The Psychometric Network Structure of Maladaptive Personality trait facets in Eating Disorder Patients

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Abstract

Personality can play an important role in relation to eating disorders (EDs). Empirical studies suggest that certain maladaptive personality trait facets are associated with EDs and might act as ED maintaining factors. However, there is a lack of understanding of how maladaptive personality trait facets are interconnected in ED patients. Psychometric network theory proposes that personality can be explained as a network of interconnected trait facets in which trait facets can be more or less influential. Centrality, a unique feature of psychometric network analysis, can indicate the importance of each trait facet in the context of other trait facets. Thus, trait facets with high centrality can be considered those that influence other trait facets and the whole personality. Knowing the high central trait facets of ED patients can provide us with information that has not been explored before. Using data from 1,224 Dutch ED patients, psychometric network analysis of the 25 trait facets from PID-5 was applied to explore the maladaptive personality network structure and centrality. Depressivity, withdrawal, anhedonia and hostility were the most central trait facets uniquely associated with many other trait facets. Centrality indices were not significantly different across age and ED psychopathology severity. However, youth ED patients' personality network had some significantly stronger interconnections compared to adult patients' network, leading to significant difference between the network structure of youth and adult ED patients. The current study findings may be helpful in the ED treatment or its planning process. Central trait facets may be considered in ED treatment to promote the overall adaptive personality of ED patients. Future longitudinal studies may investigate how the most central trait facets are connected with ED treatment outcomes.

Keywords: maladaptive personality, personality pathology, personality dysfunction, trait facet, eating disorder, eating disorder psychopathology, PID-5, network approach, psychometric network, centrality

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The Psychometric Network Structure of Maladaptive Personality Trait Facets in Eating Disorder Patients

Eating disorders (EDs) are a group of conditions characterized by disturbed eating-related behavior and cognitions (DSM-5, 2013). The most common types of EDs are anorexia nervosa (AN), bulimia nervosa (BN), binge eating disorder (BED), and other specified feeding and eating disorders (OSFED). The last one is an umbrella term for the conditions when symptoms do not fully meet the criteria of AN, BN, or BED (DSM-5, 2013). Depending on which ED type an individual has, symptoms can be a distorted body image, shape and weight concerns, an unhealthy body weight, a lack of or excessive control over food intake, restrictive behaviour, binge eating, and compensatory behaviours (Davey, 2014). Depending on how intensive and frequent ED symptoms are and to what degree bio-psycho-social functioning is impaired, the severity level of ED psychopathology can be defined (DSM-5, 2013). Thus, ED psychopathology can vary from low to high severity.

The estimated lifetime prevalence of any ED in the general population is 1%, and it is more common in women than men (Qian et al., 2013). People diagnosed with an ED often have comorbid mental disorders such as major depressive disorder, anxiety disorder, personality disorder, substance use disorder, etc. (Fernandez-Aranda et al, 2007; Swinbourne & Touyz, 2007; Agras, 2001; Herzog, Keller, Lavori, Kenny, & Sacks, 1992). Besides, most ED patients suffer from psychological distress, social problems, significantly impaired self-esteem, and self-criticism (Didie & Fitzgibbon, 2005; Dunkley & Grilo, 2007). Furthermore, EDs can lead to somatic complications such as cardiovascular diseases, nutritional deficiencies, and osteoporosis (Zipfel et al., 2001; Swenne, 2000; Agras, 2001). Individuals with EDs have elevated mortality rates (including suicide), with the highest rates occurring in those with AN compared to all other mental disorders in general (Arcelus, Mitchell, Wales, & Nielsen, 2011).

The personality of ED patients has been the subject of research for decades. Lilenfeld, Wonderlich, Riso, Corsby, and Mitchell (2006) conducted a methodological and empirical review of models of the relationships between personality and EDs, which vary from correlational to causal. Among those, all models except “pathoplasty model” are beyond our present scope, as this study examines maladaptive personality among patients with ongoing EDs. The "pathoplasty model" of the relationship between maladaptive personality and EDs implies that, once both maladaptive personality and ED are established, they are likely to interact in ways that contribute to the maintenance of EDs and modify treatment outcome (Lilenfeld et al., 2006). Maladaptive personality is explained as an entity of personal traits of a person that are dysfunctional and negatively affect the adaptation process of a person and responses to various life challenges, including mental disorders such as EDs (Davey, 2014).

In Section III of the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders a dimensional model of maladaptive personality traits was proposed (Krueger, Derringer, Markon, Watson, & Skodol, 2012; DSM-5, 2013). This dimensional model consists of five broad trait domains and 25 underlying trait facets considered maladaptive and dysfunctional. Maladaptive personality trait facets are specific and unique personal characteristics defined as a tendency to feel, perceive, behave, and think in particular dysfunctional ways across time and in various situations (DSM-5, 2013). However, even malfunctioning personality traits can change in the course of life and can become more adaptive than it was before with or without interventions (Roberts, & Mroczek, 2008; Roberts et al., 2017).

There is multiple evidence that personality pathology is elevated among ED patients compared to people without EDs. For example, obsessive-compulsive personality disorder and borderline personality disorder are the most highly comorbid personality disorders among ED patients and are far more common in this population compared to healthy controls

(Sansone, & Sansone, 2011). Also, higher maladaptive personality traits such as perfectionism, neuroticism (i.e., depression, anxiety, anhedonia, impulsiveness, and stress vulnerability), avoidance motivation, sensitivity (to social rewards), extraversion, and self-directedness are strongly associated with EDs (Farstad, McGeown, & Von Ranson, 2016; De Vos, Radstaak, Bohlmeijer, & Westerhof, 2021). Besides, some specific maladaptive personality trait facets are uniquely associated with specific ED symptoms. For example, higher rigid perfectionism is associated with restriction, whereas higher impulsivity and anxiousness are associated with binge eating in ED patients (Solomon-Krakus, Uliaszek, & Bagby, 2020). Also, there is empirical evidence of personality being a predictor of recovery from ED and ED treatment outcome. Vall & Wade (2015) investigated that lower depressivity is strongly associated with better treatment outcomes among ED patients. Additionally, maladaptive personality trait facets may play a deterrent role in the experience of well-being among ED patients. For example, the trait facets anhedonia and depression are strongly and negatively associated with all three well-being dimensions (psychological, social, and emotional) (de Vos et al., 2021). Moreover, more extreme maladaptive personality traits related to affectivity (e.g., neuroticism-anxiety, emotionality) and impulsivity (e.g., impulsivity-sensation seeking, behavioural disinhibition, aggression-hostility) were associated with more severe ED psychopathology (Legg, & Turner, 2021). Thus, as the personality becomes more maladaptive, we can suppose that severity of ED psychopathology increases. Maladaptive personality traits can hinder or make the treatment process harder for ED patients and become an obstacle for ED recovery. Reducing maladaptive personality trait facets to stimulate adaptive personality of ED patients is very important for their treatment and ED recovery process. Therefore, further study of maladaptive personality among ED patients is necessary.

Although a lot is already known about the association between maladaptive personality and EDs, there is not enough information about the overall structure of the maladaptive personality of ED patients. We do not know how all those trait facets, which form maladaptive personalities, are interconnected with each other. Besides, we also do not know which trait facets have the most connections with other trait facets in the process of forming maladaptive personality. Knowing how strongly trait facets are interconnected can be valuable information in terms of proper treatment to improve the overall personality of ED patients. For example, highly interconnectedness among maladaptive personality trait facets may indicate that there is no need to improve every trait facet separately in order to improve overall personality. Knowing which trait facets have the most connections with other trait facets could inform us about trait facets that are potentially most responsible for general maladaptive personality and play the biggest role in the development of other personality trait facets in a maladaptive way. Thus, identifying such personality trait facets and addressing them during a treatment may have a positive impact on other trait facets without directly addressing them. A novel method of analysing personality data, psychometric network analysis, could address this knowledge gap.

