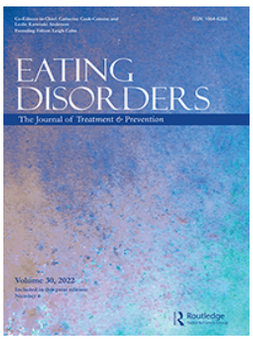

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Testing intrusive thoughts as illness pathways between eating disorders and obsessive-compulsive disorder symptoms: a network analysis

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ABSTRACT

Obsessive-compulsive disorder (OCD) and eating disorders (EDs) frequently co-occur. Intrusive thoughts are a mechanism that may maintain this comorbidity. This study used network analysis to identify central ED-related intrusive thoughts and tested which intrusive thoughts connected ED and OCD symptoms. Two cross-sectional graphical LASSO networks were computed using a sample of 353 non-clinical participants (mean age = 35.38, *SD* = 9.9, 40% female, 81.6% Caucasian) with elevated disordered eating symptoms. Model 1 included just ED-related intrusive thoughts, and Model 2 included ED-related intrusive thoughts, ED, and OCD symptoms. In Model 1, we found that thoughts about one's bodily appearance (i.e., looking horrible, getting fat, gaining weight) were most central. In Model 2, we found that desire to lose weight, eating in secret, and shape dissatisfaction were most central. We identified one illness pathway (i.e., difficulty concentrating due to thoughts of food/calories) connecting intrusive thoughts, ED symptoms, and OCD symptoms. However, intrusive thoughts did not bridge ED and OCD symptoms. Hence, we found some evidence that ED-related intrusive thoughts may contribute to ED and OCD symptoms based on thought content and frequency. However, other aspects of intrusive thoughts should be considered to ascertain whether they do in fact significantly contribute to ED and OCD comorbidity. Prevention efforts targeting ED-related intrusive thoughts may attenuate ED and OCD symptoms among subclinical individuals

Clinical implications

- ED-related intrusive thoughts may contribute to ED and OCD comorbidity.
- Targeting body dissatisfaction and other ED cognitions may prevent onset of ED and OCD.

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Supplemental data for this article can be accessed on the publisher's website.

- Cognitions surrounding food/calories may promote intrusive fears about fatness and weight gain.
- ED cognitions and intrusive fears may be associated with engagement in compulsions.

Introduction

Eating disorders (EDs) are serious psychological disorders related to preoccupation with one's shape, weight, and eating habits, and dysfunctions in one's cognitions and behaviors associated with food and body image (American Psychiatric Association [APA], 2013). Obsessive-compulsive disorder (OCD) is similarly a serious, chronic psychological disorder but one that involves uncontrollable, re-occurring thoughts, or obsessions, and behaviors one feels compelled to perform to reduce anxiety related to these obsessions, or compulsions (APA, 2013). OCD frequently co-occurs with EDs; approximately 41% of individuals with a primary ED diagnosis also report having a lifetime OCD diagnosis globally (Kaye et al., 2004; Mandelli et al., 2020). ED-OCD comorbidity is associated with several poor outcomes, including a prolonged period of illness (Milos et al., 2003), worse prognosis (Wentz et al., 2001), increased risk of relapse (Carter et al., 2012), higher rates of other psychiatric comorbidities, and greater risk for suicide attempts (Sallet et al., 2010). Given these poor outcomes, it is important to identify specific mechanisms driving the ED-OCD relationship in order to identify treatment targets that can successfully reduce maladaptive cognitions and behaviors associated with both illnesses.

One mechanism proposed to maintain both OCD and EDs is experiencing intrusive thoughts (García-Soriano et al., 2014). OCD is characterized by obsessions (i.e., persistent, unwanted, and intrusive thoughts) and compulsions (i.e., behaviors aimed at alleviating the anxiety caused by obsessions; APA, 2013). EDs can also present with persistent, intrusive thinking (e.g., shape/weight preoccupation), and compulsions (e.g., purging, frequent weighing) used to mitigate the anxiety driven by these intrusive thoughts (Altman & Shankman, 2009). Thus, similar to how intrusive thoughts with particular themes (e.g., morality, contamination) may cause distress and subsequent compulsive behaviors in individuals with OCD (Moulding et al., 2014), intrusive thoughts about weight, shape, exercise, and food are associated with an increased engagement in disordered eating behaviors in individuals with EDs (Perpiñtá et al., 2011). Preliminary evidence indicates that intrusive thoughts appear with comparable frequency and emotional disturbance between individuals with OCD and ED (García-Soriano et al., 2014). Moreover, disordered eating-related intrusive thoughts are common in the general public, with individuals without a clinical ED endorsing high levels of ED-related thoughts, such as body dissatisfaction and fear of weight gain (Miller et al., 2009). Given

that ED-related intrusive thoughts are common within clinical and community samples, particularly in those with ED or OCD symptoms, ED-related intrusive thoughts need to be tested as a factor promoting the comorbidity between EDs and OCD. It is important to note that while ED-related intrusive thoughts may be similar in nature to other ED cognitions, there are important differences. ED-related intrusive thoughts are similar to intrusive thoughts seen in OCD as they are specifically recurrent and unwanted and may promote compensatory behaviors to neutralize the thought. However, they also differ from OCD intrusive thoughts as the content of the thoughts are more so related to disordered eating, rather than general OCD-related fears. There are various aspects of intrusive thinking that are candidates for further examination in relation to ED-OCD comorbidity, but this study sought to focus on thought content and frequency specifically as an initial examination of this relationship.

Network analysis is a statistical approach that provides a framework for mapping the relations among the symptoms of comorbid conditions (Borsboom et al., 2011; Cramer et al., 2010). Based on network theory, network analysis identifies core features (i.e., central symptoms) of a specific disorder, as well as the strongest maintaining symptoms across disorders (i.e. bridge symptoms; Borsboom, 2017). Central symptoms refer to the symptoms that are most strongly associated with the other symptoms in a network of psychopathology (Borsboom & Cramer, 2013). To explain comorbidities, network theory proposes the existence of bridge symptoms—that is, symptoms in one diagnostic cluster that activate symptoms in another cluster (Borsboom & Cramer, 2013). In sum, central symptoms are theorized to potentially maintain the psychopathology of a specific disorder, while strong bridge symptoms may serve as illness pathways which may contribute towards the comorbidity between two disorders.

