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**Feeling imperfect and imperfectly feeling: A network analysis on perfectionism, interoceptive sensibility, and eating symptomatology in anorexia nervosa**

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1 **Feeling imperfect and imperfectly feeling: a network analysis on perfectionism, interoceptive**  
2 **sensibility, and eating symptomatology in anorexia nervosa**

3 Matteo Martini, Enrica Marzola, Annalisa Brustolin, Giovanni Abbate-Daga

4

5 Eating Disorders Center, Department of Neuroscience “Rita Levi Montalcini”, University of Turin,  
6 Italy

7 Matteo Martini: [matteomartini90@gmail.com](mailto:matteomartini90@gmail.com), <https://orcid.org/0000-0001-8877-0138>

8 Enrica Marzola: [enrica.marzola@unito.it](mailto:enrica.marzola@unito.it), <https://orcid.org/0000-0003-1328-9678>

9 Annalisa Brustolin: [annalisa.brustolin@gmail.com](mailto:annalisa.brustolin@gmail.com)

10 Giovanni Abbate-Daga: [giovanni.abbatedaga@unito.it](mailto:giovanni.abbatedaga@unito.it), <https://orcid.org/0000-0002-5826-5664>

11

12 §Corresponding author:

13 Prof. Giovanni Abbate-Daga

14 Eating Disorders Center

15 Department of Neuroscience, “Rita Levi Montalcini”

16 University of Turin, Via Cherasco 11, 10126, Turin, Italy

17 Tel and fax: +39 011 6335749

18 Email: [giovanni.abbatedaga@unito.it](mailto:giovanni.abbatedaga@unito.it)

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16 **Author statement**

17 MM and GAD designed the project. AB and MM acquired and managed the data. MM performed  
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1 **Feeling imperfect and imperfectly feeling: a network analysis on perfectionism, interoceptive**  
2 **sensibility, and eating symptomatology in anorexia nervosa**

3 **Abstract**

4 **Objective:** In recent years, the network analysis (NA) methodology has been applied to identify the  
5 central features of the psychopathology of anorexia nervosa (AN) and specific connections to  
6 previously recognized vulnerabilities. However, an NA investigating both multidimensional  
7 perfectionism and interoceptive sensibility in connection to eating symptomatology is currently  
8 missing.

9 **Method:** A total of 260 individuals (139 patients with AN, 121 healthy control individuals)  
10 completed the Frost Multidimensional Perfectionism Scale, the Multidimensional Assessment of  
11 Interoceptive Awareness, and the Eating Disorders Inventory-2. Using state-of-the-art techniques,  
12 we estimated a main network with data from all participants and then compared the two separated  
13 networks. We checked the variables for empirical overlap through goldbricker, combined as  
14 suggested, and implemented the empirical measure of the bridge nodes.

15 **Results:** Ineffectiveness and need for control over self and body (resulting from combining  
16 Asceticism and Drive for Thinness) were the most central nodes, whereas perfectionistic evaluative  
17 concerns (resulting from combining Doubts about Actions and Concern over Mistakes) and mistrust  
18 in body sensations were the bridge nodes. No significant differences between the patient and control  
19 networks emerged.

20 **Conclusions:** Perfectionistic evaluative concerns and mistrust in body sensations could be key  
21 components in the relationships among perfectionism, interoceptive sensibility, and eating  
22 symptomatology.

23 **Keywords:** eating disorders, interoceptive awareness, ineffectiveness, drive for thinness, eating  
24 psychopathology

## 1 **Highlights**

- 2 • Perfectionism and interoceptive alterations are highly relevant features of Anorexia Nervosa  
3 (AN)
- 4 • Network Analysis allows to identify central symptoms as well as elements bridging different  
5 psychological constructs
- 6 • Ineffectiveness and need for control over self and body were the most central nodes.  
7 Perfectionistic evaluative concerns and mistrust in body sensations were the bridge nodes  
8 and could represent relevant intervention points in AN

## 1 **1. Introduction**

2 Network analyses (NAs) have recently been applied to investigate the connections between  
3 the core features of anorexia nervosa (AN) and vulnerability factors (Levinson, Vanzhula, et al.,  
4 2018). NA is a statistical tool to investigate the cooccurrence of symptoms or affective states,  
5 rooted in the network theory of mental disorders, which conceives syndromes as emerging from  
6 symptom interactions (Robinaugh et al., 2020). NAs on eating disorders (EDs) have reported shape  
7 and weight overvaluation (DuBois et al., 2017; Forrest et al., 2019; Wang et al., 2018), fear of  
8 weight gain (Christian et al., 2019; Forrest et al., 2018; Levinson et al., 2017; Vanzhula et al.,  
9 2019), ineffectiveness, and interoceptive awareness (Cascino et al., 2019; Monteleone et al., 2019;  
10 Olatunji et al., 2018; Solmi et al., 2018) as having the highest centrality (i.e., supposedly more  
11 relevant for psychopathology; Robinaugh et al., 2020). Networks comprising not only symptoms  
12 but also personality traits have been advocated for (Fried & Cramer, 2017) and studied (e.g.,  
13 Levinson, Brosof, et al., 2018; Monteleone et al., 2019; Vervaet et al., 2020).

14 Traditionally, the need for control and difficulties in recognizing bodily sensations have  
15 conceptualized AN pathogenesis (Bruch, 1962) with increasing support found for this view over the  
16 past decades (Kaye et al., 2009). Empirical research (including NAs) has confirmed the relevance of  
17 *perfectionism* (Dahlenburg et al., 2019; Fairburn et al., 2003; Gárriz et al., 2020), a personality trait  
18 expressing “the tendency to set high standards and employ overly critical self-evaluations” (Frost &  
19 Marten, 1990, p. 559), and *altered interoception*, namely, the perception of the internal state of the  
20 body (Khalsa et al., 2018) in the vulnerability to AN.

21

### 22 **1.1 Perfectionism**

23 The main conceptualizations of perfectionism (Frost et al., 1990; Hewitt & Flett, 1991)  
24 recognize it as a construct with several dimensions and a two-factor solution (Limburg et al., 2017).  
25 Dimensions pertaining to “maladaptive” evaluative concerns (Frost et al., 1990) show a stronger  
26 association with clinical conditions such as depression, anxiety, obsessive–compulsive disorder

1 (OCD), and EDs (Limburg et al., 2017) than do “adaptive” perfectionistic strivings. However, both  
2 are associated with the psychopathology of AN and bulimia nervosa (BN) (Dahlenburg et al., 2019;  
3 Limburg et al., 2017), with unclear implications for treatment. Shafran et al. (2002; 2010) have  
4 considered only what they define as “clinical” perfectionism as relevant for the maintenance of  
5 EDs. In this regard, NA identifying specific and unique connections between constructs could help  
6 clarify the relationship between perfectionism dimensions and eating symptomatology.

7         Currently, three NAs have introduced a multidimensional investigation of perfectionism,  
8 using the Frost Multidimensional Perfectionism Scale (FMPS; Frost et al., 1990). In one study with  
9 a mixed clinical and nonclinical sample, only seven items of the FMPS were used, with few results  
10 on perfectionism and focusing on the comorbidity between social anxiety disorder and EDs  
11 (Levinson, Brosos, et al., 2018). A second NA, with a large ED sample utilizing all FMPS  
12 subscales, found Personal Standards as highly central among vulnerability and resilience traits in  
13 connection to eating symptomatology (Vervaeke et al., 2020). The most central node in the entire  
14 network was a *maladaptive schemata measure*, referring to “excessive focus on inhibiting emotions  
15 and feelings in order to avoid mistakes” (Vervaeke et al., 2020, p. 8). More recently, Vanzhula and  
16 collaborators (2021) have applied NA to a large mixed sample of students and patients with EDs,  
17 introducing the FMPS in a network investigating the comorbidity between OCD and EDs, finding  
18 the highest centrality for elements of perfectionism and items from the FMPS subscale Doubts  
19 about Actions, as bridging OCD and EDs.

20

## 21 **1.2 Interoception**

22         The perception of the internal state of the body (Khalsa et al., 2018), *interoception*, has been  
23 increasingly investigated in AN, shifting from interoceptive awareness (Garner et al., 1983) to the  
24 distinction between interoceptive accuracy or sensitivity, namely, the correct detection of internal  
25 sensations and sensibility, that is, the self-perceived disposition to attend to bodily sensations  
26 (Khalsa et al., 2018). In line with earlier data (Fassino et al., 2004), a more recent meta-analysis

1 found significantly-lower interoceptive sensibility in patients with AN and BN compared with  
2 healthy control individuals (HCs) and patients with binge-eating disorder (Jenkinson et al., 2018).

3 Moreover, recent studies on patients with ED have shown interoceptive awareness and  
4 ineffectiveness, as measured by the Eating Disorders Inventory–2 (EDI-2), as the most central  
5 subscales (Olatunji et al., 2018; Solmi et al., 2018; Vervaet et al., 2020). In an NA exploring anxiety  
6 in BN, body sensations bridged eating symptoms and anxiety and depressive symptoms (Levinson  
7 et al., 2017); in another study with mixed clinical patients, interoceptive deficits strongly connected  
8 ED symptoms and suicidality (Smith et al., 2020). Similarly, interoceptive awareness has emerged  
9 as the node of connection between childhood maltreatment experiences and eating psychopathology  
10 in an NA in patients with AN (Monteleone et al., 2019). Only one NA, specifically investigating  
11 interoception in patients with EDs, has been recently published and found that mistrust in body  
12 sensations is a bridge to eating symptomatology (Brown et al., 2020).

13

### 14 **1.3 Present study: the rationale**

15 Taken together, the aforementioned studies have clarified the relevance of both  
16 perfectionism and interoception as separate constructs in AN. Notwithstanding, few investigations  
17 of the potential connections between such constructs and symptoms of AN exist despite some  
18 literature-based considerations. First, it has been proposed that patients' need for control could  
19 affect their intolerance of uncertainty (Abbate-Daga et al., 2015), with the latter possibly involved  
20 with interoception. Second, recent literature has provided preliminary evidence on the relationship  
21 between perfectionism and AN grounded in interoceptive alterations (Duffy et al., 2019). In fact,  
22 both starvation (“starvation to avoid actual sensing of visceral sensations”; Paulus et al., 2019, p.  
23 111) and cognitive control (i.e., perfectionism) could provide patients with a brief respite from  
24 uncertain or aversive bodily sensations (Boswell et al., 2019; Duffy et al., 2019) thus, contributing  
25 to AN pathogenesis (Barca & Pezzulo, 2020). In other words, feeling uncertain about eating-related



1 interoceptive signals could alter patients' ability to accurately perceive and manage bodily  
2 sensations (Boswell et al., 2019; Duffy et al., 2019; Merwin et al., 2010).

3         Consequently, to avoid such aversive interoceptive stimuli, patients with AN could activate  
4 their well-known cognitive strategies (Kaye et al., 2009) to regulate uncertain—thus aversive—  
5 interoceptive signals. Therefore, perfectionism, a hallmark of AN (Dahlenburg et al., 2019), could  
6 be a “safe” cognitive strategy to shift the focus from internal values to external and more  
7 controllable ones (Duffy et al., 2019). Similarly, prompted by earlier studies on marked  
8 interoceptive difficulties in perfectionistic patients with AN (Fassino et al., 2004), a path analysis  
9 study has found a significant indirect pathway linking high perfectionism to AN cognitions and  
10 behaviors through interoceptive dysfunction (Duffy et al., 2019).

11

### 12 **1.3 Present study: methodology and aims**

13         Given these premises, we adopted the NA methodology to clarify the relationships among  
14 perfectionism, interoceptive sensibility, and eating psychopathology in AN. First, to provide a  
15 detailed investigation, we performed a fine-grained multidimensional measurement of both  
16 perfectionism and interoceptive awareness, thus, complementing previous results. Second, we  
17 guided our investigation using the network theory that conceptualizes syndromes as the product of  
18 symptom interactions; NA provides a model for these interactions by estimating them from data.  
19 Third, we adhered to the principle by which an adequate network model must contain all relevant  
20 constructs but not several elements referred to the same symptom; if the latter is the case, an overlap  
21 rather than an association would be reported (Fried & Cramer, 2017). As a result, the evaluation of  
22 content overlap before the inclusion of variables in the network represents another expansion of the  
23 earlier literature (Vanzhula et al., 2021; Vervaeke et al., 2020) provided by our work.  
24 Fourth, in keeping with previous explorative studies (Levinson, Brossof, et al., 2018; Levinson &  
25 Williams, 2020; Olatunji et al., 2019; Vanzhula et al., 2021), we included HCs in our analysis  
26 because, although reporting lower scores on clinical measures, their data still can be informative.

1 Finally, while modeling this network, we were mostly interested in the nodes serving as bridges  
2 among three communities: a) multidimensional perfectionism, b) interoceptive sensibility, and c)  
3 the eating psychopathology of AN.

4 Therefore, the overarching aim of this exploratory study was to investigate the interactions  
5 among perfectionism, interoceptive sensibility, and eating psychopathology in AN. Our goals were  
6 to ascertain the most central nodes and clarify the bridge nodes. We expected to find ineffectiveness  
7 as central to the network, in keeping with previous studies with EDI, with concern over mistakes as  
8 having a higher bridge value than have other perfectionism nodes and mistrust in body sensations  
9 reporting the highest bridge centrality.

10

11

## 1 **2. Method**

### 2 **2.1 Participants**

3 We consecutively recruited 146 patients seeking treatment at [affiliation], and 140 HCs.  
4 Patients were both hospitalized and partially-hospitalized inpatients with AN, whereas HCs  
5 comprised university students, medical residents and individuals from the general population all  
6 coming from the same catchment area as the patients.

7 In order to maximise the representativeness of the sample, the following inclusion criteria  
8 were adopted for patients: a) age between 16 and 55 years; (b) formal diagnosis of AN according to  
9 DSM-5 criteria as assessed by an experienced psychiatrist per clinical interview (First et al., 2016);  
10 c) being fully or partially hospitalized at [affiliation]. Moreover, for HCs, inclusion criteria were: a)  
11 age between 16 and 55 years; b) absence of a lifetime diagnosis of ED; c) being not on medications.  
12 Similarly, in order to avoid bias, exclusion criteria for both patients and HCs were: a) psychotic-  
13 spectrum disorders, bipolar disorders, or substance-use dependence, b) organic illnesses (e.g.,  
14 epilepsy or diabetes), c) failing to provide a valid written informed consent or returning incomplete  
15 assessments.

16 Out of the 146 candidates, three patients refused study participation, and four returned  
17 incomplete assessments; similarly, 19 HCs returned incomplete questionnaires. Therefore, the final  
18 sample was 260 individuals: 139 inpatients and partially hospitalized patients with AN (99 AN  
19 restricting, 40 AN binge–purging subtype) and 121 HCs. Three patients were in partial remission at  
20 the time of the assessment (Body Mass Index; BMI > 19, still fulfilling the other AN criteria) and  
21 showing clinical-level scores at psychometric questionnaires so they were retained in the study  
22 sample.

### 23 24 **2.2 Procedure**

25 For patients, an experienced psychiatrist assessed patients' diagnosis and study eligibility  
26 upon admission using the Structured Clinical Interview from the *DSM–5* (First et al., 2016).

1 Subsequently, height and weight were measured, and BMI was calculated. Patients were then  
2 administered the questionnaires which were completed within the first week of the treatment.

3 HCs were recruited from the community via flyers and word of mouth. Once they accepted  
4 to participate in the study, they also underwent an assessment with a psychiatrist (or a psychiatric  
5 trainee at [affiliation]) who conducted a clinical interview aimed at assessing the fulfilment of the  
6 aforementioned inclusion and exclusion criteria. Individual's height and weight were measured to  
7 calculate BMI and then participants were administered the questionnaires. HCs were enrolled on a  
8 voluntary basis and did not receive monetary compensation for their participation since this practice  
9 is not allowed in our country; rather, they received the researchers' feedback on the scoring of their  
10 assessments.

11  
12 This study was approved by the local Ethical Committee, and all participants (or parents in  
13 case of patient's age < 18 years old) provided written informed consent.

### 15 **2.3 Measures**

16 All participants completed the following measures; We reversed the scores for the  
17 Multidimensional Assessment of Interoceptive Awareness (MAIA) (as also done by Brown et al.,  
18 2020) to be congruent with the EDI-2 and the FMPS so that, in all subscales, higher scores signified  
19 higher symptomatology.

20 The FMPS, Italian version (Lombardo, 2008) which evaluates perfectionism with sound  
21 psychometric properties, comprises 35 items organized into 6 subscales: Concern over Mistakes,  
22 Personal Standards, Parental Expectations, Parental Criticism, Doubts about Actions, and  
23 Organization. Personal Standards and Organization capture adaptive (as opposed to maladaptive)  
24 perfectionism. Items are rated on a 5-point Likert scale. Cronbach's alpha in our sample was .76.

25 The MAIA, Italian version (Cali et al., 2015) which evaluates interoceptive sensibility with  
26 robust psychometric properties, comprises 32 items rated with a 5-point Likert scale and 8

1 dimensions: Noticing, Not Worrying, Not Distracting, Attention Regulation, Emotional Awareness,  
2 Self-Regulation, Body Listening, and Trusting. Its psychometric properties have been evaluated in  
3 nonclinical and ED samples (Brown et al., 2017). In the reliability analysis of the study sample, the  
4 Not Distracting subscale was negatively correlated with the total test score, as was previously  
5 reported (Mehling et al., 2018) so we excluded it. In our sample, the Cronbach's alpha after  
6 subscale removal was .77.

7 The EDI-2, Italian version (Rizzardi M. et al., 1995) which evaluates eating  
8 psychopathology and has been widely used in Italian samples with sound psychometric properties,  
9 comprises 91 items and 11 subscales: Drive for Thinness (DT), Bulimia (BU), Body Dissatisfaction  
10 (BD), Ineffectiveness (IN), Perfectionism, Interpersonal Distrust, Interoceptive Awareness,  
11 Maturity Fears, Asceticism (Asc), Impulse Regulation (IR), and Social Insecurity (SI). Cronbach's  
12 alpha in our sample was .93.

13 We used the subscales from these three measures as nodes in the network in this study,  
14 comparable to that done in previous research with a similar methodology (Olatunji et al., 2018;  
15 Solmi et al., 2018).

16

## 17 **2.4 Data analysis**

18 We conducted analyses using R version 4.0.2 in R-Studio 1.3.959. See the supporting  
19 information for the code used.

20 Although general recommendations on sample size have been proposed (Epskamp et al.,  
21 2018), no power analysis is available for NAs; therefore, network stability is fundamental  
22 (Epskamp et al., 2018). Indeed, the more parameters that are estimated in the NA, the higher the  
23 number of participants is required. After node selection (explained below), we introduced 18 nodes  
24 (5 perfectionism, 6 interoceptive sensibility, 7 eating psychopathology).

25 As done in previous research (Levinson, Brosos, et al., 2018; Olatunji et al., 2019), we  
26 estimated a main network, using data from all participants. We then calculated separated networks

1 for patients and HCs and compared them via state-of-the-art techniques to check for structural or  
2 connectivity differences.

