forrest, Jones, Ortiz, & Smith, 2018; Forrest, Sarfan, Ortiz, Brown, & Smith, 2019; Levinson, Brosof, et al., 2018; Levinson, Vanzhula, & Brosof, 2018; Levinson et al., 2017; Vanzhula, Calebs, Fewell, & Levinson, 2019). Notably, few network studies in the ED field have examined whether central symptoms predict outcomes longitudinally. For instance, in one study of anorexia nervosa (AN), higher levels of weight- and shape-related central symptoms predicted failure to recover and greater impairment at 12-month follow-up (Elliot, Jones, & Schmidt, 2018). Research examing whether central ED symptoms predict longitudinal outcomes is critical to both test the prognostic utility of networks and to develop more targeted treatments (Rodebaugh et al., 2018). In the only study to our knowledge that has used network analysis to examine IA within an ED symptom network, findings revealed that interoceptive deficits were highly central to ED symptom networks at both admission and discharge in a large ED residential treatment sample (Olatunji, Levinson, & Calebs, 2018). However, the study utilized the Interoceptive Deficits subscale of the Eating Disorder Inventory-2 (EDI-2; Garner, 1991), conceptualized IA symptoms as part of the ED symptom network, rather than a separate network that may importantly connect to ED symptoms, and did not examine item level data. The EDI scale assesses both body- and emotion-related awareness and may conflate IA with alexithymia, a related, yet distinct construct focused on awareness of and reactivity to one's emotions (Merwin, Zucker, Lacy, & Elliott, 2010). Further, the EDI assumes IA is unidimensional. Given recent research suggesting that IA includes multiple dimensions or subscales (Mehling et al., 2012), investigating pathways that connect specific IA dimensions and ED symptoms may help inform interventions targeting the co-occurrence of IA deficits and EDs. Network theory posits that disrupting bridge pathways should theoretically help to break the connection between symptom networks (e.g., disturbed IA and ED symptoms). Therefore, these targeted treatments may focus particularly on IA dimensions that connect most strongly to ED symptoms. For instance, the choice of a clinical approach may differ if the identified bridge symptom was emotion-related versus body-related awareness. Given that initial data suggest that greater IA deficits, as measured by the EDI, are associated with poorer ED treatment outcome (Bizeul, Sadowsky, & Rigaud, 2001; Carter, Blackmore, Sutandar-Pinnock, & Woodside, 2004), it is plausible that intervening on the connections between specific IA and ED symptoms may have positive downstream effects on longer-term ED outcomes.

The Multidimensional Assessment of Interoceptive Awareness (MAIA; Mehling et al., 2012) is a self-report measure of eight specific IA dimensions and is well-suited to probe associations between IA dimensions and ED symptoms. The measure was originally developed and evaluated in a body-aware population (e.g., yoga experts) to characterize adaptive and maladaptive IA dimensions. The MAIA differentiates between ability to: 1) notice body sensations (“Noticing” subscale), 2) attend to body sensations without distraction (“Not Distracting”) or 3) worry (“Not Worrying”), 4) control attention to body signals (“Attention Regulation”), 5) be aware of the link between body signals and emotions (“Emotional Awareness”), 6) regulate distress by attending to body signals (“Self-Regulation”), 7) listen to the body for insight (“Body Listening”) and 8) trust in body sensations (“Trusting”). A recent study from our group provided support for the reliability and validity of the MAIA in a clinical sample of adolescents and adults with EDs (Brown et al., 2017), with results also showing that several MAIA subscales were associated with specific symptoms of ED psychopathology. Specifically, lower ability to maintain awareness of body sensations without distraction (i.e., “Not Distracting”) was associated with higher restraint, eating concern, and weight and shape concern; lower abilities to regulate distress by attending to body sensations (i.e., “Self-Regulation”) and listen to the body for insight (i.e., “Body Listening”) was related to higher eating concerns; and lower trust in one’s body signals (i.e., “Trusting”) was associated with higher restraint, eating concern, weight and shape concern, and binge/purge symptoms (Brown et al., 2017). These findings tentatively suggest that that these IA dimensions, especially attending to body sensation without distraction and body trust, may have particular relevance to global ED psychopathology.

The present study used network analysis to test links between IA dimensions and specific ED symptoms in a sample of patients seeking ED treatment at the partial hospitalization level of care. Our first aim was to identify core symptoms within an IA and ED symptom network. Consistent with previous research (DuBois et al., 2017; Forbush et al., 2016; Forrest et al., 2018; Forrest et al., 2019; Levinson et al., 2017; Vanzhula et al., 2019), we hypothesized that symptoms related to weight/shape concerns would be central to the network. Secondly, we aimed to identify bridge pathways between IA and ED symptoms. Based on previous findings from our group described above, we hypothesized that items from the MAIA Not Distracting subscale and the Trusting subscale would serve as bridges to the ED symptom network. Finally, given the limited ED research examining the predictive validity of networks, we tested whether central and bridge symptoms within the network predicted likelihood of remission at treatment discharge. Given previous research and presuppositions from network theory, bridge symptoms were tested to demonstrate the predictive sensitivity of central symptoms. Thus, we hypothesized that central, but not bridge, symptoms would predict lower likelihood of remission.

Method

Participants and Procedure

Participants were 428 adult and adolescent patients (*n* = 241 and *n* = 187, respectively) admitted to the UCSD Eating Disorders Center for Treatment and Research between December 2013 and November 2018 who completed IA and ED measures. Participants completed IA and ED assessments within 14 days of treatment admission and 14 days of discharge. Discharge data to determine remission status were available for 71.3% (n = 305) of the sample. Diagnoses prior to August 2016 were assigned using an unstandardized semi-structured interview by staff psychiatrists, based on 2010 draft criteria for the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5; APA, 2013). Diagnoses after August 2016 were determined using the Structured Clinical Interview for DSM-5 Disorders (SCID-5; First, Williams, & Spitzer, 2015) administered by trained, bachelor's-level research assistants. Table 1 displays descriptive data, including overall levels of ED symptoms[1]. Adults and adolescents did not differ on sex, race, or ethnicity. Adolescents had a lower admission body mass index (BMI), shorter length of stay and length of illness, were less likely to be on medication, and more likely to be diagnosed with AN-restricting type (AN-R) compared to adults. Adolescents reported lower overall eating pathology. The Institutional Review Board approved all study procedures.