Identifying central and bridge symptoms has significant clinical utility. For example, Elliott et al. (2020) recently found that the strongest central and bridge baseline symptoms in a sample of patients with anorexia nervosa predicted post-treatment recovery status and clinical impairment. Other recent studies have also found that central ED symptoms at the time of admission predict treatment outcomes at discharge (Olatunji et al., 2018) and likelihood of remission (Brown et al., 2020). Finally, treatments that target and reduce bridge symptoms have the potential to hasten recovery from the comorbid disorders by disrupting relevant illness pathways (Borsboom & Cramer, 2013; Borsboom et al., 2011; McNally, 2016). Together, these findings support the theory that central and bridge symptoms are important maintaining factors of psychopathology and potential treatment targets. For example, evidence that intrusive thoughts may bridge ED and OCD symptoms could provide rationale for adapting OCD treatments for ED symptoms—treatments

such as exposure and response prevention (ERP), cognitive therapy, and acceptance and commitment therapy (ACT) could address intrusive thoughts in EDs (Cottraux et al., 2001; Stech & Grisham, 2017; Twohig et al., 2010).

To date, two studies have examined the comorbid occurrence of ED and OCD by means of network analysis (Meier et al., 2020; Vanzhula et al., 2021). Meier et al. (2020) found that fear of weight gain and dietary restraint were the most central ED symptoms, while interference due to obsessions was the most central OCD symptom, with few potential bridge symptoms connecting each disorder. Vanzhula et al. (2021) found that perfectionism bridged the relationship between ED and OCD symptoms, suggesting the perfectionism may contribute to ED-OCD comorbidity. However, while ED network analyses have found that cognitive symptoms (i.e., fear of weight gain) are more central than behavioral symptoms (e.g., fasting, purging; DuBois et al., 2017; Olatunji et al., 2018), neither of these studies included a measure of ED-related intrusive thoughts.

Furthermore, while ED treatments are effective at reducing ED behaviors, ED cognitions persist and continue to interfere with functioning (Bardone-Cone et al., 2010). Thus, it is important to investigate cognitive aspects of EDs such as ED-related intrusive thoughts. By exploring cognitive aspects of EDs, such as ED-related intrusive thought content and frequency, in relation to ED and OCD symptoms, we can identify potential shared cognitive mechanisms of EDs and OCD symptoms that could aid conceptualization and treatment.

Thus, the current study aimed to use network analysis to (1) identify central ED-related intrusive thoughts symptoms in a subclinical, community sample, and (2) test if the content and frequency of these ED-related intrusive thoughts might bridge ED and OCD symptoms. As body dissatisfaction and shape/weight overvaluation have previously been found to be central to EDs, we hypothesized that ED-related intrusive thoughts related to body dissatisfaction and shape/weight overvaluation would be central and bridge to ED symptoms in a network of ED-related intrusive thoughts and ED symptoms (e.g., DuBois et al., 2017; Wang et al., 2019). We also hypothesized that ED-related intrusive thoughts would be identified as bridge symptoms in a network of ED-related intrusive thoughts, ED symptoms, and OCD symptoms.

Method

Participants and procedure

Study procedures were approved by the University's institutional review board. 400 verified participants from Amazon's Mechanical Turk (MTurk) platform provided informed consent and completed an online questionnaire.

All participants had a high approval rating (90%) and resided in the United States. Participant data were excluded if they came from more than one IP address ($n = 3$), if they failed any of the five attention checks placed throughout the survey ($n = 38$), if survey completion time was less than five minutes ($n = 6$), or if they completed less than 10% of the questionnaires* ($n = 1$). Our final sample consisted of 352 individuals.

*We generated boxplots and analyzed the rates of missing data and found that for the most part the outliers were individuals who had more than 10% of missing data, with the vast majority of participants having 0-2% missing data. There were very few, if any, participants that had for example, 10-20% missing data, and hence 10% was chosen to eliminate those outliers.

The final sample consisted of individuals between 19 to 72 years old ($M = 35.38$, $SD = 9.90$), who identified as male (~60%) and European-American (81.6%). A community sample was chosen to reflect recent efforts to conceptualize psychopathology using a dimensional approach (Lilienfeld & Treadway, 2016). Moreover, there is elevated ED prevalence and psychopathology present in MTurk samples (Kambanis et al., 2021). We found this to be true in our sample, where 49.1% ($n = 173$) endorsed clinically significant levels of ED symptoms (Mond et al., 2004). Additionally, 33.5% of the sample ($n = 118$) endorsed moderate, 19.0% ($n = 67$) endorsed severe and 6.5% ($n = 23$) endorsed extreme levels of OCD symptoms, per the Yale-Brown Obsessive Compulsive Scale (YBOCS; Rapp et al., 2016). 37.8% of the sample ($n = 133$) met criteria for both clinically significant ED symptoms and severe levels of OCD symptoms, making this a highly symptomatic community sample (see Table 1 for demographics). Moreover, researching ED and OCD symptoms, as

Table 1. Participant demographic information.

	N	%
Sample Size	352	100%
Gender		
Male	210	59.7%
Female	140	39.8%
Not Listed	1	.3%
Rather Not Say	1	.3%
Race		
White/European-American	287	81.5%
Black/African-American	25	7.1%
Asian/Asian-American	22	6.3%
Multiracial	14	4.0%
Other	3	.9%
Not Reported	1	.3%
Ethnicity		
Hispanic/Latinx	31	8.8%
Not Hispanic/Latinx	321	91.2%
Current ED Dx	21	6.0%
Current OCD Dx	n/a (not reported)	

is done in the current study, rather than focusing on diagnoses reflects more recent efforts to conceptualize psychopathology using a dimensional approach (Lilienfeld & Treadway, 2016).

Measures

ED symptoms

ED symptoms were assessed using the Eating Disorder Examination-Questionnaire, 6th Edition (EDE-Q; Fairburn & Beglin, 1994). The EDE-Q consists of 28 items and four subscales that assess behavior and attitudes with regard to: 1) eating concerns, 2) shape concerns, 3) weight concerns, and 4) restraint across the past 28 days. Reliability in the present sample ranged from good to excellent for the global score and all subscales (McDonald's Ω = .86-.93).