3

#### 4 **2.4.1 Data preparation**

##### 5 *Preliminary steps*

6 We examined data mean and standard deviation (SD), skewness, and kurtosis. Because the  
7 Shapiro–Wilk test revealed nonnormal distribution in many of the variables, we used  
8 nonparanormal transformation through the R-package *huge* version 1.3.4.1 as advised (Epskamp et  
9 al., 2018). We used the *t* test,  $\chi^2$  test and Fisher’s exact test to compare the groups.

10

##### 11 *Nodes selection*

12 Selection of the variables for NA is critical because the inclusion of multiple nodes assessing  
13 the same construct can result in inflated centrality (Levinson, Vanzhula, et al., 2018). Current  
14 methodology suggests the use of theory and data-driven variable selection, with a preliminary  
15 inspection of data by experienced clinicians and the subsequent use of an algorithm to detect  
16 topological overlap, which can be done through the goldbricker function contained in the package  
17 *networktools* (P. Jones, 2018). In this study, we removed the EDI-2 subscales Perfectionism and  
18 Interoceptive Awareness as unidimensional measures of the constructs assessed by FMPS and  
19 MAIA.

20 We then searched the complete database for further redundancies with goldbricker  
21 (*networktools* version 1.2.3), which was run by setting the threshold to .20 ( $p = .01$ ). We examined  
22 the suggested reductions and, if deemed clinically appropriate, automatically combined these  
23 through principal component analysis using the `net_reduce` function. We opted for this method  
24 because it allows for correct network representation, even though it could limit the interpretability  
25 of the combined nodes.

26 Goldbricker returned nine “bad pairs” (see the supporting information). The `net_reduce`

1 function produced four combinations considered appropriate by the authors. Here we provide a list  
2 of the combined nodes and briefly describe the commonalities that justified their combination from  
3 a clinical perspective (only combined node 2. and 3. are further discussed; in parenthesis is  
4 indicated how they are referred to in the discussion section).

- 5 1. MAIA Emotional Awareness & Noticing (awareness of body sensations and of physiological  
6 manifestations of emotions): both dimensions point to the awareness of the connections  
7 between body sensations and emotions;
- 8 2. FMPS Doubts about Actions & Concern over Mistakes (perfectionistic evaluative concerns):  
9 these two dimensions are long recognized to be the main components of maladaptive  
10 perfectionism;
- 11 3. EDI-2 Asceticism & Drive for Thinness (need for control over self and body): both  
12 dimensions points to the self-imposed limitations on physiological needs in order to achieve  
13 valued goals;
- 14 4. EDI-2 Impulse Regulation & Social Distrust (lack of control over self and over social  
15 relationships): these two dimensions refers to untrustworthiness in both personal and  
16 relational context.

17

## 18 **2.4.2 Network analysis**

### 19 *Network stability*

20 We used R-package *bootnet* version 1.4.3 to estimate network stability (Epskamp et al.,  
21 2018). We performed a person-dropping bootstrap to calculate the correlation stability coefficient  
22 (CS coefficient) for strength and expected influence (EI), bridge strength, bridge EI, and edges.  
23 These indices express the maximum drop proportions to retain a correlation of .7 in at least 95% of  
24 the sample and are considered acceptable if above .25 and good from .5 (Epskamp et al., 2018). We  
25 performed the nonparametric bootstrap for the difference tests for centrality measures, bridge  
26 measures, and network edges.

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## ***Network estimation, centrality, and predictability***

We estimated the regularized partial correlation networks for the entire sample. In these undirected, weighted networks, an edge between two nodes represents a conditional (i.e., given all other nodes) dependence relationship, whereas an absent edge signifies conditional independence. The strength of the correlation is visualized by the thickness of the edge. We utilized *qgraph* version 1.6.5 (Epskamp et al., 2012), which uses graphical LASSO (least absolute shrinkage and selection operator regularization) in combination with the extended Bayesian information criteria model selection, to visualize the networks. We used the Fruchterman–Reingold algorithm for node positioning to allow for easy visualization.

We utilized *centralityPlot* and *centralityTable* functions to inspect centrality measures. We calculated *strength* (the sum of the absolute values of a node connection) and *EI* (similar to strength but considering the positive or negative value of an edge), as other centrality indices have emerged to be less reliable in psychological networks (Bringmann et al., 2019). We chose to report both measures only if they provided meaningfully different information. Because differential node variability could potentially drive node centrality (Epskamp et al., 2018), we checked for correlations between centrality measures and node SD. We used the R-package *mgm* version 1.2-10 to estimate the predictability, a measure indicating how well a node is explained by all other nodes in the network (by computing each node’s  $R^2$ ; Haslbeck & Waldorp, 2018).

## ***Bridge nodes***

Elements that connect different predefined clusters (“communities,” e.g., symptoms of two separate disorders) in psychopathological networks are called *bridge nodes*, and according to the network theory, they can represent key intervention points to prevent the “spread” from one disorder to the other (P. J. Jones et al., 2019). We used the bridge function of the package *networktools* to calculate *bridge strength* (a node’s total connectivity with nodes in other



1 communities in the network) and *bridge EI* (like bridge strength, but summing positive and negative  
2 values; P. J. Jones et al., 2019).

3

#### 4 ***Separated networks estimation and comparison***

5 We used the fused graphical LASSO method to estimate separated networks for patients and  
6 HCs. We utilized the R-package *EstimateGroupNetwork* version 0.2.2 (Costantini et al., 2019) to  
7 estimate both networks simultaneously and the R-package *NetworkComparisonTest* version 2.2.1  
8 (van Borkulo et al., 2017) to compare the two networks' structure and connectivity.

9

### 1 **3. Results**

#### 2 **3.1 Participants' characteristics**

3 As shown in Table 1, patients with AN were more frequently single, lived more frequently  
4 with the family of origin, had less frequently completed university studies, and were more  
5 frequently unemployed than HCs. No gender differences emerged between the patients with AN and  
6 the HCs. The percentage of male individuals was consistent with other cited ED NA studies (Brown  
7 et al., 2020; Forrest et al., 2019; Vanzhula et al., 2021) and with data on male prevalence in EDs  
8 (Sweeting et al., 2015).

9 Patients had significantly higher scores than did the HCs in all EDI-2 subscales, in all FMPS  
10 subscales except for Parental Expectations and Organization, and in the MAIA subscales Attention  
11 Regulation, Self-Regulation, Body Listening, and Trusting.

12

#### 13 **3.2 Network structure**

14 Table 2 shows all the nodes included in the network, with their corresponding abbreviations.  
15 The network had good stability (CS coefficient for strength, EI, and edges were all .67). Correlation  
16 between EI and strength was high (.94,  $p < .001$ ); hence, only EI is shown (see Table 2 and the  
17 supporting information for strength). Correlation between nodes SD and EI was nonsignificant (.35,  
18  $p = .15$ ). Mean predictability was .53. Predictability was highest for IN (.78), as reported in the  
19 network plot (Figure 1).

20 Figure 2 shows the bootstrapped EI differences. The node with the highest EI was IN (1.2),  
21 followed by Asc&DT (1.18). These were significantly higher than 77% (Asc&DT) and 65% (IN) of  
22 the other nodes. Doubts&Concern (1.12) was significantly higher than 59% of the other nodes;  
23 IR&SD (1.08) and SI (1.07) were significantly higher than 53% of the other nodes.

24 See the supporting information for edge weight matrix and edge difference test.

25 The strongest connections in the network were between Parent\_Expect and Parent\_Critic (part  
26  $r = .49$ ) and between Standards and Doubts&Concern (part  $r = .38$ ). The strongest connections to

1 central nodes were SI (part  $r = .3$ ) for IN and BD (part  $r = .32$ ) for Asc&DT.

2

### 3 **3.3 Bridge nodes**

4 The CS coefficients for both bridge strength and bridge EI were .67, and the correlation  
5 between the two was high (.82,  $p < .001$ ). We reported only bridge EI (Table 2). Bootstrapped  
6 bridge EI differences are shown in Figure 3. The nodes with the highest bridge EI were  
7 Doubts&Concern (.53) and Trust (.52), which were significantly higher, respectively, than 88% and  
8 82% of the other nodes. Asc&DT (.33) was significantly higher than 53% of the other nodes.

9 Regarding bridge pathways, Doubts&Concern was most strongly connected to Asc&DT  
10 (part  $r = .2$ ), Self\_Regul (part  $r = .11$ ), SI (part  $r = .08$ ), Not\_Worry (part  $r = .08$ ), IN (part  $r = .07$ ),  
11 IR&SD (part  $r = .01$ ), Emot&Notice (part  $r = -.03$ ). Trust was most strongly connected to IN (part  $r$   
12  $= .18$ ), Asc&DT (part  $r = .1$ ), BD (part  $r = .1$ ), SI (part  $r = .08$ ), Parent\_Critic (part  $r = .07$ ). Asc&DT,  
13 beside the connections reported above, was connected to Standards (part  $r = .04$ ), Organized (part  $r =$   
14  $.02$ ), Emot&Notice (part  $r = -.03$ ). Bridge pathways are depicted in Supporting information.

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### 16 **3.4 Jointly-estimated patient and HC networks and NCT**

17 Patients' network was at acceptable levels of stability (CS coefficient .36), whereas that of  
18 HCs' was below the threshold (CS coefficient .21). Network invariance test ( $p = .36$ ) and global  
19 strength invariance test ( $p = .23$ ) were nonsignificant; therefore, no evidence of network differences  
20 between the two groups emerged from this analysis. Networks plots and bootstrapped difference  
21 tests of the networks estimated for the patient and HC groups are reported in the supporting  
22 information.

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## 1 **4. Discussion**

2 We performed an NA to investigate the interactions among perfectionism, interoceptive  
3 sensibility, and eating psychopathology in AN. The network calculated from patients with AN and  
4 the HCs had good stability and could be interpreted. Ineffectiveness and need for control over self  
5 and body were the most central nodes (i.e., supposedly representing the most relevant  
6 psychopathological symptoms in the network), whereas perfectionistic evaluative concerns and  
7 mistrust in body sensations were the bridge nodes (i.e., the “junctions” between groups of  
8 symptoms). The most relevant bridge pathways were between perfectionistic evaluative concerns  
9 and need for control over self and body, mistrust in body sensations and ineffectiveness,  
10 perfectionistic evaluative concerns and self-regulation, mistrust in body sensations and need for  
11 control over self and body and body dissatisfaction. These connections could represent potential  
12 ways through which the relationships among perfectionism, interoceptive sensibility, and eating  
13 symptoms are maintained. The relevance of these connections is underscored by the relatively-high  
14 predictability values. These results confirm the relevance of both perfectionism and interoceptive  
15 sensibility for AN and begin to illuminate their complex mutual relationships related to eating  
16 symptomatology—expanding the NA literature addressing core AN characteristics and  
17 symptomatology.

18

### 19 ***Central nodes***

20 Consistent with our first hypothesis, ineffectiveness resulted the most central node in the  
21 entire network, as found in previous NAs using the EDI-2 (Olatunji et al., 2018; Solmi et al., 2018).  
22 As previously proposed by other researchers (Monteleone et al., 2019; Olatunji et al., 2018; Solmi  
23 et al., 2018), our findings also highlight the importance of considering not only the main diagnostic  
24 criteria but also other psychological elements (e.g., the pervading sense of inadequacy) as central  
25 for the maintenance of AN. The concept of ineffectiveness encompasses feelings of worthlessness,  
26 insecurity, and negative self-evaluation (Garner et al., 1983; Olatunji et al., 2018) and could

1 represent the emotional and cognitive ground on which ED behaviours and cognitions are built  
2 (Fairburn et al., 2013; Zipfel et al., 2014)

3 For both ineffectiveness and the second most central node (which contained the core eating  
4 symptom of drive for thinness), the strongest connections were internal to the ED community;  
5 however, they showed significant direct connections to perfectionism and interoceptive sensibility  
6 nodes as described in the “Bridge nodes” section below. The strong connections between  
7 ineffectiveness and social insecurity and between drive for thinness and body dissatisfaction are  
8 known from previous studies (Olatunji et al., 2018; Solmi et al., 2018) and expected from clinical  
9 observation.

10 Somewhat different from previous NA studies using the Eating Disorders Examination–  
11 Questionnaire (EDE–Q; Forrest et al., 2019; Wang et al., 2018) reporting shape and weight  
12 concerns as central, in our analysis, the node body dissatisfaction did not have high centrality. This  
13 could be determined by the EDI structure and its relationships with the construct introduced in the  
14 network, as further discussed below.

15

### 16 ***Bridge nodes***

17 Our second a priori hypothesis was partially confirmed, as perfectionistic evaluative  
18 concerns (Concern over Mistakes empirically combined with Doubts about Actions) was the node  
19 most connected to the other communities. This result complements two recently-published ED  
20 networks on all FMPS subscales reporting high centrality for perfectionistic strivings (i.e., Personal  
21 Standards) in a network where the most central node was a measure related to overvigilance to  
22 avoid mistakes (Vervaet et al., 2020) and Doubts about Actions as a bridge between perfectionism  
23 and OCD (Vanzhula et al., 2021). Through the study of bridge pathways, the present analysis adds  
24 to current literature that perfectionistic evaluative concerns showed a direct connection to a node of  
25 core eating psychopathology (need for control over self and body) and only through this node to the  
26 other eating symptomatology subscales (i.e., Body Dissatisfaction and Bulimia). Personal standards

1 although strongly related to perfectionistic evaluative concerns, was only weakly linked to need for  
2 control over self and body and failed to show other relevant connections. Therefore, fear of making  
3 mistakes and doubt about one's own performance seem to link perfectionism to the need for  
4 keeping the body under strict control through externally-evaluable parameters (Duffy et al., 2019).

5 The connection between parental criticism and parental expectations was the strongest in the  
6 entire network; however, only the former showed relationships to the other nodes, suggesting that  
7 perceived negative judgments from parents seem more directly relevant to psychopathology than  
8 did their unrealistically-high expectations.

9 This is the first NA study that clearly shows the direct relationship between maladaptive  
10 perfectionism and core eating psychopathology previously highlighted in research conducted with  
11 different methodologies (Bulik et al., 2003). As described above, the added value of this analysis is  
12 the possibility to model both the connection that bridges maladaptive perfectionism to eating  
13 symptoms and the internal structure of relationships among perfectionism dimensions. Although  
14 what happens in an individual may vary, both in comparison to other individuals (i.e., cross-  
15 sectionally), and to the same person (i.e., longitudinally; Levinson, Vanzhula, et al., 2018) this  
16 study suggests that it is fearing mistakes and doubting oneself that directly "fuels" eating problems.  
17 Alternatively, or rather complementary to this, also the inverse relationship may hold true, in that  
18 eating concerns may spill over to preoccupations with self-presentation and performance in a  
19 broader context. Even though the present analysis does not allow to infer directionality, previous  
20 research highlighted perfectionism as a rather ED-specific vulnerability trait which tends to persist  
21 after acute illness (Dahlenburg et al., 2019), and predictively influences eating symptoms (Halmi et  
22 al., 2012; Wade et al., 2015) giving support to the first hypothesis both in illness development and  
23 in its maintenance.

24 Our third hypothesis, that mistrust in body sensations would have the highest bridge value  
25 overall, was partially confirmed, in that, this node did have the highest bridge value, but was not  
26 significantly different from perfectionistic evaluative concerns. In respect to the study by Brown et

1 al. (2020) investigating interoceptive sensibility and eating symptomatology with EDE–Q, this  
2 study adds the bridge pathway between this node and ineffectiveness (not contained as a node in the  
3 previous study), which is consistent with the strong connection between ineffectiveness and  
4 unidimensional Interoceptive Awareness in another recent NA (Vervaeet et al., 2020). Feeling unsafe  
5 in one’s own body seems, therefore, tightly linked to the belief of being ineffective in the world;  
6 this relationship could lead to one feeling unsafe in one’s social context (social insecurity) and to  
7 eating symptomatology. Alternatively, these insecurities could add to the belief of a general lack of  
8 control over one’s own life. Interestingly, the link between interoception and social connection has  
9 been explored in experimental studies (see Arnold et al., 2019, for a review), and flexibility in  
10 engaging interoception in social situations (i.e., shifting attention focus between internal sensations  
11 and external events) has been proposed as crucial to overcome feelings of social isolation.

12         The overarching aim of our study was to model the mutual relationships between  
13 interoceptive sensibility and perfectionism on eating symptoms. In this regard, a bridge pathway  
14 emerged between perfectionistic evaluative concerns and the interoceptive node self-regulation,  
15 which can suggest that perfectionistic evaluative concerns could be related to being unable to use  
16 body sensations to ease distressing thoughts. The strong connection between perfectionistic  
17 evaluative concerns and need for control over self and body suggests that maintaining one’s own  
18 self-presentation and performance in subjectively-acceptable ranges could be linked, bypassing  
19 interoception, thus, making use of external cues and rules (Barca & Pezzulo, 2020). Maladaptive  
20 perfectionism, applied to body parameters, could indeed contribute to determine the general attitude  
21 through which AN patients integrate their body perceptions. Given the goal of maintaining body  
22 parameters in controlled ranges, body sensations, being too vague for the scope, would not  
23 represent a reliable source of information to direct one's actions (and more so in moments of  
24 distress). On a similar line, restriction in food intake might represent a way to reduce and manage  
25 the otherwise confused and unpredictable body sensations (Barca & Pezzulo, 2020). Further studies  
26 are needed to clarify the interactions between these two highly relevant features.

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***Strengths and limitations***

This study has several strengths, such as the use of state-of-the-art methodology and sharing code. We selected nodes in the network using an empirically-validated algorithm and controlled for the differential variability as a potential drive to centrality. Our analysis included predictability highlighting the relevance of the reported connections, and the network was stable. To our knowledge, this is the first NA study to include multidimensional assessments of both perfectionism and interoceptive sensibility.

Limitations include that the cross-sectional nature of the analysis does not allow for the inference of the directionality of the associations, and correlations that emerge at a group level may not reflect the individual level. Even though we controlled for potential overlaps in the variables, the measures introduced were not specifically designed for NAs. Furthermore, all variables were self-reported, so the inclusion of objective measures could help enrich the picture. We did not find significant network differences between the patients and HCs; however, it may be possible that some would emerge with a larger sample size. Nonetheless, the inclusion of a population without ED allows to reflect dynamics that might be common to both affected and healthy individuals and contribute to illness maintenance and development.

Finally, the empirical combination of asceticism and drive for thinness did not allow us to infer the relative strength of the direct connection of perfectionistic evaluative concerns and drive for thinness.

***Conclusions and clinical implications***

This study provided specific links to key features of AN psychopathology (drive for thinness and ineffectiveness) for perfectionistic evaluative concerns and mistrust in body sensations. The clinical implications of NAs are still a matter of debate (Robinaugh et al., 2020). However, we raise the hypothesis that the psychological therapies recommended for AN could intervene on the nodes



1 that emerge as important in the network. Enhanced Cognitive–Behavior Therapy and therapies  
2 designed for perfectionism could act primarily on the cognitions connected to core ED  
3 symptomatology (Fairburn et al., 2013), whereas therapies focusing on feelings of inadequacy in  
4 social interactions—as psychodynamic treatment (Zipfel et al., 2014) and interpersonal treatment  
5 (Miniati et al., 2018)—could work on the key node of ineffectiveness. In addition, a new model on  
6 interoceptive exposure (Boswell et al., 2019) that specifically targets interoception deserves further  
7 investigation.