Measures

ED Symptoms.—The Eating Disorder Examination–Questionnaire (EDE-Q version 6.0; Fairburn & Beglin, 1994) was used to assess ED symptoms (see Figure 1 for item descriptions) during the previous 28 days. Consistent with prior research applying network analyses with ED samples (Levinson, Brosof, et al., 2018; Levinson et al., 2017), the present study used the continuously rated (non-frequency count) items (#s:1–12,19–28), which are all rated on a 0–6 scale, with higher values indicating more severe ED symptoms. The EDE-Q has demonstrated good internal consistency, construct validity, and 2-week test-retest reliability (Berg, Peterson, Frazier, & Crow, 2011). Internal consistency across items in the present study was α =.96 for adolescents and α = .95 for adults.

Interoceptive Awareness.—As previously described, the MAIA (Mehling et al., 2012) is a 32-item self-report measure of eight IA dimensions: 1) Noticing ("I notice where in my body I am comfortable"), 2) Not-Distracting ("I distract myself from sensations of discomfort"), 3) Not-Worrying ("I can notice an unpleasant sensation without worrying"), 4) Attention Regulation ("I am able to consciously focus on my body as a whole"), 5) Emotional Awareness ("”When something is wrong in my life, I can feel it in my body"), 6) Self-Regulation ("When I am caught in my thoughts, I can calm my mind by focusing on my body/breathing"), 7) Body Listening ("I listen to my body to inform me about what to do"), and 8) Trusting ("I trust my body sensations") (see Figure 1 for item descriptions). Items are rated on a 0 (never) to 5 (always) scale, with higher scores indicating better IA; however, to facilitate interpretation in the present study, items were recoded consistent with the EDE-Q so that higher scores were more pathological (i.e., indicated poorer IA). The MAIA

[1] To provide context for severity of the sample, ED symptoms were assessed using the full global EDE-Q score.

subscales have demonstrated acceptable psychometric properties in ED (Brown et al., 2017) and non-ED populations (Machorrinho, Veiga, Fernandes, Mehling, & Marmeleira, 2019; Mehling et al., 2012). Internal consistency across the items used in the present study was α =.87 for adolescents and α = .89 for adults.

Remission Status.—Consistent with previous ED research (Bardone-Cone et al., 2010), individuals were considered remitted if they met the following criteria at treatment discharge: (1) BMI > 18.5; (2) no fasting, binge eating, or purging in the previous 28 days on the EDE-Q, and (3) EDE-Q Global scores within 1 SD of community means (Mond, Hay, Rodgers, & Owen, 2006).

Data Analyses

Missing Data.—One percent of the data at admission were missing. Little's MCAR test was statistically significant ($X^2(2038) = 2268.2$, $p < 0.001$), indicating data were not missing completely at random (MCAR). Thus, missing data were handled using multiple imputation, conducted using the mice package in R (Groothuis-Oudshoorn & Van Buuren, 2011). Data for determining remission status at discharge were not imputed.

Item Selection.—An empirical approach (Levinson et al., 2018) was used to select items for inclusion in the network, using the goldbricker function in R package *networktools* (Jones, 2017), which wraps the R package *cocor* (Diedenhofen & Musch, 2015). Goldbricker identifies potential issues with item redundancy by comparing every possible combination of correlations within the network. This function determines whether correlations between each node in a pair to each other node in the network are significantly different from one another; if only a small proportion of correlations are different, that suggests that the pair of nodes are redundant. Once the redundant pairs are identified, the *best_goldbricker* function suggests which nodes to remove. All MAIA items and all continuously rated items of the EDE-Q were initially retained; after applying goldbricker, EDE-Q items 3, 8, and 23 and MAIA items 1, 8, 12, 14, 17, 21, 23, and 30 were removed. This approach resulted in a final network with 45 nodes (26 MAIA, 19 EDE-Q).

Network Estimation.—Networks were estimated using a partial correlation graphical least absolute shrinkage and selection operator (GLASSO) estimator using *bootnet*. Regularized partial correlation networks (GLASSO networks) estimate edges (i.e., the partial correlation between two nodes) that are likely to be spurious as zero, leading to a more parsimonious and theoretically more accurate network (Epskamp & Fried, 2018). Correlations between nodes in GLASSO networks represent unique partial relationships among symptoms while accounting for all symptoms in the network. The initial networks were estimated using polychoric correlations. The resulting network was dense and had several unexpected negative edges. Thus, per recommendation of Epskamp and Fried (2018), we used Spearman correlations in our final analysis. Multidimensional scaling for visualization (Jones, Mair, & McNally, 2018) was used to allow for meaningful interpretation of distances between nodes.

Centrality Indices.—We identified central nodes by calculating strength centrality and strength expected influence (EI). Strength centrality is defined as the sum of the absolute values of the connections between one node and all other nodes (McNally, 2016). Similarly, EI is the sum of connections between one node and all other nodes, but it accounts for both positive and negative connections. EI may be a more accurate centrality measure in networks with negative edges (e.g., negative associations among nodes; McNally, 2016). We identified bridge nodes between MAIA and EDE-Q symptom clusters by calculating bridge strength centrality and bridge expected influence. Bridge strength is defined as the sum of the absolute values of the connections that exist between a node and all nodes that are not in the same cluster (IA items were designated as one cluster and ED symptoms as another). Bridge EI is a similar bridge centrality estimate that accounts for both positive and negative connections. Strength centrality and EI were calculated using the *centralityPlot* and *centralityTable* functions in the *qgraph* package in R (Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom, 2012). We used the bridge function of the *networktools* package (Jones, 2017) to identify bridge symptoms between IA and ED symptom items. We also performed both node centrality and bridge centrality difference tests to determine whether nodes with higher centrality statistics were significantly different from nodes with lower values (Epskamp, Borsboom, & Fried, 2018).