ED intrusive thoughts

The Eating Intrusive Thoughts Inventory (INPIAS; Perpiñá et al., 2008; Perpiñtá et al., 2011) is a self-report questionnaire assessing the existence, nature of, and resulting behaviors of ED intrusive thinking. The INPIAS was originally developed by Perpiñá and colleagues in Spanish and was later translated into English by the authors. Consisting of two parts, only Part 1 (50 items) was used as we were primarily interested in the content and frequency of the intrusive thoughts overall and could only allow a limited number of items into our constraints. The INPIAS is unique from other ED measures as other measures typically measure the frequency of engagement in urges and behaviors. Instead, the INPIAS evaluates the types of sudden thoughts, images, and urges experienced in life situations including: when they see food or are eating, when someone is looking at them, when getting ready to go out, pass by a mirror or weighing themselves, when out with friends on the street or at a party, and "just because" without any reason. Participants evaluated the frequency of unwanted ED-related intrusive thoughts, images and impulses on a 6-point Likert scale, with higher scores indicating greater frequency. Reliability in the present sample was excellent (Ω = .98).

OCD symptoms

The YBOCS is a psychometrically sound self-report measure of obsessive-compulsive symptoms over the past week (Steketee et al., 1996). The obsessive and compulsive subscales each contain five items that measure aspects of obsessive-compulsive pathology on a five-point Likert scale. Total scores range from 0 to 40 with higher scores indicating higher severity. Reliability in the present sample was excellent (Ω = .93).

Missing data

Missing data was minimal (less than 0.004%) and did not follow any detectable pattern; hence the few cases of missing data were handled using pairwise deletion.

Data analytic plan

Item selection

The *goldbricker* function in the *networktools* package in R (Jones, 2021) was used to identify items with highly similar correlations to other items to avoid including items that measure the same construct. Including multiple items of the same construct may inflate centrality (Fried & Cramer, 2017). In addition to *goldbricker*, the exclusion of items was considered by two graduate level and two PhD level specialists based on expertise and theory, who identified 16 items to be excluded. Additionally, the item *thinking one has a spare tire* was excluded because the authors felt the item used outdated terminology and was poorly translated. As a result, 33 items from the INPIAS and 25 items from the EDE-Q were included in the analysis.

Network analyses

Two *Glasso* networks were estimated using the *estimateNetwork* function of the *bootnet* package in R version 4.0.0 and R studio version 1.3.959 (Epskamp et al., 2018; Epskamp & Fried, 2018). Model 1 included only INPIAS items, and Model 2 included INPIAS, EDE-Q, and YBOCS items (see Table 2). We estimated these two models in line with our aims for the current study. Model 1 included 33 items and Model 2 included 68 items. Each item represented a symptom or "node" in the network. *Glasso* networks estimate partial correlations between symptoms while accounting for all other relationships in the network. Spearman correlations were used as they generally produce more stable networks (Epskamp & Fried, 2018). The *Glasso* function results in a 'conservative' model where a small number of correlations are included in the structure of the network (Epskamp et al., 2018). We used the *bootnet* package, which uses bootstrapping techniques, to estimate network stability values (Epskamp et al., 2016). Stability values of .50 or above indicate stable networks (Epskamp et al., 2018).

The lines connecting the symptoms in the network are referred to as "edges," with thicker edges suggesting stronger correlations between different symptoms (Epskamp et al., 2012). We estimated strength centrality, the sum of the absolute values of edges, using the *centralityplot* function in the *qgraph* package in R (Epskamp et al., 2012). We utilized strength centrality estimates as they are the most stable and appropriate measures of centrality in psychological networks (Bringmann et al., 2019). Centrality difference tests, which assess whether specific

Table 2. Items included in the networks.

OCD Symptoms	
Time spent obsessing	TimeObsess
Thoughts interfering with functioning	FxObsess
Distress from thoughts	DistressThought
Resisting thoughts	ResistObsess
Control over thoughts	ControlThought
Time spent on compulsions	TimeCompulse
Compulsions interfering with functioning	FxCompulse
Distress from compulsions	AnxiousCompulse
Resisting compulsions	ResistCompulse
Control over compulsions	ControlCompulse
Cognitive restraint	LimitFood
Restricting	Restrict
Excluding food	ExcludeFood
Following food rules	FoodRules
Desiring an empty stomach	EmptyStom
Desiring a flat stomach	FlatStom
Difficulty concentrating	DiffConcentrate
Shape and weight preoccupation	ShapeWeightPreoc
Fear of losing control over eating	LoseControl
Fear of weight gain	FearWtGain
Feeling fat	FeltFat
Desire to lose weight	LoseWeight
Binge eating	Binge
Self-induced vomiting	Vomit
Laxative use	Laxative
Compulsive exercise	OverExercise
Eating in secret	SecretEat
Guilt while eating	GuiltEat
Concern about being seen while eating	SeeEat
Judging self based on weight	WeightJudge
Judging self based on shape	ShapeJudge
Concern over weighing	Weighself
Weight dissatisfaction	WeightDiss
Shape dissatisfaction	ShapeDiss
Discomfort seeing own body	SeeDiscomfort
Discomfort when others see body	OthersSee
Thoughts about food while eating	ThoughtFood
Thoughts about not eating after seeing food	ThoughtNoEat
Thoughts about needing to eat slowly while eating	EatSlow
Thoughts about cutting up food into small pieces while eating	CutSmall
Thoughts about getting fat while eating	GetFat
Thoughts about gaining weight while eating	GainKilo
Thoughts about needing to do exercise while eating	DoExercise
Urge to could calories while eating	CountCals
Urge to eat without stopping around food	UrgeEat
Urge to hoard food while eating	HoardFood
Thoughts about fat accumulating on body after mealtime	FatAccumulate
Thoughts about calories consumed after eating	CalBody
Thoughts about compensatory exercise after eating	BurnExercise
Regretting eating after meal	RegretEat
Urge to vomit after eating	UrgeVomit
Urge to use laxatives after eating	UrgeLaxative
Thoughts about weight gain after being looked at by others	ThoughtWtGn
Sudden thoughts about being fat	FatTht
Sudden thoughts about needing to go on a diet	DietTht
Sudden thoughts about stomach being bigger	BigStomTht
Sudden thoughts about belly being enormous	BellyTht
Sudden thoughts that one will never be content with appearance	DiscontentTht
Sudden thoughts about looking horrible	HorribleTht
Sudden urges to fast	FastUrge
Sudden urges to exercise	ExerUrge
Sudden urge to hide certain body parts	HideUrge

(*Continued*)

Table 2. (Continued).

