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Perfectionism, self-esteem, and affective symptoms in anorexia nervosa subtypes: A network analysis of French inpatients

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Abstract

Objective: Previous studies have highlighted the relevance of perfectionism, self-esteem, and anxio-depressive symptoms in anorexia nervosa (AN). However, the relationships between these factors and cardinal eating disorders (ED) symptoms remain unclear, particularly in AN subtypes. This study aimed to examine their interconnections using network analysis.

Method: The sample included $n = 338$ inpatients with AN who completed the Eating Disorder Examination Questionnaire, Frost Multidimensional Perfectionism Scale, Rosenberg Self-Esteem Scale, and Hospital Anxiety and Depression Scale. Using network analysis, we estimated three networks: full sample, AN-restrictive (AN-R) and AN-binge/purging (AN-BP) subtypes. We estimated central and bridge symptoms using expected influence

and conducted an exploratory network comparison test to compare AN subtypes.

Results: Overvaluation of Weight and Shape, Concern over Mistakes, and Personal Standards were consistently central in all networks. The most central bridge symptoms across all networks were Concern over Mistakes and Self-Esteem. Concern over Mistakes bridged perfectionism and ED symptoms, while Self-Esteem was highly connected to all symptom clusters. Anxiety was significantly more central in the AN-R network compared to the AN-BP network.

Conclusions: The present study contributes to a growing body of network studies suggesting that nodes related to perfectionism are just as central as cardinal ED symptoms, indicating the relevance of perfectionism in ED pathology. The high bridge centrality of self-esteem suggests that it may be an important link between perfectionism, mood, and ED symptoms. Future research should investigate the efficacy of targeting multiple psychological factors in the treatment of AN, as well as their potential transdiagnostic relevance.

KEYWORDS

anorexia nervosa, eating disorders, mood, network analysis, perfectionism, self-esteem

1 | INTRODUCTION

Anorexia nervosa (AN) is characterized by the cardinal symptoms of very low body weight, fear of weight gain, extreme weight-control behaviors, and self-worth dependent on body weight and/or shape (American Psychiatric Association, 2013). AN is also associated with other psychological factors such as perfectionism (Dahlenburg et al., 2019), low self-esteem (Brockmeyer et al., 2013), and comorbidity with anxiety and depressive disorders (Jagielska & Kacperska, 2017). AN has an estimated recovery rate of less than 50%, with relapse rates of around 40% and an 18-fold increase in suicide risk compared to age-matched females in the general population (Miskovic-Wheatley et al., 2023). A more comprehensive understanding of the relationships between AN and broader psychological factors is needed to develop more effective, targeted treatments.

Perfectionism is a multidimensional transdiagnostic process defined as setting unrealistically high standards and engaging in harsh self-criticism when these standards are not met (Fairburn et al., 2003; Shafran et al., 2002). The most common measure of perfectionism is the Frost Multidimensional Perfectionism Scale (FMPS) (Frost et al., 1990). The FMPS is composed of six subscales that map onto two factors: perfectionistic concerns (Concern over Mistakes, Doubt about Actions, Parental Expectations, Parental Criticism) and perfectionistic strivings (Personal Standards, Organization) (Bieling et al., 2004; Frost et al., 1993). Perfectionistic concerns represent a fear of failure and making mistakes (Frost et al., 1993; Limburg et al., 2017), while perfectionistic strivings can indicate

an adaptive focus on goal achievement, or the rigid pursuit of unrealistically high standards in clinical cases (Bieling et al., 2004; Shafran et al., 2002).

While perfectionistic concerns are considered to be maladaptive and have been associated with psychopathology (Limburg et al., 2017), the adaptiveness of perfectionistic strivings has been highly debated for decades. Some researchers assert that perfectionistic strivings can be healthy and associated with positive outcomes, becoming maladaptive only when high perfectionistic concerns are also present (Frost et al., 1993; Slade & Owens, 1998; Stoeber & Otto, 2006). Others maintain that “the term *perfectionist* should be reserved for those individuals who hold rigidly to their standards, even in situations that do not call for perfection, and who continue to place and irrational importance on the attainment of impossibly high standards in not just one but in several life domains” (Flett & Hewitt, 2006, p. 476). An additional consideration is the important distinction between perfectionistic strivings, the rigid and ultimately impossible pursuit of perfection, and striving for an excellent performance in a conscientious and organized way (Flett & Hewitt, 2006; Gaudreau, 2018). Clinical perfectionism, a proposed maintenance factor in the transdiagnostic theory of ED and the cognitive-interpersonal model of AN (Schmidt & Treasure, 2006; Treasure & Schmidt, 2013), refers to setting perfectionistic personal standards and evaluating self-worth based on their achievement, despite negative psychological consequences (Fairburn et al., 2003; Shafran et al., 2002). This definition emphasizes that both perfectionistic concerns and strivings may play a maladaptive role with respect to wellbeing, if not for all people, then at the very least in clinical populations specifically. Clinical perfectionism thus appears to be particularly relevant in the psychopathology of EDs.

High levels of perfectionistic concerns and strivings have been found across EDs (Limburg et al., 2017; Livet et al., 2023; Sassaroli et al., 2008; Stackpole et al., 2023) and in nonclinical samples with disordered eating behaviors (Livet et al., 2023; Stackpole et al., 2023). While the associations between disordered eating symptomatology and perfectionistic strivings are not typically as robust as those seen with perfectionistic concerns, these findings remain relevant in the debate on the adaptiveness of perfectionism. Further, the finding of elevated levels of perfectionism is more consistent in AN compared to bulimia nervosa (BN) and binge eating disorder (BED) (Bardone-Cone et al., 2007; Limburg et al., 2017). Individuals with AN tend to score higher on perfectionistic concerns and strivings than both healthy controls and other psychiatric disorders (Bardone-Cone et al., 2007; Dahlenburg et al., 2019; Limburg et al., 2017; Stackpole et al., 2023). In AN, high perfectionism has been found to predict poor prognosis and to remain elevated after recovery (Bardone-Cone et al., 2007; Sutandar-Pinnock et al., 2003). However, it remains unclear whether perfectionism differs between the AN restrictive (AN-R) or binge/purging (AN-BP) subtypes (American Psychiatric Association, 2013; Bardone-Cone et al., 2007; Dahlenburg et al., 2019).

An additional maintaining process proposed by the transdiagnostic cognitive behavioral model is core low self-esteem, the unconditional negative self-judgment that becomes part of one's permanent identity (Fairburn et al., 2003). Low self-esteem interacts with perfectionism in that any perceived failure is seen as a confirmation that the individual is a failure as a person (Fairburn et al., 2003). Individuals with AN, even in recovery, present with lower self-esteem compared to healthy controls (Brockmeyer et al., 2013). Moreover, self-esteem has been shown to moderate the relationship between eating disorder symptoms and perfectionism (Peck & Lightsey, 2008; Puttevils et al., 2019).

Perfectionism is also considered to be a risk and maintenance factor for anxiety and depression (Egan et al., 2011, 2022; Limburg et al., 2017). Qualitative evidence shows that pressure to meet high standards and hypervigilant monitoring of mistakes can lead to anxiety, while failure to meet personal standards often results in depression (Egan et al., 2022). Anxiety and mood disorders are among the most common ED comorbidities (Godart et al., 2007; Himmerich et al., 2019; Swinbourne et al., 2012). The estimated lifetime prevalence of at least one anxiety or mood disorder in AN is 40.5% and 54%, respectively (Udo & Grilo, 2019). Further, both the cognitive-behavioral and cognitive-interpersonal models emphasize the role of emotional distress in EDs, with the former pointing to a difficulty tolerating negative emotion leading to disordered eating behaviors and the latter emphasizing the role of anxiety-related traits (Fairburn et al., 2003; Schmidt & Treasure, 2006; Treasure & Schmidt, 2013). Additionally, longitudinal meta-analytic evidence shows that low self-esteem has a bidirectional relationship with anxiety and contributes to depression (Sowislo & Orth, 2013).