Network Stability.—The R package *bootnet* (Epskamp et al., 2018) was used to assess stability of the networks. We computed five stability parameters (a strength centrality stability coefficient (CS-coefficient), an EI stability coefficient (EI-coefficient), an edge stability coefficient (ES-coefficient), a bridge strength stability coefficient (BS-coefficient), and a bridge EI stability coefficient (BEI-coefficient)), which reflect the maximum proportion of cases that can be dropped such that the correlation between original centrality indices and the reduced sample is at least .70. Coefficients between .20 and .50 are acceptable, above .50 and below .70 are good, and above .70 are excellent (Epskamp et al., 2018).

Network Comparison.—We conducted the Network Comparison Test (NCT) to test for differences in strength centrality between adult and adolescent networks using the *NetworkComparisonTest* package in R (van Borkulo et al., 2015). The NCT can determine if there are differences in network structure (i.e., node connectivity across samples), and/or global strength (i.e., the sum of the strengths of all edges in the network) differs across samples (van Borkulo et al., 2015).

Logistic Regression.—Finally, two separate logistic regression models were run to examine whether (1) central and (2) bridge symptoms predicted likelihood of remission at treatment discharge in the subset of individuals with discharge data ($n = 304$). In each model, the central or bridge symptoms with the highest centrality, as noted in the results, were included as predictors.

Results

Central Symptoms

Network stability was good (CS-coefficient = .67, EI-coefficient = .67; ES-coefficient = .67). Figure 1 presents the IA and ED symptom network and Figure 2 presents the centrality plots. Because our network had several negative edges, we chose to report both strength centrality and EI results. When negative edges are present, strength and EI values may provide unique information, although in our case they were highly correlated ($r = .70$, $p < .001$). The symptoms with the highest strength centrality were: having a strong desire to lose weight (*losew*; strength = 1.58), feeling guilty (*guilty*; strength = 1.45), and listening for information from the body about emotional state (*emotional*; strength = 1.35). Having a strong desire to lose weight had significantly higher strength centrality than 70% of other nodes, feeling guilty had significantly higher strength centrality than 53% of other nodes, and listening for information from the body about emotional state had significantly higher strength centrality than only 51% of the nodes. See Figure 3 for the centrality difference graph. The symptoms with the highest EI were: having a strong desire to lose weight (*losew*; EI = 1.42), (mis)trust in body sensations (*trust*; EI = .95), and restricting food intake (*restrict*; EI = .91). Having a strong desire to lose weight had significantly higher EI than 79% of other nodes, (mis)trust in body sensations and restricting food intake had significantly higher EI than only 40% of other nodes. Because nodes *guilty, emotional, trust, and restrict* had inconsistent strength and EI and were only significantly different from about half of other nodes, we chose not to interpret them in the discussion.

Bridge Symptoms

Bridge strength stability was acceptable, but low (BS-coefficient = .36). Bridge EI was good (BEI-coefficient = .52). Due to low bridge strength stability, we chose to report and interpret bridge EI. The nodes with the highest bridge EI were all IA symptoms. The node with the highest bridge EI was the IA item, (not) feeling that one's body is a safe place (*safe*, IA symptom, bridge EI = .20). It was most strongly associated with the following ED symptoms: overvaluation of weight (*judge*; part $r = .06$), and desire for a flat stomach (*flatstom*; part $r = .06$). Additional IA nodes with the highest bridge EI were (mis)trust in body sensations (*trust*; bridge EI = 13) and ignoring physical tension/discomfort until it becomes severe (*tension*; bridge EI = 12.). (Mis)trust in body sensations was most strongly associated with the following ED symptoms: shape dissatisfaction (dissshape; part r = .04) and distress about weighing (weigh; part r = .04). Ignoring physical tension/discomfort until it becomes severe was most strongly associated with the following ED symptoms: desire for an empty stomach (emptystom; part r = .05) and fear of losing control over eating (fearlose; part r = .04). These three top IA bridge symptoms were not significantly different from each other (*p*s > .05). Feeling that one's body is a safe place had significantly higher bridge EI than 91% of other bridge nodes. (Mis)trust in body sensations had higher bridge EI than 47% of nodes, and ignoring physical tension/discomfort had higher bridge IE than 42% of nodes. See Figure 4 for the bridge EI centrality difference graph.

The ED symptoms that were most strongly connected to the IA cluster were overvaluation of weight (*judge*, bridge EI = .10) and others seeing one's shape (*othersee*; bridge EI = .10)

Notably, these ED bridge symptoms were not significantly different from any other bridge symptoms, thus we did not interpret these bridge symptoms.

The NCT showed that the adult and adolescent networks were not different in overall structure (p = .32) or global strength (p = .81).

Predictive Validity of Central and Bridge Symptoms

Around one third of the sample (35.1%; n=110/313) met criteria for remission at discharge. Results from the logistic regression model of central symptoms (predictors: *losew, guilty, emotional, trust, restrict*) showed that stronger desire to lose weight at admission was associated with lower likelihood of achieving remission at discharge; no other central symptoms significantly predicted remission (see Table 2). Regarding the model of bridge symptoms (predictors: *safe, trust, tension, judge, othersee*), no symptoms predicted remission (see Table 2).

Discussion

The present study used network analysis to identify how dimensions of IA are connected to ED symptoms and explored whether central and bridge symptoms predicted outcome at discharge from intensive treatment. The most central node in the IA-ED network was having a strong desire to lose weight. The primary symptom that connected IA and ED symptoms was *(not) feeling one's body is a safe place*, from the MAIA Trusting subscale. This suggests that body (mis)trust may be the most relevant aspect of IA for understanding EDs, and that this construct may be important for understanding the overlap between IA and EDs. Network structure did not differ significantly between adolescents and adults. Importantly, the central symptom of having a strong desire to lose weight significantly predicted lower likelihood of remission at discharge, whereas bridge symptoms did not.

Results demonstrating the centrality of desire to lose weight are consistent with previous network analyses using the EDE-Q in clinical samples (Forrest et al., 2018; Levinson et al., 2017), and research demonstrating that weight and shape concerns are central to ED networks (DuBois et al., 2017; Forbush et al., 2016; Forrest et al., 2018; Forrest et al., 2019; Levinson et al., 2017; Vanzhula et al., 2019). These results also provide further support for the enhanced cognitive behavioral therapy (CBT-E) model of EDs (Fairburn, 2008) in a transdiagnostic sample of adults and adolescents seeking treatment at higher levels of care, given a primary aim is to disrupt overvaluation of weight and shape.