8           Moreover, the connections highlighted in the network are relevant also in the light of the  
9 sample comprising both patients with AN and healthy individuals, since perfectionism and  
10 interoceptive traits could be distributed continuously in the population and their extreme concurrent  
11 alterations could make it difficult to overcome eating and weight problems, even in the absence of a  
12 full-fledged diagnosis (Vacca et al., 2020). Even though identifying ED risk factors and the  
13 interplay between them is beyond the scope of the present exploratory analysis, this and other  
14 studies hint at the co-occurrence of high maladaptive perfectionism and mistrust in body sensations  
15 as particularly relevant for the maintenance of AN symptomatology, and potentially for its  
16 development (Duffy et al., 2019). It is worthy of further studies the idea that, rather than just  
17 screening for abnormal eating behaviors and concerns, investigating for the presence of high  
18 concerns for mistakes, self-doubts and mistrust in body sensations could benefit the prevention and  
19 early detection of AN in community and clinical settings.

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## 1 **References**

- 2 Abbate-Daga, G., Quaranta, M., Marzola, E., Amianto, F., & Fassino, S. (2015). The relationship between  
3 alexithymia and intolerance of uncertainty in anorexia nervosa. *Psychopathology*, *48*(3), 202–208.  
4 <https://doi.org/10.1159/000381587>
- 5 Arnold, A. J., Winkielman, P., & Dobkins, K. (2019). Interoception and Social Connection. In *Frontiers in*  
6 *Psychology* (Vol. 10). Frontiers Media S.A. <https://doi.org/10.3389/fpsyg.2019.02589>
- 7 Barca, L., & Pezzulo, G. (2020). Keep your interoceptive streams under control: An active inference  
8 perspective on anorexia nervosa. *Cognitive, Affective and Behavioral Neuroscience*, *20*(2), 427–440.  
9 <https://doi.org/10.3758/s13415-020-00777-6>
- 10 Boswell, J. F., Anderson, L. M., Oswald, J. M., Reilly, E. E., Gorrell, S., & Anderson, D. A. (2019). A  
11 preliminary naturalistic clinical case series study of the feasibility and impact of interoceptive exposure  
12 for eating disorders. *Behaviour Research and Therapy*, *117*, 54–64.  
13 <https://doi.org/10.1016/j.brat.2019.02.004>
- 14 Bringmann, L. F., Elmer, T., Epskamp, S., Krause, R. W., Schoch, D., Wichers, M., Wigman, J. T. W., &  
15 Snippe, E. (2019). What Do Centrality Measures Measure in Psychological Networks? *Journal of*  
16 *Abnormal Psychology*. <https://doi.org/10.1037/abn0000446>
- 17 Brown, T. A., Berner, L. A., Jones, M. D., Reilly, E. E., Cusack, A., Anderson, L. K., Kaye, W. H., &  
18 Wierenga, C. E. (2017). Psychometric Evaluation and Norms for the Multidimensional Assessment of  
19 Interoceptive Awareness (MAIA) in a Clinical Eating Disorders Sample. *European Eating Disorders*  
20 *Review*, *25*(5), 411–416. <https://doi.org/10.1002/erv.2532>
- 21 Brown, T. A., Vanzhula, I. A., Reilly, E. E., Levinson, C. A., Berner, L. A., Krueger, A., Lavender, J. M.,  
22 Kaye, W. H., & Wierenga, C. E. (2020). Body mistrust bridges interoceptive awareness and eating  
23 disorder symptoms. *Journal of Abnormal Psychology*, *129*(5), 445–456.  
24 <https://doi.org/10.1037/abn0000516>
- 25 Bruch, H. (1962). Perceptual and conceptual disturbances in anorexia nervosa. *Psychosomatic Medicine*, *24*,  
26 187–194. <https://doi.org/10.1097/00006842-196203000-00009>
- 27 Bulik, C. M., Tozzi, F., Anderson, C., Mazzeo, S. E., Aggen, S., & Sullivan, P. F. (2003). The relation  
28 between eating disorders and components of perfectionism. *American Journal of Psychiatry*, *160*(2),  
29 366–368. <https://doi.org/10.1176/appi.ajp.160.2.366>
- 30 Calì, G., Ambrosini, E., Picconi, L., Mehling, W. E., & Committeri, G. (2015). Investigating the relationship  
31 between interoceptive accuracy, interoceptive awareness, and emotional susceptibility. *Frontiers in*  
32 *Psychology*, *6*. <https://doi.org/10.3389/fpsyg.2015.01202>
- 33 Cascino, G., Castellini, G., Stanghellini, G., Ricca, V., Cassioli, E., Ruzzi, V., Monteleone, P., &  
34 Monteleone, A. M. (2019). The role of the embodiment disturbance in the anorexia nervosa  
35 psychopathology: A network analysis study. *Brain Sciences*, *9*(10).  
36 <https://doi.org/10.3390/brainsci9100276>
- 37 Christian, C., Williams, B. M., Hunt, R. A., Wong, V. Z., Ernst, S. E., Spoor, S. P., Vanzhula, I. A.,  
38 Tregarthen, J. P., Forbush, K. T., & Levinson, C. A. (2019). A network investigation of core symptoms  
39 and pathways across duration of illness using a comprehensive cognitive-behavioral model of eating-  
40 disorder symptoms. *Psychological Medicine*. <https://doi.org/10.1017/S0033291719003817>
- 41 Costantini, G., Richetin, J., Preti, E., Casini, E., Epskamp, S., & Perugini, M. (2019). Stability and variability  
42 of personality networks. A tutorial on recent developments in network psychometrics. *Personality and*  
43 *Individual Differences*, *136*, 68–78. <https://doi.org/10.1016/j.paid.2017.06.011>

- 1 Dahlenburg, S. C., Gleaves, D. H., Hutchinson, A. D., & Sophie Dahlenburg, C. C. (2019). *Anorexia nervosa*  
2 *and perfectionism: A meta-analysis*. <https://doi.org/10.1002/eat.23009>
- 3 DuBois, R. H., Rodgers, R. F., Franko, D. L., Eddy, K. T., & Thomas, J. J. (2017). A network analysis  
4 investigation of the cognitive-behavioral theory of eating disorders. *Behaviour Research and Therapy*,  
5 97, 213–221. <https://doi.org/10.1016/j.brat.2017.08.004>
- 6 Duffy, M. E., Rogers, M. L., Joiner, T. E., Bergen, A. W., Berrettini, W., Bulik, C. M., Brandt, H., Crawford,  
7 S., Crow, S., Fichter, M., Halmi, K., Kaplan, A. S., Klump, K. L., Lilenfeld, L., Magistretti, P. J.,  
8 Mitchell, J., Schork, N. J., Strober, M., Thornton, L. M., ... Keel, P. K. (2019). An investigation of  
9 indirect effects of personality features on anorexia nervosa severity through interoceptive dysfunction  
10 in individuals with lifetime anorexia nervosa diagnoses. *International Journal of Eating Disorders*,  
11 52(2), 200–205. <https://doi.org/10.1002/eat.23008>
- 12 Epskamp, S., Borsboom, D., & Fried, E. I. (2018). Estimating psychological networks and their accuracy: A  
13 tutorial paper. *Behavior Research Methods*, 50(1), 195–212. [https://doi.org/10.3758/s13428-017-0862-](https://doi.org/10.3758/s13428-017-0862-1)  
14 1
- 15 Epskamp, S., Cramer, A. O. J., Waldorp, L. J., Schmittmann, V. D., & Borsboom, D. (2012). Qgraph:  
16 Network visualizations of relationships in psychometric data. *Journal of Statistical Software*, 48(1), 1–  
17 18. <https://doi.org/10.18637/jss.v048.i04>
- 18 Fairburn, C. G., Cooper, Z., Doll, H. A., O'Connor, M. E., Palmer, R. L., & Dalle Grave, R. (2013).  
19 Enhanced cognitive behaviour therapy for adults with anorexia nervosa: A UK-Italy study. *Behaviour*  
20 *Research and Therapy*, 51(1). <https://doi.org/10.1016/j.brat.2012.09.010>
- 21 Fairburn, C. G., Cooper, Z., & Shafran, R. (2003). Cognitive behaviour therapy for eating disorders: A  
22 “transdiagnostic” theory and treatment. In *Behaviour Research and Therapy*.  
23 [https://doi.org/10.1016/S0005-7967\(02\)00088-8](https://doi.org/10.1016/S0005-7967(02)00088-8)
- 24 Fassino, S., Pierò, A., Gramaglia, C., & Abbate-Daga, G. (2004). Clinical, psychopathological and  
25 personality correlates of interoceptive awareness in anorexia nervosa, bulimia nervosa and obesity.  
26 *Psychopathology*, 37(4), 168–174. <https://doi.org/10.1159/000079420>
- 27 First, M., Williams, J., Karg, R., & Spitzer, R. (2016). *User's guide for the SCID-5-CV Structured Clinical*  
28 *Interview for DSM-5® disorders: Clinical version*. <https://psycnet.apa.org/record/2016-15667-000>
- 29 Forrest, L. N., Jones, P. J., Ortiz, S. N., & Smith, A. R. (2018). Core psychopathology in anorexia nervosa  
30 and bulimia nervosa: A network analysis. *International Journal of Eating Disorders*, 51(7), 668–679.  
31 <https://doi.org/10.1002/eat.22871>
- 32 Forrest, L. N., Sarfan, L. D., Ortiz, S. N., Brown, T. A., & Smith, A. R. (2019). Bridging eating disorder  
33 symptoms and trait anxiety in patients with eating disorders: A network approach. *International*  
34 *Journal of Eating Disorders*, 52(6), 701–711. <https://doi.org/10.1002/eat.23070>
- 35 Fried, E. I., & Cramer, A. O. J. (2017). Moving Forward: Challenges and Directions for Psychopathological  
36 Network Theory and Methodology. *Perspectives on Psychological Science*, 12(6), 999–1020.  
37 <https://doi.org/10.1177/1745691617705892>
- 38 Frost, R. O., & Marten, P. A. (1990). Perfectionism and evaluative threat. *Cognitive Therapy and Research*,  
39 14(6), 559–572. <https://doi.org/10.1007/BF01173364>
- 40 Frost, R. O., Marten, P., Lahart, C., & Rosenblate, R. (1990). The dimensions of perfectionism. *Cognitive*  
41 *Therapy and Research*, 14(5), 449–468. <https://doi.org/10.1007/BF01172967>

- 1 Garner, D. M., Olmstead, M. P., & Polivy, J. (1983). Development and validation of a multidimensional  
2 eating disorder inventory for anorexia nervosa and bulimia. *International Journal of Eating Disorders*,  
3 2(2), 15–34. [https://doi.org/10.1002/1098-108X\(198321\)2:2<15::AID-EAT2260020203>3.0.CO;2-6](https://doi.org/10.1002/1098-108X(198321)2:2<15::AID-EAT2260020203>3.0.CO;2-6)
- 4 Gárriz, M., Andrés-Perpiñá, S., Plana, M. T., Flamarique, I., Romero, S., Julià, L., & Castro-Fornieles, J.  
5 (2020). Personality disorder traits, obsessive ideation and perfectionism 20 years after adolescent-onset  
6 anorexia nervosa: a recovered study. *Eating and Weight Disorders*. [https://doi.org/10.1007/s40519-](https://doi.org/10.1007/s40519-020-00906-7)  
7 020-00906-7
- 8 Halmi, K. A., Bellace, D., Berthod, S., Ghosh, S., Berrettini, W., Brandt, H. A., Bulik, C. M., Crawford, S.,  
9 Fichter, M. M., Johnson, C. L., Kaplan, A., Kaye, W. H., Thornton, L., Treasure, J., Woodside, D. B.,  
10 & Strober, M. (2012). An examination of early childhood perfectionism across anorexia nervosa  
11 subtypes. *International Journal of Eating Disorders*, 45(6), 800–807.  
12 <https://doi.org/10.1002/EAT.22019>
- 13 Haslbeck, J. M. B., & Waldorp, L. J. (2018). How well do network models predict observations? On the  
14 importance of predictability in network models. *Behavior Research Methods*, 50(2), 853–861.  
15 <https://doi.org/10.3758/s13428-017-0910-x>
- 16 Hewitt, P. L., & Flett, G. L. (1991). Perfectionism in the Self and Social Contexts: Conceptualization,  
17 Assessment, and Association With Psychopathology. *Journal of Personality and Social Psychology*,  
18 60(3), 456–470. <https://doi.org/10.1037/0022-3514.60.3.456>
- 19 Jenkinson, P. M., Taylor, L., & Laws, K. R. (2018). Self-reported interoceptive deficits in eating disorders: A  
20 meta-analysis of studies using the eating disorder inventory. In *Journal of Psychosomatic Research*  
21 (Vol. 110, pp. 38–45). Elsevier Inc. <https://doi.org/10.1016/j.jpsychores.2018.04.005>
- 22 Jones, P. (2018). *Tools for Identifying Important Nodes in Networks [R package networktools version 1.2.3]*.  
23 Comprehensive R Archive Network (CRAN). <https://CRAN.R-project.org/package=networktools>
- 24 Jones, P. J., Ma, R., & McNally, R. J. (2019). *Bridge Centrality: A Network Approach to Understanding*  
25 *Comorbidity*. <https://doi.org/10.1080/00273171.2019.1614898>
- 26 Kaye, W. H., Fudge, J. L., & Paulus, M. (2009). New insights into symptoms and neurocircuit function of  
27 anorexia nervosa. In *Nature Reviews Neuroscience* (Vol. 10, Issue 8, pp. 573–584). Nat Rev Neurosci.  
28 <https://doi.org/10.1038/nrn2682>
- 29 Khalsa, S. S., Adolphs, R., Cameron, O. G., Critchley, H. D., Davenport, P. W., Feinstein, J. S., Feusner, J.  
30 D., Garfinkel, S. N., Lane, R. D., Mehling, W. E., Meuret, A. E., Nemeroff, C. B., Oppenheimer, S.,  
31 Petzschner, F. H., Pollatos, O., Rhudy, J. L., Schramm, L. P., Simmons, W. K., Stein, M. B., ... Zucker,  
32 N. (2018). Interoception and Mental Health: A Roadmap. In *Biological Psychiatry: Cognitive*  
33 *Neuroscience and Neuroimaging* (Vol. 3, Issue 6, pp. 501–513). Elsevier Inc.  
34 <https://doi.org/10.1016/j.bpsc.2017.12.004>
- 35 Levinson, C. A., Brosf, L. C., Vanzhula, I., Christian, C., Jones, P., Rodebaugh, T. L., Langer, J. K., White,  
36 E. K., Warren, C., Weeks, J. W., Menatti, A., Lim, M. H., & Fernandez, K. C. (2018). Social anxiety  
37 and eating disorder comorbidity and underlying vulnerabilities: Using network analysis to  
38 conceptualize comorbidity. *International Journal of Eating Disorders*, 51(7), 693–709.  
39 <https://doi.org/10.1002/eat.22890>
- 40 Levinson, C. A., Vanzhula, I. A., Brosf, L. C., & Forbush, K. (2018). Network Analysis as an Alternative  
41 Approach to Conceptualizing Eating Disorders: Implications for Research and Treatment. In *Current*  
42 *Psychiatry Reports* (Vol. 20, Issue 9, pp. 1–15). Current Medicine Group LLC 1.  
43 <https://doi.org/10.1007/s11920-018-0930-y>

- 1 Levinson, C. A., & Williams, B. M. (2020). Eating disorder fear networks: Identification of central eating  
2 disorder fears. *International Journal of Eating Disorders*, eat.23382. <https://doi.org/10.1002/eat.23382>
- 3 Levinson, C. A., Zerwas, S., Calebs, B., Forbush, K., Kordy, H., Watson, H., Hofmeier, S., Levine, M.,  
4 Crosby, R. D., Peat, C., Runfola, C. D., Zimmer, B., Moesner, M., Marcus, M. D., & Bulik, C. M.  
5 (2017). The core symptoms of bulimia nervosa, anxiety, and depression: A network analysis. *Journal of*  
6 *Abnormal Psychology*, 126(3), 340–354. <https://doi.org/10.1037/abn0000254>
- 7 Limburg, K., Watson, H. J., Hagger, M. S., & Egan, S. J. (2017). The Relationship Between Perfectionism  
8 and Psychopathology: A Meta-Analysis. In *Journal of Clinical Psychology* (Vol. 73, Issue 10, pp.  
9 1301–1326). John Wiley and Sons Inc. <https://doi.org/10.1002/jclp.22435>
- 10 Lombardo, C. (2008). Adattamento italiano della Multidimensional Perfectionism Scale (MPS) Summary  
11 Italian adaptation of the Multidimensional Perfectionism Scale (MPS). In *Edizioni Erickson-Trento*  
12 *Psicoterapia Cognitiva e Comportamentale* (Vol. 14, Issue •).
- 13 Mehling, W. E., Acree, M., Stewart, A., Silas, J., & Jones, A. (2018). The multidimensional assessment of  
14 interoceptive awareness, version 2 (MAIA-2). *PLoS ONE*, 13(12).  
15 <https://doi.org/10.1371/journal.pone.0208034>
- 16 Merwin, R. M., Zucker, N. L., Lacy, J. L., & Elliott, C. A. (2010). Interoceptive awareness in eating  
17 disorders: Distinguishing lack of clarity from non-acceptance of internal experience. *Cognition and*  
18 *Emotion*, 24(5), 892–902. <https://doi.org/10.1080/02699930902985845>
- 19 Miniati, M., Callari, A., Maglio, A., & Calugi, S. (2018). Interpersonal psychotherapy for eating disorders:  
20 Current perspectives. In *Psychology Research and Behavior Management* (Vol. 11, pp. 353–369).  
21 Dove Medical Press Ltd. <https://doi.org/10.2147/PRBM.S120584>
- 22 Monteleone, A. M., Cascino, G., Pellegrino, F., Ruzzi, V., Patriciello, G., Marone, L., de Felice, G.,  
23 Monteleone, P., & Maj, M. (2019). The association between childhood maltreatment and eating  
24 disorder psychopathology: A mixed-model investigation. *European Psychiatry*, 61, 111–118.  
25 <https://doi.org/10.1016/j.eurpsy.2019.08.002>
- 26 Olatunji, B. O., Christian, C., Brosnoff, L., Tolin, D. F., & Levinson, C. A. (2019). What is at the core of  
27 OCD? A network analysis of selected obsessive-compulsive symptoms and beliefs. *Journal of Affective*  
28 *Disorders*, 257, 45–54. <https://doi.org/10.1016/j.jad.2019.06.064>
- 29 Olatunji, B. O., Levinson, C., & Calebs, B. (2018). A network analysis of eating disorder symptoms and  
30 characteristics in an inpatient sample. *Psychiatry Research*, 262, 270–281.  
31 <https://doi.org/10.1016/j.psychres.2018.02.027>
- 32 Paulus, M. P., Feinstein, J. S., & Khalsa, S. S. (2019). An Active Inference Approach to Interoceptive  
33 Psychopathology. In *Annual Review of Clinical Psychology* (Vol. 15, pp. 97–122). Annual Reviews  
34 Inc. <https://doi.org/10.1146/annurev-clinpsy-050718-095617>
- 35 Rizzardi M., Trombini E., & Trombini G. (1995). *Manuale EDI-2*. O.S. Organizzazioni Speciali.
- 36 Robinaugh, D. J., Hoekstra, R. H. A., Toner, E. R., & Borsboom, D. (2020). The network approach to  
37 psychopathology: A review of the literature 2008-2018 and an agenda for future research. In  
38 *Psychological Medicine* (Vol. 50, Issue 3, pp. 353–366). Cambridge University Press.  
39 <https://doi.org/10.1017/S0033291719003404>
- 40 Shafran, R., Cooper, Z., & Fairburn, C. G. (2010). *Overcoming Perfectionism: A Self-Help Guide Using*  
41 *Cognitive-Behavioral Techniques*. Constable & Robinson.