As such, the literature highlights that a complex relationship exists between perfectionism, self-esteem, and anxiety/depression in AN; however, the specific interrelationships between these factors and cardinal ED symptoms are still unclear, particularly in AN subtypes.

Network analysis (NA) is increasingly being used to study the complex relationships between psychological conditions and identify central symptoms (Borsboom, 2017; Levinson, Vanzhula, et al., 2018; Smith et al., 2018). Central symptoms are thought to spread activation throughout the network (Borsboom, 2017) and have been shown to predict clinical outcomes (Elliott et al., 2020). Networks allow for the exploration of the relational nature of symptoms; therefore, noncentral symptoms may also be clinically relevant (Smith et al., 2018). In addition, NA can identify nodes that bridge different clusters of symptoms to model comorbidity (Borsboom, 2017). As such, NA is an important tool that can be used to investigate the complex relationships between cardinal ED symptoms and psychological factors that lie outside of traditional diagnostic categories.

Four network studies have investigated ED symptomatology and perfectionism using the FMPS in mixed ED samples (Levinson, Brosf, et al., 2018; Ralph-Nearman et al., 2023; Vanzhula et al., 2021; Vervaet et al., 2021). One study (42.2% AN, 31.3% BN, 18.8% Eating Disorder Not Otherwise Specified, and 7.6% BED) found that personal standards were a central symptom (Vervaet et al., 2021), while a network investigating social anxiety disorder and ED (79.2% AN, 9.7% BN, 11% BED, and 13% Other Specified Feeding and Eating Disorder [OSFED]) found that perfectionism, measured by seven FMPS items, was not central (Levinson, Brosf, et al., 2018). An investigation of comorbid ED (33.9% AN, 37.4% atypical AN, 13.1% BN, 3.5% atypical BN, 5.1% BED, 7% OSFED) and obsessive-compulsive disorder (OCD) found that items related to parental expectations and organization were central, while items from the Concern over Mistakes and Doubt about Actions subscales were central bridge nodes between ED and OCD (Vanzhula et al., 2021). Most recently, an investigation of clinical perfectionism (43.1% AN, 12.3% BN, 4.8% BED, 39.3% OSFED, 0.5% Avoidant/Restrictive Food Intake Disorder) found that Concern over Mistakes was the most central symptom, with a strong connection to Personal Standards (Ralph-Nearman et al., 2023).

Two additional network studies investigated perfectionism in AN only (Delaquis et al., 2023; Martini et al., 2021). One found that perfectionistic evaluative concerns (Concern over Mistakes combined with Doubt about Actions) were the most central bridge symptom connecting ED symptoms to interoceptive sensibility (Martini et al., 2021). Similarly, in a network of adolescent (<25 years old) inpatients, Concern over Mistakes was the most central symptom and bridged perfectionism and ED symptoms. Further, Doubt About Actions bridged affective symptoms (i.e., anxiety and depression) and perfectionism (Delaquis et al., 2023).

Therefore, results from network studies indicate that facets of perfectionism related to both perfectionistic concerns and strivings play an important role in ED, particularly in AN.

Network studies also show that low self-esteem (e.g., feelings of worthlessness, feeling like a failure, and low self-confidence) is a central bridge symptom to eating disorder symptoms (Elliott et al., 2020; Forrest et al., 2019; Monteleone et al., 2019; Sahlan et al., 2021; Smith et al., 2018), anxiety (Forrest et al., 2019), and depression (Elliott et al., 2020; Monteleone et al., 2019; Sahlan et al., 2021). This link existed in networks both of transdiagnostic samples (Forrest et al., 2019; Sahlan et al., 2021; Smith et al., 2018) and in AN only (Elliott et al., 2020; Monteleone et al., 2019).

Network evidence investigating potential differences between AN subtypes is scarce. A network composed of 27 items from the EDEQ found no significant differences between AN-R and AN-BP (Forrest et al., 2018). None of the network studies investigating perfectionism or self-esteem in AN compared subtypes. One meta-analysis found significantly higher levels of perfectionism in AN-BP compared to AN-R; however, this result was not considered reliable due to publication bias (Dahlenburg et al., 2019). The question of subtypes is relevant as AN-BP may be a more severe subtype of AN (Miskovic-Wheatley et al., 2023) and there is a large amount of diagnostic crossover from AN-R to AN-BP (Peat et al., 2009).

Evidence from both NA and non-network studies points to the relevance of perfectionism (Bardone-Cone et al., 2007; Dahlenburg et al., 2019; Fairburn et al., 2003), self-esteem (Peck & Lightsey, 2008; Puttevils et al., 2019), and anxiety/depression (Forrest et al., 2019; Haynos et al., 2015; Hughes, 2020) in AN. To date, no network study has investigated their interconnections in AN nor compared AN subtypes. The current study aims to: (1) investigate how

perfectionism, self-esteem, and anxiety/depression connect to ED symptoms and one another among inpatients with AN; (2) identify central and bridge symptoms; and (3) conduct an exploratory comparison of AN subtypes.

2 | METHOD

2.1 | Participants

Participants ($n = 338$) were patients hospitalized for AN combined from two independent clinical trials ($n = 116$ from TREGAM, [ClinicalTrials.gov](https://clinicaltrials.gov) id: NCT01772394; $n = 222$ from EVHAN, [ClinicalTrials.gov](https://clinicaltrials.gov) id: NCT00910169). In the current analysis, only baseline variables are used.

Inclusion/exclusion criteria for each clinical trial can be found in Supporting Information S1. Both were conducted in compliance with the Good Clinical Practices (ICH-GCP) and Declaration of Helsinki and have been approved by an independent ethics committee.

Our sample was composed of $n = 338$ ($n = 10$ males) inpatients diagnosed with AN, $n = 173$ (51.0%) with AN-R, and $n = 165$ (48.7%) with AN-BP. Most participants ($n = 240$; 71.1%) were less than 25 years old and $n = 152$ (45.1%) were below the age of 18 years. For the majority of participants (84.1%), this was not their first hospitalization for AN: $n = 128$ (38%) had one previous hospitalization, $n = 108$ (31.9%) reported between two and five previous hospitalizations, and the maximum reported number was 37 ($n = 1$). The average duration of illness was 4.4 (SD = 5.5) years. Descriptive statistics are presented in Table 1.

Information on comorbid disorders was not available for all participants; therefore, the HAD was used to determine clinically significant levels of anxiety and depression (Herrmann, 1997). Anxiety was probable in $n = 73$ (21.6%) participants while caseness was detected in $n = 201$ (59.5%). Depression was probable in $n = 98$ (29.0%) participants and caseness was detected in $n = 100$ (29.6%).

Descriptive statistics by clinical trial, t -tests comparing AN subtypes and more detailed information on the anxiety and depression categories can be found in the Supporting Information S1.

2.2 | Measures

The Eating Disorder Examination Questionnaire (EDE-Q; French version; Monneyron et al., 1994) measures ED symptoms over the past 28 days with 28 items. Twenty-two of these items are rated on a Likert scale of 0 (no days/not at all) to 6 (everyday/markedly). The EDEQ has four subscales. *Restraint* (5 items) assesses food/eating avoidance, dietary rules, and desire for an empty stomach. *Eating* (5 items) measures preoccupation with food, guilt about eating, and fear of losing control over eating. *Shape concern* (8 items) includes feelings of fatness, as well as discomfort and preoccupation with shape. *Weight concern* (5 items) measures the importance, dissatisfaction, and preoccupation with weight as well as the desire to lose weight.

The FMPS (French version; Bouvard, 2000) evaluates perfectionism with 35-items rated on a 5-point Likert scale grouped into six subscales. *Concern Over Mistakes* reflects interpreting mistakes as failure and the belief that one will lose the respect of others if one makes a mistake. *Personal Standards* refers to the tendency to set very high standards for oneself and place excessive importance on meeting them. *Parental Expectations* refers to the belief that one's parents have high standards and the perception that one's parents are overly critical is reflected in the *Parental Criticism* subscale. *Doubt about Actions* reflects the extent to which people doubt their ability to accomplish tasks. *Organization* measures the tendency to value neatness and organization.