Bridge analyses revealed that IA was linked to ED symptoms through low levels of body trust. In particular, *feeling unsafe in one's body* represented the strongest link between the clusters and was most strongly connected to weight and shape concerns (i.e., overvaluation of weight, desire for a flat stomach). The IA item *(mis)trust in body sensations* also demonstrated relatively strong bridge EI and was also most strongly connected to ED items related to weight and shape (i.e., shape dissatisfaction, distress about weighing). These results are consistent with previous research linking deficits in body trust and interoception to body image and drive for thinness (Brown et al., 2017; Denny, Loth, Eisenberg, & Neumark-Sztainer, 2013; Duffy, Rogers, Joiner, et al., 2019). Body (mis)trust characterizes

EDs (Brown et al., 2017;Khalsa et al., 2015) as well as several other clinical conditions, including suicidality (Duffy, Rogers, Gallyer, & Joiner, 2019; Duffy, Rogers, & Joiner, 2018), panic disorder (Clark et al., 1997), complex trauma (Gene-Cos, Fisher, Ogden, & Cantrell, 2016), and somatoform disorders (Kalisvaart et al., 2012). However, based on our results, the presence of weight and shape concerns (e.g., overvaluation of weight and desire for a flat stomach) appears to distinguish EDs from other disorders characterized by low body trust. Indeed, individuals who overvalue weight in their self-evaluation, desire a flat stomach, and experience low body trust may be more likely to rely on external body standards and engage in body checking behaviors to ensure/reassure that they have not gained weight. However, if the perceptual information they receive about their body is distorted or inaccurate, this may exacerbate feeling unsafe in one's body and lead to greater body monitoring and avoidance of food in an attempt to prevent disproportionate and unexpected weight gain.

Consistent with our previous research supporting the relevance of the MAIA Not Distracting subscale for ED symptoms (Brown et al., 2017), in addition to body trust, *ignoring physical discomfort or tension until it becomes severe* also demonstrated relatively strong bridge EI. This aspect of IA was most strongly connected to restraint (desire for an empty stomach) and eating concerns (fear of losing control). This finding is also consistent with previous research documenting elevated pain threshold and tolerance in EDs (de Zwaan, Biener, Schneider, & Stacher, 1996) and research linking pain insensitivity with ED psychopathology (Smith et al., 2013). Indeed, the ability to ignore physical sensations of discomfort may help maintain restrictive eating to avoid fullness or cognitive concerns about losing control. Alternatively, restriction may lead to greater ability to ignore physical discomfort over time.

Low body trust also may be influenced by valenced judgements of internal experiences. For example, research on other forms of psychopathology characterized by altered interoceptive processing (e.g., panic disorder) supports the common experience of interpretations/ judgements of body signals as dangerous or aversive—a tendency termed *anxiety sensitivity* (Reiss et al., 1986). Although tentative, initial research also indicates elevated anxiety sensitivity in EDs (Anestis, Selby, Fink, & Joiner, 2007; Fulton et al., 2012; Thompson-Brenner, Boswell, Espel-Huynh, Brooks, & Lowe, 2018), suggesting that this construct may influence an individual's self-reported bodily trust. For example, a patient may feel full, bloated, or notice their clothing tighten after eating and may (mis)interpret these sensations as indicating that they are becoming fat. This misinterpretation may occur, in part, due to believing that these body sensations are abnormal and/or dangerous, given their perceived association with weight gain. Importantly, the directionality of associations between an individual's experience of an interoceptive sensation, their negative judgements of interoceptive sensations, and their level of body trust remains unclear. Future research is needed to gain a more complete understanding of these phenomena. Given documented comorbidities between gastrointestinal disorders and EDs, future research may also benefit from exploring whether body mistrust may connect these disorders.

Critically, our finding that desire to lose weight predicted lower likelihood of remission at discharge supports the posited role of central symptoms in network theory and adds to a growing literature focused on identifying symptoms with prognostic value using network analysis (Elliot et al., 2018; Olatunji et al., 2019; Olatunji et al., 2018; Rodebaugh et al., 2018). This result in a transdiagnostic sample aligns with previous network analytic research in AN (Elliot et al., 2018), where desire to lose weight was among the strongest predictors of recovery status and clinical impairment at 12-month follow-up from outpatient treatment. Given the limited and often inconsistent literature on predictors of ED treatment outcomes, it is notable that the predictive ability of desire to lose weight replicates across at least two independent samples. In contrast, bridge symptoms did not significantly predict remission status. However, this is consistent with network theory, which suggests that bridge symptoms should help explain co-occurrence between symptoms networks, rather than demonstrating predictive validity (Borsboom & Cramer, 2013; Borsboom, 2017). While results suggest that targeting bodily trust may not impact likelihood of remission, based on network theory, intervening on this pathway should theoretically disrupt the connections among IA and ED symptoms, thereby weakening the overall comorbidity network.

Although one might expect network relationships between IA and ED symptoms to be stronger in adults (e.g., given longer duration of illness), we did not find significant differences in network structure between adolescents and adults. The present study found that ED psychopathology was more severe in adults, and a previous study from our group found that adolescents scored significantly higher than adults on the MAIA Trusting subscale. However, mean differences in ED symptoms or IA dimensions across age groups does not necessarily reflect differences in the nature of the associations between these constructs. Thus, the relationship between IA and ED may not differ across adolescents and adults even if adults exhibit greater severity in certain IA dimensions and ED symptoms. Notably, given recent network analysis research demonstrating more tightly connected ED symptoms in older compared to younger individuals with ED (Christian et al., in press), future research should continue to compare networks across ages.

Clinical Implications

The current results support that desire to lose weight may be a salient ED treatment target and reinforce the importance of targeting weight/shape concerns. Cognitive-behavioral interventions (e.g., CBT-E) aim to target weight-focused cognitions and desires via cognitive (e.g., pie chart) and behavioral (e.g., reducing body checking and body avoidance) strategies. Additionally, recent evidence suggests that dissonance-based techniques focused on challenging social pressures to lose weight/be thin may be helpful in ED populations (Stice, Rohde, Butryn, Menke, & Marti, 2015); however, additional research is needed.