- 1 Shafran, Roz, Cooper, Z., & Fairburn, C. G. (2002). Clinical perfectionism: A cognitive-behavioural  
2 analysis. *Behaviour Research and Therapy*, 40(7), 773–791. [https://doi.org/10.1016/S0005-](https://doi.org/10.1016/S0005-7967(01)00059-6)  
3 7967(01)00059-6
- 4 Smith, A. R., Forrest, L. N., Duffy, M. E., Jones, P. J., Joiner, T. E., & Pisetsky, E. M. (2020). Identifying  
5 Bridge Pathways Between Eating Disorder Symptoms and Suicidal Ideation Across Three Samples.  
6 *Journal of Abnormal Psychology*. <https://doi.org/10.1037/abn0000553>
- 7 Solmi, M., Collantoni, E., Meneguzzo, P., Degortes, D., Tenconi, E., & Favaro, A. (2018). Network analysis  
8 of specific psychopathology and psychiatric symptoms in patients with eating disorders. *International*  
9 *Journal of Eating Disorders*, 51(7), 680–692. <https://doi.org/10.1002/eat.22884>
- 10 Sweeting, H., Walker, L., MacLean, A., Patterson, C., Räisänen, U., & Hunt, K. (2015). Prevalence of eating  
11 disorders in males: a review of rates reported in academic research and UK mass media. *International*  
12 *Journal of Men's Health*, 14(2), 86–112. <https://doi.org/10.3149/JMH.1402.86>
- 13 Vacca, M., Ballesio, A., & Lombardo, C. (2020). The relationship between perfectionism and eating-related  
14 symptoms in adolescents: A systematic review. *European Eating Disorders Review*, February, 1–20.  
15 <https://doi.org/10.1002/erv.2793>
- 16 van Borkulo, C., Boschloo, L., Kossakowski, J., & Tio, P. (2017). *Comparing network structures on three*  
17 *aspects: A permutation test*. <https://doi.org/10.13140/RG.2.2.29455.38569>
- 18 Vanzhula, I. A., Calebs, B., Fewell, L., & Levinson, C. A. (2019). Illness pathways between eating disorder  
19 and post-traumatic stress disorder symptoms: Understanding comorbidity with network analysis.  
20 *European Eating Disorders Review*, 27(2), 147–160. <https://doi.org/10.1002/erv.2634>
- 21 Vanzhula, I. A., Kinkel-Ram, S. S., & Levinson, C. A. (2021). Perfectionism and Difficulty Controlling  
22 Thoughts Bridge Eating Disorder and Obsessive-Compulsive Disorder Symptoms: A Network  
23 Analysis. *Journal of Affective Disorders*, 283(February), 302–309.  
24 <https://doi.org/10.1016/j.jad.2021.01.083>
- 25 Vervaet, M., Puttevils, L., Hoekstra, R. H. A., Fried, E., & Vanderhasselt, M. (2020). Transdiagnostic  
26 vulnerability factors in eating disorders: A network analysis. *European Eating Disorders Review*,  
27 February. <https://doi.org/10.1002/erv.2805>
- 28 Wade, T. D., Wilksch, S. M., Paxton, S. J., Byrne, S. M., & Austin, S. B. (2015). How perfectionism and  
29 ineffectiveness influence growth of eating disorder risk in young adolescent girls. *Behaviour Research*  
30 *and Therapy*, 66, 56–63. <https://doi.org/10.1016/j.brat.2015.01.007>
- 31 Wang, S. B., Jones, P. J., Dreier, M., Elliott, H., & Grilo, C. M. (2018). *Core psychopathology of treatment-*  
32 *seeking patients with binge-eating disorder: a network analysis investigation*.  
33 <https://doi.org/10.1017/S0033291718002702>
- 34 Zipfel, S., Wild, B., Grob, G., Friederich, H. C., Teufel, M., Schellberg, D., Giel, K. E., de Zwaan, M.,  
35 Dinkel, A., Herpertz, S., Burgmer, M., Löwe, B., Tagay, S., Wietersheim, J. von, Zeeck, A., Schade-  
36 Brittinger, C., Schauenburg, H., & Herzog, W. (2014). Focal psychodynamic therapy, cognitive  
37 behaviour therapy, and optimised treatment as usual in outpatients with anorexia nervosa (ANTOP  
38 study): Randomised controlled trial. *The Lancet*, 383(9912), 127–137. [https://doi.org/10.1016/S0140-](https://doi.org/10.1016/S0140-6736(13)61746-8)  
39 6736(13)61746-8

**Table 1. Clinical characteristics of the sample**

<b>Variable</b>	<b>Total sample (n=260) mean (SD)</b>	<b>AN (n=139) mean (SD)</b>	<b>HC (n=121) mean (SD)</b>	<b>T test† or <math>\chi^2</math></b>	<b>p</b>
<b>Age, years</b>	24.15 ( 5.95 )	22.89 ( 6.98 )	25.61 ( 4.05 )	-3.910	< .001
<b>Females, percentage</b>	93.46%	94.96%	91.74%	-	.324‡
<b>BMI</b>	17.48 ( 3.84 )	14.64 ( 2.23 )	20.74 ( 2.45 )	-20.864	< .001
<b>Duration of illness, years</b>	-	5.20 (6.06)	-	-	-
<b>Marital status</b>				14.368	0.002
single	172	111	61		
relationship	46	19	27		
married	12	3	9		
separated or divorced	1	1	0		
missing	29	5	24		
<b>Living arrangement</b>				35.662	< .001
independent	64	18	46		
living with parents	150	108	42		
other	16	9	7		
missing	30	4	26		
<b>Education level</b>				70.840	< .001
primary school	32	26	6		
high school	80	70	10		
university	119	37	82		
missing	29	6	23		

<b>Employment</b>				20.124	< .001
student	144	81	63		
employed	61	28	33		
unemployed	27	26	1		
missing	28	4	24		
<b>MAIA Noticing §</b>	1.99 ( 1.07 )	1.98 ( 1.04 )	1.99 ( 1.1 )	-.052	.959
<b>MAIA Not Distracting§</b>	2.67 ( .92 )	2.53 ( 1.03 )	2.82 ( .75 )	-2.567	.011
<b>MAIA Not Worrying§</b>	2.54 ( 1.17 )	2.75 ( 1.23 )	2.3 ( 1.06 )	3.170	.002
<b>MAIA Attention Regulation§</b>	2.25 ( 1.05 )	2.51 ( 1.1 )	1.94 ( .92 )	4.599	< .001
<b>MAIA Emotional Awareness §</b>	1.81 ( 1.04 )	1.83 ( 1.09 )	1.79 ( 1 )	.318	.751
<b>MAIA Self-Regulation§</b>	2.94 ( 1.19 )	3.26 ( 1.19 )	2.58 ( 1.08 )	4.764	< .001
<b>MAIA Body Listening§</b>	2.79 ( 1.26 )	3.09 ( 1.26 )	2.45 ( 1.16 )	4.286	< .001
<b>MAIA Trusting §</b>	2.52 ( 1.56 )	3.4 ( 1.39 )	1.51 ( 1.03 )	12.518	< .001
<b>FMPS Concern over Mistakes</b>	26.39 ( 10.58 )	30.53 ( 9.96 )	21.63 ( 9.2 )	7.490	< .001
<b>FMPS Personal Standards</b>	23.02 ( 7.24 )	24.74 ( 6.92 )	21.03 ( 7.13 )	4.242	< .001
<b>FMPS Parental Expectations</b>	10.64 ( 5.25 )	10.46 ( 5.37 )	10.85 ( 5.12 )	-.600	.549



<b>FMPS Parental Criticism</b>	8.47 ( 3.98 )	9.59 ( 4.14 )	7.18 ( 3.37 )	5.166	< .001
<b>FMPS Doubts About Actions</b>	11.43 ( 4.24 )	12.97 ( 4.11 )	9.65 ( 3.67 )	6.882	< .001
<b>FMPS Organization</b>	22.83 ( 5.2 )	23.38 ( 5.48 )	22.2 ( 4.81 )	1.855	.065
<b>EDI-2 Drive For Thinness</b>	8.04 ( 8.25 )	13.19 ( 7.48 )	2.12 ( 4.06 )	15.088	< .001
<b>EDI-2 Bulimia</b>	2.32 ( 4.21 )	3.6 ( 5.23 )	0.85 ( 1.63 )	5.866	< .001
<b>EDI-2 Body Dissatisfaction</b>	11.03 ( 8.04 )	15.04 ( 7.02 )	6.42 ( 6.55 )	10.243	< .001
<b>EDI-2 Ineffectiveness</b>	8.27 ( 8.31 )	12.78 ( 8.2 )	3.09 ( 4.59 )	11.945	< .001
<b>EDI-2 Perfectionism</b>	5.07 ( 4.22 )	5.94 ( 4.22 )	4.08 ( 4.03 )	3.620	< .001
<b>EDI-2 Social Distrust</b>	5.13 ( 4.9 )	7.33 ( 4.72 )	2.61 ( 3.76 )	8.967	< .001
<b>EDI-2 Interoceptive Awareness</b>	7.19 ( 7.89 )	11.75 ( 7.88 )	1.99 ( 3.44 )	13.186	< .001
<b>EDI-2 Maturity Fears</b>	6.61 ( 5.9 )	9 ( 6.05 )	3.87 ( 4.32 )	7.936	< .001
<b>EDI-2 Asceticism</b>	5.78 ( 4.91 )	8.13 ( 5.01 )	3.08 ( 3.09 )	9.914	< .001
<b>EDI-2 Impulse Regulation</b>	4.51 ( 5.72 )	6.56 ( 6.26 )	2.15 ( 3.86 )	6.927	< .001
<b>EDI-2 Social Insecurity</b>	6.75 ( 5.25 )	9.32 ( 4.66 )	3.8 ( 4.26 )	9.964	< .001

†Welch test

‡Fisher's exact test

§Values reversed (see Method section)

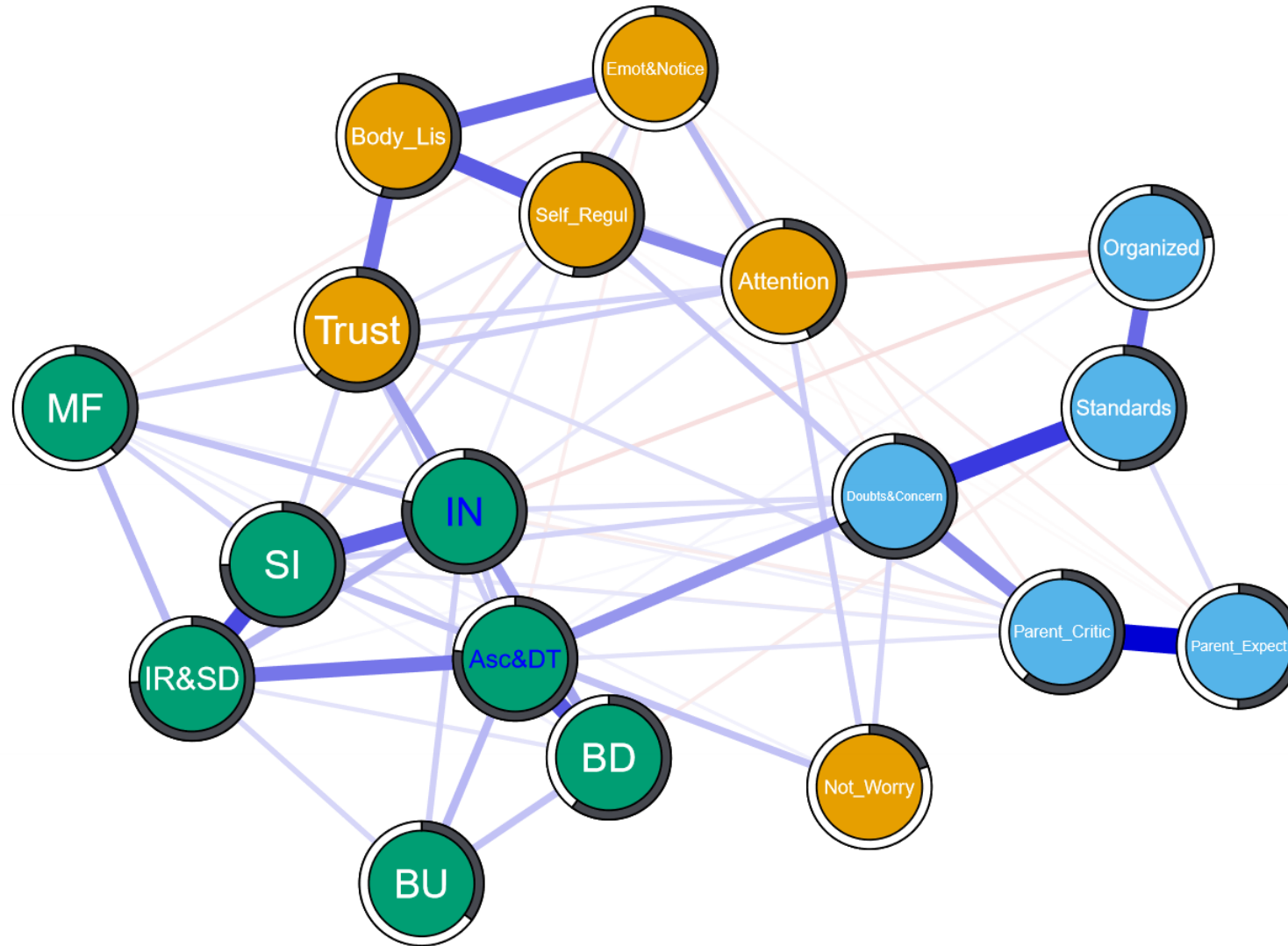
Legend: BMI: Body mass Index; MAIA: Multidimensional Assessment of Interoceptive Awareness; FMPS: Frost Multidimensional Perfectionism Scale; EDI-2: Eating Disorder Inventory-2

**Table 2. Expected influence, bridge expected influence, predictability**

<b>Node name</b>	<b>Abbreviation</b>	<b>Expected influence</b>	<b>Bridge expected Influence</b>	<b>Predictability</b>
<b>not worrying</b>	Not_Worry	.32	.22	.2
<b>attention regulation</b>	Attention	.64	.01	.44
<b>self -regulation</b>	Self_Regul	.89	.22	.54
<b>body listening</b>	Body_Lis	.97	-.01	.55
<b>mistrust in body sensations</b>	Trust	.94	.52	.62
<b>personal standards</b>	Standards	.73	-.01	.51
<b>parental expectations</b>	Parent_Expect	.44	-.12	.5
<b>parental criticism</b>	Parent_Critic	.9	.19	.61
<b>organization</b>	Organized	.15	-.14	.22
<b>bulimia</b>	BU	.38	-.04	.38
<b>body dissatisfaction</b>	BD	.79	.1	.6
<b>ineffectiveness</b>	IN	1.2	.27	.78
<b>maturity fears</b>	MF	.48	.11	.38

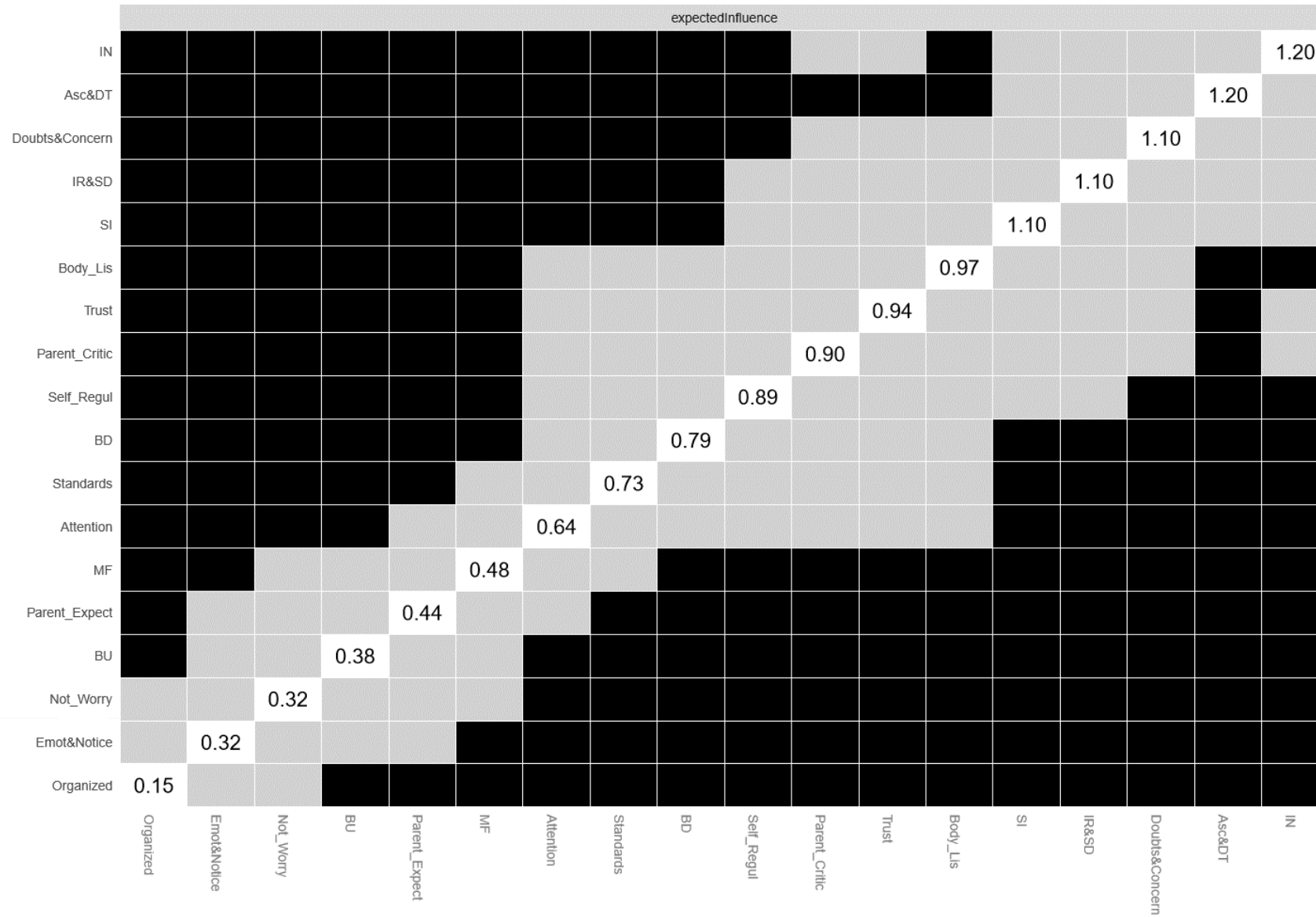
<b>social insecurity</b>	SI	1.07	.32	.75
<b>awareness of body sensations and of physiological manifestations of emotions</b>	Emot&Notice	.32	-.19	.35
<b>need for control over self and body</b>	Asc&DT	1.18	.33	.77
<b>lack of control over self and over social relationships</b>	IR&SD	1.08	.07	.74
<b>perfectionistic evaluative concerns</b>	Doubts&Concern	1.12	.53	.67

**Figure 1. Network plot**



Nodes are represented as circles, color-coded for each community (MAIA: Multidimensional Assessment of Interoceptive Sensibility, FMPS: Frost Multidimensional Perfectionism Scale, EDI-2: Eating Disorders Inventory-2). Blue lines between nodes represent positive association, red lines negative association; thicker lines correspond to stronger associations. Predictability is represented as the shaded area around the circles (higher predictability corresponds to a greater shaded area). Nodes with the highest expected influence values are indicated by the blue label. Not\_Worry: Not Worrying; Attention: Attention Regulation; Self\_Reg: Self-Regulation; Body\_Lis: Body Listening; Trust: Trusting; Standards: Personal Standards; Parent\_Expect: Parental Expectations; Parent\_Critic: Parental Criticism; Organized: Organization; BU: Bulimia; BD: Body Dissatisfaction; IN: Ineffectiveness; MF: Maturity Fears; SI: Social Insecurity; Emot&Notice: Emotional Awareness & Noticing; Asc&DT: Asceticism & Drive for Thinness; IR&SD: Impulse Regulation & Social Distrust; Doubts&Concern: Concern over Mistakes & Doubts about Actions.