The Rosenberg Self-Esteem Scale (RSES, French version; Vallieres & Vallerand, 1990) is a unidimensional scale that measures global self-worth with both positive and negative feelings about the self. The RSES consists of 10 items rated on a 4-point Likert scale ranging from strongly agree to strongly disagree.

TABLE 1 Descriptives of full sample and anorexia nervosa subtypes.

	N	Missing	Mean	Median	SD	Min.	Max.
Age							
AN-BP	165	0	21.0	19.2	6.4	13.4	52.3
AN-R	173	0	20.7	18.2	6.4	13.2	51.2
Full	338	0	20.8	18.5	6.4	13.2	18.5
BMI							
AN-BP	165	0	15.1	15.0	1.7	10.3	19.3
AN-R	173	0	14.5	14.3	1.5	11.1	20.3
Full	338	0	14.8	14.6	1.6	10.3	20.3
Minimum BMI							
AN-BP	165	0	13.4	13.5	1.5	7.6	18.5
AN-R	173	0	12.7	12.5	1.6	7.6	18.2
Full	338	0	13.0	13.1	1.6	7.6	18.5
Illness duration							
AN-BP	165	0	4.5	2.3	5.3	0.0	35.3
AN-R	172	1	4.3	2.0	5.7	0.0	43.2
Full	337	1	4.4	2.0	5.5	0.0	43.2
EDEQ							
Restraint							
AN-BP	164	1	3.0	3.2	1.7	0.0	6.0
AN-R	172	1	2.1	1.6	1.8	0.0	6.0
Full	336	2	2.5	2.6	1.8	0.0	6.0
Eating							
AN-BP	163	2	3.0	3.2	1.4	0.0	6.0
AN-R	172	1	2.2	2.3	1.3	0.0	5.4
Full	335	3	2.6	2.6	1.4	0.0	6.0
Shape							
AN-BP	162	3	4.2	4.4	1.3	0.9	6.0
AN-R	172	1	3.6	3.7	1.6	0.0	6.0
Full	334	4	3.9	4.0	1.5	0.0	6.0
Weight							
AN-BP	162	3	3.7	3.8	1.4	0.2	6.0
AN-R	172	1	2.8	2.8	1.4	0.0	6.0
Full	334	4	3.2	3.2	1.5	0.0	6.0

(Continues)

TABLE 1 (Continued)

	N	Missing	Mean	Median	SD	Min.	Max.
Anxiety							
AN-BP	165	0	12.0	12.0	4.5	2.0	21.0
AN-R	173	0	11.3	11.0	4.5	2.0	21.0
Full	338	0	11.7	12.0	4.5	2.0	21.0
Depression							
AN-BP	165	0	9.2	9.0	4.2	0.0	18.0
AN-R	173	0	8.0	8.0	4.2	0.0	17.0
Full	338	0	8.6	9.0	4.2	0.0	18.0
RSES							
AN-BP	155	10	13.8	13.0	6.4	3.0	32.0
AN-R	155	18	15.5	14.0	7.3	3.0	35.0
Full	310	28	14.7	14.0	6.9	3.0	35.0
F-MPS							
Concern over Mistakes							
AN-BP	163	2	32.3	34.0	7.4	12.0	45.0
AN-R	170	3	29.7	30.5	9.3	9.0	45.0
Full	333	5	31.0	32.0	8.5	9.0	45.0
Personal Standards							
AN-BP	163	2	26.4	27.0	5.1	11.0	35.0
AN-R	170	3	25.4	25.0	5.5	10.0	35.0
Full	333	5	25.9	26.0	5.3	10.0	35.0
Parental Expectations							
AN-BP	164	1	12.6	12.0	5.5	5.0	24.0
AN-R	170	3	10.8	10.0	5.1	5.0	24.0
Full	334	4	11.7	11.0	5.4	5.0	24.0
Parental Criticism							
AN-BP	164	1	10.1	10.0	3.9	4.0	20.0
AN-R	171	2	8.9	9.0	3.4	4.0	17.0
Full	335	3	9.5	9.0	3.7	4.0	20.0
Doubt about Actions							
AN-BP	163	2	13.2	13.0	3.6	5.0	20.0
AN-R	170	3	12.3	12.0	3.7	4.0	20.0
Full	333	5	12.8	12.0	3.7	4.0	20.0

TABLE 1 (Continued)

	N	Missing	Mean	Median	SD	Min.	Max.
Organization							
AN-BP	163	2	25.1	25.0	4.2	8.0	30.0
AN-R	170	3	24.8	25.0	4.1	11.0	30.0
Full	333	5	24.9	25.0	4.2	8.0	30.0

Abbreviations: AN-BP, Anorexia Nervosa Binge/Purge subtype; AN-R, Anorexia Nervosa Restrictive subtype; BMI, body mass index; EDEQ, Eating Disorder Examination Questionnaire; FMPS, Frost Multidimensional Perfectionism Scale; RSES, Rosenberg Self-Esteem Scale.

The Hospital Anxiety and Depression Scale (HAD, French version; Boc er an & Dupret, 2014) assesses anxiety and depression symptoms over the past week with 14 items rated on a 4-point Likert scale (0–3). Subscale scores range from 0 to 21 and index the following categories: <7: no anxiety/depression, 8–10: probable anxiety/depression, >11: caseness of anxiety/depression (Herrmann, 1997).

2.3 | Data analysis

Data analysis was conducted in R version 4.2.1 with RStudio version 2022.12.0 + 353. The code can be found on Open Science Framework (<https://osf.io/u58cf>). This paper follows the recommended reporting standards for psychological network analyses (Burger et al., 2022). These standards outline recommendations for (1) preparing the data, including handling missing data and checking assumptions and variance; (2) variable selection to reduce topological overlap; (3) network estimation and visualization; (4) assessing accuracy, stability and using bootstrapped confidence intervals and case-drop bootstrapping; and (5) reporting of results, including stability coefficients, centrality indices, and predictability.

2.3.1 | Data preparation and node selection

Pairwise complete observations were used. Missing data were imputed using median values. The nonparanormal transformation was used to relax the normality assumption with the R-package *huge* version 1.3.5, as recommended (Epskamp et al., 2018).

To reduce the risk of inflating centrality due to the inclusion of variables measuring the same underlying construct, we used the *goldbricker* function in the *networktools* package to detect topological overlap between variables with a threshold of 0.20 ($p = .01$) (Borsboom et al., 2021). If clinically appropriate, nodes with significant overlap were combined with principal component analysis using the *net_reduce* function.

2.3.2 | Network estimation

We estimated three regularized partial correlation networks: (1) full sample, (2) AN-R, and (3) AN-BP. Nodes represent variables and edges represent partial correlations. Each edge represents a conditional dependence between two nodes, and an absent edge signifies conditional independence. The thickness of the edge represents the strength of the correlation between variables. The networks were visualized with the *qgraph* version 1.9.2 (Epskamp et al., 2012), which uses graphical least absolute shrinkage and selection operator regularization (GLASSO)

with the extended Bayesian information criteria (EBIC) set at a threshold of 0.5. The Fruchterman–Reingold algorithm was used for node positioning, where nodes are organized based on the strength of their connections, facilitating visualization.

2.3.3 | Network stability

To estimate edge and centrality stability, we used the *bootnet* package version 1.5 (Epskamp et al., 2018). Non-parametric bootstrapping was used to create 2500 samples to estimate edge weight stability and difference tests for centrality and bridge measures. Case-dropping bootstrap samples ($n = 2500$) were used to estimate the stability of centrality indices. The Correlation Stability (CS) coefficient measures the stability of centrality indices by indicating the proportion of participants that can be dropped to maintain, with a 95% confidence interval, a correlation value of equal to or above $r = .7$. The CS-coefficient is considered acceptable when above 0.25 and good from 0.5 (Epskamp et al., 2018).