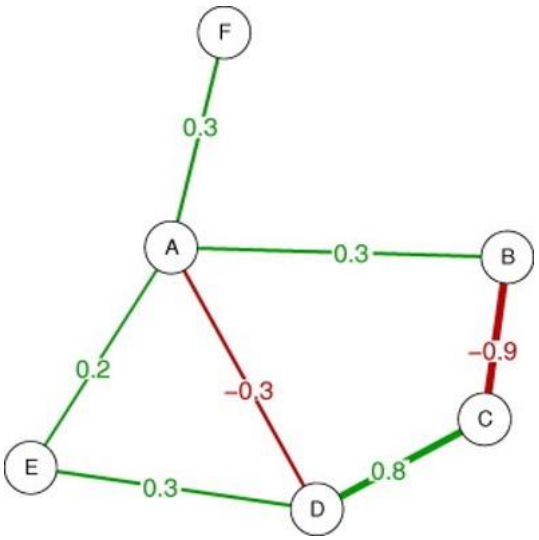
Psychometric Network Analysis

Psychometric network analysis is a process of interpreting and evaluating psychological phenomena as a network of interconnected variables (Cramer et al. 2012). A psychometric network is an abstract model that consists of nodes and edges. Nodes represent any kind of variables (e.g., symptoms, personality trait facets) and edges represent relations between them (e.g., causality, correlation) (Costantini, 2014, Costantini et al., 2015). Psychometric networks can be visualized with graphs that mostly are based on correlational matrices. For example, a simple 6-node (circles - A, B, C, D, E, F) and 7-edges (lines that connect nodes) network graph is shown in Figure 1. Green and red edges indicate positive

and negative associations between the nodes, respectively. This network is weighted because every edge has a number that shows the strength of the association between two nodes (Costantini, 2014; Costantini et al., 2015). Furthermore, this network is undirected as edges have no arrow to demonstrate causal connections between the nodes (Costantini, 2014; Costantini et al., 2015).

Figure 1

A Hypothetical Network with Six Nodes (A, B, C, D, E, F) and Seven Edges (green and red lines)



Note. Green edges represent a positive connection between nodes and red ones negative. Numbers on the edges show the strengths of each connection (Costantini et al., 2015).

Cramer et al. (2012) suggested that psychometric network analysis can also provide valuable information in understanding personality. Personality can be presented as a network, where nodes represent personality trait facets and edges correlations between them (Cramer et al., 2012). Every trait facet has a unique role in the personality network and is connected to other trait facets in a particular pattern. In this way, it can be used to visualize the relations among all trait facets via an easily perceivable and interpretable graph (similar to the graph in Figure 1). For example, almost 300 individual correlations among 25 trait facets can be seen

and interpreted from one structured graph of the network in a much easier way than it would be possible by using a matrix of the same correlation coefficients (See, Klimstra, Cramer, & Denissen, 2020). Second of all, information about the centrality of each trait facet can be estimated by using psychometric network analysis. Centrality indicates the importance of the role a trait facet plays in the context of other trait facets and the whole network (Opsahl, Agneessens, & Skvoretz, 2010). Simply, trait facets (nodes) with high strength centrality indicate that these trait facets have the most and the strongest associations (correlations) with the rest of trait facets in the personality network. Psychometric network theory suggests that trait facets (nodes) with high centrality are strong enough to influence other facets and the whole personality network because they are associated with many other trait facets in the personality network. Trait facets with a high centrality may be the ones that highly affect other trait facets in the network as they are strongly connected to them. It means that if these trait facets change, the chance is that the rest of the trait facets and the whole network structure may change as well. For example, central nodes, maladaptive personality trait facets, in this case, can influence less central nodes in terms of becoming less maladaptive. In this case complete network of maladaptive personality can become less dense overall that would affect the whole network structure of maladaptive personality trait facets.
Being able to identify such potentially influential trait facets is thought to be of importance because it could be beneficial for those trait facets to be addressed and improved during treatment to contribute to the improvement of the rest of the trait facets as well.

In the study of See et al. (2020), anxiousness and callousness were identified as the highest central trait facets in the maladaptive personality network for a representative Dutch sample of adolescents. However, the network structure of maladaptive personality trait facets has not been examined specifically for ED patients. The personality functioning of ED patients can differ from people without an ED. All ED diagnoses tend to be characterized by

elevated perfectionism, neuroticism, and avoidance motivation; heightened sensitivity to social rewards; and lower extraversion and self-directedness than controls (Frastad et al., 2016). Thus, maladaptive personality network structure and node centrality may differ as well. Therefore, it is especially necessary to investigate the maladaptive personality network of ED patients. Knowing centrality measures of maladaptive personality trait facets among ED patients can be helpful for clinical purposes. Particularly, highly central personality trait facets may be addressed during treatments to promote overall more adaptive personality functioning.

The Current Study

The main goal is to investigate the maladaptive personality network structure and node centrality of ED patients. Besides, as personality may change during the course of life (Roberts & Mroczek, 2008), maladaptive personality network structure and node centrality may be different for youths and adults as well. The World Health Organization (WHO) guidelines define "Youths" as individuals in the 15-24 years age group and "Adults" as the 25+ year age group (WHO, 2018). Therefore, the second aim of this study is to compare maladaptive personality network structure and centrality of youth and adult age groups of ED patients. Finally, higher ED psychopathology is related to more extreme maladaptive personality traits. This means that the structure and centrality of maladaptive personality traits may also differ between groups with less and more severe ED psychopathology. Therefore, the third aim of this study is to compare maladaptive personality network structure and centrality of different groups with low and high ED psychopathology.

Consequently, the current study aims to answer three different questions:

- How are personality trait facets interconnected in a psychometric network, and which personality trait facets are most central in ED patients?

- What are the differences in the maladaptive personality network structure between ED patients in the youth and adult age groups?

- What are the differences in the maladaptive personality network structure between the groups of ED patients with low and high severe ED psychopathology?

Methods

Participants and Procedures

The study participants were Dutch ED patients ($N = 1356$) referred to Stichting Human Concern by a general practitioner for further diagnoses and treatment between January 2016 and March 2020. Stichting Human Concern is a treatment center for EDs located in several cities in the Netherlands. The inclusion criteria were: (1) 17 years as the minimum age of participants, (2) a primary ED diagnosis at intake according to the criteria of the diagnostic and statistical manual (DSM-5, 2013), (3) participants' ability to understand and fill in the questionnaires, and (4) participants' informed consent to participate in the research. Every participant received a brochure about the aim of the study and the information to contact the researchers. The informed consent included that participants had been given information about the study, as well as the option to withdraw. One hundred and thirty-two patients were excluded because they did not give consent, leading to a total of 1,224 included patients with 37 (3.0%) men and 1187 (97.0%) women. Patients were diagnosed by a psychiatrist in collaboration with an intake team, a family therapist, a dietician, and a psychologist.

Data Collection

Information such as patients' age, start age of ED, ED duration, BMI kg/m2, ED diagnoses, and a comorbid mental disorder diagnosis including personality disorder was collected and are presented below in Table 1.

Table 1

Statistical Characteristics of the Sample

	Measure		
Variable	*M*	*SD*	Range
Age (years)	26.9	8.9	17-66
Start age (years)	16.6	5.6	4-55
ED duration (years)	9.7	9.0	0.2-50
BMI (kg/m2)	22.6	7.6	10.2-59
ED diagnose	*N*	*%*	
AN	388	31.7	
BN	266	21.7	
BED	135	11.0	
OSFED	435	35.5	
Comorbid disorder	*N*	*%*	
PD	132	10.8	
MAD	453	37.0	
ND	100	8.2	
TSRD	105	8.6	
SRAD	40	3.3	
Other	36	2.9	

Note. AN = anorexia nervosa; BN = bulimia nervosa; BED = binge eating disorder; OSFED = other specified feeding and eating disorder; PD = personality disorder; MAD = mood and anxiety disorder; ND = neurodevelopmental disorder; TSRD = trauma and stress related disorder; SRAD = substance-related and addictive disorder.

Maladaptive personality trait facets were measured with the Dutch self-report Personality Inventory for DSM-5 (PID-5) according to the dimensional model of personality (Al-Dajani, Gralnick, & Bagby, 2016; Bastiaens et al., 2016). PID-5 is a 220 item self-report questionnaire that measures five broad pathological personality factors (antagonism,

detachment, disinhibition, negative affectivity, and psychoticism) and 25 personality trait facets (DSM-5, 2013). Descriptions of 25 maladaptive personality trat facets can be found in Table 2 below. The items are assessed on a 4-point Likert scale, ranging from 0 (very false or often false) to 3 (very true or often true). Higher scores indicate higher maladaptive personality functioning. The overall internal consistency of the trait facet items was good with Cronbach's Alpha 0.89. Internal consistencies for each trait facet item are presented in Table 2 below.