**Figure 2. Bootstrapped difference test results for expected influence**



Variables are presented in descending order of expected influence values. Black squares represent statistically significant differences. Not\_Worry:  
Not Worrying; Attention: Attention Regulation; Self\_Reg: Self-Regulation; Body\_Lis: Body Listening; Trust: Trusting; Standards: Personal  
Standards; Parent\_Expect: Parental Expectations; Parent\_Critic: Parental Criticism; Organized: Organization; BU: Bulimia; BD: Body  
Dissatisfaction; IN: Ineffectiveness; MF: Maturity Fears; SI: Social Insecurity; Emot&Notice: Emotional Awareness & Noticing; Asc&DT:  
Asceticism & Drive for Thinness; IR&SD: Impulse Regulation & Social Distrust; Doubts&Concern: Concern over Mistakes & Doubts about  
Actions.





Variables are presented in descending order of bridge expected influence values. Black squares represent statistically significant differences.

Not\_Worry: Not Worrying; Attention: Attention Regulation; Self\_Reg: Self-Regulation; Body\_Lis: Body Listening; Trust: Trusting; Standards: Personal Standards; Parent\_Expect: Parental Expectations; Parent\_Critic: Parental Criticism; Organized: Organization; BU: Bulimia; BD: Body Dissatisfaction; IN: Ineffectiveness; MF: Maturity Fears; SI: Social Insecurity; Emot&Notice: Emotional Awareness & Noticing; Asc&DT: Asceticism & Drive for Thinness; IR&SD: Impulse Regulation & Social Distrust; Doubts&Concern: Concern over Mistakes & Doubts about Actions.

**Supplemental Table 1. Goldbricker results and node combined through PCA**

<b>“bad pairs”</b>	<b>% of different correlations</b>	<b>Resulting nodes</b>	<b>Description</b>
<b>MAIA Emotional Awareness &amp; MAIA Noticing</b>	.05	combined	awareness of body sensations and of physiological manifestations of emotions
<b>EDI-2 Asceticism &amp; EDI2 Drive for Thinness</b>	.05	combined	need for control over self and body
<b>EDI-2 Impulse Regulation &amp; EDI2 Social Distrust</b>	.05	combined	lack of control over self and over social relationships
<b>EDI-2 Impulse Regulation &amp; EDI-2 Asceticism</b>	.05		
<b>EDI2 Body Dissatisfaction &amp; EDI2 Drive for Thinness</b>	.10		
<b>EDI-2 Social Distrust &amp; Body Dissatisfaction</b>	.10		
<b>FMPS Doubts about Actions &amp; FMPS Concern over Mistakes</b>	.15	combined	perfectionistic evaluative concerns
<b>EDI-2 Impulse Regulation &amp; Drive for Thinness</b>	.15		
<b>EDI-2 Impulse Regulation &amp; Body Dissatisfaction</b>	.15		

Legend: MAIA: Multidimensional Assessment of Interoceptive Sensibility; EDI-2: Eating Disorders Inventory-2; FMPS: Frost Multidimensional Perfectionism Scale. In bold characters variables that were empirically combined.

**Table 2. Nodes' mean and SD**

<b>Nodes</b>	<b>Abbreviation</b>	<b>Mean (SD) †</b>
<b>MAIA Not Worrying</b>	Not_Worry	0 ( .99 )
<b>MAIA Attention Regulation</b>	Attention	0 ( 1.01 )
<b>MAIA Self -Regulation</b>	Self_Regul	-.01 ( .99 )
<b>MAIA Body Listening</b>	Body_Lis	0 ( .99 )
<b>MAIA Trusting</b>	Trust	-.01 ( .96 )
<b>FMPS Personal Standards</b>	Standards	0 ( 1 )
<b>FMPS Parental Expectations</b>	Parent_Expect	.01 ( .98 )
<b>FMPS Parental Criticism</b>	Parent_Critic	.01 ( .98 )
<b>FMPS Organization</b>	Organized	-.01 ( .98 )
<b>EDI-2 Bulimia</b>	BU	.07 ( .84 )
<b>EDI-2 Body Dissatisfaction</b>	BD	.01 ( .98 )
<b>EDI-2 Ineffectiveness</b>	IN	.02 ( .96 )
<b>EDI-2 Maturity Fears</b>	MF	.01 ( .98 )
<b>EDI-2 Social Insecurity</b>	SI	.01 ( .99 )
<b>MAIA Emotional Awareness &amp; Noticing</b>	Emot&Notice	0 ( 1.23 )
<b>EDI-2 Asceticism &amp; Drive For Thinness</b>	Asc&DT	0 ( 1.3 )
<b>EDI-2 Impulse Regulation &amp; Social Distrust</b>	IR&SD	0 ( 1.25 )
<b>FMPS Concern Over Mistakes &amp; Doubts</b>	Doubts&Concern	0 ( 1.29 )
<b>About Actions</b>		

Legend: MAIA: Multidimensional Assessment of Interoceptive Awareness; FMPS: Frost Multidimensional Perfectionism Scale; EDI-2: Eating Disorder Inventory-2.

† Values after nonparanormal transformation

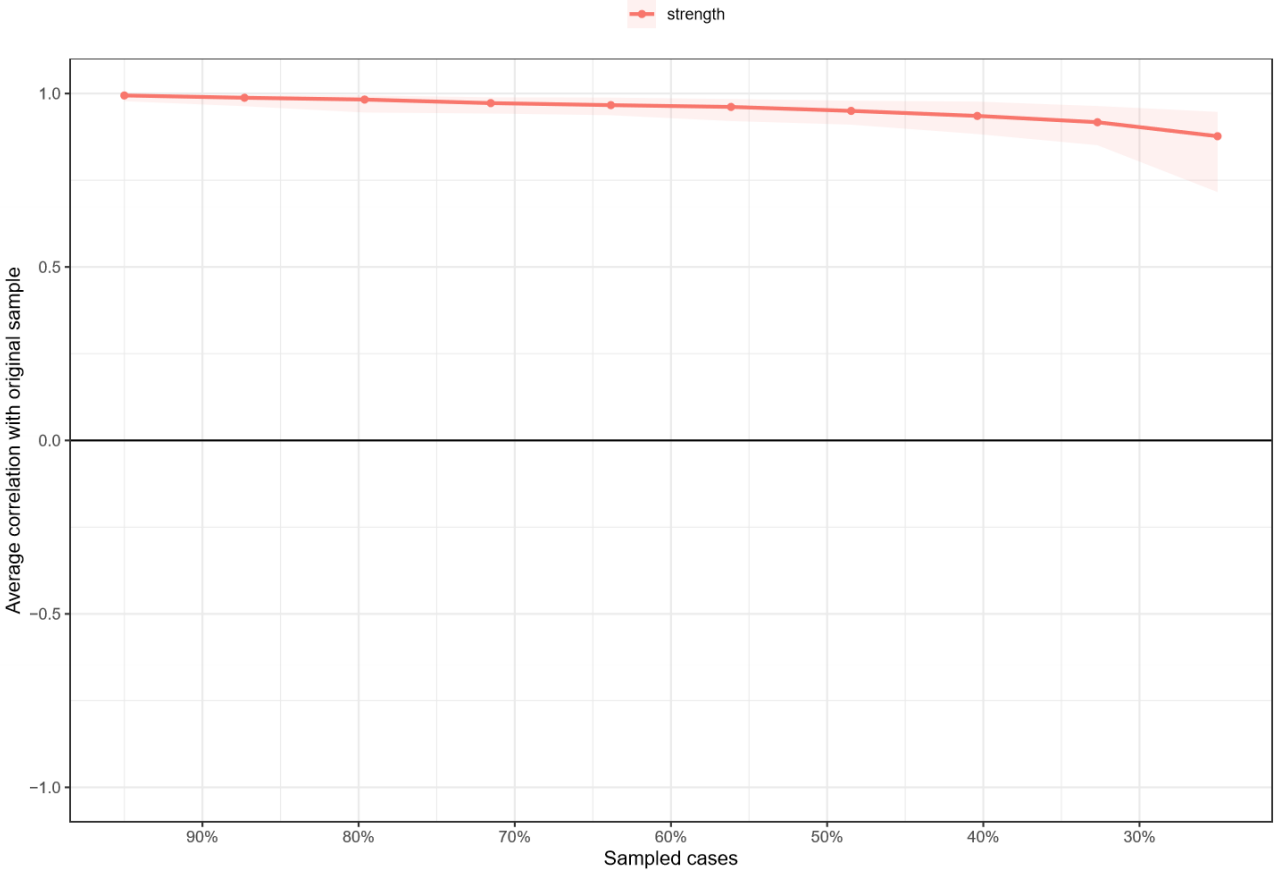
Supplemental Table 2. Weight matrix

	Organized	Parent_Criti	Parent_Expe	Standards	Trust	Body_Lis	Self_Regul	Attention	Not_Worry	
BU										
0	0	0	0	0	0	0	0	.1	0	Not_Worry
0	-.1	-.04	0	.08	.09	.22	0	.1		Attention
0	0	-.01	0	.05	.31	0	.22	0	0	Self_Regul
0	0	-.01	0	.28	0	.31	.09	0	0	Body_Lis
0	0	.07	0	0	.28	.05	.08	0	0	Trust
-.04	.29	0	.07	0	0	0	0	0	0	Standards
0	0	.49	0	0	-.01	-.01	-.04	0	0	Parent_Expect
0	0	0	.49	.07	0	0	0	0	0	Parent_Critic
0	0	0	0	.29	0	0	-.1	0	0	Organized
0	0	0	-.04	0	0	0	0	0	0	BU
.12	0	0	0	.1	0	0	0	0	0	BD
.09	-.06	.03	0	.18	0	.04	.05	0	0	IN
0	0	.02	0	0	0	0	.1	.03		MF
0	0	.05	0	.08	0	.08	0	.12		SI
0	0	-.03	0	0	.29	.08	.13	0	0	Emot&Notice
.13	.02	0	.04	.1	0	0	0	0	0	Asc&DT
.08	0	.05	0	0	0	0	0	0	0	IR&SD
0	0	.22	0	0	.38	.11	0	0	.08	Doubts&Concern

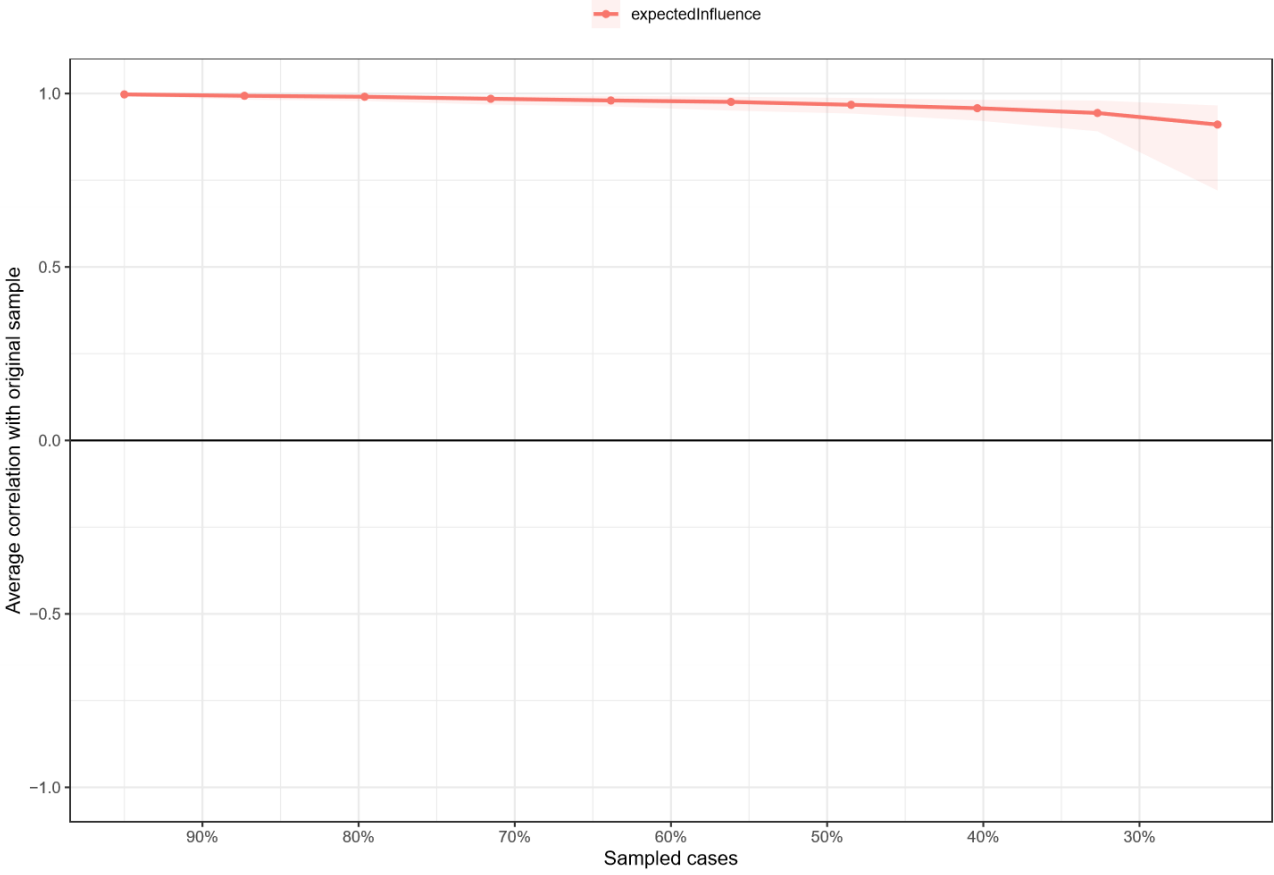
	Doubts&Con	IR&SD	Asc&DT	Emot&Notic	SI	MF	IN	BD
	.08	0	0	0	.12	.03	0	0
	0	0	0	.13	0	.1	.05	0
	.11	0	0	.08	.08	0	.04	0
	0	0	0	.29	0	0	0	0
	0	0	.1	0	.08	0	.18	.1
	.38	0	.04	-.01	0	0	0	0
	0	0	0	0	-.04	0	-.04	0
	.22	.05	0	-.03	.05	.02	.03	0
	0	0	.02	0	0	0	-.06	0
	0	.08	.13	0	0	0	.09	.12
	0	.05	.32	0	.03	0	.17	0
	.07	.15	.11	0	.3	.12	0	.17
	0	.13	.04	-.04	.08	0	.12	0
	.08	.35	0	-.04	0	.08	.3	.03
	-.03	0	-.03	0	-.04	-.04	0	0
	.2	.26	0	-.03	0	.04	.11	.32
	.01	0	.26	0	.35	.13	.15	.05
	0	.01	.2	-.03	.08	0	.07	0

Legend: Not\_Worry: Not Worrying; Attention: Attention Regulation; Self\_Reg: Self-Regulation; Body\_Lis: Body Listening; Trust: Trusting; Standards: Personal Standards; Parent\_Expect: Parental Expectations; Parent\_Critic: Parental Criticism; Organized: Organization; BU: Bulimia; BD: Body Dissatisfaction; IN: Ineffectiveness; MF: Maturity Fears; SI: Social Insecurity; Emot&Notice: Emotional Awareness & Noticing; Asc&DT: Asceticism & Drive for Thinness; IR&SD: Impulse Regulation & Social Distrust; Doubts&Concern: Concern over Mistakes & Doubts about Actions.