2.3.4 | Network centrality and predictability

To inspect centrality measures, we used expected influence (EI; the sum of the values of a node connection) rather than strength (the absolute sum of the values of a node connection), as the connections between variables were both positive and negative (Robinaugh et al., 2016). Strength centrality metrics are included in the Supporting Information S1. Note that a negative EI indicates that when this node changes, it will influence the overall network in the opposite direction (e.g., increases in node activation will lead to decreases in overall activation) (Robinaugh et al., 2016). Network predictability was assessed with the R-package *mgm* version 1.2-13. Predictability refers to how well each node is explained by all other nodes in the network by computing each node's R^2 (Haslbeck & Waldorp, 2018).

2.3.5 | Bridge nodes

Nodes that connect different clusters of symptoms (i.e., communities) are called bridge nodes. Communities were formed based on the *spinglass* algorithm. The algorithm was run 10 times and the most frequently endorsed community was retained. The bridge function in the package *network tools* was used to calculate bridge expected influence (BEI), which represents a node's total connectivity with nodes in other communities in the network considering both positive and negative edges (Jones et al., 2019; Robinaugh et al., 2016).

2.3.6 | Network comparison test (NCT)

The NCT is a permutation test (e.g., 1000 iterations) that compares two networks based on (1) network structure invariance, (2) invariant edge strength, and (3) invariant global strength. These represent global (i.e., network structure and global EI) and local differences (i.e., edge strength) (Van Borkulo et al., 2021). We also tested for differences in EI between AN subtypes. As our analyses were exploratory, we did not correct for multiple testing. This is in line with the recommendation that correcting for multiple comparisons while conducting an exploratory NCT is not necessary but should be considered in the interpretation of results (Van Borkulo et al., 2021).

3 | RESULTS

3.1 | Node selection

In network 1 (full sample), the goldbricker function revealed three bad pairs. After consultation with a clinical expert (S. B.), we chose to combine EDEQ Weight Concern and EDEQ Shape Concern to form Overvaluation of Weight and Shape. Goldbricker analysis of networks 2 (AN-R) and 3 (AN-BP) showed six bad pairs. Only Weight and Shape Concerns were combined to facilitate comparability across networks. Further, as we aimed to examine distinct aspects of perfectionism and their role in AN subtypes, we elected to keep these variables separate to allow for this comparison (see Supporting Information S1).

3.2 | Network stability and predictability

The CS coefficients for each centrality index were as follows. Network 1: EI = 0.75, BEI = 0.75; network 2: EI = 0.60, BEI = 0.60; network 3: EI = 0.44, BEI = 0.29. The mean predictability for each network was 0.48, 0.51, and 0.45, respectively. The nodes with the highest predictability were Eating in Networks 1 and 3 and Concern over Mistakes in Network 2. See the Supporting Information S1 for the edge weight matrix, bootstrapped confidence intervals, and predictability values and networks.

3.3 | Network 1 (full sample)

3.3.1 | Centrality and bridge symptoms

See Figure 1a for the network and Figure 1b for the centrality plot. The three highest EIs were Concern over Mistakes (EI = 1.00), Weight and Shape Concern (EI = 1.00), and Personal Standards (EI = 0.92). The EI centrality estimates were not significantly different from one another (p 's > .05). The lowest positive EIs were Organization and Depression (both EIs = 0.37). The strongest connections were between Parental Expectations and Parental Criticism (edge = 0.55), Overvaluation of Weight and Shape and Eating (edge = 0.50), and Concern over Mistakes and Personal Standards (edge = 0.46).

BEI is shown in Figure 1c. Four communities were detected: Community 1 included Parental Expectations and Criticism; Community 2 included Concern over Mistakes, Personal Standards, Organization and Self-Esteem; Community 3 included Doubt about Actions, Anxiety and Depression; and Community 4 consisted of Overvaluation of Weight and Shape, Eating, Restraint. The most significant bridge symptoms were Self-Esteem (BEI = -0.58) and Concern over Mistakes (BEI = 0.62). Bootstrapped difference tests for EI and BEI are found in Figure 2a,b.

3.4 | Network 2 (AN-R)

3.4.1 | Centrality and bridge symptoms

See Figure 3a for the network and Figure 3b for the centrality plot. The three highest EIs were Concern over Mistakes (EI = 1.10), Weight and Shape Concerns (EI = 1.10), and Anxiety (EI = 0.88). The EIs were not significantly different from one another (p 's > .05). The node with the lowest EI was Depression (EI = 0.42). The strongest connections were between Overvaluation of Weight and Shape and Eating (edge = 0.47), Parental Expectations and Parental Criticism (edge = 0.44), and Concern over Mistakes and Personal Standards (edge = 0.38).

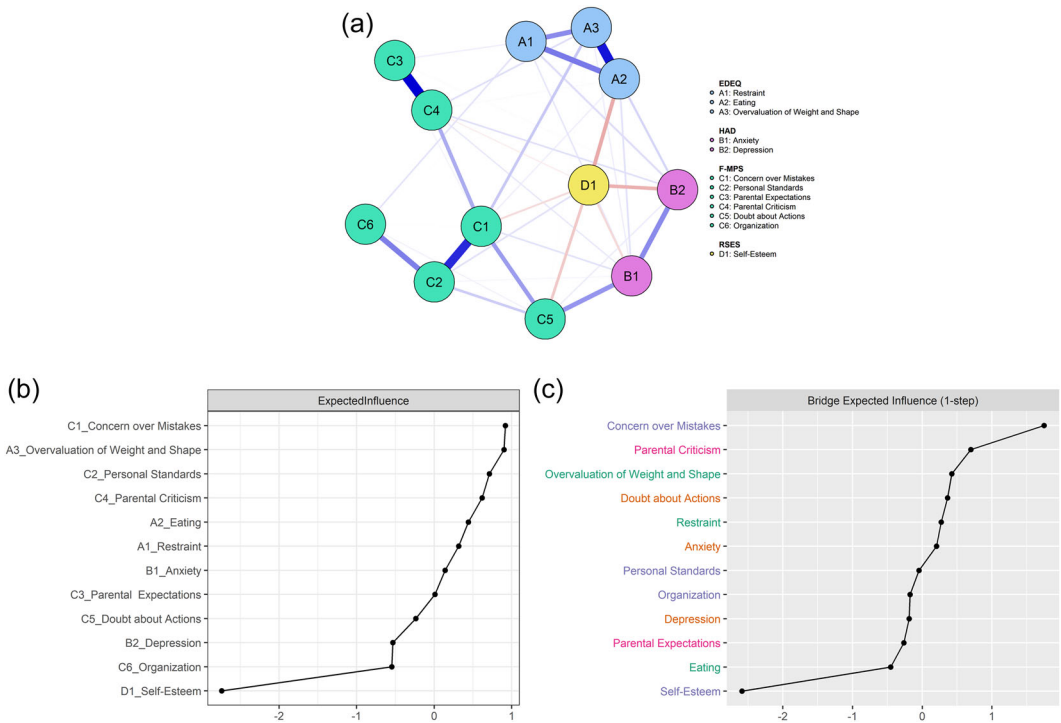


FIGURE 1 Network plot, centrality, and bridge expected influences (BEIs) for the full sample. (a) Visualized network for Network 1. Blue lines between nodes represent a positive association and red lines represent negative associations; thicker lines correspond to stronger associations. (b) Expected influence (EI) plot for Network 1. EI values are standardized. (c) BEI for Network 1. Values for BEI are standardized. Colors represent the different communities.