Results also suggest that targeting body mistrust may be helpful in improving body image in patients with EDs by disrupting the IA-ED network. In the anxiety field, mistrust of interoceptive signals has been targeted using interoceptive exposure. In recent years, researchers have begun to examine the efficacy of ED-specific interoceptive exposures (Boswell et al., 2019; Hildebrandt, Bacow, Greif, & Flores, 2014; Zucker et al., 2017), such as rapidly drinking water to simulate fullness/bloating or wearing tight clothing to elicit body image concerns. Initial research supports that interoceptive exposure may help improve ED symptoms and the tendency to perceive body signals as dangerous (Boswell et al., 2019;

Thompson-Brenner et al., 2018), suggesting that this may be one way to challenge body mistrust.

Body mistrust and ignoring physical discomfort until severe could also be targeted through mindfulness-based approaches. In a prior study, IA was found to mediate the relationship between mindfulness and disordered eating behaviors in an at-risk non-clinical sample (Lattimore et al., 2017). Thus, mindfulness interventions focused on non-judgmentally noticing uncomfortable body sensations without acting on them or distracting (e.g., noticing fullness and the urge to purge without acting) may be useful. Further, mindfulness may increase awareness of hunger/fullness sensations (Kristeller & Hallett, 1999). However, it is unclear whether mindfulness may influence body trust, even if it does increase IA. Therefore, more research on this topic is needed.

Strengths & Limitations

The present study has notable strengths, including the large transdiagnostic clinical sample of adolescent and adult patients with EDs, implementation of methods to reduce network collinearity, examination of network and bridge stability, and examination of central and bridge symptom predictive. These strengths notwithstanding, there were also limitations. First, smaller sample sizes within specific diagnostic subgroups precluded examination of whether the IA-ED symptoms associations differed across ED diagnoses. Further, given differences in how diagnoses were assessed, inter-rater reliability was not established across diagnoses. Second, data for the present study came from a treatment-seeking sample that was predominately female, Caucasian, and non-Hispanic. Thus, results may not generalize to other demographic groups. Third, network analyses are inherently limited by the items included in the models. Although we used an empirical approach for item selection to help reduce item redundancy, this did result in the removal of certain IA and ED items, and items were not selected based on clinical usefulness or relevance, which may have influenced our results. Results may have differed if other items were or were not included. Additionally, objectively measurable mechanisms that may explain the link between "feeling unsafe in one's body" and ED symptoms should be the focus of future studies.

Conclusions

The present study utilized network analysis to more precisely characterize associations between ED symptoms and multiple dimensions of IA. Results support that feeling unsafe in one's body may be one factor that maintains associations between IA and ED symptoms and could represent an important focus for future research. Results further underscore the importance of weight and shape concerns in network models of eating pathology and suggest that targeting desire to lose weight may be helpful in promoting symptom remission across ED diagnoses. Future longitudinal research clarifying the nature of body mistrust in EDs will be essential to appropriately inform ED interventions that may target altered IA.

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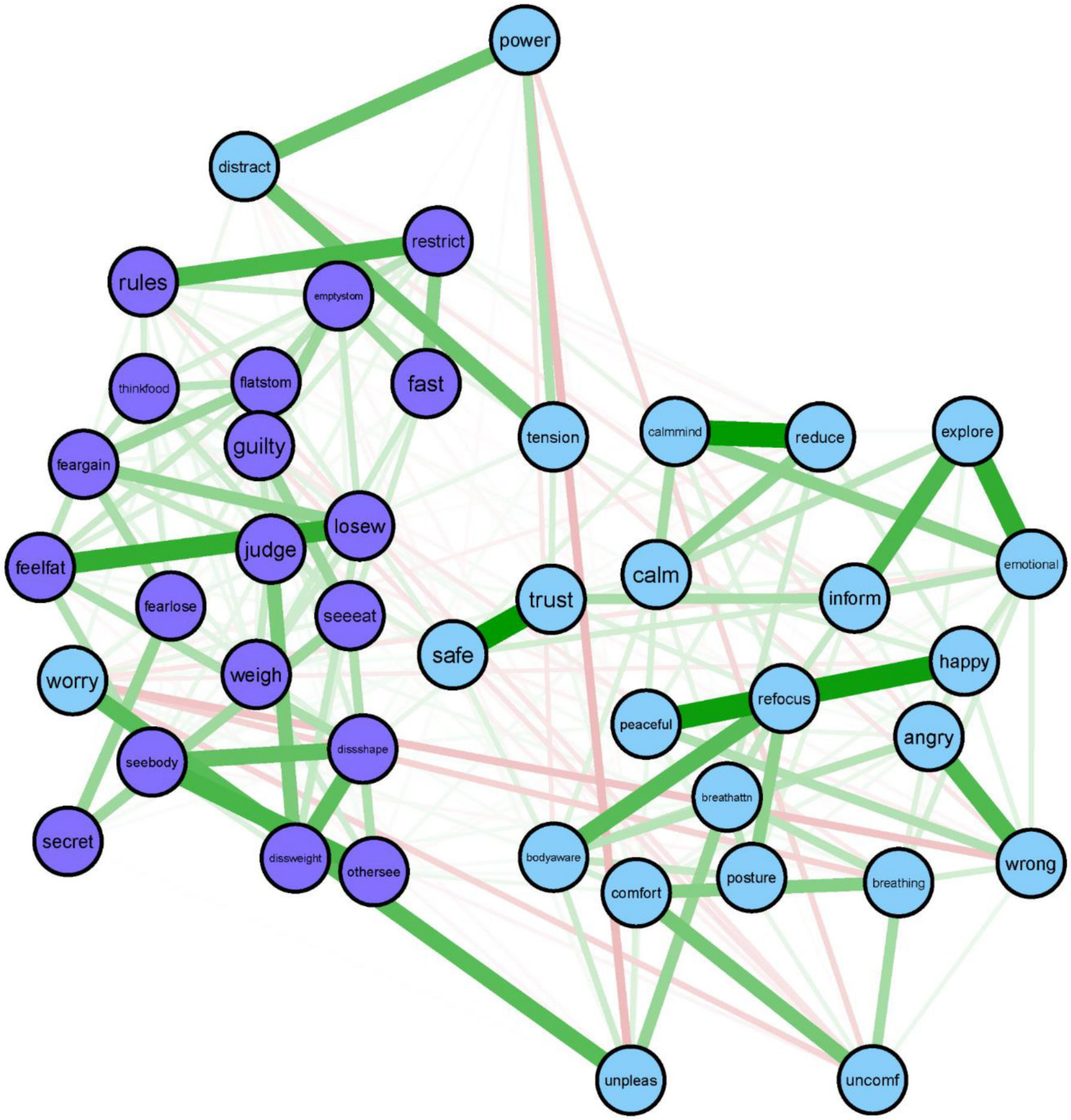

Figure 1.