Table 2

25 Maladaptive Personality Trait Facets, Their Corresponding Labels and Definitions, and Internal Consistencies (DSM-5, 2013)

Label	Description	Meaning	Chronbach's Alpha
Facets (Domain)			
AH (DE)	Anhedonia	Lack of satisfaction from, engagement in, or energy for life's experiences; scarcities in the capacity to feel pleasure and take interest in things.	.883
AN (NA)	Anxiousness	Feelings of nervousness, tenseness, or panic in reaction to various situations; regular worry about the adverse effects of past unpleasant experiences and future negative possibilities; feeling frightful and apprehensive about uncertainty; expecting the worst to happen.	.880
AS (A)	Attention Seeking	Engaging in behavior aimed to attract notice and to make yourself the focus of others' attention and admiration.	.890
CN (AT)	Callousness	Shortage of concern for the feelings or problems of others; lack of guilt or remorse about the damaging effects of one's actions on others.	.888

Label	Description	Meaning	Chronbach's Alpha
Facets (Domain)			
DF (AT)	Deceitfulness	Dishonesty and fraudulence; misrepresentation of self; exaggeration or fabrication when relating events.	.885
DE (DE, NA)	Depressivity	Feelings of being down, miserable, and/or hopeless; difficulty recovering from such states; pessimism about the future; pervasive shame and/or guilt; feelings of inferior self-worth; suicidal cognitions and behaviors.	.881
DS (DI)	Distractibility	The struggle of concentrating and focusing on tasks; attention is easily diverted by extraneous stimuli; difficulty maintaining goal-focused behavior, including each of two planning and completing assignments.	.882
EC (P)	Eccentricity	Odd, unusual, or bizarre behavior, appearance, and/or speech; having strange and unpredictable cognitions; saying uncommon or inappropriate things.	.879
EL (NA)	Emotional Lability	Instability of emotional experiences and mood; emotions that are simply aroused, intense, and/or out of proportion to events and circumstances.	.885
GR (A)	Grandiosity	Believing that one is superior to others and deserves special treatment; self-centeredness; feelings of entitlement; condescension toward others.	.889
HO (NA, A)	Hostility	Persistent or frequent irate feelings; anger or irritability in response to minor slights and insults; mean, unpleasant, or vengeful behavior.	.884
IM (DI)	Impulsivity	Acting on the spur of the moment in response to immediate stimuli; acting on a momentary basis without a plan or consideration of outcomes; difficulty establishing and following plans; a sense of urgency and self-harming behavior under emotional distress.	.888

Label	Description	Meaning	Chronbach's Alpha
Facets (Domain)			
IA (DE)	Intimacy Avoidance	Avoidance of close or romantic relationships, interpersonal attachments, and intimate sexual relationships.	.888
IR (DI)	Irresponsibility	Disregard for and failure to honor financial and other obligations or commitments; lack of respect for and lack of follow-through on agreements and promises; negligence with others' property.	.884
MA (A)	Manipulativeness	Use of subterfuge to influence or control others; use of seduction, charm, glibness, or ingratiation to achieve one's ends.	.888
PD (P)	Cognitive and Perceptual Dysregulation	Odd or unusual thought processes and experiences, including depersonalization, derealization, and dissociative experiences; mixed sleep-wake state experiences; thought-control experiences.	.882
PE (NA)	Perseveration	Persistence at tasks or in a particular way of doing things long after the behavior has ceased to be functional or effective; continuance of the same behavior despite repeated failures or clear reasons for stopping.	.880
RA (NA, DE)	Restricted Affectivity	Little reaction to emotionally arousing situations; constricted emotional experience and expression; indifference and aloofness in normatively engaging situations.	.888
RI (DI)	Rigid Perfectionism	Rigid insistence on everything to be flawless, perfect, and without errors or faults, including one's own and others' performance; sacrificing of timeliness to ensure accuracy in every detail; believing that there is only one right way to do things; the difficulty of changing ideas and/or viewpoint; preoccupation with details, organization, and order.	.887

Label	Description	Meaning	Chronbach's Alpha
Facets (Domain)			
RT (DI)	Risk Taking	Engagement in hazardous, risky, and potentially self-damaging activities, unnecessarily and without regard to consequences; lack of concern for one's limitations and denial of the reality of personal danger; reckless pursuit of goals regardless of the level of risk involved.	.893
SI (NA)	Separation Insecurity	Fears of being alone due to rejection by and/or separation from important ones, based on a lack of confidence in one's ability to care for oneself, both physically and emotionally.	.887
SB (NA)	Submissiveness	Adaptation of one's behavior to the actual or perceived interests and desires of others even when doing so is antithetical to one's interests, needs, or desires.	.889
SU (DE, NA)	Suspiciousness	Expectations of and sensitivity to signs of interpersonal ill-intent or harm; doubts about the fidelity of others; feelings of being mistreated, used, and/or persecuted by others.	.883
UB (P)	Unusual Beliefs and Experiences	A belief that one has atypical abilities, such as mind-reading, telekinesis, thought-action fusion, unusual experiences of reality, including hallucination-like experiences.	.886
WI (DE)	Withdrawal	Preference for being alone to being with others; reticence in social situations; avoidance of social interactions and activities; lack of initiation of social contact.	.883

Note. A = antagonism; DE = detachment; DI = disinhibition; NA = negative affectivity; P = psychoticism (meaning of each trait facet is citated from DSM-5 (2013)).

ED psychopathology (EDP) was measured with the Dutch 36 self-report Eating Disorder Examination (EDE-Q) with the global score (Fairburn & Cooper, 1993). Each item

of EDE-Q measures the frequency of cognitive and behavioral symptoms during the last 28 days on a 7-point Likert scale from zero to six (0 = not 1 day; 6 = every day), with higher scores indicating higher EDP (Berg, 2016). The internal consistency of the global scale was acceptable with Cronbach's Alpha 0.79.

Analysis

The full dataset comprised 1,224 participants without missing data. Number and percentage of study participants by age and ED psychopathology severity groups are presented in Table 3. Age groups were differentiated based on WHO guidelines that define "Youth" as individuals in the 15-24 years age group and "Adult" as the 25+ year age group (WHO, 2018). Two ED psychopathology severity groups were generated below and above the mean score of EDE-Q global norm score (M = 4.02, SD = 1.28) of the ED population (Aardoom, Dingemans, Slof Op't Landt & Van Furth, 2012).

Table 3

Number and percentage of study participants by age and ED psychopathology severity groups

Variables		Measures	
		N	*%*
Age group	Years		
Youth	15 - 24	631	51.6
Adult	25+	593	48.4
EDP severity	EDE-Q global score		
Low	≤ 4.02	496	38.3
High	> 4.02	755	61.7

Note. EDP = eating disorder psychopathology

All network analyses were conducted in R (see Appendix D for the whole R code that was applied in the current study) (R Development Core Team, 2014). Five different networks

(whole sample; youth group; adult group; low ED psychopathology group; high ED psychopathology group) were estimated and visualized using the R-package "qgraph" (Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom, 2012). To estimate partial correlations in the network a gaussian graphical model (GGM) was fitted to the data by using the graphical least absolute shrinkage and selection operator (LASSO) in combination with the Extended Bayesian Information criterion (EBIC) model (Lauritzen and Wermuth, 1989; Foygel & Drton, 2010). This procedure checks which partial correlation coefficients between 25 trait facets are small and non-significant and shrinks those to be precisely zero in the correlation matrix. This results in parsimonious and easier interpretable networks and makes sure that each edge in the network represents a structural relation between two trait facets instead of a spurious one (Costantini et al., 2015; Epskamp, Borsboom, & Fried, 2017).

Although there are several types of centrality measures (e. g., strength, closeness, betweenness), only strength (*S*) centrality has been calculated for each network and plotted with the R package "qgraph". This decision was made according to the conclusion of Bringmann et al (2019) that closeness and betweenness centrality is unsuitable as measures of node importance in psychometric networks. In a personality network, the trait facet with the highest strength centrality is the one that is directly interacting or associated with many other trait facets in the personality network. Furthermore, to test for differences in the estimated network across groups (i.e., youth versus adults, as well as low versus high ED psychopathology groups), network structure and centrality indices were compared using the R package "NetworkComparisonTest" (NCT; Van Borkulo, 2016). Currently, we can answer four questions by using NCT: (1) whether the structure of the network as a whole should be considered as identical or dissimilar across subpopulations, (2) whether there is a significant difference in the strength of a specific edge of interest, (3) whether there is a significant

difference in the strength centrality of a specific node of interest, and (4) whether the overall level of connectivity is equal or significantly unalike across groups (Van Borkulo, 2016).