BEI is shown in Figure 3c. Four communities were detected: Community 1 included Concern over Mistakes, Doubt about Actions, Personal Standards, Organization and Self-Esteem; Community 2 consisted of Anxiety and Depression; Community 3 included Parental Expectations and Criticism; and Community 4 consisted of Overvaluation of Weight and Shape, Eating and Restraint. The three highest BEIs were Anxiety, (BEI = 0.54), Concern over Mistakes (BEI = 0.51), and Self-Esteem (BEI = -0.47). Bootstrapped difference tests for EI and BEI are found in Figure 4a,b.

3.5 | Network 3 (AN-BP)

3.5.1 | Centrality and bridge symptoms

See Figure 5a for the network and Figure 5b for the centrality plot. The four highest EIs were Personal Standards (EI = 0.92), Parental Criticism (EI = 0.91), Weight and Shape Concerns (EI = 0.91), and Concern over Mistakes (EI = 0.91). The EIs were not significantly different from one another (p 's > .05). The node with the lowest EI was Depression (EI = 0.26). The strongest connections were between Parental Expectations and Parental Criticism (edge = 0.60), Concern over Mistakes and Personal Standards (edge = 0.52), and Overvaluation of Weight and Shape and Eating (edge = 0.49).

BEI is shown in Figure 5c. Four communities were detected: Community 1 included Doubt about Actions, Anxiety and Depression; Community 2 consisted of Overvaluation of Weight and Shape, Eating and Restraint; Community 3 included Parental Expectations and Criticism; and Community 4 consisted of Concern over Mistakes, Personal

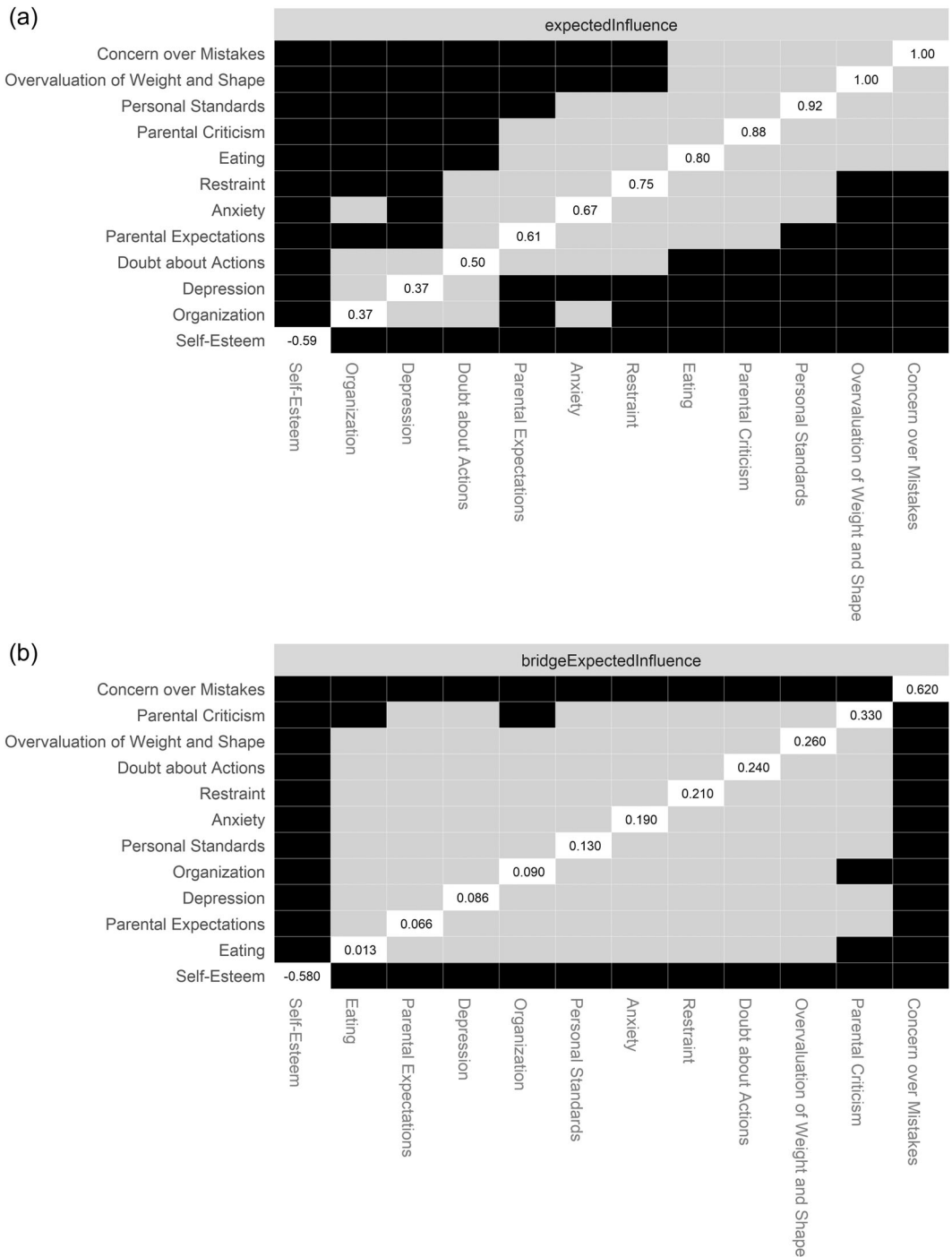


FIGURE 2 Bootstrapped difference test of expected influence (EI) and bridge expected influence (BEI) for the full sample. (a) EI and (b) BEI in Network 1. Variables are presented in descending order of EI or BEI values. Black squares represent statistically significant differences.

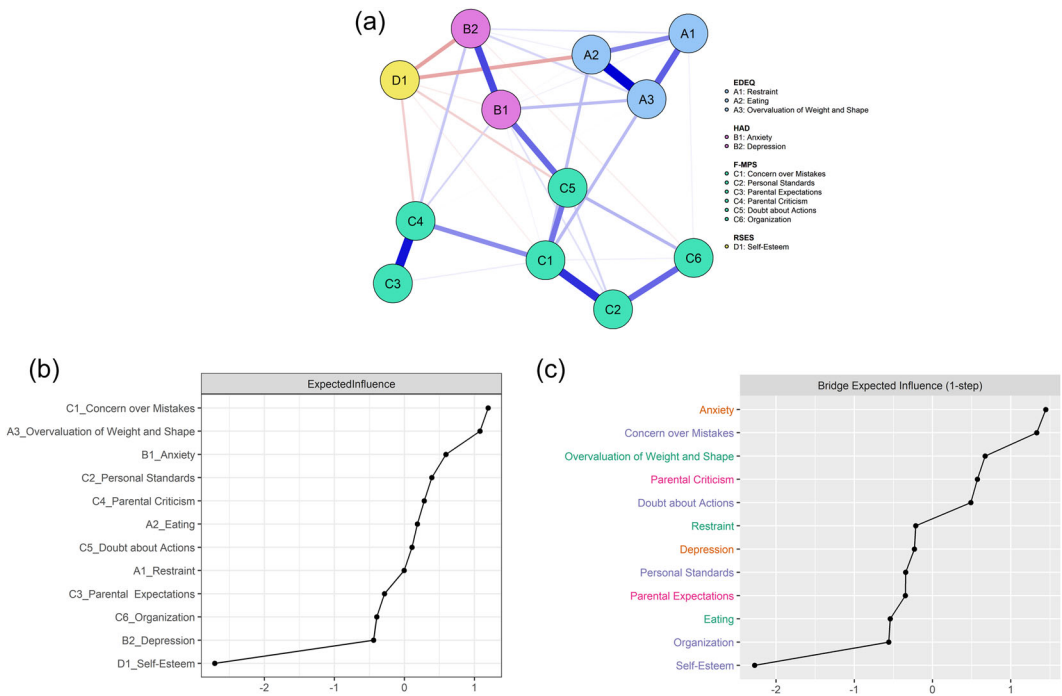


FIGURE 3 Network plot, centrality, and bridge expected influences for AN-R. (a) Visualized network for Network 2. Blue lines between nodes represent a positive association and red lines represent negative associations; thicker lines correspond to stronger associations. (b) Expected influence (EI) plot for Network 2. EI values are standardized. (c) Bridge expected influence (BEI) for Network 2. Values for BEI are standardized. Colors represent the different communities.