OCD Symptoms	
Thoughts that others think one is fat at a social event	JudgeFat
Thoughts about one's friends being thinner at a social event	FriendThin
Thoughts that one will never be attractive enough at a social event	NotEnough
Sudden thoughts that being fat is horrible	FatHorrible
Sudden thoughts about thin ideal	ThinWonder
Sudden thoughts about restricting	NotEat
Sudden urge to weigh self	WeighSelfUrge

symptoms are significantly more central than others, were conducted using the *bootnet* package (Epskamp & Fried, 2018). "Central" symptoms indicate that a symptom has the highest strength centrality values, indicating that they have more and/or stronger associations with other symptoms in the network.

Bridge symptoms were measured in Model 2 using the *bridge* function of the *networktools* package in R (Jones et al., 2021). The *bridge* function analyzes groups of symptoms by estimating the partial correlations between nodes. This function produces two centrality measures: bridge strength (BS) and bridge expected influence (BEI; Jones et al., 2021). BS is the sum of the absolute value of the edges between one node and the nodes in all other groups. BEI (one-step) is the sum of the value of the edges between one node and the nodes in all other groups (Jones et al., 2021). BS and BEI stability, as well as BS and BEI difference tests were estimated using the *bootnet* package in R (Epskamp & Fried, 2018).

Results

Model 1: ED-related intrusive thoughts

Central symptoms

Network stability was adequate (strength stability [*SS*] = .52) and edge weights were stable (edge stability [*ES*] =.75). The symptoms with the highest strength centrality were: *sudden thoughts about looking horrible* (strength [*S*] = 1.77; significantly greater than 39.39% of other symptom estimates [*p*s < .05]), *thoughts about getting fat while eating* (*S* = 1.09; significantly greater than 18.18% of other symptom estimates [*p*s < .05]), and *thoughts about weight gain after being looked at by others* (*S* = 1.07; significantly greater than 21.21% of other symptom estimates [*p*s < .05]). See Figures 1 and 2 for the network and corresponding centrality plot.

Model 2: ED-related intrusive thoughts, ED and OCD symptoms

Central symptoms

Network stability was adequate (*SS* = .67) and edge weights were stable (*ES* =.67). In this network with ED-related intrusive thoughts, and ED and OCD symptoms, the symptoms with the highest strength centrality

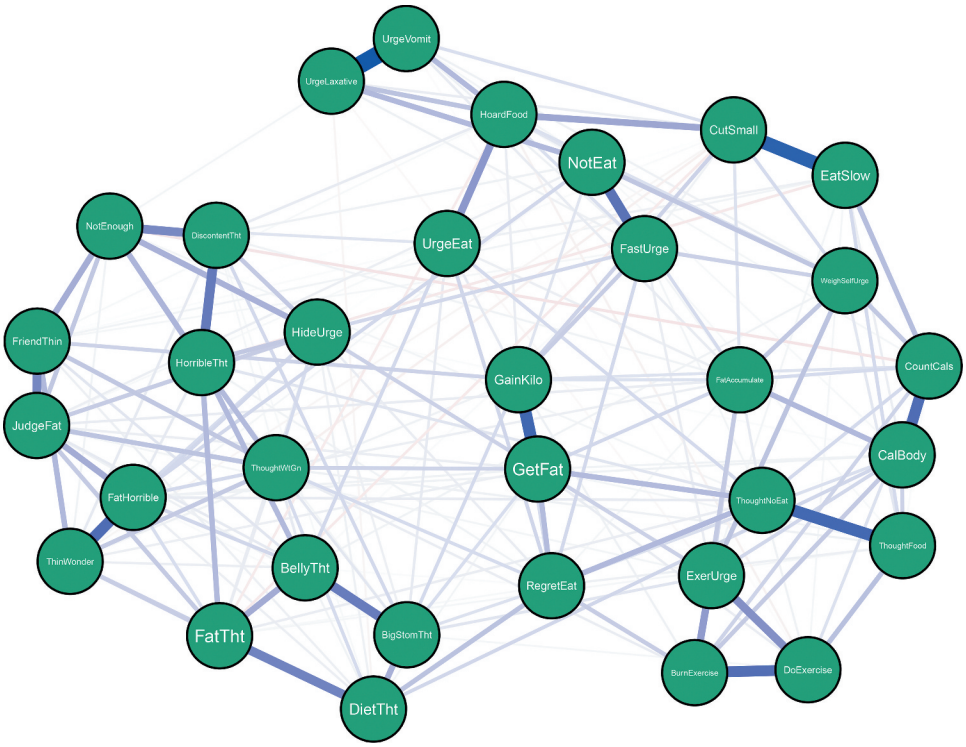

Figure 1. Network of ED-related intrusive thought symptoms (Model 1). Red lines indicate negative associations between symptoms; blue lines indicate positive associations between symptoms; thicker lines indicate stronger associations.

were: *desire to lose weight* (EDE-Q; $S = 2.09$; significantly greater than 70.15% of other symptom estimates [$ps < .05$]), *eating in secret* (EDE-Q; $S = 2.02$; significantly greater than 25.37% of other symptom estimates [$ps < .05$]), and *shape dissatisfaction* (EDE-Q; $S = 1.91$; significantly greater than 65.67% of other symptom estimates [$ps < .05$]). See Figures 3 and 4 for the network and corresponding centrality plot.

Bridge symptoms

Bridge symptoms were stable (BS stability = .52). The bridge symptoms with the greatest strength were *desire to lose weight* (EDE-Q; BS = .41) and *sudden thoughts about being fat (*INPIAS; BS = .36). Other bridge symptoms were also identified, including *self-induced vomiting* (EDE-Q; BS = .35), *distress about weekly weighing* (EDE-Q; BS = .35), and *difficulty concentrating due to thoughts of food/calories* (EDE-Q; BS = .35).