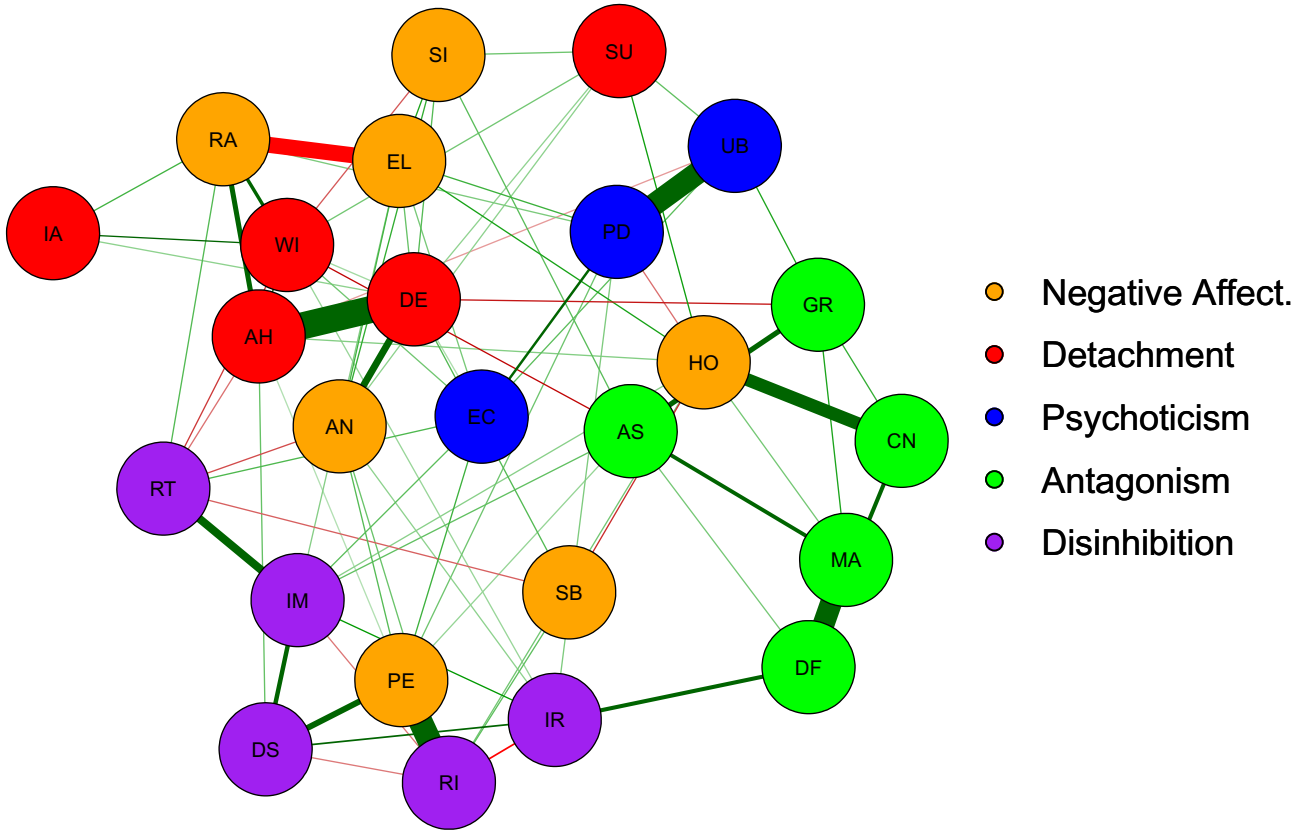
Currently, there are no clear guidelines on the minimum sample size required per parameter when estimating personality network and strength centrality. Therefore, we followed recommendations by Epskamp et al., (2017) to check how accurate (i.e., prone to sampling variation) networks are estimated and how stable (i.e., interpretation remains similar with fewer observations) strength centrality indices are. Network accuracy and stability of strength centrality indices have been checked by using the R-package "bootnet". Firstly, the accuracy of the edge-weights was estimated by drawing bootstrapped 95% confidence intervals (CIs) on the edge-weights with 1000 bootstraps. Then, the stability of strength centrality indices was estimated using the correlation-stability (CS) coefficients (CS-coefficients) with 1000 bootstraps. Strength centrality indices can be considered stable if CS-coefficient is not below 0.25 and is preferably above 0.5 (Epskamp et al., 2017).

Results

The network of the whole study sample (N = 1,224) of ED patients based on 25 PID-5 trait facets is visualized in Figure 2 (see Appendix A Table A1 for the correlation matrix). In general, the network consists of 81 weighted edges, among which positive edges (N = 67) exceed the negative ones (N = 14) approximately five times. All nodes in the network are connected to at least three other nodes, and none of them stand in the network separately, without connections. As you can see in Figure 3, the nodes with the highest node strength centrality were depressivity (S = 1.95), withdrawal (S = 1.40), anhedonia (S = 1.12), and hostility (S = 1.09) (see Appendix A Table A2 for standardized strength centrality coefficients (Z-scores) for the other nodes).

Figure 2

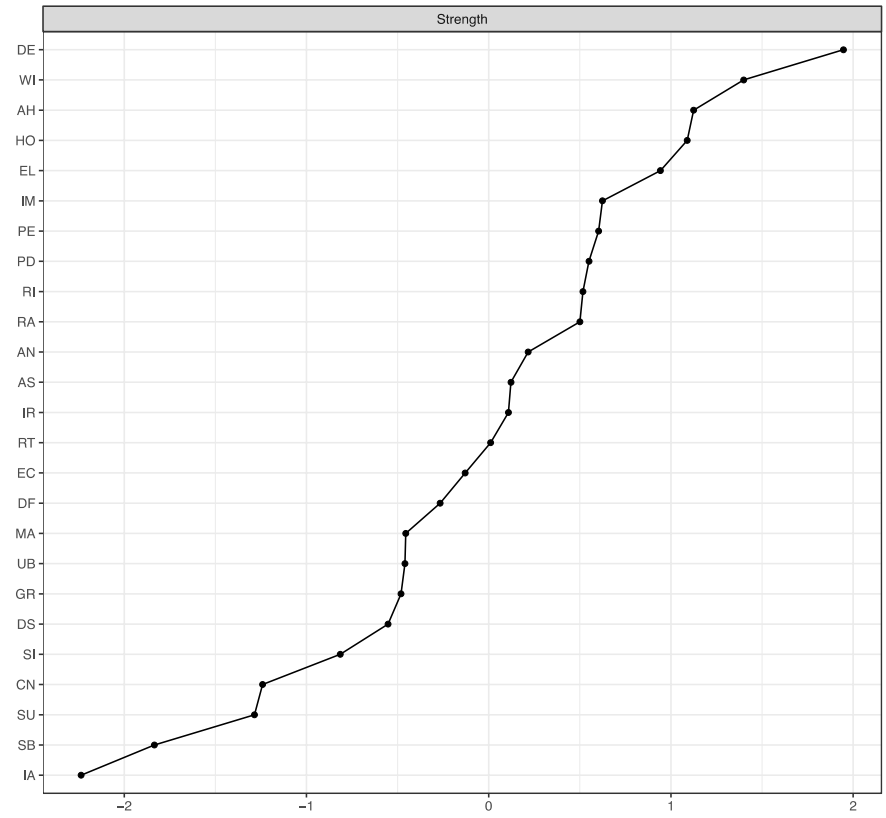
Network of the 25 PID-5 Trait Facets of ED Patients



Note. Facets belonging to the same domain appear in the same color. Green edges represent positive regularized partial correlations between facets, while red edges represent positive regularized partial correlations. As thick the edge is between two nodes as strong the correlation is between them. The description of the nodes can be found in Table 2.

Figure 3

Standardized Strength Centrality Estimates of the 25 PID-5 Trait Facets



Note. There are z-scores instead of raw centrality indices. The higher the z-score is the higher the centrality coefficient is for each trait facet. The description of the nodes can be found in Table 2.

We evaluated the stability of the estimated network and the accuracy of centrality measures. Results are presented in Figure B1 and Figure B2 (see Appendix B). The first plot in Figure B1 (see Appendix B) visualizes the 95% confidence intervals around the edge weights. The edge weight bootstrap revealed that the network is accurately estimated: there is overlap among the 95% CIs of edge weights and the CS-coefficient indicates that the strength centrality (CS (cor = .7) = .59) is stable under different subsamples (see Appendix B Figure B2).

Maladaptive personality networks for the ED patients in youth and adult age groups were estimated and are presented in Figure 6 (see Appendix A Table A3 for the standardized centrality coefficients (*Z*-scores) per node and *P*-values, and Figure A1 for strength centrality plot). The youth ED patients' network is denser with five more non-zero edges (weighted edges) compared to the adult ED patients' network. The youth ED patients' network consists of 58 edges of which eight edges are negative and 50 are positive. The adult network consists of 53 edges. Among those, 8 edges are negative and 45 are positive. The network comparison test indicated that the difference of the network structure of youth and adult ED patients' networks is statistically significant ($p < .05$) (see Appendix C Figure C1 for network structure invariance plot). Specifically, several edges differ significantly. Partial correlation coefficients per edge that differed significantly between the networks of ED patients in youth and adult age groups and p-values are presented in Figure 5, below. The global network strength test revealed no significant differences between the networks of ED patients in youth and adult age groups (youth - $S = 11.68$, adult - $S = 10.33$, $p > .05$) (see Appendix C Figure C3 for global strength invariance plot).