Standards, Organization, and Self-Esteem. The most significant bridge symptoms were Self-Esteem (BEI = -0.58) and Concern over Mistakes (BEI = 0.47). Bootstrapped difference tests for EI and BEI are found in Figure 6a,b.

3.6 | NCT

3.6.1 | AN-R versus AN-BP

The NCT revealed no significant difference in network structure between AN-R and AN-BP networks (network structure invariance [M] = 0.18, $p = 0.53$). The global EI for the AN-R and the AN-BP networks were 3.70 and 3.36, respectively, and were not significantly different (global EI invariance [EI] = 0.34, $p = .28$). The centrality difference test comparing EI between both networks found that Anxiety had a significantly higher EI in the AN-R network compared to AN-BP (difference = 0.40, $p < .05$).

4 | DISCUSSION

4.1 | Central symptoms

We investigated the network structure of perfectionism, self-esteem, anxiety/depression and ED symptoms among inpatients with AN. We found that Concern over Mistakes and Overvaluation of Weight and Shape were among the

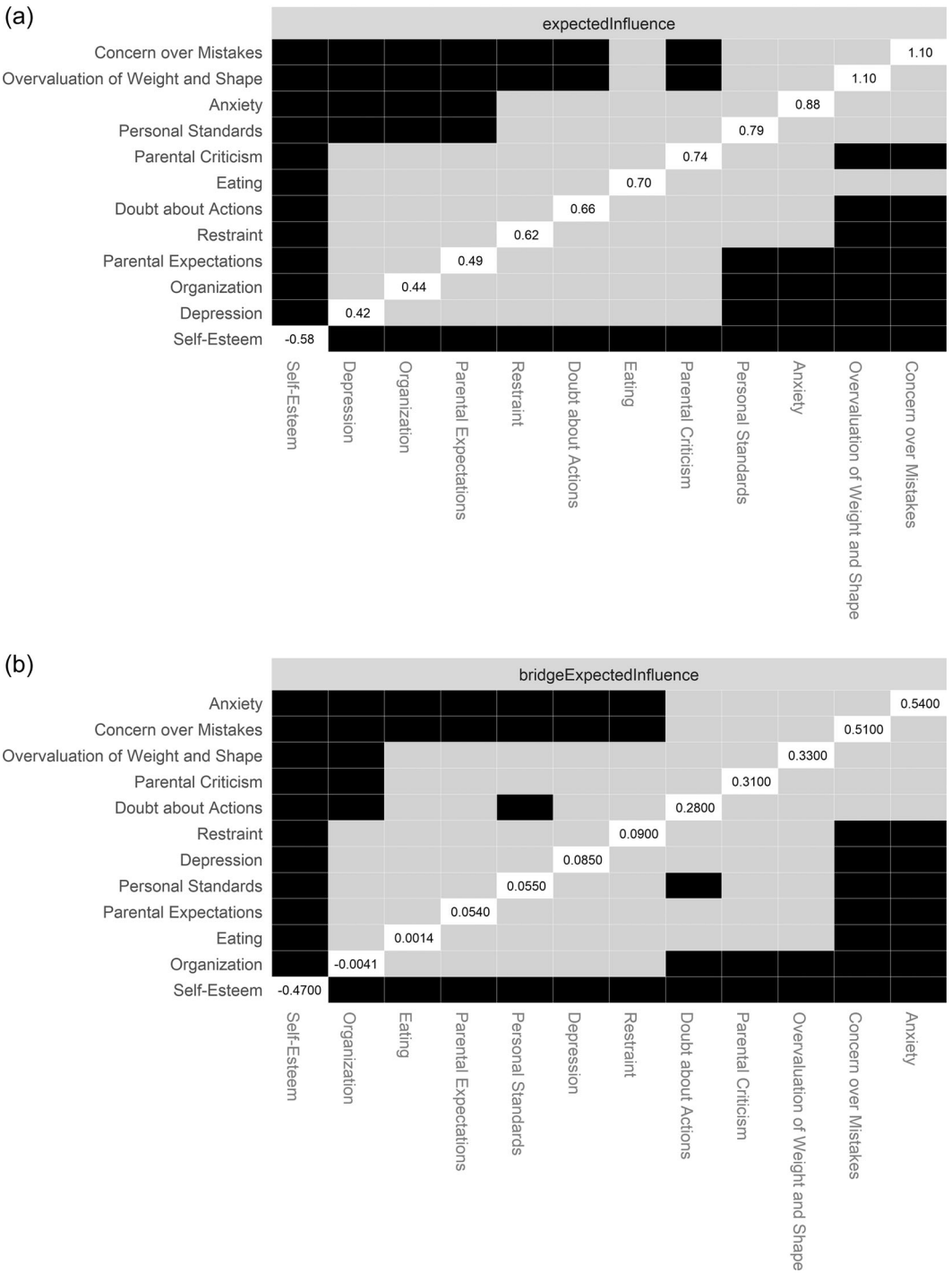


FIGURE 4 Bootstrapped difference test of expected influence (EI) and bridge expected influence (BEI) for AN-R. (a) EI and (b) BEI in Network 2. Variables are presented in descending order of EI or BEI values. Black squares represent statistically significant differences.

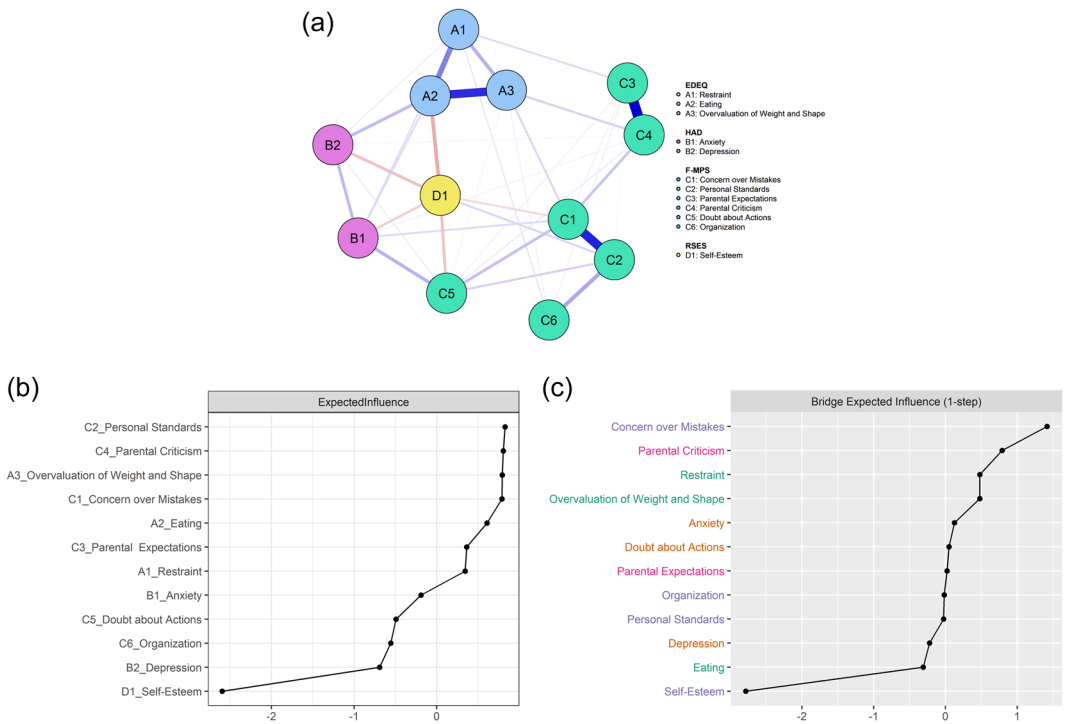


FIGURE 5 Network plot, centrality, and bridge expected influences (BEIs) for AN-BP. (a) Visualized network for Network 3. Blue lines between nodes represent a positive association and red lines represent negative associations; thicker lines correspond to stronger associations. (b) Expected influence (EI) plot Network 3. EI values are standardized. (c) BEI plot Network 3. BEI values are standardized. Colors represent the different communities.

most central symptoms across all three networks. Personal Standards and Anxiety also emerged as central symptoms. When comparing AN subtypes, we found that anxiety was more central in AN-R compared to AN-BP.