Desire to lose weight was connected *urge to exercise* (INPIAS; partial $r = .03$) and *thinking it would be wonderful to be thin* (INPIAS; partial $r = .03$). Desire to lose weight was also negatively connected to *thinking about*

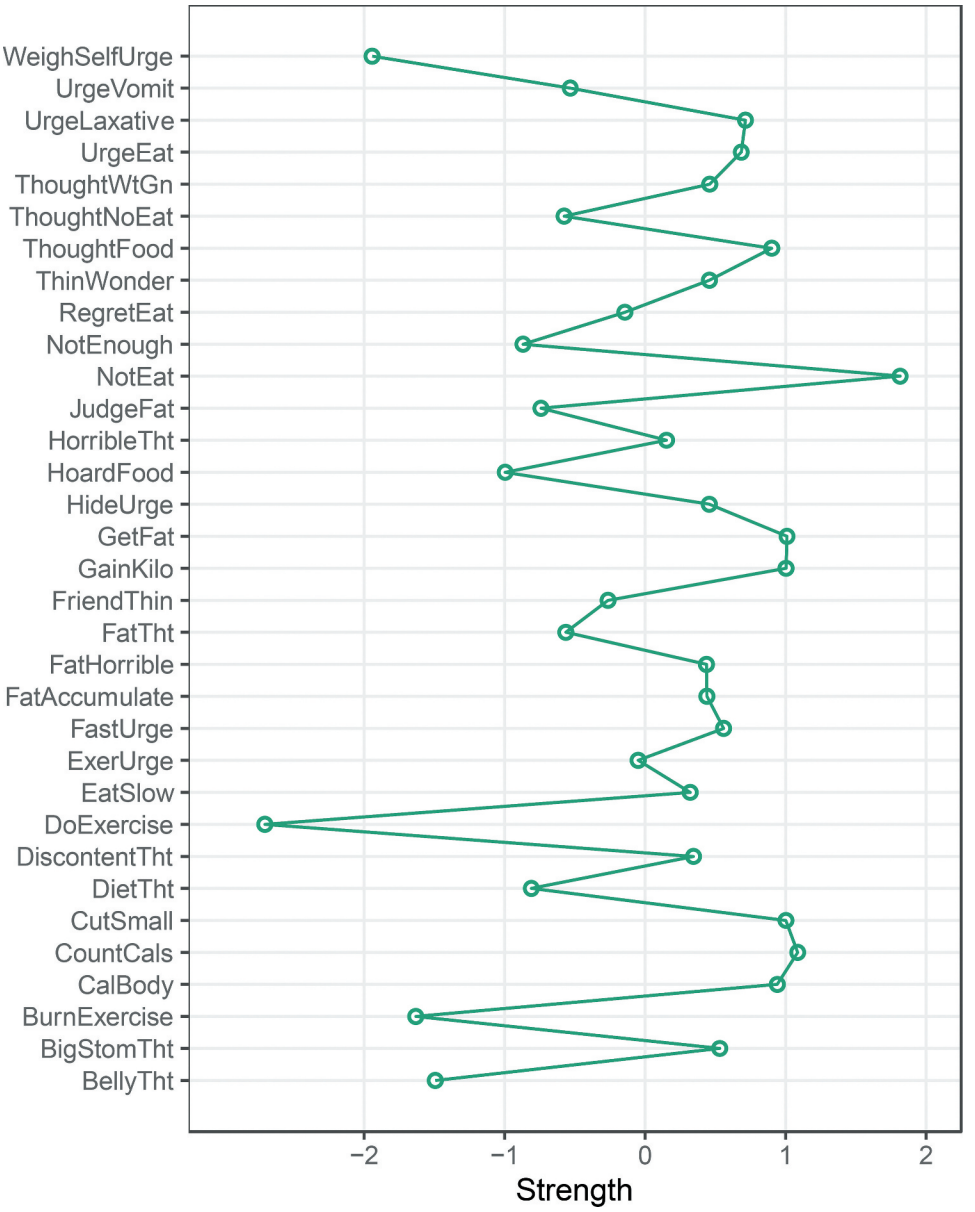

Figure 2. Strength centrality plot of the ED-related intrusive thought network (Model 1). The plot is standardized ($M = 0$, $SD = \pm 1$), where larger scores indicate greater centrality.

cutting food into small pieces (INPIAS; partial $r = -.07$). Sudden thoughts about being fat was connected to *feeling fat* (EDE-Q; partial $r = .22$), *shape dissatisfaction* (EDE-Q; partial $r = .05$), and *discomfort seeing one's own body* (EDE-Q; partial $r = .05$). Self-induced vomiting was connected to *urge to use laxatives* (INPIAS; partial $r = .18$). Distress about weekly weighing was connected to *sudden thoughts about getting fat* (INPIAS;

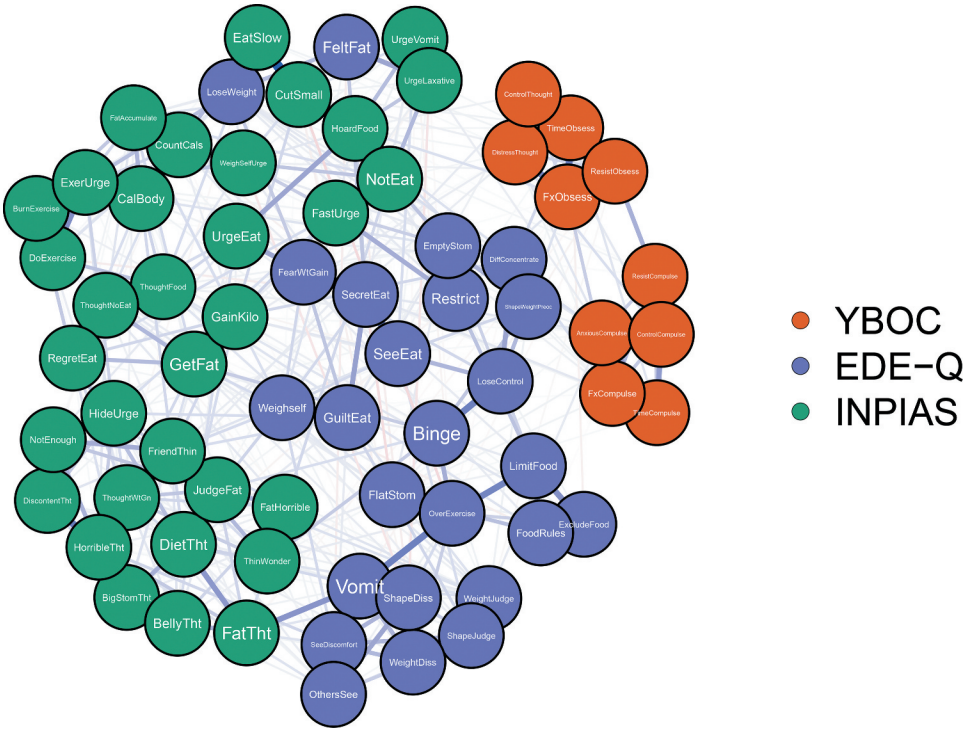

Figure 3. Network of ED-related intrusive thought, ED and OCD symptoms (Model 2). Red lines indicate negative associations between symptoms; blue lines indicate positive associations between symptoms; thicker lines indicate stronger associations.