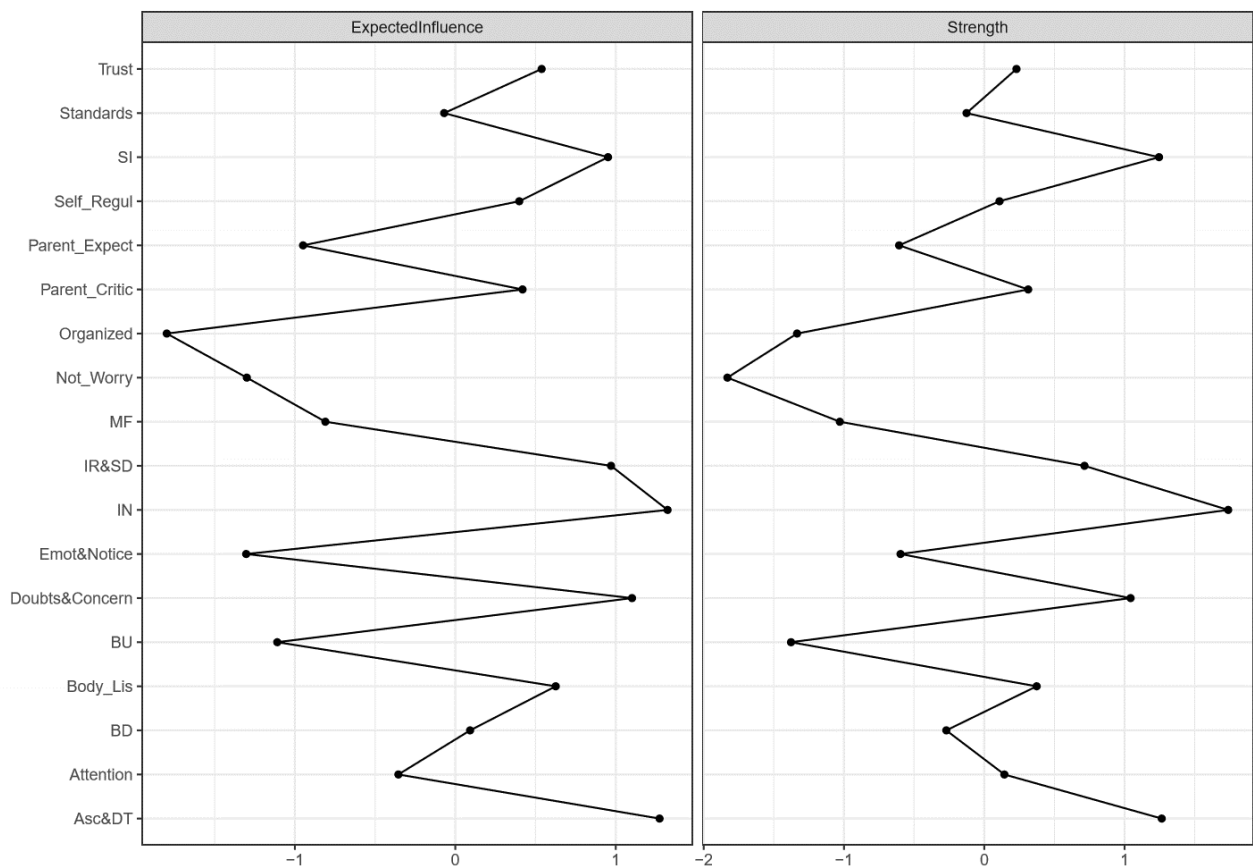
Supplemental Figure 1. Bootstrapped strength stability



Supplemental Figure 2. Bootstrapped expected influence stability



**Supplemental figure 3. Strength and expected influence plot**



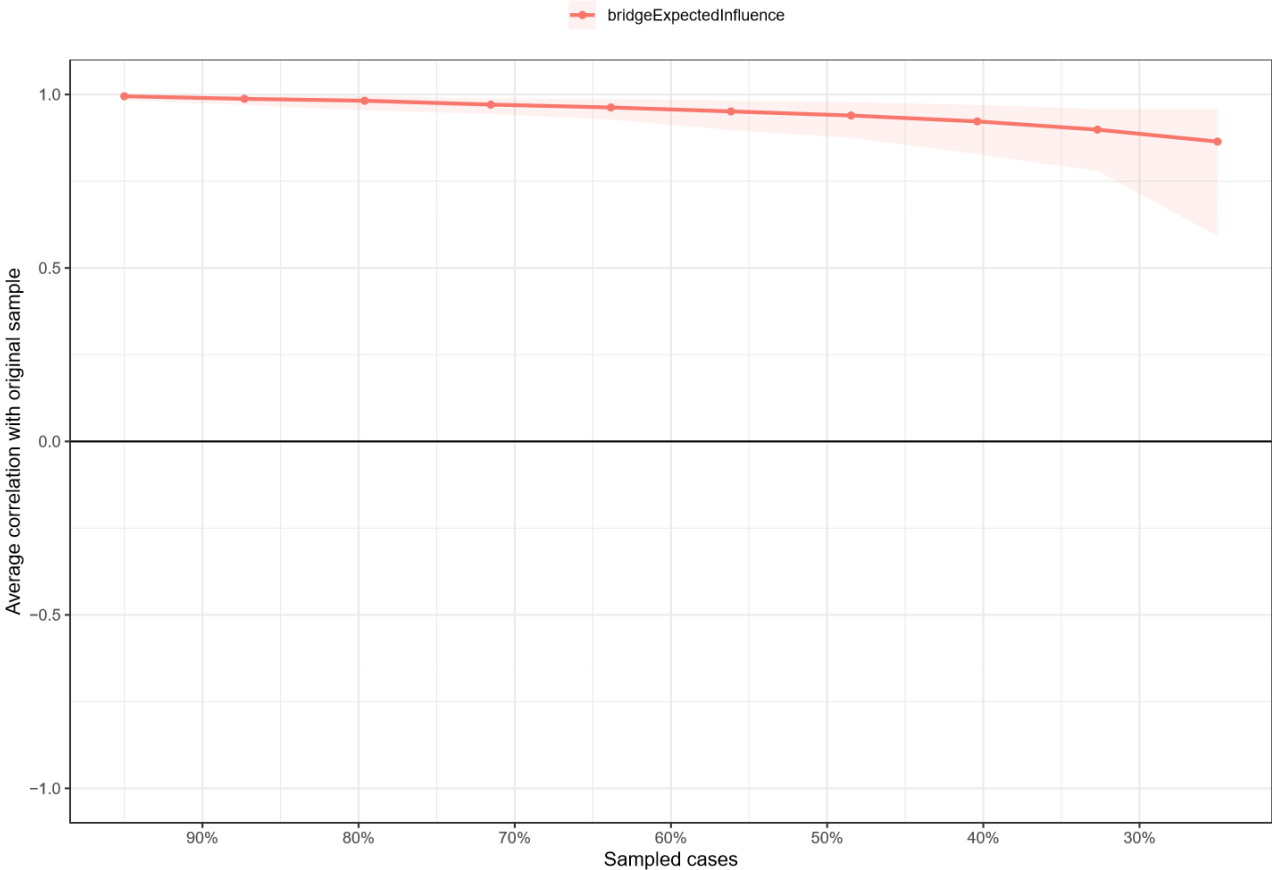
Legend: Not\_Worry: Not Worrying; Attention: Attention Regulation; Self\_Reg: Self-Regulation; Body\_Lis: Body Listening; Trust: Trusting; Standards: Personal Standards; Parent\_Expect: Parental Expectations; Parent\_Critic: Parental Criticism; Organized: Organization; BU: Bulimia; BD: Body Dissatisfaction; IN: Ineffectiveness; MF: Maturity Fears; SI: Social Insecurity; Emot&Notice: Emotional Awareness & Noticing; Asc&DT: Asceticism & Drive for Thinness; IR&SD: Impulse Regulation & Social Distrust; Doubts&Concern: Concern over Mistakes & Doubts about Actions.

Note: z-scores shown on x axis.

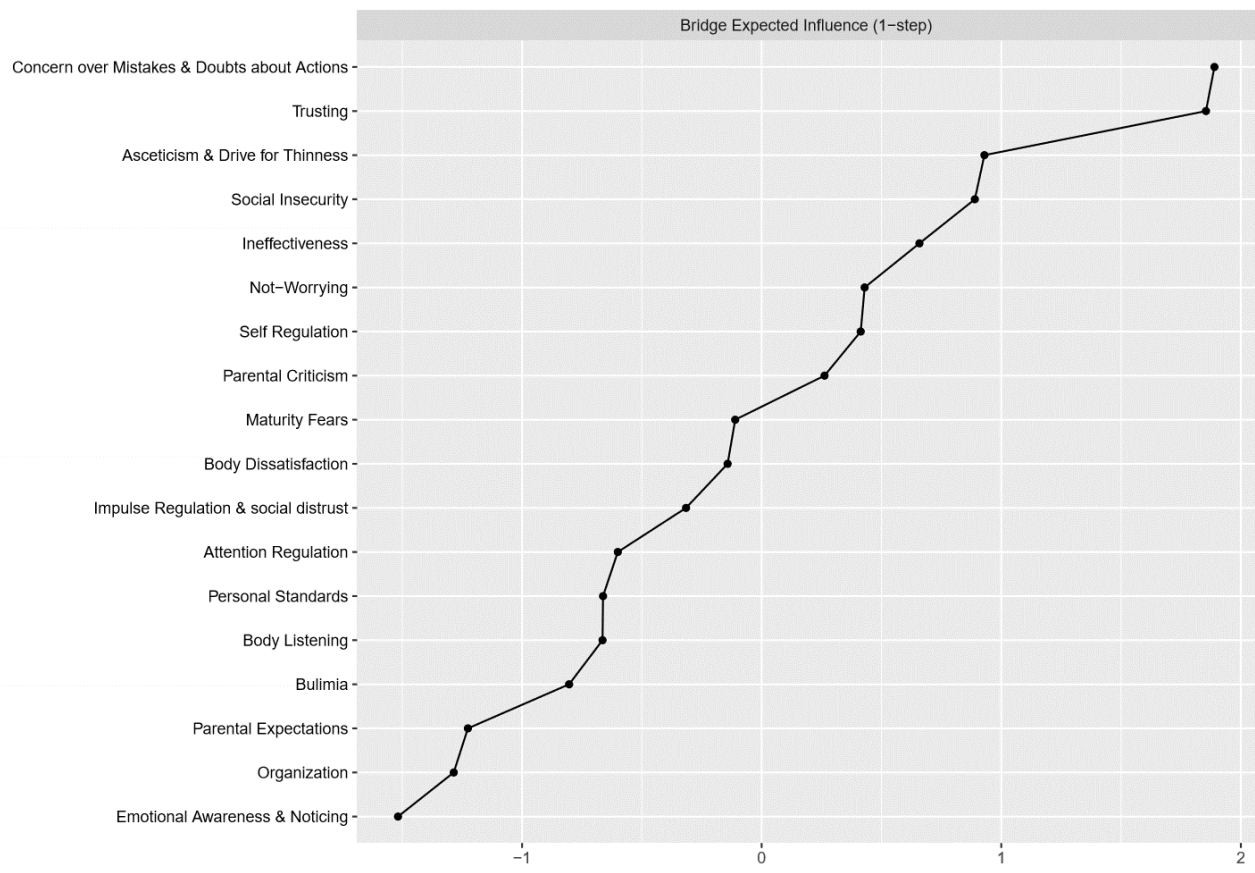


**BRIDGE**

**Supplemental Figure 4. Bootstrapped bridge expected influence stability**



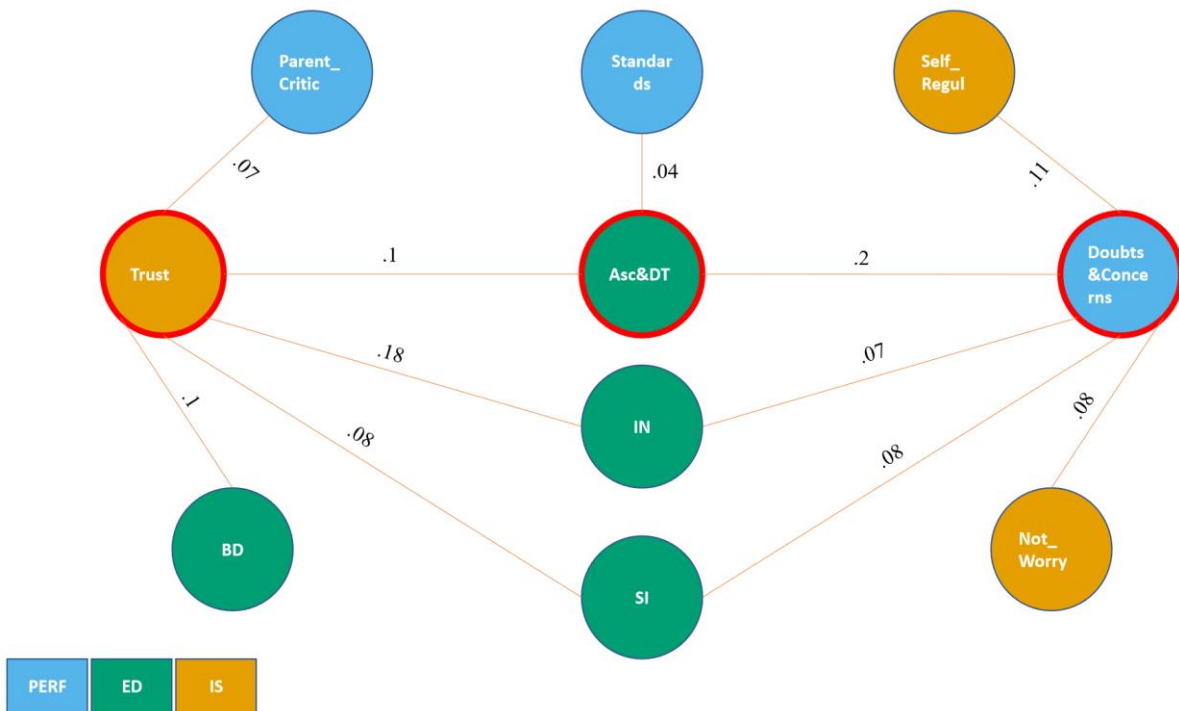
**Supplemental Figure 5. Bridge expected influence plot**



Legend: Not\_Worry: Not Worrying; Attention: Attention Regulation; Self\_Reg: Self-Regulation; Body\_Lis: Body Listening; Trust: Trusting; Standards: Personal Standards; Parent\_Expect: Parental Expectations; Parent\_Critic: Parental Criticism; Organized: Organization; BU: Bulimia; BD: Body Dissatisfaction; IN: Ineffectiveness; MF: Maturity Fears; SI: Social Insecurity; Emot&Notice: Emotional Awareness & Noticing; Asc&DT: Asceticism & Drive for Thinness; IR&SD: Impulse Regulation & Social Distrust; Doubts&Concern: Concern over Mistakes & Doubts about Actions.

Note: z-scores shown on x axis.

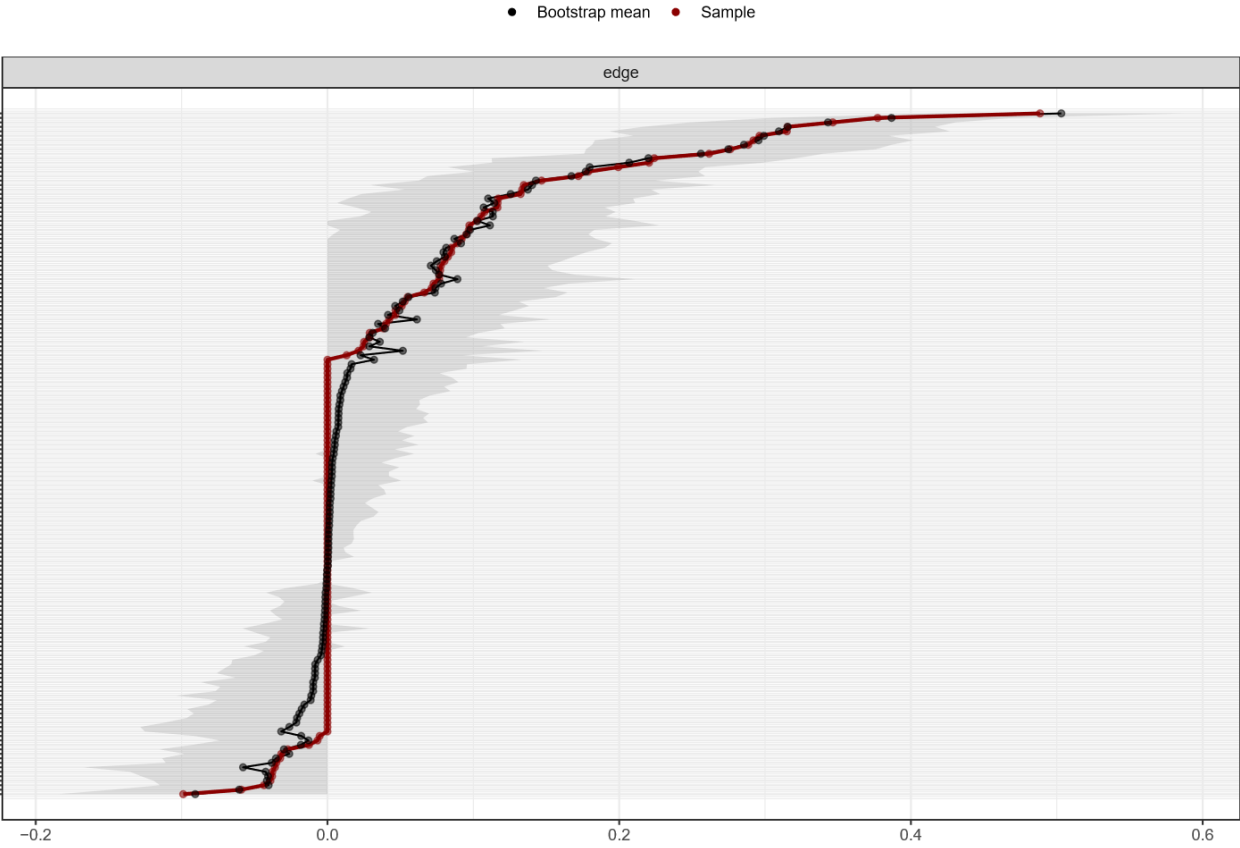
**Supplemental Figure 6. Bridge pathways**



Nodes are represented as circles, color-coded for each community. Nodes circled in red are those with the highest bridge centrality. Lines between nodes represent partial correlations, whose value is indicated by the number above them. Note: for ease of visualization an arbitrary cut-off of .03 was selected leaving out the following connections: Doubts&Concern and IR&SD (part  $r = .01$ ), Doubts&Concern and Emot&Notice (part  $r = -.03$ ), Asc&DT and Organized (part  $r = .02$ ), Asc&DT and Emot&Notice (part  $r = -.03$ ).