Interoceptive awareness (IA) and eating disorder (ED) symptom network.

IA symptoms (top of figure) are in light blue (light gray without color) and ED symptoms (bottom) are in purple (dark gray). Thicker lines represent stronger relationships.

IA labels: Angry = noticing body changes when angry; Bodyaware = maintain awareness of whole body when distressed; Breathattn = pay attention to breathe without being distracted; Breathing = notice changes in breathe; Calm = ability to calm mind by focusing on body/ breathing; Calmmind = can calm mind by focusing on body/breathing; Comfort = notice where comfortable in the body; Emotional = listening to the body for information about emotional state; Explore = exploring how body feels when upset; Happy = noticing body changes when happy; Inform = listening to the body to inform action; Peaceful = noticing body differences when peaceful; Posture = pay attention to posture; Power = “power through" pain; Reduce = can use breathe to reduce tension; Refocus = refocus attention from thinking to sensing; Safe = feeling body is a safe place; Tension = Ignore physical tension/discomfort until severe; Trust = trusting body sensations; Unconf = notice body discomfort; Unpleas = notice unpleasant body sensations without worrying; Worry = worry something is wrong if uncomfortable; Wrong = feeling body changes when something is wrong.

ED labels: Dissshape = shape dissatisfaction; Dissweight = weight dissatisfaction; Emptystom = desire to have empty stomach; Fast = long time without eating; Feargain = fear of gaining weight; Fearlose = fear of losing control; Feelfat = feeling fat; Flatstom = desire to have flat stomach; Guilty = guilt after eating; Judge = overvaluation of weight; Losew = desire to lose weight; Othersee = uncomfortable with others seeing shape; Restrict = limiting amount of food; Rules = following rules regarding eating; Secret = eating in secret; Seeeat = concern about others observing eating; Seebody = discomfort seeing body; Thinkfood = concentration problems regarding eating; Weigh = distress about weighing.

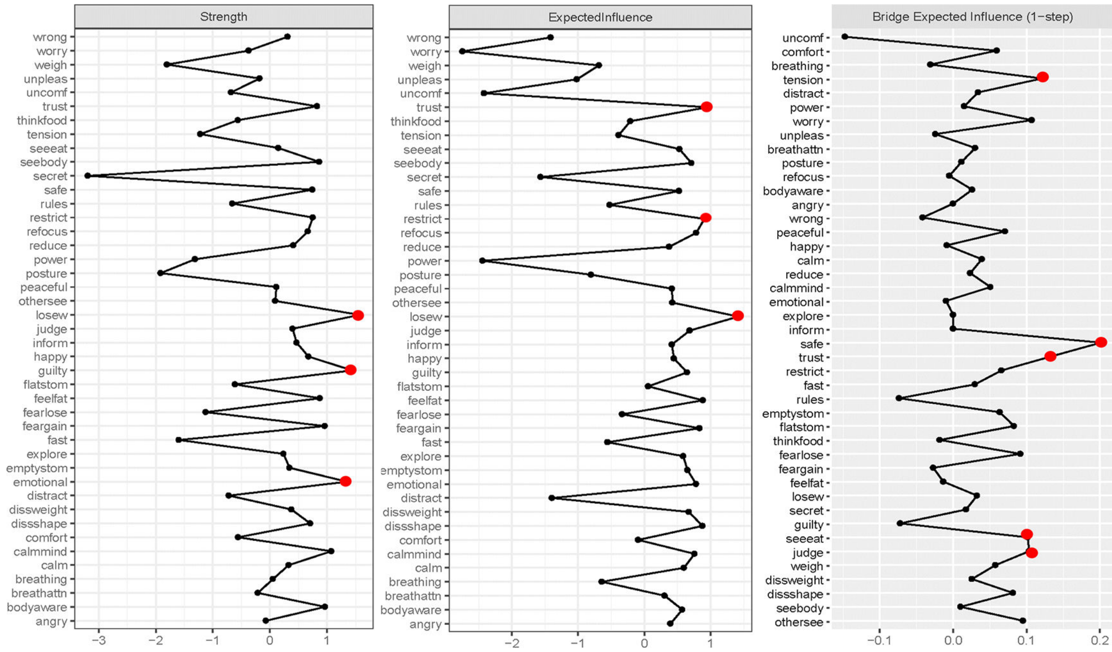

Figure 2.

Network strength and expected influence and bridge expected influence plots for the interoceptive awareness (IA) and eating disorder (ED) symptom network.

The strongest central and bridge symptoms are highlighted with a red (dark gray) dot.

IA labels: Angry = noticing body changes when angry; Bodyaware = maintain awareness of whole body when distressed; Breathattn = pay attention to breathe without being distracted; Breathing = notice changes in breathe; Calm = ability to calm mind by focusing on body/ breathing; Calmmind = can calm mind by focusing on body/breathing; Comfort = notice where comfortable in the body; Emotional = listening to the body for information about emotional state; Explore = exploring how body feels when upset; Happy = noticing body changes when happy; Inform = listening to the body to inform action; Peaceful = noticing body differences when peaceful; Posture = pay attention to posture; Power = “power through” pain; Reduce = can use breathe to reduce tension; Refocus = refocus attention from thinking to sensing; Safe = feeling body is a safe place; Tension = Ignore physical tension/ discomfort until severe; Trust = trusting body sensations; Unconf = notice body discomfort; Unpleas = notice unpleasant body sensations without worrying; Worry = worry something is wrong if uncomfortable; Wrong = feeling body changes when something is wrong.