Figure 5

Partial Correlation Coefficients Per Edge in Youth and Adult Age Group of ED Patients that Differ Significantly and P-values

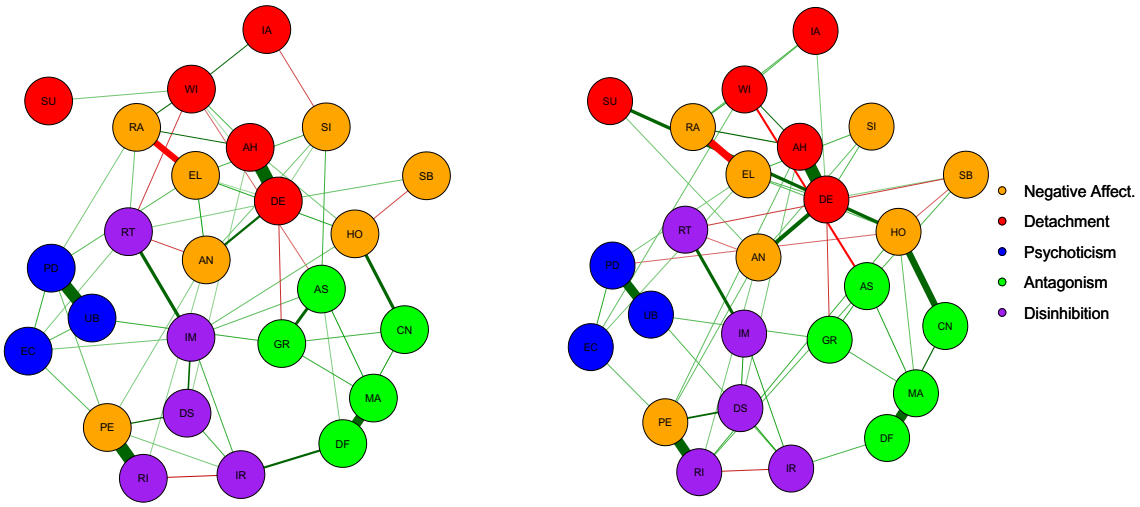
Edge	Youth	Adult	*P*
	r	*r*	
HO – IM	.15	.00	< .05
DF – IR	.27	.16	< .01
AN – EL	.23	.00	< .01
AH – PE	.00	.14	< .01
IR – PE	.13	.00	< .01
HO – RI	.00	.17	< .01
AS – SI	.18	.00	< .05

Edge	Youth	Adult	*P*
	r	*r*	
IA – SI	-.17	.00	< .01
HO – SU	.00	.27	< .01

Note. Edge = correlation between two different nodes. The description of the nodes can be found in Table 2.

Figure 6

Networks of PID-5 25 Trait Facets of ED Patients in Youth and Adult Age Groups



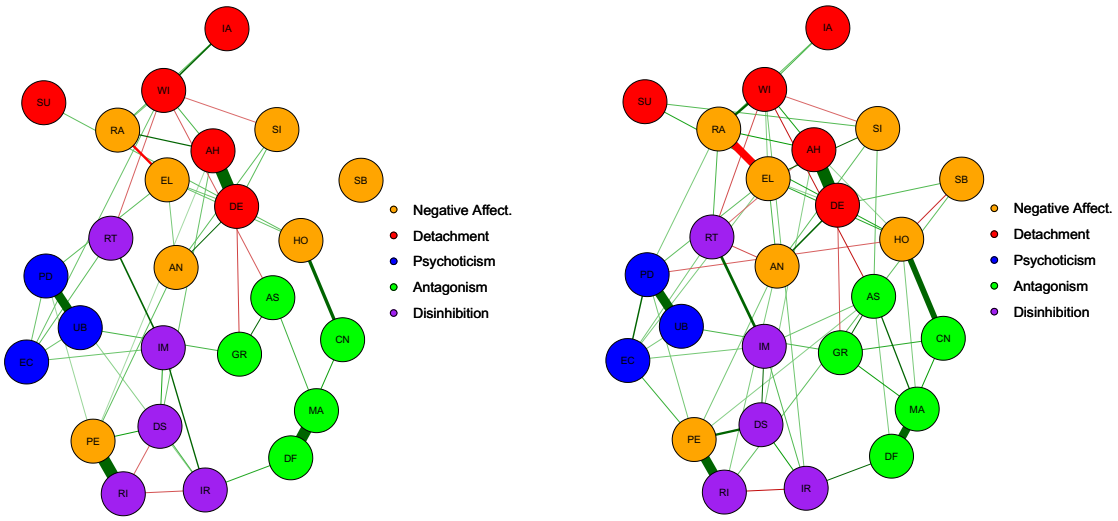
Note. The network on the left side represents patients in the youth age group and the network on the right side represents patients in the adult age group.

Networks for the low and high ED psychopathology groups were also estimated and are presented in Figure 7 (see Appendix A Table A4 for the standardized centrality coefficients (*Z*-scores) per node and *P*-values, and Figure A2 for strength centrality plot). The high ED psychopathology network is denser 23 more non-zero edges compared to the low ED psychopathology network. The low ED psychopathology network has 45 edges and among those, 7 edges are negative and 38 are positive. The high ED psychopathology

network has 68 edges. Among those 10 edges are negative and 58 are positive. However, the NCT indicated that there was no significant difference in the network structure ($p > .05$) nor global strength (low ED psychopathology – $S = 9.78$, high ED psychopathology – $S = 11.66$, $p > .05$) between the networks of the ED patients with low and high ED psychopathology (see Appendix C Figure C2 for network structure invariance plot, and Figure C4 for global strength invariance plot).

Figure 7

Networks of PID-5 25 Trait Facets of ED Patients with Low and High ED psychopathology



Note. The network on the left side represents patients in the low ED psychopathology group and the network on the right side represents patients in the high ED psychopathology group.

Finally, for the results of the NCT to be trustworthy, the accuracy and stability of all of those four networks of youth and adult groups, with low and high ED psychopathology groups, were estimated (for corresponding raw results see Appendix B Figures: B1, B2, B3, B4, B5, B6, B7, B8, B9, B10). The edge weight bootstrap revealed that all networks were relatively accurately estimated. The centrality stability measures showed that the node

strength centrality for all those four networks was relatively stable with the CS-coefficient that was .53 for the youth age group network, .36 for the adult age group network, .36 for the low and high ED psychopathology group networks.

Discussion

The aim of the current study was to investigate the network structure of maladaptive personality trait facets based on the PID-5 in a large sample of ED patients. To the author's knowledge, this is the first study investigating the structure of a maladaptive personality network in such a sample. Additionally, the study explored the following issues: (1) potential differences in network structure between youth and adult age groups of ED patients, and (2) between patients with low and high ED psychopathology. This knowledge could be used to make valuable treatment decisions to improve overall personality of ED patients in terms of aiming those personality trait facets during the treatment that are the most highly connected with all the rest of personality trait facets. The psychometric network approach was used to explore interconnections among maladaptive personality trait facets measured with PID-5.

Regarding the overall interconnectivity of trait facets and the structure of the maladaptive personality network of ED patients, the current study revealed several interesting insights. First, increasing or decreasing one personality trait facet can lead to increasing or decreasing several other personality trait facets due to a lot of positive interconnections in the network of PID-5 personality inventory that measures only maladaptive personal characteristics. This implies that many different personality trait facets together contribute to ED patients' maladaptive personality, and the most of the maladaptive personality trait facets act synchronously and affect each other. It is therefore expected that many different personality trait facets in ED patients can develop in maladaptive way simultaneously. This finding is in line with research done by See et al. (2020) as they found similar results in the maladaptive personality network of healthy adolescents without an ED. The maladaptive

personality network of healthy adolescents also had a lot of correlational associations among its nodes most of which were positive. Positively interconnected maladaptive personality networks in two different samples of ED patients and healthy adolescents may indicate the following. Maladaptive personality trait facets can be well interconnected and influence each other in a way that increasing several maladaptive trait facets can lead to increasing general maladaptive personality functioning regardless of whether the individual has ED. Thus, having a mental disorder, ED, in particular, is not necessary for a maladaptive personality network to be mainly positively interconnected. However, ED patients' network was considerably less interconnected with 2.5 times fewer associations among its nodes (trait facets) compared to healthy adolescents. It may indicate that the maladaptive personality network structure may be different for ED patients and healthy adolescents. However, further research is needed to explore how significantly those two samples differ from each other in the terms of maladaptive personality network structure and interconnectivity.