partial r = .07), *sudden thoughts about fat accumulating in the body* (INPIAS; partial r = .06), *urge to fast* (INPIAS; partial r = .05), *worries about others thinking one is fat* (INPIAS; partial r = .08), and *thinking that one's friends are thinner* (INPIAS; partial r = .07). Difficulty concentrating due to thoughts of food/calories was connected to *time spent obsessing* (YBOCS; partial r = .07), *compulsions interfering with functioning* (YBOCS; partial r = .06), *sudden thoughts about fat accumulating in the body* (INPIAS; partial r = .05), and *thinking that one will keep gaining weight* (INPIAS; partial r = .07). Difficulty concentrating due to thoughts of food/calories was the only identified bridge symptom that connected to both groups (i.e., ED-related intrusive thoughts and OCD symptoms). See Figure 5 for the bridge centrality plots. See supplementary materials for the R script for both models.

Discussion

Using network analyses, we investigated how ED-related intrusive thoughts may contribute to ED-OCD comorbidity among a symptomatic, community sample. In a network of ED-related intrusive thoughts, we found that intrusive

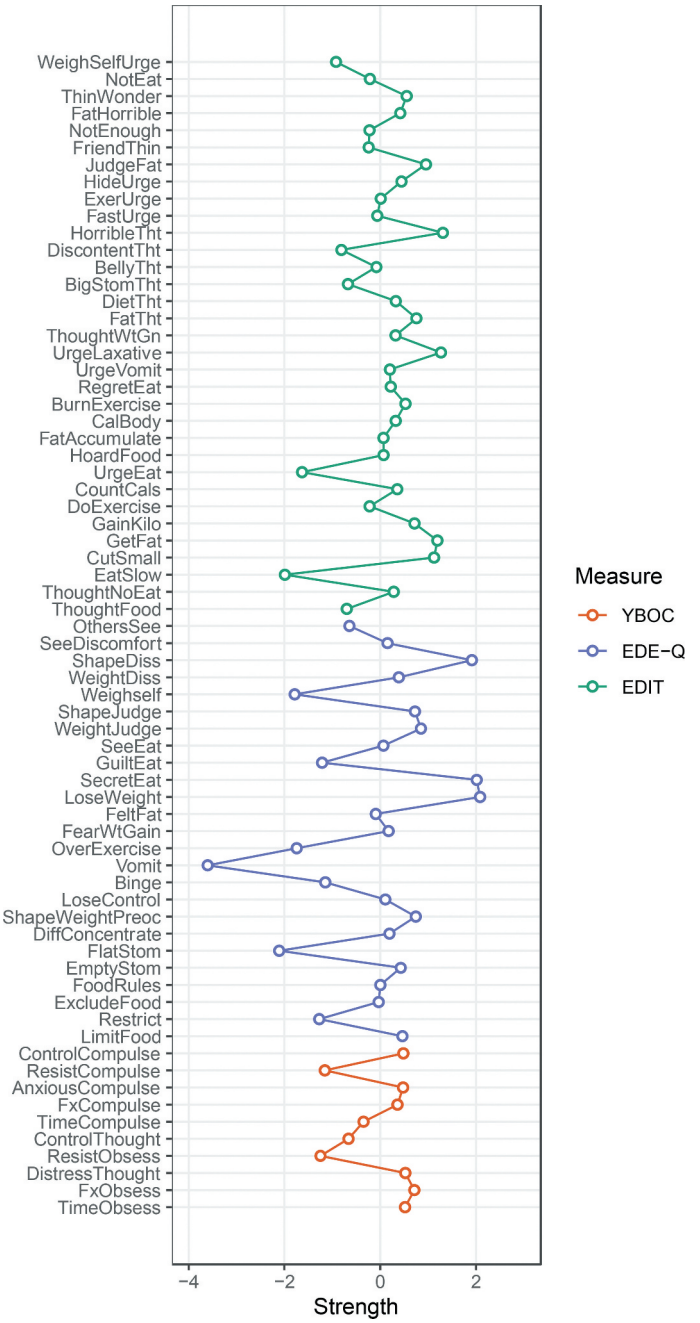

Figure 4. Strength centrality plot of the ED-related intrusive thought, ED and OCD symptoms (Model 2). The plot is standardized ($M = 0$, $SD = \pm 1$), where larger scores indicate greater centrality.

thoughts around one's appearance were most central. A network of ED-related intrusive thoughts, ED symptoms, and OCD symptoms indicated that ED symptoms were most central among this sample, and one illness pathway connecting ED-related intrusive thoughts, ED and OCD symptoms emerged.