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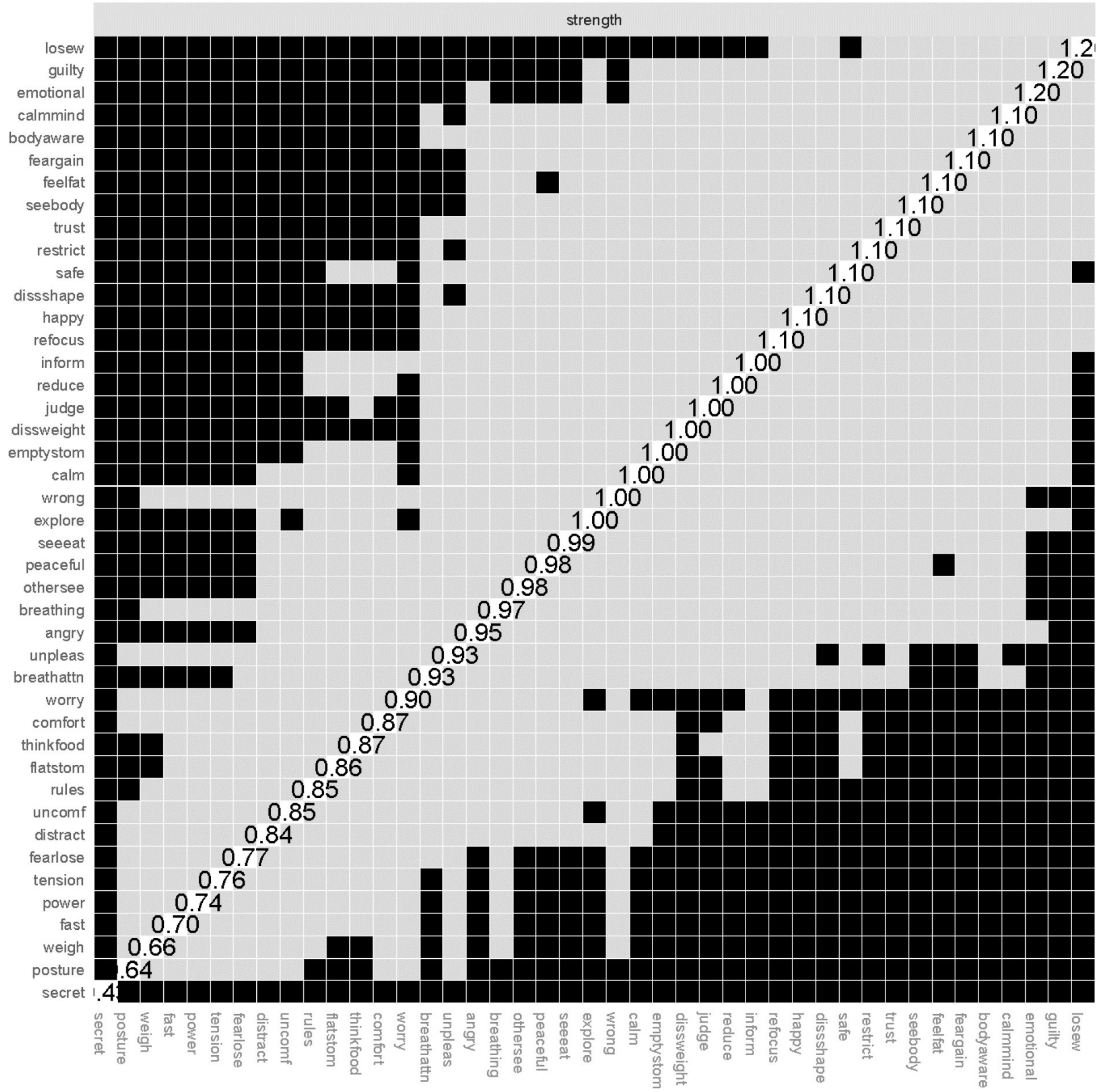

Figure 3.

Strength centrality difference graph.

Symptoms are presented in descending order of strength. Values on the diagonal indicate unstandardized strength values. Black squares indicate statistically significant difference between nodes at $p < .05$.