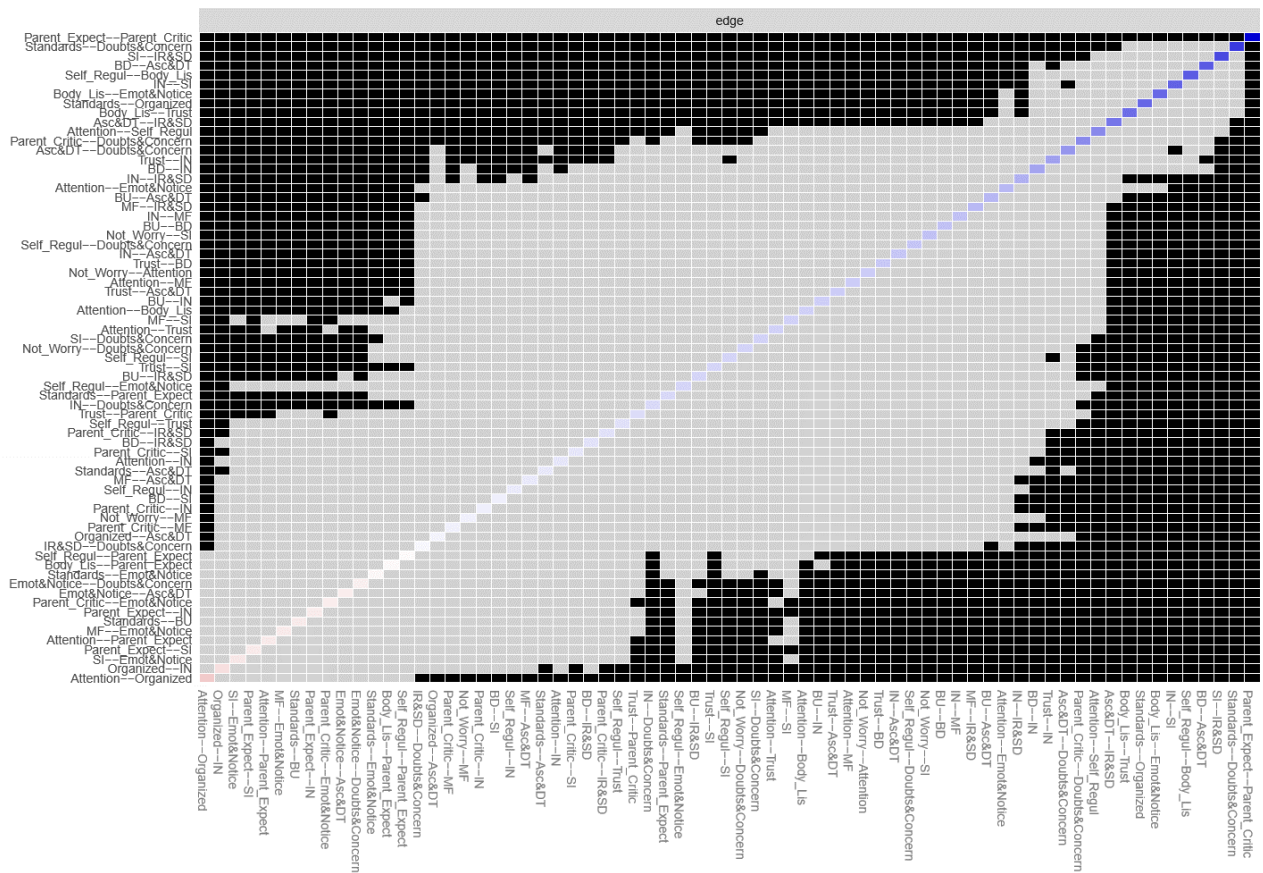
EDGES

Supplemental Figure 7. Bootstrapped confidence intervals of edge weights



Note: grey areas represent confidence intervals

Supplemental Figure 8. Results of edge difference test

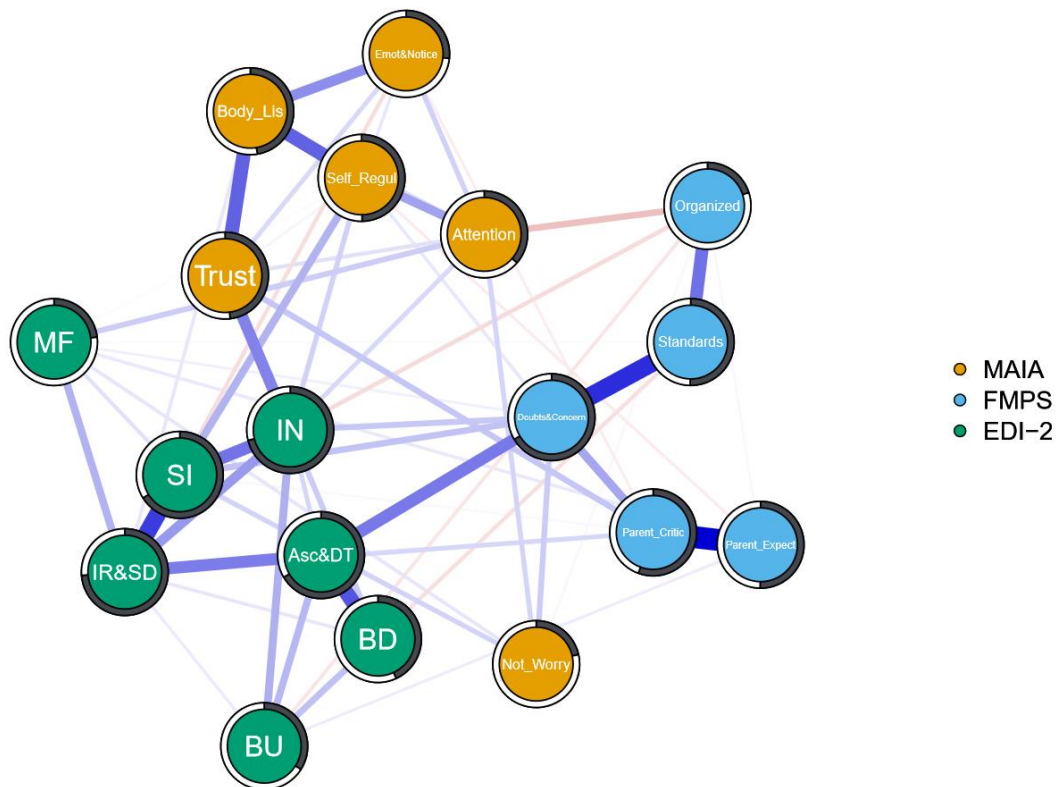


Legend: edges are presented in descending order of edge weight value. Black squares represent statistically significant differences. Not\_Worry: Not Worrying; Attention: Attention Regulation; Self\_Reg: Self-Regulation; Body\_Lis: Body Listening; Trust: Trusting; Standards: Personal Standards; Parent\_Expect: Parental Expectations; Parent\_Critic: Parental Criticism; Organized: Organization; BU: Bulimia; BD: Body Dissatisfaction; IN: Ineffectiveness; MF: Maturity Fears; SI: Social Insecurity; Emot&Notice: Emotional Awareness & Noticing; Asc&DT: Asceticism & Drive for Thinness; IR&SD: Impulse Regulation & Social Distrust; Doubts&Concern: Concern over Mistakes & Doubts about Actions.

## JOINTLY ESTIMATED CASES' AND CONTROLS' NETWORKS

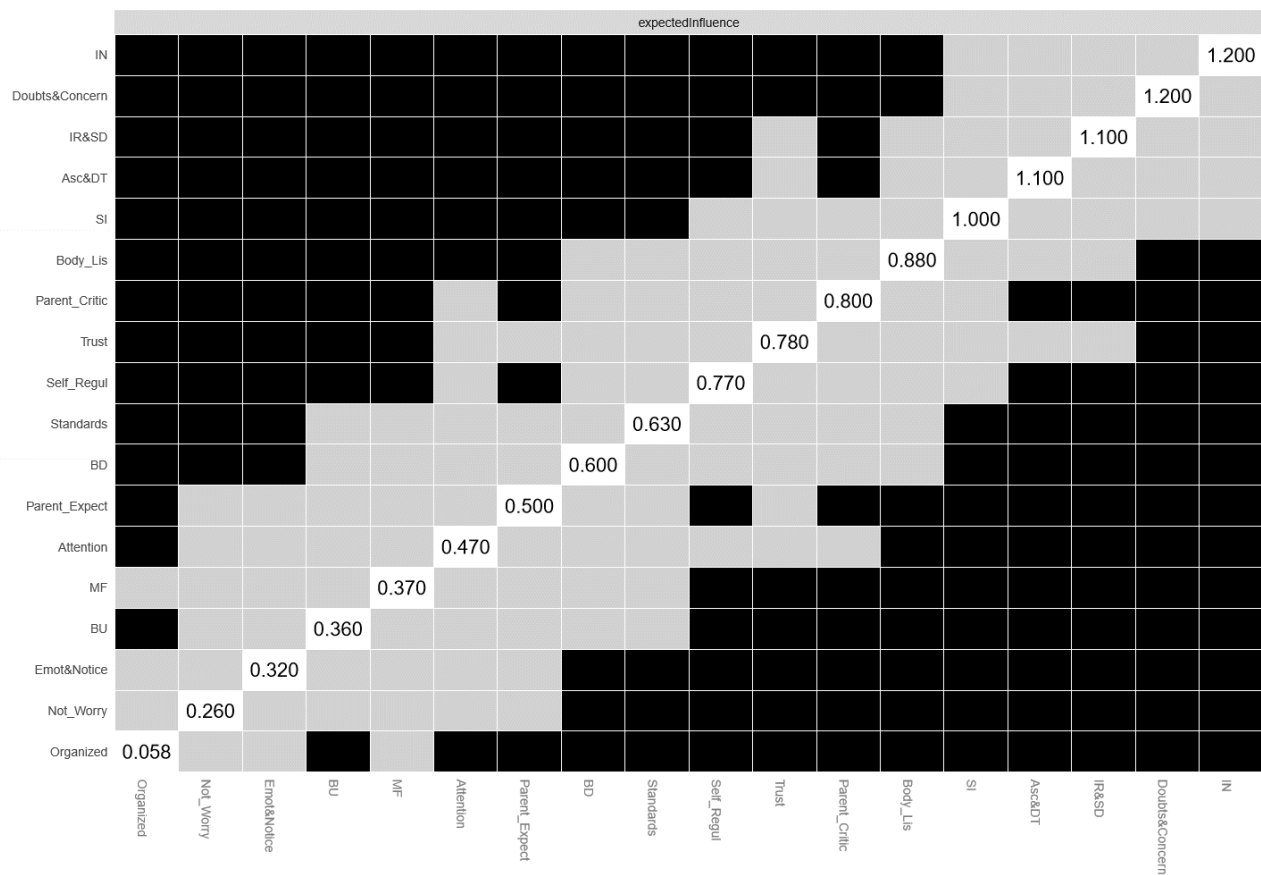
Supplemental Figure 9. Cases' network plot

Case



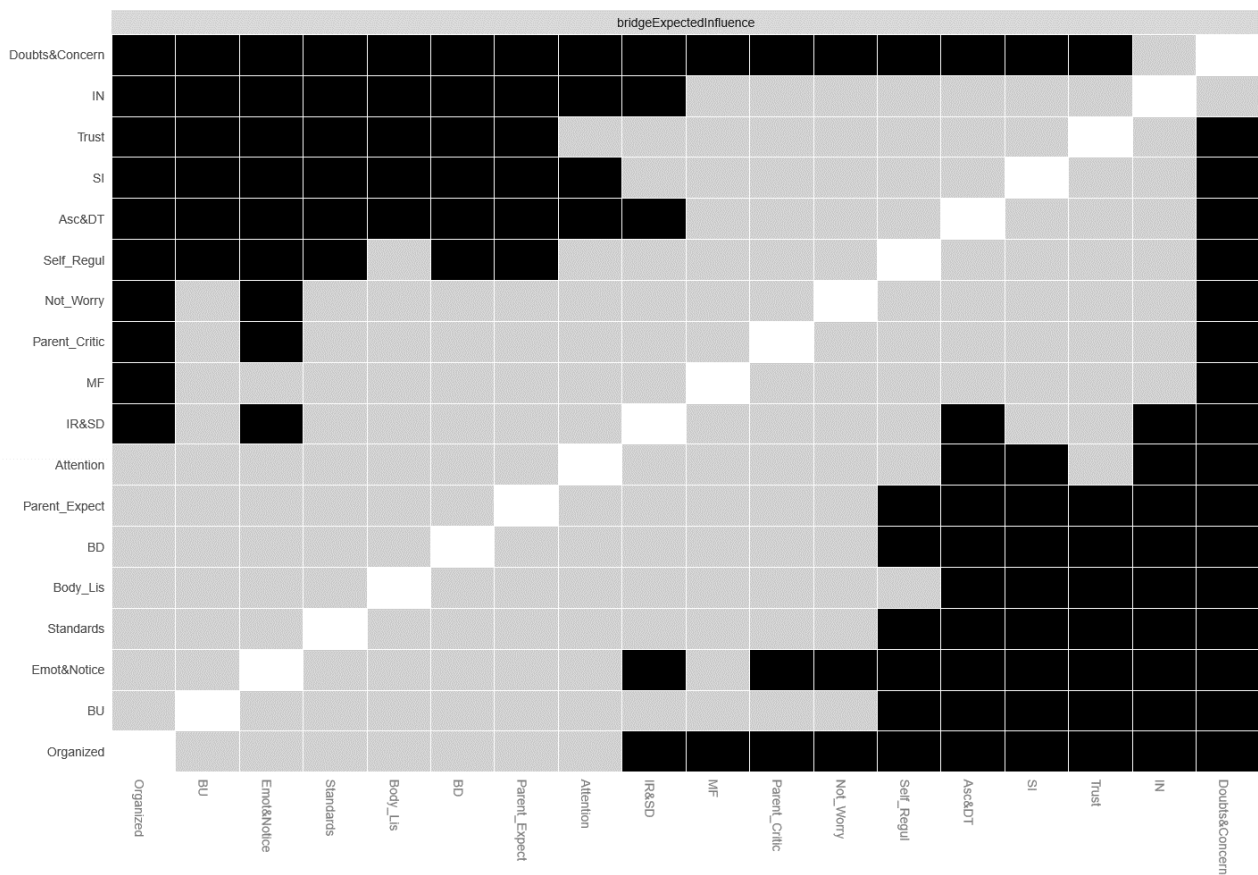
Legend: nodes are represented as circles, color-coded for each community (MAIA: Multidimensional Assessment of Interoceptive Sensibility, FMPS: Frost Multidimensional Perfectionism Scale, EDI-2: Eating Disorders Inventory-2). Blue lines between nodes represent positive association, red lines negative association; thicker lines correspond to stronger associations. Predictability is represented as the shaded area around the circles (higher predictability corresponds to a greater shaded area).

**Supplemental Figure 10. Cases' network bootstrapped difference test results for expected influence**



Legend: Variables are presented in descending order of expected influence values. Black squares represent statistically significant differences. Not\_Worry: Not Worrying; Attention: Attention Regulation; Self\_Reg: Self-Regulation; Body\_Lis: Body Listening; Trust: Trusting; Standards: Personal Standards; Parent\_Expect: Parental Expectations; Parent\_Critic: Parental Criticism; Organized: Organization; BU: Bulimia; BD: Body Dissatisfaction; IN: Ineffectiveness; MF: Maturity Fears; SI: Social Insecurity; Emot&Notice: Emotional Awareness & Noticing; Asc&DT: Asceticism & Drive for Thinness; IR&SD: Impulse Regulation & Social Distrust; Doubts&Concern: Concern over Mistakes & Doubts about Actions.

**Supplemental Figure 11. Cases' network bootstrapped difference test results for bridge expected influence**

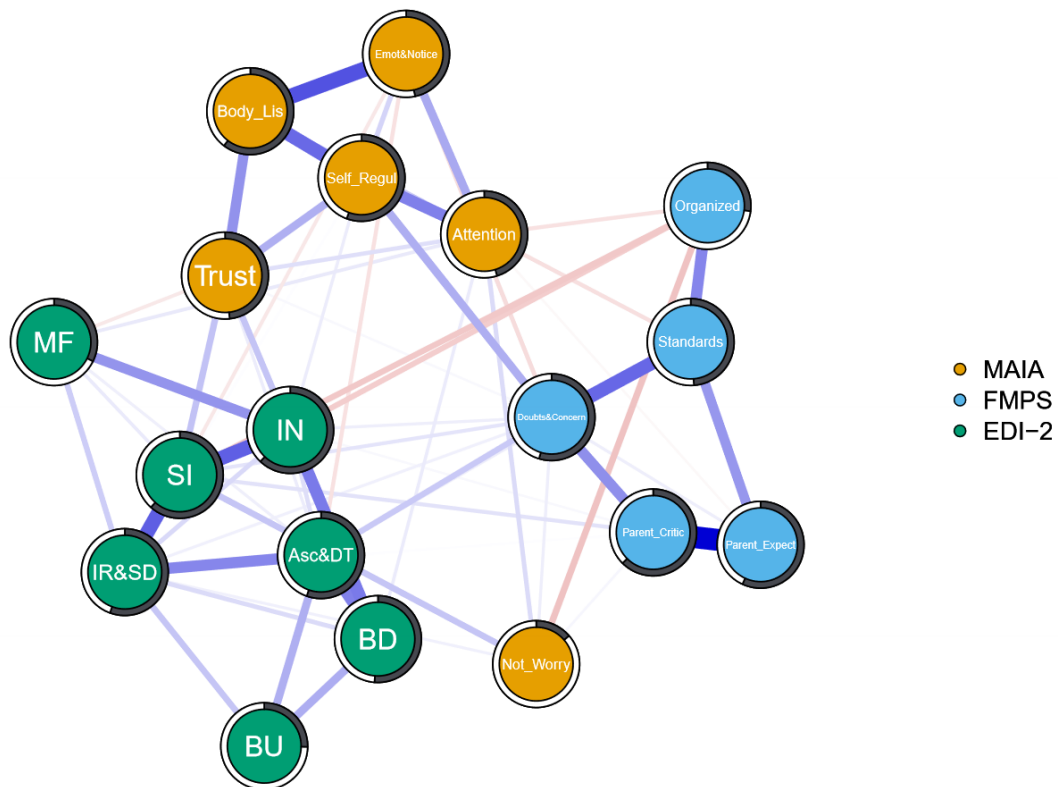


Legend: Variables are presented in descending order of bridge expected influence values. Black squares represent statistically significant differences. Not\_Worry: Not Worrying; Attention: Attention Regulation; Self\_Reg: Self-Regulation; Body\_Lis: Body Listening; Trust: Trusting; Standards: Personal Standards; Parent\_Expect: Parental Expectations; Parent\_Critic: Parental Criticism; Organized: Organization; BU: Bulimia; BD: Body Dissatisfaction; IN: Ineffectiveness; MF: Maturity Fears; SI: Social Insecurity; Emot&Notice: Emotional Awareness & Noticing; Asc&DT: Asceticism & Drive for Thinness; IR&SD: Impulse Regulation & Social Distrust; Doubts&Concern: Concern over Mistakes & Doubts about Actions.