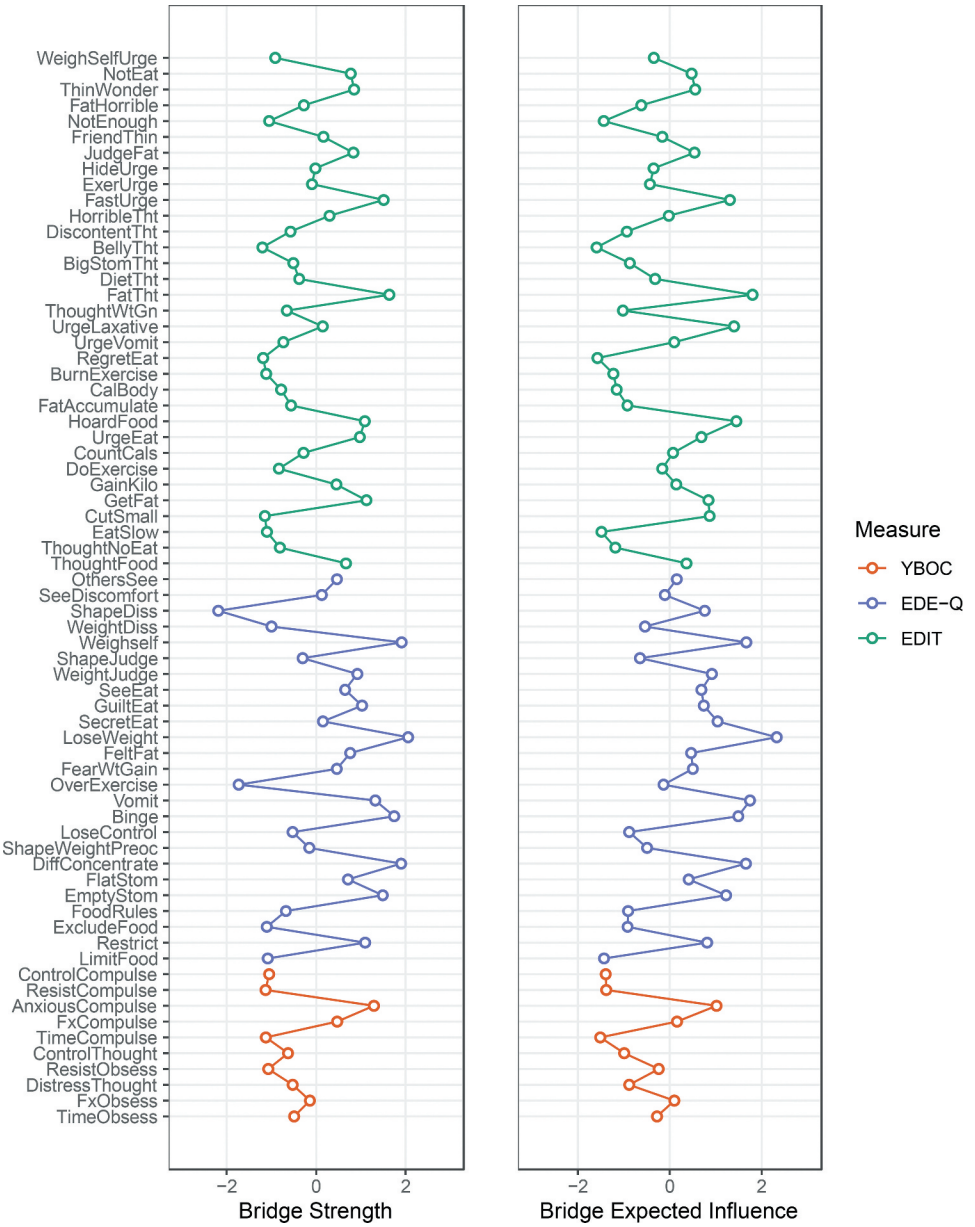

Figure 5. Bridge centrality plots of the ED-related intrusive thought, ED and OCD symptoms (Model 2).

These findings suggest that certain ED-related intrusive thoughts may contribute to ED-OCD comorbidity, providing potential treatment targets for these commonly comorbid conditions. However, further research is warranted as our hypotheses were only partially supported—in fact it was an ED symptom (difficulty concentrating due to thoughts about food and calories) that bridges ED-related intrusive thoughts and OCD symptoms, rather than intrusive thoughts bridging ED and OCD symptoms.

In Model 1, thoughts about looking horrible, getting fat, and gaining weight were most central, suggesting that these ED-related intrusive thoughts were the most influential in our sample. These findings support our hypothesis that symptoms related to body dissatisfaction and shape/weight overvaluation would be most central in a network of ED-intrusive thoughts. For instance, intrusive thoughts about looking horrible relate to body dissatisfaction, which is an identified risk factor for EDs (Dakanalis et al., 2016; Stice et al., 2011; Stice & Shaw, 2002). Body dissatisfaction also predicts greater levels of ED behaviors, including dieting, purging, laxative use, and binge eating (Neumark-Sztainer et al., 2006). Fears of fatness and weight gain have also been proposed as characteristic symptoms of EDs (APA, 2013; Fairburn et al., 2003) and predict engagement in ED symptoms (Linardon et al., 2018). A previous study using network analysis found fear of weight gain was central to ED and OCD symptoms (Meier et al., 2020).

Notably, our identified central symptoms in Model 1 were similar in centrality to the other ED-related intrusive thoughts included in the network, suggesting that other ED-related intrusive thoughts (i.e., those not related to body dissatisfaction or fear of weight gain/fatness) could also be ideal treatment and prevention targets. This finding is in line with research demonstrating that thoughts can be idiosyncratic in nature, such that the content and appraisals vary from individual to individual (Clark & Rhyno, 2005; Julien et al., 2007).

In Model 2, the most central symptoms were *desire to lose weight, eating in secret*, and *shape dissatisfaction*. Eating in secret is associated with binge episodes (Marcus & Kalarchian, 2003), and could have been central due to the high incidence of binge eating symptoms in this sample (38.2% of participants endorsed this behavior). The finding that desire to lose weight and shape dissatisfaction were central symptoms is consistent with previous ED network analysis studies (Goldschmidt et al., 2018; Wang et al., 2019). These findings further support that body dissatisfaction may be associated with ED symptoms and an important treatment target for ED patients.

Against our hypotheses, no ED-related intrusive thoughts were identified as illness pathways between ED and OCD symptoms. However, the ED symptom of *difficulty concentrating due to thoughts of food/calories* was identified as an illness pathway to ED-related intrusive thoughts regarding fatness and weight gain, as well as OCD symptoms related to time spent obsessing and compulsions interfering with functioning. Specifically, our results suggest that that being distracted by thoughts of food and calories may be associated with higher ED-related intrusive thoughts around fatness and weight gain. This difficulty concentrating and experience of ED-related intrusive thoughts could promote increased obsessions about food and weight and engagement in compulsions that may be functionally impairing. Importantly, this finding is similar to another study by Jones and colleagues finding that difficulty

concentrating can be an illness pathway between OCD and comorbid symptoms of depression among adolescents with OCD (Jones et al., 2018). Future studies should continue to consider the role difficulty concentrating may play in OCD comorbidity with other psychological disorders.