The centrality of Overvaluation of Weight and Shape is consistent with a large body of network studies in both AN and transdiagnostic ED samples (Christian et al., 2020; DuBois et al., 2017; Mares et al., 2022; Monteleone & Cascino, 2021). The high centrality of Concern over Mistakes aligns with network studies of AN (Delaquis et al., 2023; Martini et al., 2021) and one study in a transdiagnostic ED sample that was composed primarily of individuals with AN (Ralph-Nearman et al., 2023). Personal Standards was also a central symptom across networks, consistent with evidence that both perfectionistic concerns and strivings are present in AN (Bardone-Cone et al., 2007; Limburg et al., 2017).

The strong connection between Personal Standards and Concern over Mistakes (i.e., clinical perfectionism) replicates the NA findings in a transdiagnostic ED sample (Ralph-Nearman et al., 2023). The strongest connections to ED symptoms were Concern over Mistakes to Overvaluation of Weight and Shape and Self-Esteem to Eating preoccupation. The high centrality of Concern over Mistakes and Personal Standards, as well as the strong connections between Concern over Mistakes and Self-Esteem with ED symptoms, support the transdiagnostic theory that clinical perfectionism and self-esteem are key processes in AN (Fairburn et al., 2003).

Our results also show that nodes related to perfectionism were just as central as cardinal ED symptoms. While replication studies are needed, these results raise the question of whether multidimensional perfectionism should be part of the evaluation and diagnostic criteria of EDs in routine clinical care. Further, in line with network theory (Borsboom, 2017), targeting Concern over Mistakes in treatment, which was connected to ED and perfectionism

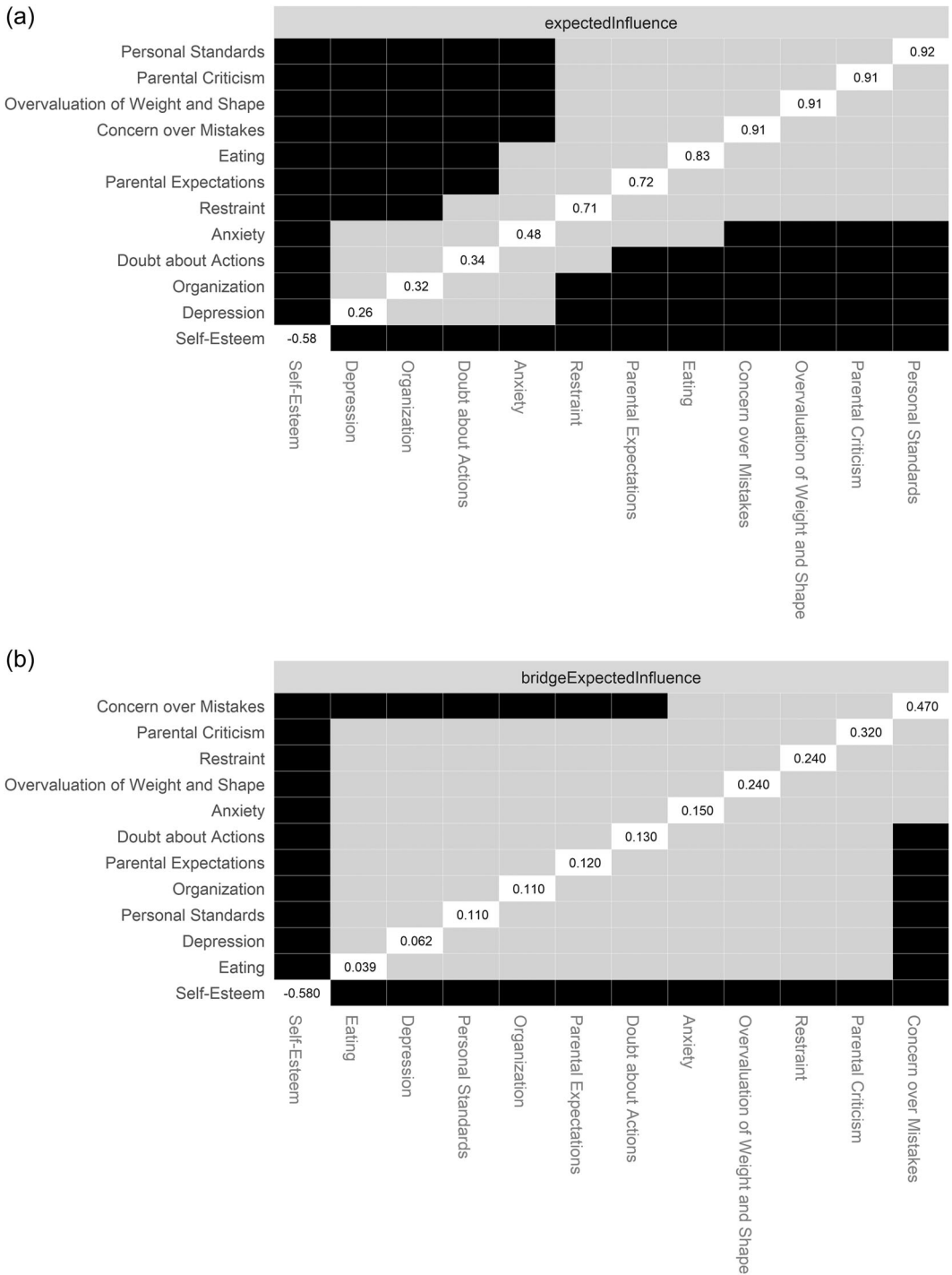


FIGURE 6 Bootstrapped difference test of expected influence (EI) and bridge expected influence (BEI) for AN-BP. (a) EI and (b) BEI in Network 3. Variables are presented in descending order of EI or BEI values. Black squares represent statistically significant differences.

symptoms, may reduce these symptoms in individuals with AN. More research on BN and BED is needed to determine if these symptoms hold potential as transdiagnostic treatment targets.

4.2 | Bridge symptoms and communities

The most central bridge symptoms across all networks were Concern over Mistakes and Self-Esteem. Concern over Mistakes bridged perfectionism and ED symptoms, while Self-Esteem was highly connected to all symptom clusters.

Self-Esteem consistently clustered with perfectionism symptoms in the community detection analyses. This is in line with research pointing to the central role of low and contingent self-worth in perfectionism (Shafran et al., 2002). Of note, some items in the FMPS Personal Standards subscale have been found to measure evaluative self-worth (DiBartolo et al., 2004). Previous research emphasizes the importance of context in the (mal) adaptiveness of Personal Standards, as perfectionistic personal standards appear to be maladaptive if these standards are used to determine self-worth (DiBartolo et al., 2004; Greenspon, 2000). Future research should examine the relationship between contingent self-worth and Personal Standards using dynamic measurement tools to better capture the complexity of their interplay.

Four communities were detected across all networks. Interestingly, the FMPS subscales measuring both perfectionistic concerns (Concern over Mistakes) and strivings (Personal Standards and Organization) consistently clustered together. This is in line with the theory of clinical perfectionism, where a failure to meet impossibly high personal standards results in harsh self-criticism (Shafran et al., 2002). While high personal standards may represent an adaptive striving for excellence in nonclinical cases, in AN it appears that these standards are not adaptive, as self-worth becomes contingent on meeting these standards.