The current study found four trait facets: depressivity, withdrawal, anhedonia, and emotional lability that had high strength centrality with a mostly positive association to the rest of the trait facets in the network. These findings indicate that depressivity, withdrawal, anhedonia, and emotional lability influence many other facets and perhaps the whole personality functioning in ED patients. So, activating or decreasing depressivity, withdrawal, anhedonia and emotional lability may result in activating or decreasing more trait facets they are connected to as well. Besides, these four trait facets are also very strongly connected to depression, which is one of the most common comorbid mental disorders among ED patients (Farstad et al., 2016). Thus, the high strength centrality of those four trait facets may be one of the factors that are responsible for the common comorbidity among EDs and depressive disorders. Further research may investigate whether high centrality of depressivity,

withdrawal, anhedonia, and emotional lability is responsible or otherwise related to the high comorbidity of depressive disorders among ED patients.

It is also of note that all central trait facets correspond to the same two corresponding trait domains, namely, detachment and negative affectivity. This obvious dominance of detachment and negative affectivity with strength centrality in the network may indicate two things. First, ED patients may face problems in detachment and negative affectivity trait domains. This finding corresponds to the outcome of the study conducted by Dufresne et al., (2020) that revealed that ED patients have a greater propensity for personality trait domains negative affectivity and detachment. Second, because of their high strength centrality and positive associations with the rest of the trait facets in the network, depressivity, withdrawal, anhedonia and emotional lability may have an important impact on the rest of the network. It means that concentrating on those trait facets during the treatment can lead to decreasing other maladaptive trait facets and contribute to more adaptive personality functioning in ED patients.

Regarding the maladaptive personality trait facet of rigid perfectionism, the current study revealed that rigid perfectionism has low strength centrality with few edges related to other trait facets in the network. This result is important considering that rigid perfectionism may have become a target of ED treatment since it is strongly associated with EDs and is significantly increased in ED patients (Wade, O'Shea, & Shafran, 2016). However, the most important, the results of the current study suggest that reduction of rigid perfectionism would not make an important contribution to the improvement of general personal functioning in ED patients, because rigid perfectionism does not have a high strength centrality. In other words, when treated, it does not have the potential to simultaneously reduce other maladaptive personality traits This finding is in line with the outcome of the study conducted by Goldstein et al., (2014) that suggested that adding direct treatment for clinical

perfectionism, did not enhance treatment in ED patients. Therefore, if the main goals of ED treating include improving adaptive personal functioning, then working to reduce rigid perfectionism may not be beneficial and may have only local, rigid perfectionism-oriented outcomes. Further study may investigate and compare treatment outcomes between interventions that specifically target high strength centrality personality trait facets (such as depressvity, withdrawal, anhedonia, hostility) and treatment focused on low strength centrality personality trait facets (such as rigid perfectionism, etc.). This may reveal to what extend strength centrality can predict treatment outcomes, particularly related to improving personality functioning in individuals with EDs.

Another important finding was that rigid perfectionism appeared to be positively correlated with anxiousness in the maladaptive personality network of ED patients. This finding corresponds to the study of Egan et. al., (2013) that found that anxiety is one of the mediating factors between perfectionism and eating pathology in ED patients. In contrast, those two trait facets negatively associated in the maladaptive personality network of healthy adolescents without an ED (See et al., 2020). This difference may be due to different types of perfectionism in different samples. According to Hamachek (1978), perfectionism can be adaptive and maladaptive. The meaning of both types of perfectionism is the same, which involves setting and maintaining higher than normal standards for one's self but are differentiated by the inability of individuals with maladaptive perfectionism to gain a sense of satisfaction from any of their efforts in order to meet their high standards. Conversely, individuals with adaptive perfectionism can gain a sense of satisfaction and pleasure from their intense efforts to meet their high standards. A study by Gnilka, Ashby and Noble (2012) conducted on healthy college students showed that perfectionism was most highly related to high anxiety when it was maladaptive, whereas more adaptive perfectionism was associated with less anxiety. Thus, ED patients may have maladaptive perfectionism, and which may

explain why perfectionism is positively correlated to anxiety in their personality network, whereas in the network of healthy adolescents' perfectionism and anxiousness is negatively associated with each other.

Interestingly, it turned out that the maladaptive personality network structure of youth and adult ED patients differ significantly. It appears that edge-weights that contribute to this notable difference are significantly higher in the youth age group network than in adults. Nine out of eleven edge-weights, that differed remarkably from each other between youth and adult age groups, are presented only in the youth network or are higher in the youth network compared to the adult network. This implies that there is a higher overall connectivity of trait facets in youth network compared to adults' network. This may be interpreted as following. Maladaptive trait facets in the youth network are more interconnected and influenceable onto each other compared to adult network. Thus, activating overall maladaptive personality functioning among youth ED patients may be easier or quicker compared to adult ED patients. Therefore, we can assume that the youth ED patients' group may be at higher risk of developing maladaptive personality compared to the adult ED patients' group. This assumption is supported by the fact that clinically significant personality disorder usually appears during the transition between childhood and adulthood (Chanen, & Thompson, 2019). However, as far as the author is aware, there is no clear information about which age groups, youth or adults, have more rates of personality pathology, particularly in ED patients. Further research may be necessary to investigate if overall connectivity in the maladaptive personality network of ED patients is associated with higher rates of personality pathology in youth patients compared to adult patients.

Strengths and Limitations

The current study is characterized with several strengths. First, there was a large sample size – 1,224 participants – which is essential for the network analysis aiming to

estimate a large number of parameters in a replicable way. Furthermore, we implemented recommendations following a discussion on the network accuracy under-sampling variation by conducting robustness checks (Epskamp et al., 2017). Specifically, we assessed the accuracy of estimated network connections (edge-weights) and the stability of strength centrality indices using the bootstrapped difference test with 1000 sub-samples and the correlation stability coefficient. These steps increased confidence in the replicability of the estimated network structure, indicating that the findings were robust although validation in another sample is preferable. Second, PID-5 trait facets were used instead of items in the network, potentially increasing the reliability of our findings (See et al., 2020).

Despite some strengths, there were a number of limitations that need to be taken into account when interpreting the results. First, measuring maladaptive personality traits with only a self-report questionnaire is limited because of the absence of additional information from various informants. Limitations can be due to the self-representation and social desirability biases of the participant. Second, the current study estimated a cross-sectional network in a sample with EDs such as AN, BN, BED, and OSFED, although there are other ED types as well. Therefore, our results may not be generalizable to the ED population in general. Third, two more extreme categories of EDE-Q global scores would be preferable to consider as indicators of low and high ED psychopathology. Those categories could contain, for example, scores that are at least one score higher than the norm mean EDE-Q global score indicating high ED psychopathology, and scores that are minimum one score below the norm mean EDE-Q global score indicating low ED psychopathology. The number of participants in those categories was very low and insufficient to generate networks. Consequently, to create two different groups of low and high ED psychopathology, a cut-off was done on the norm score of EDE-Q global score. Lower than norm score has been considered as low ED psychopathology and higher than norm score has been considered as high ED

psychopathology. This division may contain some inaccuracies that can lead to a Type II error. It means that no significant structural differences between low and high ED psychopathology participants' maladaptive personality networks may be false negative. However, future studies with more participants can overcome this limitation and compare networks of two groups with more extreme scores, as suggested above.

Conclusion

The present study showed that maladaptive personality trait facets of ED patients are highly interconnected through mainly positive associations. Centrality, a unique feature of network analysis, has been explored, and depressivity, withdrawal, hostility, and anhedonia were found to be the most central trait facets with the highest strength centrality in the maladaptive personality network of ED patients. Also, rigid perfectionism, strongly associated with EDs and often being addressed during ED treatments, was found to be less important in the terms of strength centrality in the maladaptive personality network of ED patients. In addition, a significant difference in the network structure was found between youth and adult ED patients. Generally, youth ED patients' maladaptive personality network was more interconnected compared to the adult ED patients' network. However, there were no significant differences in global strength and overall network centrality between youth and adult ED patients. Similarly, no significant differences in network structure, global strength of the network, and network centrality were found between ED patients with low and high ED psychopathology. Overall, the findings of this study were found to be an interesting new insight in analysing ED patients' maladaptive personality network in terms of more or less influential trait facets. The findings of this study were found to be a potentially valuable additional information to improve ED patients' maladaptive personality functioning. The findings of this study may guide future research and treatment focused on high central trait facets and ED maintenance or ED treatment outcomes.