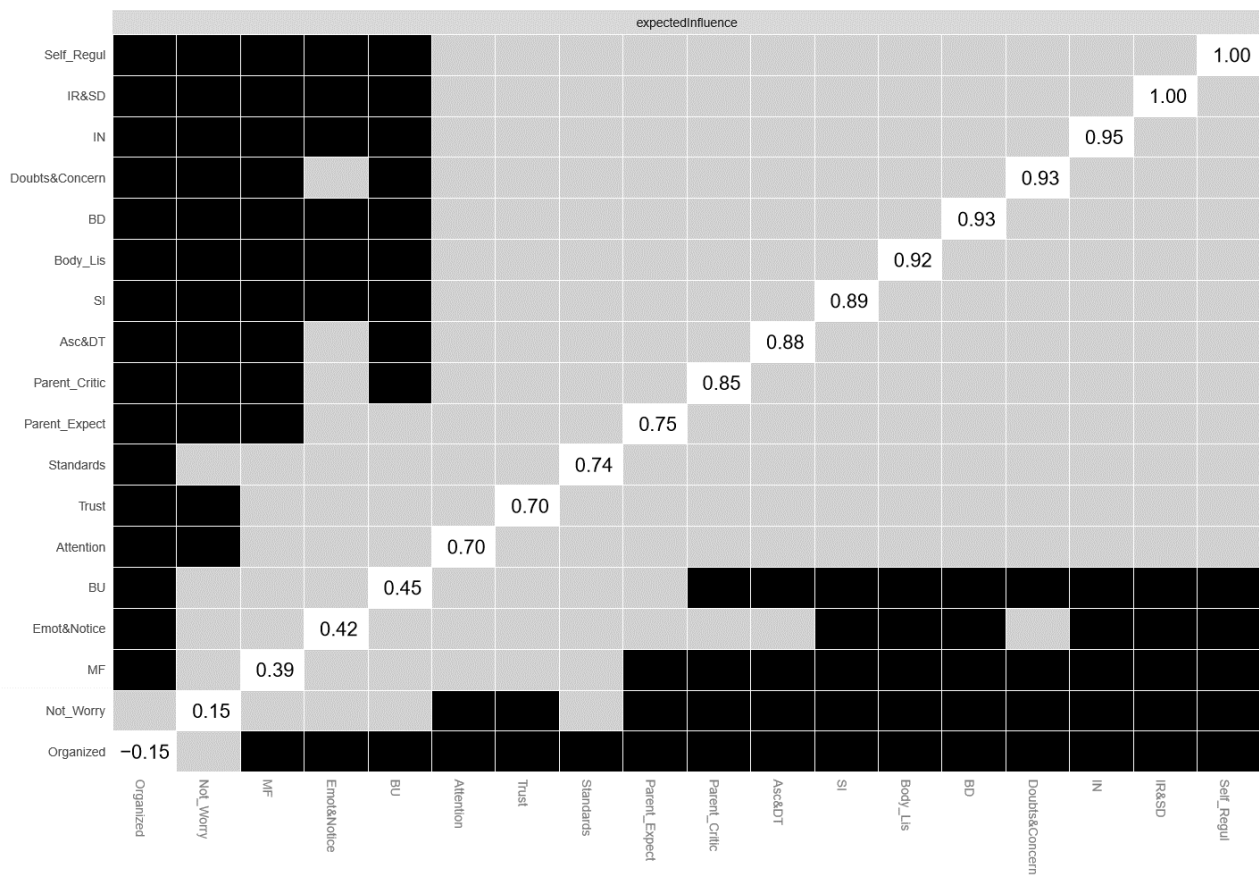
## Supplemental Figure 12. Control's network plot

Control



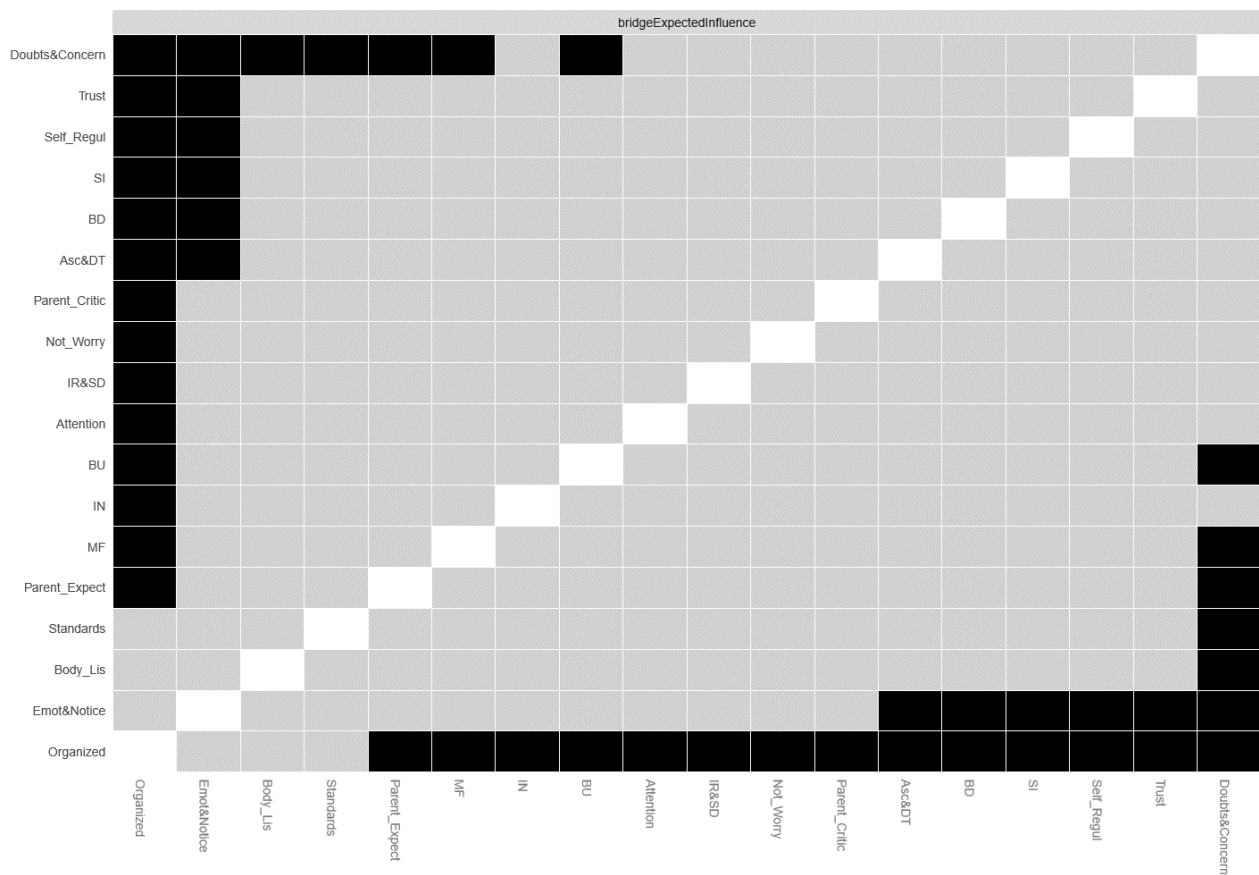
Legend: nodes are represented as circles, color-coded for each community (MAIA: Multidimensional Assessment of Interoceptive Sensibility, FMPS: Frost Multidimensional Perfectionism Scale, EDI-2: Eating Disorders Inventory-2). Blue lines between nodes represent positive association, red lines negative association; thicker lines correspond to stronger associations. Predictability is represented as the shaded area around the circles (higher predictability corresponds to a greater shaded area).

**Supplemental Figure 13. Controls' network bootstrapped difference test results for expected influence**



Legend: Variables are presented in descending order of expected influence values. Black squares represent statistically significant differences. Not\_Worry: Not Worrying; Attention: Attention Regulation; Self\_Reg: Self-Regulation; Body\_Lis: Body Listening; Trust: Trusting; Standards: Personal Standards; Parent\_Expect: Parental Expectations; Parent\_Critic: Parental Criticism; Organized: Organization; BU: Bulimia; BD: Body Dissatisfaction; IN: Ineffectiveness; MF: Maturity Fears; SI: Social Insecurity; Emot&Notice: Emotional Awareness & Noticing; Asc&DT: Asceticism & Drive for Thinness; IR&SD: Impulse Regulation & Social Distrust; Doubts&Concern: Concern over Mistakes & Doubts about Actions.

**Supplemental Figure 14. Controls' network bootstrapped difference test results for bridge expected influence**



Legend: Variables are presented in descending order of bridge expected influence values. Black squares represent statistically significant differences. Not\_Worry: Not Worrying; Attention: Attention Regulation; Self\_Reg: Self-Regulation; Body\_Lis: Body Listening; Trust: Trusting; Standards: Personal Standards; Parent\_Expect: Parental Expectations; Parent\_Critic: Parental Criticism; Organized: Organization; BU: Bulimia; BD: Body Dissatisfaction; IN: Ineffectiveness; MF: Maturity Fears; SI: Social Insecurity; Emot&Notice: Emotional Awareness & Noticing; Asc&DT: Asceticism & Drive for Thinness; IR&SD: Impulse Regulation & Social Distrust; Doubts&Concern: Concern over Mistakes & Doubts about Actions.

## R CODE

```
library(haven)
library("qgraph")
library("networktools")
library("bootnet")
library("dplyr")
library("NetworkComparisonTest")
library("EstimateGroupNetwork")
library("ggplot2")
library("huge")
library("mgm")
library("psych")

##----Data Preparation----

##get data
db <- read_sav("C:/Users/CER_DCA/databases/ MAIA-FROST_EDI2definitivo.sav")
data <- db[,8:33]

##alpha
MAIA <-data[,1:8]
alpha(MAIA)
MAIAndremoved <- select(MAIA,-c(2))
alpha(MAIAndremoved)

FMPS <- data[9:14]
alpha(FMPS)

EDI2 <-data[15:25]
alpha(EDI2)

##data preparation and goldbricker
data_all <-select(data,-c(2,19,21,26)) ##remove EDI-2 P and IA and MAIA not distract
```

```

data_all <- na.omit(data_all)
data_all <- as.data.frame(apply(data_all,2,as.numeric))

data_all <- huge.npn(data_all)
gb <- goldbricker(data_all,threshold=0.20,p=.01)
gb
reduced_data <- net_reduce(data = data_all, badpairs = gb)
reduced_data <- as.data.frame(apply(reduced_data,2,as.numeric))
names(reduced_data) <- c ("Not_Worry", "Attention", "Self_Regul", "Body_Lis", "Trust", "Standards",
      "Parent_Expect", "Parent_Critic", "Organized",
      "BU", "BD", "IN", "MF", "SI", "Emot&Notice", "Asc&DT", "IR&SD", "Doubts&Concern")

longnames <-c('Not-Worrying','Attention Regulation','Self Regulation','Body Listening','Trusting',
      'Personal Standards','Parental Expectations','Parental Criticism','Organization',
      'Bulimia','Body Dissatisfaction','Ineffectiveness','Maturity Fears','Social Insecurity',
      'Emotional Awareness & Noticing','Asceticism & Drive for Thinness','Impulse Regulation & social distrust',
      'Concern over Mistakes & Doubts about Actions')

##separate case and controls
data_all1 <-select(data,-c(2,19,21))
data_all1 <- na.omit(data_all1)
data_all1 <- as.data.frame(apply(data_all1,2,as.numeric))

reduced_data1<-reduced_data
reduced_data1['casocontrollo']=data_all1['casocontrollo']

case <- reduced_data1 %>%
  filter(casocontrollo==0)
case <- select(case, -c(casocontrollo))

control <- reduced_data1 %>%
  filter(casocontrollo==1)
control <- select(control, -c(casocontrollo))

```

```
##-----Network-----
```

```
##1.----boot----
```

```
glasso_all<- estimateNetwork(reduced_data, default = "EBICglasso",  
                             corMethod = "cor_auto")
```

```
set.seed(500)
```

```
boot2_all <- bootnet(glasso_all,nBoots = 1000,nCores=8,type="case",statistics = "all",  
                   communities=c(1,1,1,1,1,2,2,2,2,3,3,3,3,3,1,3,3,2))
```

```
save(boot2_all, file = "boot2all.Rdata")
```

```
corStability(boot2_all)
```

```
pdf("boot2.pdf",width = 10)
```

```
plot(boot2_all)
```

```
dev.off()
```

```
pdf("boot2ei.pdf",width = 10)
```

```
plot(boot2_all,statistics = "ExpectedInfluence")
```

```
dev.off()
```

```
pdf("boot2bei.pdf",width = 10)
```

```
plot(boot2_all,statistics = "BridgeExpectedInfluence")
```

```
dev.off()
```

```
boot1_all<- bootnet(glasso_all, nBoots = 1000, type="nonparametric",statistics = "all",
```

```
                   communities=c(1,1,1,1,1,2,2,2,2,3,3,3,3,3,1,3,3,2))
```

```
save(boot1_all, file = "boot1_all.Rdata")
```

```
pdf("boot1.pdf", width=10)
```

```
plot(boot1_all, statistics = "bridgeExpectedInfluence")
```

```
dev.off()
```

```
bootd_all <- plot(boot1_all, statistics = "expectedInfluence",
```

```
order = "sample", labels = T)
```

```
pdf("bootd.pdf", width=10)
```

```
plot(bootd_all)
```

```
dev.off()
```

```
bootd_all_b <- plot(boot1_all, statistics = "bridgeExpectedInfluence",  
plot="difference", order = "sample", labels = T)
```

```
pdf("bootd_b.pdf", width=10)
```

```
plot(bootd_all_b)
```

```
dev.off()
```

```
bootd_all_e <- plot(boot1_all, statistics = "edge",  
plot="difference", onlyNonZero = TRUE, order = "sample")
```

```
pdf("bootd_e.pdf", width=10)
```

```
plot(bootd_all_e)
```

```
dev.off()
```

```
boot1_all_e <- plot(boot1_all, labels=FALSE, order = "sample")
```

```
pdf("boot1_e.pdf", width=10)
```

```
plot(boot1_all_e)
```

```
dev.off()
```

```
##2-----predictability-----
```

```
set.seed(1)
```

```
reduceddata_mgm <- mgm(data=reduced_data, type = c(rep("g", 18)),  
ruleReg = "AND", k=2)
```

```
reduceddata_pred_model <- predict(object = reduceddata_mgm,  
data = reduced_data,  
errorCon = c("R2"))
```

```

reduceddata_x2 <- as.matrix(reduceddata_pred_model$errors)
reduceddata_error_model <- c(reduceddata_x2[1:18,2])
reduceddata_error_model <- as.numeric(reduceddata_error_model)
reduceddata_error_model <- abs(reduceddata_error_model)

mean(reduceddata_error_model)

corMat <- cor_auto(reduced_data)

mygroups= list("MAIA"=c(1:5,15),"FMPS"=c(6:9,18),"EDI-2"=c(10:14,16,17))

pdf("graph_all.pdf", width=10)
graph_all <- qgraph(corMat, graph = "glasso",layout = "spring", vsize=9,
  theme="colorblind", sampleSize = nrow(reduced_data), pie=reduceddata_error_model,
  pieColor = "#46494f", labels = colnames(reduced_data),
  DoNotPlot=FALSE,
  label.color=c(rep("white",11),"blue","white","white","white","blue","white","white"), groups=mygroups,
  nodeNames = longnames,legend=FALSE)
dev.off()

wmatall<-getWmat(graph_all)
wmatall<-as.data.frame(round(wmatall,2))
write.table(wmatall, file = "wmatall.txt", sep = ",", quote = FALSE, row.names=F)

cent_all<- centrality_auto(graph_all)
centralityTable(graph_all)

pdf("strenghtEI.pdf",width = 10)
centralityPlot(graph_all, include = c("ExpectedInfluence", "Strength"))
dev.off()

cor.test(cent_all$node.centralitiy$ExpectedInfluence,cent_all$node.centralitiy$Strength)

##4.----bridge----

```



```
bridge_all<- bridge(graph_all, communities=c('1','1','1','1','1','2','2','2','2','3','3','3','3','3','1','3','3','2'),
                useCommunities = "all", directed = NULL, nodes=NULL)
```

```
plot(bridge_all, include=c("Bridge Expected Influence (1-step)"), order = "value", zscore=TRUE)
```

```
pdf("bridgeEI.pdf",width=10)
```

```
plot(bridge_all, include=c("Bridge Expected Influence (1-step)"), order = "value", zscore=TRUE)
```

```
dev.off()
```

```
cor.test(bridge_all$`Bridge Strength`,bridge_all$`Bridge Expected Influence (1-step)`)
```

```
##5.----node variance and centrality----
```

```
c<- centrality_auto(graph_all)
```

```
x <- c$node centrality$ExpectedInfluence
```

```
var <- apply(reduced_data,2,var)
```

```
cor(var,x)
```

```
cor.test(var,x)
```

```
##6.----boot case control----
```

```
##boot case
```

```
glasso_case<- estimateNetwork(case, default = "EBICglasso",
                             corMethod = "cor_auto")
```

```
set.seed(500)
```

```
boot2_case <- bootnet(glasso_case,nBoots = 1000,nCores=8,type="case")
```

```
save(boot2_case, file = "boot2case.Rdata")
```

```
plot(boot2_case)
```

```
corStability(boot2_case)
```

```
boot1_case<- bootnet(glasso_case, nBoots = 1000, type="nonparametric",
```

```
                statistics = c("strength", "expectedInfluence",
```

```
                "bridgeStrength", "bridgeExpectedInfluence"),
```

```
                communities=c('1','1','1','1','1','2','2','2','2','3','3','3','3','3','1','3','3','2'))
```

```
save(boot1_case, file = "boot1_all.Rdata")
```

```
pdf("boot1_case.pdf", width=10)
```

```

plot(boot1_case, statistics = "bridgeExpectedInfluence")
dev.off()

boot3_case <- plot(boot1_case, statistics = "expectedInfluence",
                  order = "sample", labels = T)

pdf("boot3_case.pdf", width=10)
plot(boot3_case)
dev.off()

boot3_case_b <- plot(boot1_case, statistics = "bridgeExpectedInfluence",
                    plot="difference", order = "sample", labels = T)

pdf("boot3_case_b.pdf", width=10)
plot(boot3_case_b)
dev.off()

##boot control
glasso_control<- estimateNetwork(control, default = "EBICglasso",
                                corMethod = "cor_auto")

set.seed(500)
boot2_control <- bootnet(glasso_control,nBoots = 1000,nCores=8,type="case")
save(boot2_control, file = "boot2control.Rdata")
plot(boot2_control)
corStability(boot2_control)

boot1_control<- bootnet(glasso_control, nBoots = 1000, type="nonparametric",
                       statistics = c("strength", "expectedInfluence",
                                      "bridgeStrength", "bridgeExpectedInfluence"),
                       communities=c('1','1','1','1','1','2','2','2','2','3','3','3','3','3','1','3','3','2'))
save(boot1_control, file = "boot1_control.Rdata")

pdf("boot1_control.pdf", width=10)

```

```
plot(boot1_control, statistics = "bridgeExpectedInfluence")
dev.off()
```

```
boot3_control <- plot(boot1_control, statistics = "expectedInfluence",
                    order = "sample", labels = T)
```

```
pdf("boot3_control.pdf", width=10)
plot(boot3_control)
dev.off()
```

```
boot3_control_b <- plot(boot1_control, statistics = "bridgeExpectedInfluence",
                      plot="difference", order = "sample", labels = T)
```

```
pdf("boot3_control_b.pdf", width=10)
plot(boot3_control_b)
dev.off()
```

```
##7.----predictability case control----
```

```
##predictability case
```

```
set.seed(1)
```

```
case_mgm <- mgm(data=case, type = c(rep("g", 18)),
               ruleReg = "AND", k=2)
```

```
case_pred_model <- predict(object = case_mgm,
                          data = case,
                          errorCon = c("R2"))
```

```
case_x2 <- as.matrix(case_pred_model$errors)
```

```
case_error_model <- c(case_x2[1:18,2])
```

```
case_error_model <- as.numeric(case_error_model)
```

```
case_error_model <- abs(case_error_model)
```

```
mean(case_error_model)
```

```

## predictability control
set.seed(1)
control_mgm <- mgm(data=control, type = c(rep("g", 18)),
  ruleReg = "AND", k=2)
control_pred_model <- predict(object = control_mgm,
  data = control,
  errorCon = c("R2"))

control_x2 <- as.matrix(control_pred_model$errors)
control_error_model <- c(control_x2[1:18,2])
control_error_model <- as.numeric(control_error_model)
control_error_model <- abs(control_error_model)

mean(control_error_model)

##8.----Joint network estimation----
corMatcase <- cor_auto(case)
corMatcontrol <- cor_auto(control)

joint<-EstimateGroupNetwork(list("case"=case, "control"=control),n=c(139,121))

pdf("case_network.pdf", width=10)
g_case<- qgraph(joint$case, layout = graph_all$layout, title = "Case",
  theme="colorblind", pie=case_error_model,
  pieColor = rep("#46494f"), labels = colnames(case),
  label.color="white", groups=mygroups)
dev.off()

pdf("control_network.pdf", width=10)
g_control <- qgraph(joint$control, layout = graph_all$layout, title = "Control",
  theme="colorblind", pie=control_error_model,
  pieColor = rep("#46494f"), labels = colnames(control),
  label.color="white", groups=mygroups)
dev.off()

```

```
#8.----Network comparison test----
```

```
set.seed(13)
```

```
comparison <- NCT(case,control, it=5000, weighted=TRUE, test.edges=FALSE, edges = 'all')
```

```
plot(comparison, what ="network")
```