Interestingly, while not a central bridge symptom, the perfectionism dimension Doubt about Actions clustered with anxiety and depression in the full network and the AN-BP network. This is consistent with previous findings that Doubt about Actions bridges perfectionism, anxiety, and depression (Delaquis et al., 2023), as well as ED symptoms and OCD (Vanzhula et al., 2021). Bridge nodes are thought to spread activation between different clusters of disorders and/or related symptoms (Jones et al., 2019); therefore, future research should examine if patients with AN who exhibit high Doubt about Actions are more likely to present with symptoms of anxiety and/or depression.

In addition, parental dimensions did not cluster with other facets of perfectionism, suggesting that this represents a separate construct. It has been suggested that parental dimensions represent a distinct dimension of perfectionism and previous research has shown that they cluster together (Gäde et al., 2017).

4.3 | NCT

When comparing AN subtypes, no significant differences were found in terms of network structure or global EI. Nonetheless, Anxiety was more central in the AN-R network compared to the AN-BP network, although this was not corrected for multiple comparisons due to the exploratory nature of this analysis. Future research should attempt to replicate this finding in a larger sample with the hypothesis testing method. Anxiety was also a significant bridge symptom only in the AN-R network, bridging Communities 1, 2, and 4. Previous research has shown that individuals in full or partial recovery from an ED are similar to healthy controls on most psychological and behavioral outcomes, except for elevated general anxiety (Bardone-Cone et al., 2010). Considering that anxiety tends to precede eating disorders (Barakat et al., 2023), it has been proposed that an underlying pathology drives both ED and anxiety such that, after treatment, the anxiety disorder continues to be expressed in non-ED-related domains (Bardone-Cone et al., 2010). Altogether, these findings suggest that it may be important to also target general anxiety symptoms in ED treatment.

Of note, in the current study, the median BMI was 14.3 in the AN-R group and 15.0 in the AN-BP group, which represent the “extreme” and ‘severe’ categories, respectively, according to the DSM-5 severity specifiers (American Psychiatric Association, 2013). Although we cannot draw definite conclusions, anxiety may have differential associations with other symptoms depending on nutritional status. Future research should investigate the impact of nutritional status on anxiety and its potential relationships with ED symptoms and perfectionism in a larger sample.

4.4 | Strengths and limitations

This study contributes to the growing body of network studies investigating core ED symptoms and their complex relationships with psychological factors such as perfectionism, self-esteem, and anxiety/depression. It is also the first network study to compare AN subtypes on these factors directly. We also examined network stability and predictability while controlling for topological overlap.

Some limitations should be noted. First, as our study investigates inpatients with AN, we may not generalize our results to less severe or subclinical cases, nor to transdiagnostic ED. Further, as data are cross-sectional, insight into the temporal relationship between symptoms cannot be determined. In addition, we only used the current AN subtype diagnosis rather than the lifetime diagnosis. Future research should consider including lifetime diagnoses, as there is a high rate of crossover between AN subtypes and patients who crossover may have different symptom profiles than those who do not. Further, BEI stability was only slightly above the acceptable recommended threshold for the AN-BP network, which may have impacted the results. We also did not correct for multiple comparisons when comparing AN-R and AN-BP due to the exploratory nature of this analysis. Lastly, there could be other psychological factors influencing AN pathology that were not included in the current network, such as emotion dysregulation and interpersonal factors (Fairburn et al., 2003; Schmidt & Treasure, 2006). For instance, considering that family relationships are an important component of the cognitive-interpersonal model of AN (Treasure & Schmidt, 2013) and family-based treatment is an effective treatment option for adolescents with AN (Eisler et al., 2016), interpersonal relationships may be an important factor to include in future network studies.

4.5 | Conclusions and clinical implications

We found that perfectionism, specifically Concern over Mistakes and Personal Standards, plays a central role in AN, while self-esteem acts as a bridge between perfectionism, eating symptomatology, and mood symptoms. Further, in line with previous literature, Overvaluation of Weight and Shape was also central to the network. We also highlighted that anxiety may be an important treatment target.

Our study supports certain premises put forward by the transdiagnostic cognitive-behavioral model, specifically that clinical perfectionism and low self-esteem are key processes in AN. The centrality of both Concern over Mistakes and Personal Standards indicates that, at least in the context of inpatients with AN, perfectionistic personal standards are not adaptive and contribute to AN pathology. The significant bridge centrality of self-esteem connecting cardinal ED symptoms and clinical perfectionism facets indicates the potential relevance of contingent self-worth in the pathology of AN. This relationship indicates that AN patients may experience contingent self-worth based on their weight and shape, as well as whether they meet their perfectionistic personal standards.

Interventions that target multiple central symptoms may have greater success in reducing overall severity. Targeting clinical perfectionism, both with a cognitive-behavioral approach and a tailored intervention designed to increase awareness of and challenge perfectionism while adopting more achievable standards, has been shown to reduce both Concern over Mistakes and Personal Standards while improving ED symptoms, anxiety, and depression (Lloyd et al., 2015; Tchanturia et al., 2016). In addition, a 10-session psychodynamic/interpersonal group treatment focusing on the interpersonal and relational aspects of perfectionism reduced components of perfectionism,

depression and interpersonal problems at 4-month follow-up, but not anxiety (Hewitt et al., 2015). This is interesting in the context of the results of the present study that indicate the centrality of anxiety, suggesting that additional focus should be placed on directly targeting anxiety in treatment.

Although not directly tested in our network, we propose that self-compassion may also play an important complementary role in the treatment of AN. Self-compassion is an unconditional positive self-regard that protects against self-criticism, self-judgment, rumination, and isolation (Neff, 2003). Fear of self-compassion has been found to strongly contribute to ED symptoms (Kelly et al., 2014) and predict poor response to ED treatment (Kelly et al., 2013). Fear of self-compassion can stem from a fear of lowering personal standards or the belief that one does not deserve compassion (Kelly et al., 2014). Increasing self-compassion may leverage the potentially adaptive facts of perfectionism (i.e., striving for excellence) and increase self-esteem while reducing the harsh self-criticism and self-worth contingent on goal achievement that appears to play a core role in ED pathology. Further, the dynamic measurement of contingent self-esteem would be particularly relevant for future research to investigate in eating disorder populations. One ecological momentary intervention study (EMI) found that a transdiagnostic, blended EMI targeting self-esteem was moderately efficacious in increasing self-esteem in youth who had experienced childhood adversity (Reininghaus et al., 2023). This avenue may also be promising for future research on eating disorder treatments.

Future research should include a wide range of psychological factors, such as emotion dysregulation, interpersonal factors, and self-compassion, as well as dynamic assessment measures, in a transdiagnostic ED sample to elucidate central mechanisms across disordered eating behaviors.

AUTHOR CONTRIBUTIONS

Chantal P. Delaquis: Conceptualization; methodology; formal analysis; writing—original draft; writing—review and editing. **Nathalie Godart:** Investigation; funding acquisition; data curation; writing—reviewing and editing. **Caroline Barry:** Data curation; writing—reviewing and editing. **Damien Ringuenet:** Investigation; funding acquisition; writing—reviewing and editing. **Anne-Solène Maria:** Investigation; data curation; writing—reviewing and editing. **Isabelle Nicolas:** Funding acquisition; investigation. **Sylvie Berthoz:** Conceptualization; investigation; writing—reviewing and editing; supervision; funding acquisition. All authors have read and agreed to the published version of the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data presented in this study are available upon reasonable request from the corresponding author. The data are not publicly available due to specifications from the study sponsor. Code can be found on Open Science Framework (<https://osf.io/u58cf>).

ETHICS STATEMENT

Both clinical trials were conducted in accordance with the Declaration of Helsinki and approved by the Ile-de-France III Ethics Committee and the CNIL (Commission nationale de l'informatique et des libertés; registered in Clinical trials Identifier: NCT00910169 for EVHAN and NCT01772394 for TRECOCAM). Informed consent was obtained from all subjects involved in the study and from the parents of patients less than 18 years old.

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PEER REVIEW

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