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Appendix A

Table A1

Partial Correlations among 25 PID-5 Trait Facets in the Whole ED Patients' Sample

	AH	AN	AS	CN	DF	DE	DS	EC	EL	GR	HO	IM	IA	IR	MA	PD	PE	RA	RI	RT	SI	SB	SU	UB
AH	0.00	0.00	0.00	0.00	0.00	0.48	0.12	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.06	0.24	0.00	0.00	0.00	0.00	0.00	-0.08
AN	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.13	0.00	0.11	0.00	0.00	0.00	0.00	0.00
AS	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.24	0.00	0.12	0.00	0.00	0.23	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CN	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.16	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DF	0.00	0.00	0.11	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DE	0.48	0.26	0.00	0.00	0.00	0.00	0.00	0.06	0.12	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00
DS	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.20	0.00	0.00	0.25	0.00	-0.10	0.00	0.00	0.00	0.00	0.00
EC	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.10	0.00	0.00	0.13	0.00	0.00	0.00	0.21	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.13
EL	0.00	0.14	0.00	0.00	0.00	0.12	0.00	0.10	0.00	0.00	0.18	0.09	0.00	0.00	0.00	0.15	0.00	-0.36	0.00	0.00	0.00	0.00	0.00	0.00
GR	0.00	0.00	0.24	0.16	0.00	-0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
HO	0.09	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.09	0.00	0.00	0.11	-0.11	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00
IM	0.00	0.00	0.12	0.00	0.00	0.00	0.23	0.13	0.09	0.00	0.09	0.00	0.00	0.19	0.00	0.00	0.00	0.00	-0.10	0.00	0.00	0.00	0.00	0.00
IA	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00
IR	0.00	0.09	0.00	0.00	0.23	0.00	0.20	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.10	0.00	0.00	-0.20	0.00	0.00	0.00	0.00	0.00
MA	0.00	0.00	0.23	0.00	0.42	0.00	0.00	0.00	0.00	0.17	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.15	0.00	-0.11	0.00	0.00	0.10	0.00	0.00	0.11	0.10	0.00	0.00	0.00	0.00	0.00	0.43
PE	0.06	0.13	0.08	0.00	0.00	0.00	0.25	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00
RA	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.36	0.00	0.00	0.00	0.15	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RI	0.00	0.11	0.00	0.00	0.00	0.00	-0.10	0.00	0.00	0.00	0.11	-0.10	0.00	-0.20	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RT	0.11	0.14	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00
SI	0.00	0.16	0.13	0.00	0.00	0.13	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SB	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	-0.12	0.00	0.00	0.00	0.00
SU	0.00	0.09	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.12
UB	-0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00
WI	0.20	0.00	-0.19	0.00	0.00	0.07	0.00	0.11	0.00	0.00	0.00	0.00	0.20	0.08	0.00	0.00	0.00	0.22	0.00	-0.15	-0.13	0.00	0.11	0.00

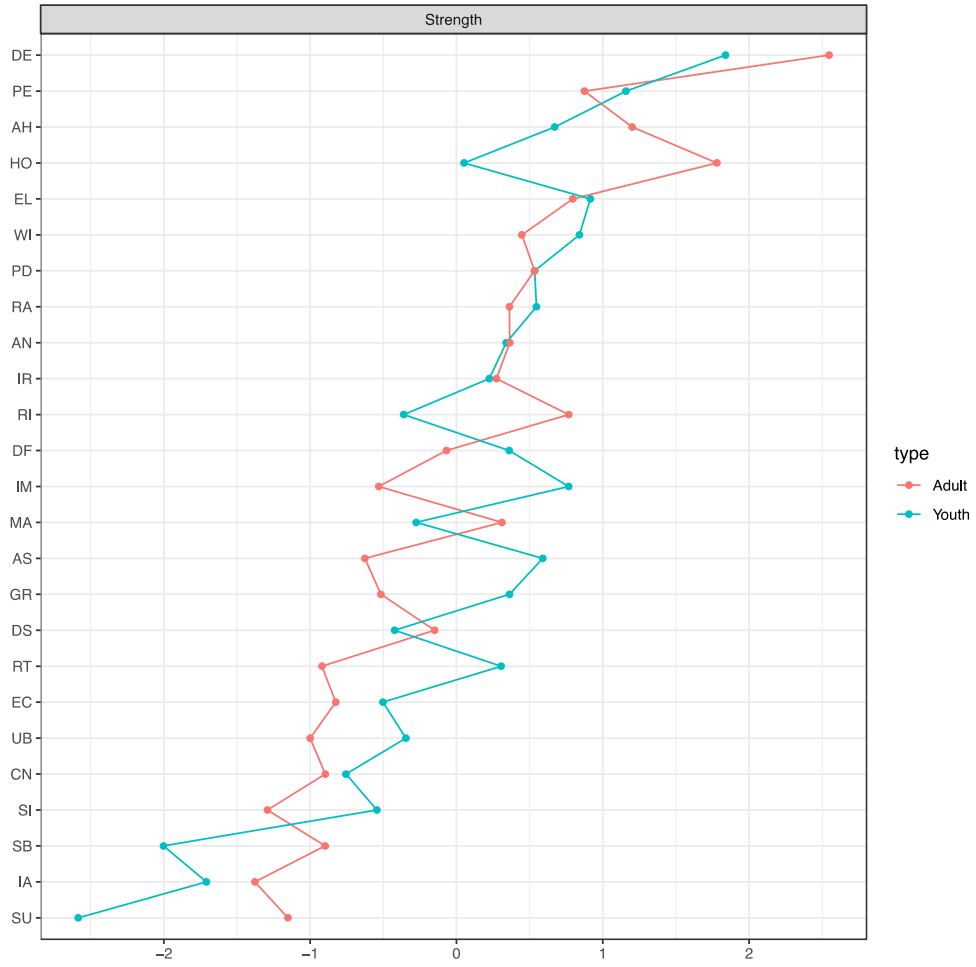
Table A2

Standardized Strength Centrality Estimates Per Node for all ED Patients' Sample

Trait facet	Z-score
Anhedonia	1.12445686
Anxiousness	0.21648542
Attention Seeking	0.12206261
Callousness	-1.24067837
Deceitfulness	-0.26674235
Depressivity	1.94681841
Distractibility	-0.55212846
Eccentricity	-0.12886006
Emotional Lability	0.94245455
Grandiosity	-0.48115231
Hostility	1.08917009
Impulsivity	0.62423439
Intimacy Avoidance	-2.23654945
Irresponsibility	0.10821454
Manipulativeness	-0.45524260
Cognitive & Perceptual Dysregulation	0.55022708
Perseveration	0.60340827
Restricted Affectivity	0.50056931
Rigid Perfectionism	0.51712597
Risk Taking	0.01053142
Separation Insecurity	-0.81438987
Submissiveness	-1.83447607
Suspiciousness	-1.28537502
Unusual Believes	-0.45952496
Withdrawal	1.39936061

Figure A1

Standardized Centrality Estimates of the 25 PID-5 Trait Facets for Youth and Adult Age Groups



Note. There are z-scores instead of raw centrality indices. The higher the z score is the higher the centrality coefficient is for each trait facet.