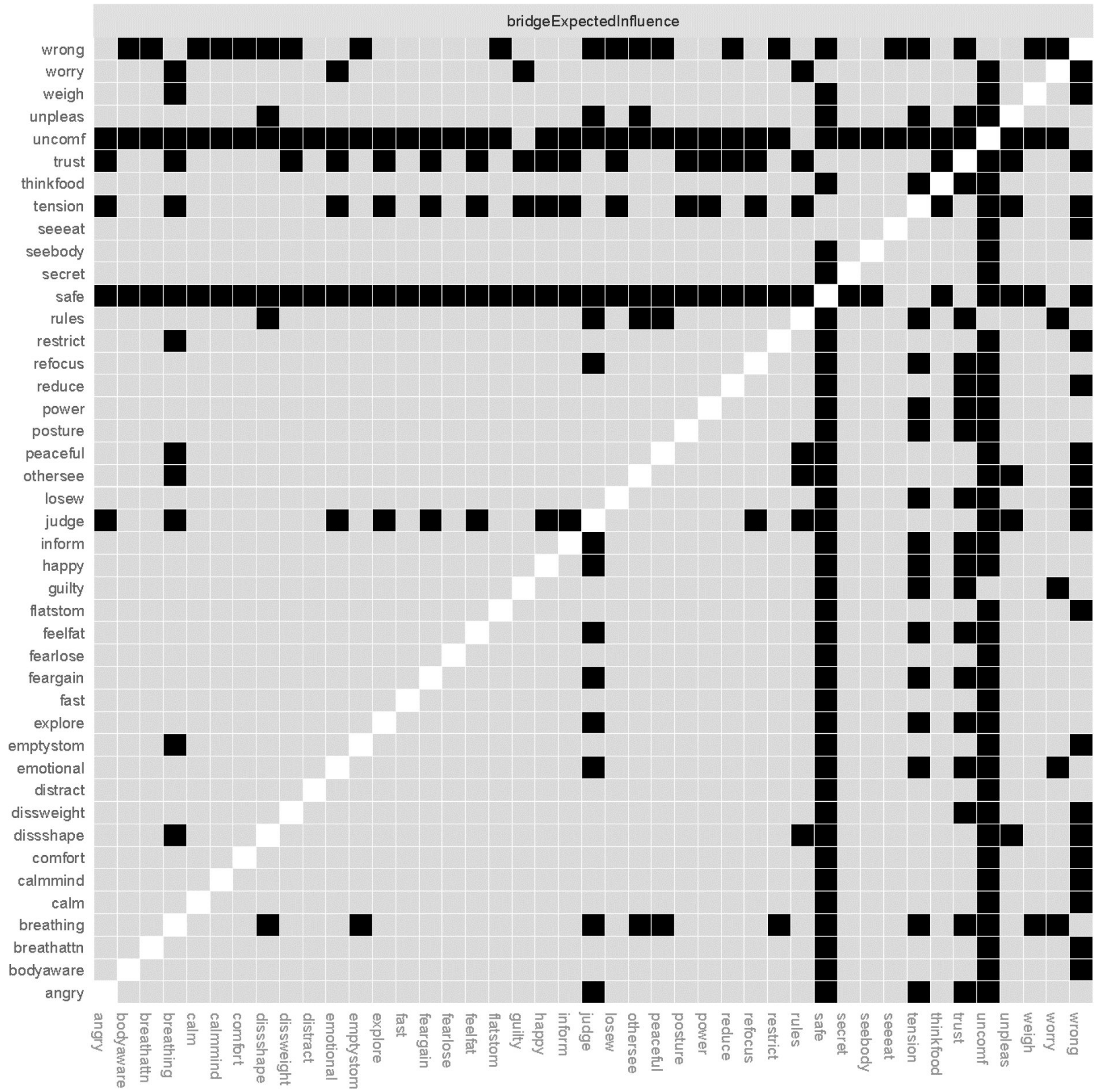

Figure 4.

Bridge expected influence difference graph.

Black squares indicate statistically significant difference between nodes at $p < .05$.

Table 1

Demographic Characteristics of the Sample

Variable	Total M(SD)/n(%)	Adolescents M(SD)/n(%)	Adults M(SD)/n(%)	F/X^2	*p*
Age	21.70 (8.78)	15.69 (1.70)	26.36 (9.22)	243.97	<.001
BMI at admission	20.41 (5.06)	18.97 (3.96)	21.54 (5.52)	29.00	<.001
Length of Illness	6.69 (8.06)	2.26 (1.80)	10.29 (9.29)	134.97	<.001
Female	406 (94.86)	178 (95.19)	228 (94.61)	0.73	.79
Race				5.53	.35
Caucasian	317 (74.59)	130 (69.89)	187 (78.24)		
Asian	26 (6.12)	13 (6.99)	13 (5.44)		
African American	2 (0.47)	1 (0.54)	1 (0.42)		
Native Hawaiian/Pacific Islander	1 (0.24)	0 (0.00)	1 (0.42)		
Native American/Alaskan Native	3 (0.71)	1 (0.54)	2 (0.84)		
Other	76 (17.88)	41 (22.04)	35 (14.64)		
Ethnicity				2.27	.13
Hispanic	70 (16.87)	25 (13.74)	45 (19.31)		
Non-Hispanic	345 (83.13)	157 (86.26)	188 (80.69)		
Antidepressant Medication	234 (59.85)	62 (39.74)	172 (73.19)	43.65	<.001
Atypical Antipsychotics	69 (17.65)	20 (12.82)	49 (20.85)	4.16	.04
Mood Stabilizer	72 (18.41)	7 (4.49)	65 (27.66)	33.51	<.001
Anxiolytic	36 (9.21)	8 (5.12)	28 (11.91)	5.17	.02
ED Diagnosis				59.89	<.001
Anorexia Nervosa – Restricting	191 (44.73)	121 (65.05)	70 (29.04)		
Anorexia Nervosa – Binge/Purge	64 (14.99)	24 (12.90)	40 (16.60)		
Bulimia Nervosa	103 (24.12)	28 (15.05)	75 (31.12)		
Binge Eating Disorder	13 (3.04)	3 (1.61)	10 (4.15)		
Other Specified Feeding or Eating Disorder	56 (13.11)	10 (5.38)	46 (19.09)		
Met Remission Criteria at Discharge	110 (33.44)	50 (33.3)	60 (33.5)	.001	.97
Admission EDE-Q Global	3.58 (1.64)	3.30 (1.73)	3.80 (1.53)	9.79	.002

Note. BMI = body mass index; ED = eating disorder. ED means reflect full-scale scores.

Table 2

Central and Bridge Symptoms as Predictors of Remission Status at Treatment Discharge

	Remission Status at Discharge			
Model of Central Symptoms Predicting Discharge Remission Status				
Variable	**OR**	**Wald X^2**	***p***	***95% CI OR***
Losew	0.80	8.24	.004	[0.69, 0.99]
Guilty	1.03	0.12	.73	[0.87, 1.22]
Emotional	1.02	0.04	.84	[0.84, 1.13]
Trust	1.03	0.11	.74	[0.86, 1.24]
Restrict	1.01	0.04	.84	[0.89, 1.16]
Model of Bridge Symptoms Predicting Discharge Remission Status				
Variable	**OR**	**Wald X^2**	***p***	***95% CI OR***
Safe	1.04	0.11	.74	[0.81, 1.34]
Trust	0.99	0.01	.95	[0.78, 1.27]
Tension	0.95	0.46	.50	[0.81, 1.11]
Judge	0.95	0.38	.54	[0.82, 1.11]
Othersee	0.91	1.64	.20	[0.79, 1.05]

Note. OR = Odds Ratio; Losew = strong desire to lose weight; Guilty = guilt after eating; Emotional= listening for information from the body about emotional state; Trust = trusting body sensations; Restrict = restricting amount of food eaten; Safe = feeling one's body is a safe place; Tension = ignoring physical tension/discomfort; Judge = overvaluation of weight; Othersee = uncomfortable with others seeing shape.