Four other bridge symptoms were identified, however these symptoms only connected ED-related intrusive thoughts to ED symptoms and vice versa. For instance, *sudden thoughts about being fat* was connected to *feeling fat, shape dissatisfaction*, and *discomfort seeing one's own body. Desire to lose* weight was positively connected with *urge to exercise* and *thinking it would be wonderful to be thin* and negatively connected with *thinking about cutting food into small pieces. Self-induced vomiting* was connected to *urge to use laxatives. Distress about weekly weighing* was connected to *sudden thoughts about getting fat, sudden thoughts about fat accumulating in the body, urge to fast, worries about others thinking one is fat*, and *thinking that one's friends are thinner than oneself*. These findings suggest that both ED-related intrusive thoughts around fatness may be highly related to body dissatisfaction. Also, ED cognitions (i.e., desire to lose weight) may promote and suppress certain ED-related intrusive thoughts depending on the content. Lastly, ED behaviors (i.e., self-induced vomiting and weighing) are highly related to ED-related intrusive thoughts. Together, these findings suggest the ED-related intrusive thoughts promote the development of ED symptoms and vice versa. This idea is consistent with literature indicating that intrusive thoughts are experienced at a high rates by individuals with clinical EDs (García-Soriano et al., 2014). These findings make sense given ED-related thoughts are more common than behaviors in non-clinical samples (Miller et al., 2009). These findings support continued emphasis on cognitions, as opposed to behaviors, in ED research and treatment. Further research regarding how ED-related cognitions contribute to ED symptoms is needed to continue to identify treatment and prevention targets that may improve outcomes.

OCD symptoms did not emerge as central or bridge symptoms in Model 2. The current study measured the content and frequency of intrusive thoughts, rather than other features (i.e., appraisals, attempts to control thoughts; Rachman, 1998). OCD symptoms not being identified as bridge symptoms is unsurprising given that we expected ED thoughts to bridge between OCD and ED symptoms. Moreover, the content of intrusive thoughts may be more disorder-bound by design, but the way an individual appraises or reacts to intrusive thoughts might be similar in individuals with EDs and OCD. As we identified more pathways connecting intrusive thoughts and ED symptoms, future studies should consider testing intrusive thought appraisal and control strategies as illness pathways between EDs and OCD.

The results from the current study have a number of potential implications. Our findings provide much-needed insight into the etiological relationship between EDs and OCD. For instance, our results provide preliminary evidence

that ED-related intrusive thoughts regarding to body dissatisfaction may be associated with the onset and incidence of disordered eating behaviors. Thus, targeting body dissatisfaction and other ED cognitions in community samples may prevent the development of ED and OCD symptoms. Despite a large number of ED patients endorsing intrusive thoughts (Roncero et al., 2013, 2011), many ED assessments and treatments do not explicitly target intrusive thoughts. These findings suggest that potentially assessing for ED-related intrusive thoughts, especially those involving body dissatisfaction, is important when conceptualizing ED and OCD symptomatology. The emergence of ED symptoms as being most central in this network suggests that it was ED symptoms that were most strongly associated with other symptoms in the network, including intrusive thought and OCD symptoms. While we need to interpret the findings cautiously, due to the utilization of a non-clinical sample, this leads further credence to the notion that ED symptoms should be assessed for and treated in individuals with OCD symptoms. Moreover, treatment of ED-related intrusive thoughts through evidence-based treatments such as cognitive restructuring using cognitive-behavioral therapy (CBT), ACT and focused distraction may be efficacious in reducing intrusive thought-related distress and negative affect (Magee & Teachman, 2012; Rupp et al., 2019), which may in turn improve ED and OCD symptoms.

Strengths of the current study include using a data-driven statistical technique, network analysis, to analyze central symptoms in ED-related intrusive thoughts and study illness pathways between ED-related intrusive thoughts, ED symptoms, and OCD symptoms. Additionally, we used a relatively symptomatic sample, allowing us to more reliably identify potentially important developmental factors for EDs and OCD. However, our study should be interpreted in consideration of its limitations. First, the cross-sectional nature of our analyses limits our ability to make predictive assumptions about the way these symptoms may interact with one another. Future studies should assess the role of ED-related intrusive thoughts as contributor to ED-OCD comorbidity using longitudinal methods. Second, while a substantial portion of our sample endorsed clinical symptoms, our sample was obtained from the community, and, as such, we are unable to generalize these results to clinical samples. Future studies should assess ED-related intrusive thoughts, ED symptoms, and OCD symptoms among clinical samples, including samples of individuals with comorbid EDs and OCD. Some of our findings may differ in clinical samples. For example, it is possible that OCD symptoms would have emerged as more central in a clinical sample, or that intrusive thoughts may have emerged as a bridge between these symptoms. On the other hand, there may also have been less illness pathways between these disorders in clinical samples. Hence, more clinical research is needed. As we utilized a non-clinical sample, our sample was also slightly skewed male, whereas men are generally underrepresented in clinical ED studies. Hence, this also potentially limits our

generalizability to clinical samples. Furthermore, identification of bridge symptoms and connections via network analysis is in its infancy, and as such there are currently no guidelines regarding the methodology of identifying significant bridge symptom connections (i.e., significant partial correlations). Lastly, while our measure for intrusive thoughts included some overlap between both OCD and ED symptoms, an alternative measure that focused less on ED-related content may have been more appropriate to study the comorbidity between these two disorders. Future research using different measures to assess intrusive thoughts would be useful in examining the ED-OCD relationship.

Conclusion

The aims of this study were to estimate central ED-related intrusive thoughts and to identify illness pathways between ED-related intrusive thoughts, ED symptoms, and OCD symptoms. This was the first study to examine these constructs together using network analysis, and utilized a non-clinical, cross-sectional sample as a preliminary investigation of this relationship. In a network of ED-related intrusive thoughts, we found that that intrusive thoughts about bodily appearance and fears of fatness/weight gain were the most central. In a comorbidity network, we found that desire to lose weight, eating in secret, and shape dissatisfaction emerged as central symptoms. Contrary to our hypotheses, intrusive thoughts did not emerge as bridge symptoms in our network. However, we found an illness pathway connecting difficulty concentrating due to thoughts of food/calories, time spent obsessing, functionally impairing compulsions, and intrusive thoughts about fears of fatness and weight gain. This study provides preliminary evidence that cognitions surrounding food and calories may promote intrusive fears about fatness and weight gain, as well as engagement in compulsions that may be functionally impairing. Efforts targeting ED-related intrusive thoughts related to body dissatisfaction and thoughts of food/calories may prevent the development of ED and OCD symptoms among the community. Further research examining other aspects of intrusive thoughts, and in a clinical sample, is warranted.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data Sharing and Data Accessibility

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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