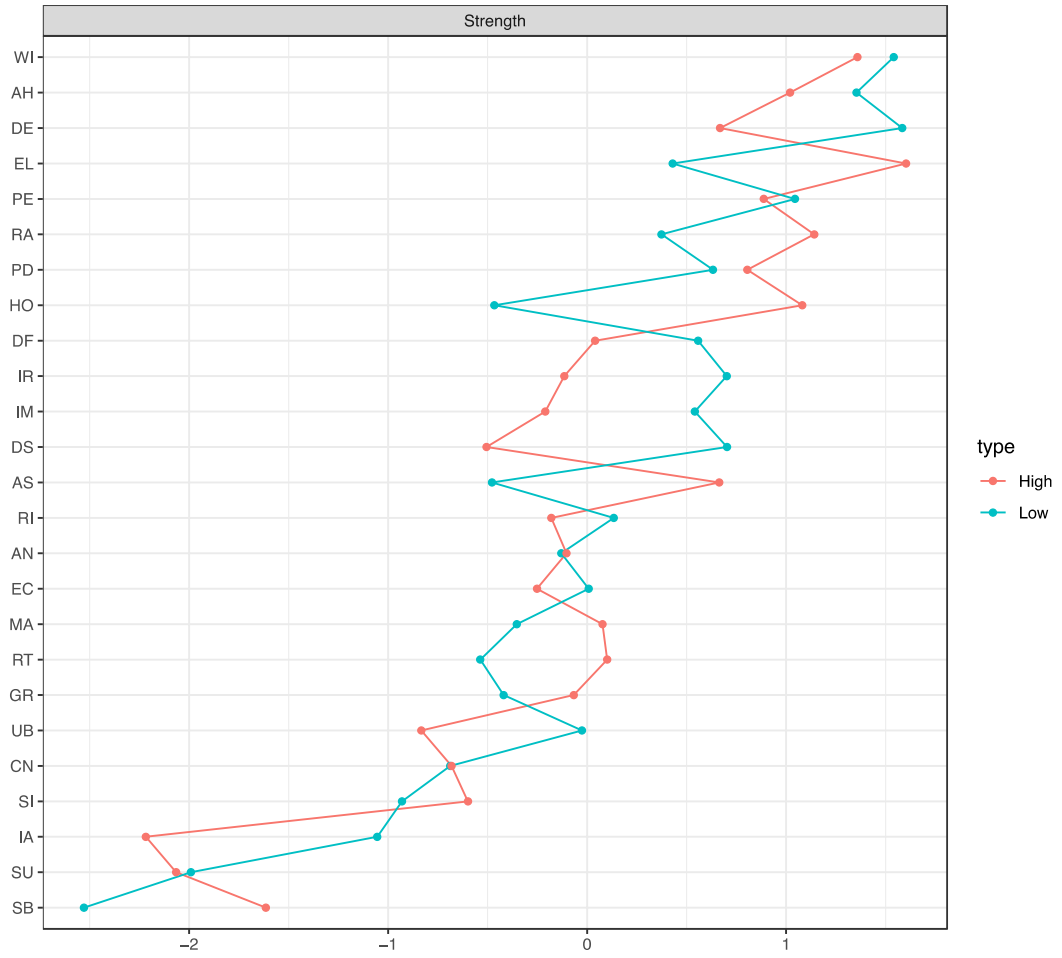
Table A3

Standardised Strength Centrality Coefficients and P-Values Per Node for the Youth and Adult ED Patients

	Z-score		
Trait facet	Youth	Adult	P-Value
Anhedonia	0.67133697	1.20087117	0.85
Anxiousness	0.33997818	0.36434988	0.50
Attention Seeking	0.58983081	-0.62592028	0.10
Callousness	-0.75511068	-0.89642684	0.55
Deceitfulness	0.36011236	-0.06799628	0.15
Depressivity	1.83871938	2.54643071	0.90
Distractibility	-0.42333242	-0.14989939	1.00
Eccentricity	-0.50254719	-0.82521848	0.50
Emotional Lability	0.91519722	0.79479187	0.25
Grandiosity	0.36249038	-0.51645608	0.05
Hostility	0.05176209	1.77984506	0.30
Impulsivity	0.76634201	-0.53175536	0.00
Intimacy Avoidance	-1.70924657	-1.37823921	0.95
Irresponsibility	0.22399639	0.27273922	0.50
Manipulativeness	-0.27561177	0.31072746	0.65
Cognitive & Perceptual Dysregulation	0.53427451	0.53353552	0.80
Perseveration	1.15850952	0.87459250	0.20
Restricted Affectivity	0.54609750	0.36180530	0.45
Rigid Perfectionism	-0.36051848	0.76719232	0.40
Risk Taking	0.30522989	-0.91946176	0.15
Separation Insecurity	-0.54426486	-1.29246813	0.25
Submissiveness	-2.00264039	-0.89772595	0.50
Suspiciousness	-2.58558909	-1.15197051	0.10
Unusual Believes	-0.34545271	-1.00017404	0.05
Withdrawal	0.84043695	0.44683130	0.65

Figure A2

Standardized Strength Centrality estimates of the 25 PID-5 Trait Facets for Low and High EDP (ED psychopathology) Groups



Note. There are z-scores instead of raw centrality indices. The higher the z score is the higher the centrality coefficient is for each trait facet.

Table A4

Standardized Strength Centrality Coefficients and P-Values Per Node for the Low and High Eating Disorder Psychopathology Study Samples

	Z - score		
Trait facet	Low EDP	High EDP	P-Value
Anhedonia	1.353695960	1.01977026	1.00
Anxiousness	-0.129873789	-0.10371503	0.65
Attention Seeking	-0.478472615	0.66389431	0.10
Callousness	-0.688273113	-0.68143384	0.30
Deceitfulness	0.557742596	0.03991517	0.95
Depressivity	1.583593810	0.66778594	0.65
Distractibility	0.702755456	-0.50590330	0.25
Eccentricity	0.007869530	-0.25218091	0.75
Emotional Lability	0.429770596	1.60286072	0.05
Grandiosity	-0.419820289	-0.06706721	0.15
Hostility	-0.465945404	1.08124994	0.10
Impulsivity	0.541278840	-0.21031163	0.70
Intimacy Avoidance	-1.054593548	-2.21794954	0.35
Irresponsibility	0.701860774	-0.11468441	0.65
Manipulativeness	-0.353280659	0.07735782	0.05
Cognitive & Perceptual Dysregulation	0.632545363	0.80507519	0.55
Perseveration	1.044444153	0.88763491	0.75
Restricted Affectivity	0.373725370	1.14092237	0.05
Rigid Perfectionism	0.133909318	-0.17992219	0.80
Risk Taking	-0.536973039	0.10077326	0.45
Separation Insecurity	-0.930677382	-0.59913841	0.50
Submissiveness	-2.528791688	-1.61434758	0.10
Suspiciousness	-1.990772534	-2.06536207	0.45
Unusual Believes	-0.026127522	-0.83372689	0.70
Withdrawal	1.540409814	1.35850313	0.85

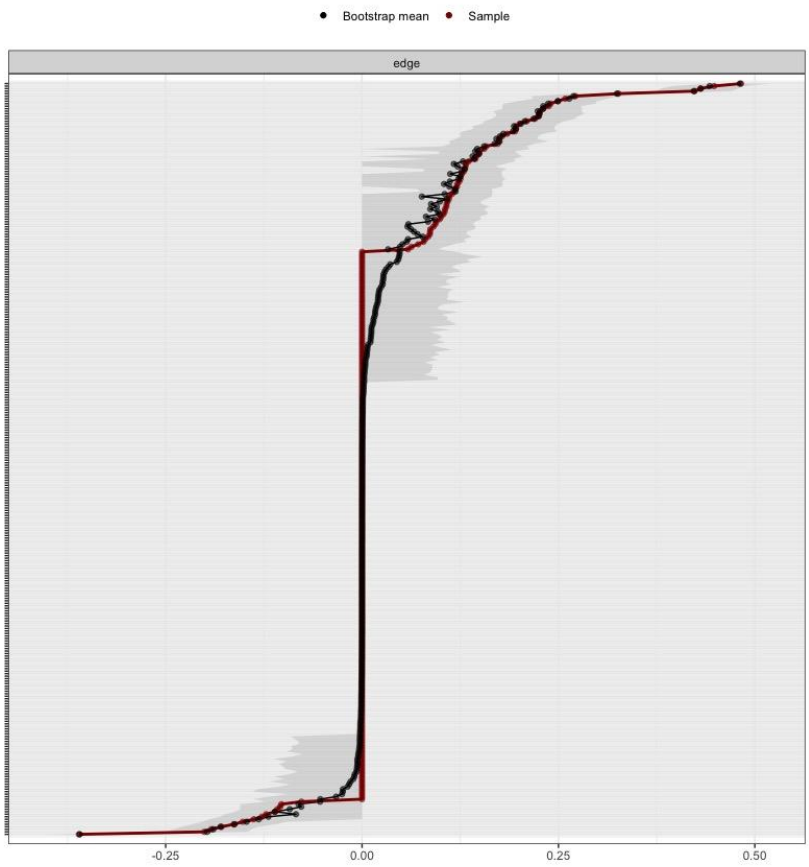
Appendix B (Robustness checks for subsamples)

1) Stability and robustness of the edge weight estimates by drawing bootstrapped 95% confidence intervals (CIs); if 1000 different subsamples within the larger sample have estimates that do not change too much (i.e., narrower CIs), it is likely that estimates are representative for current sample (Figure B1, Figure B3, Figure B5, Figure B7).

2) Robustness of the centrality measures by generating robustness coefficients, with values above >.50 considered robust (Epskamp et al., 2017) (Figure B2, Figure B4, Figure B6, Figure B8).

Figure B1

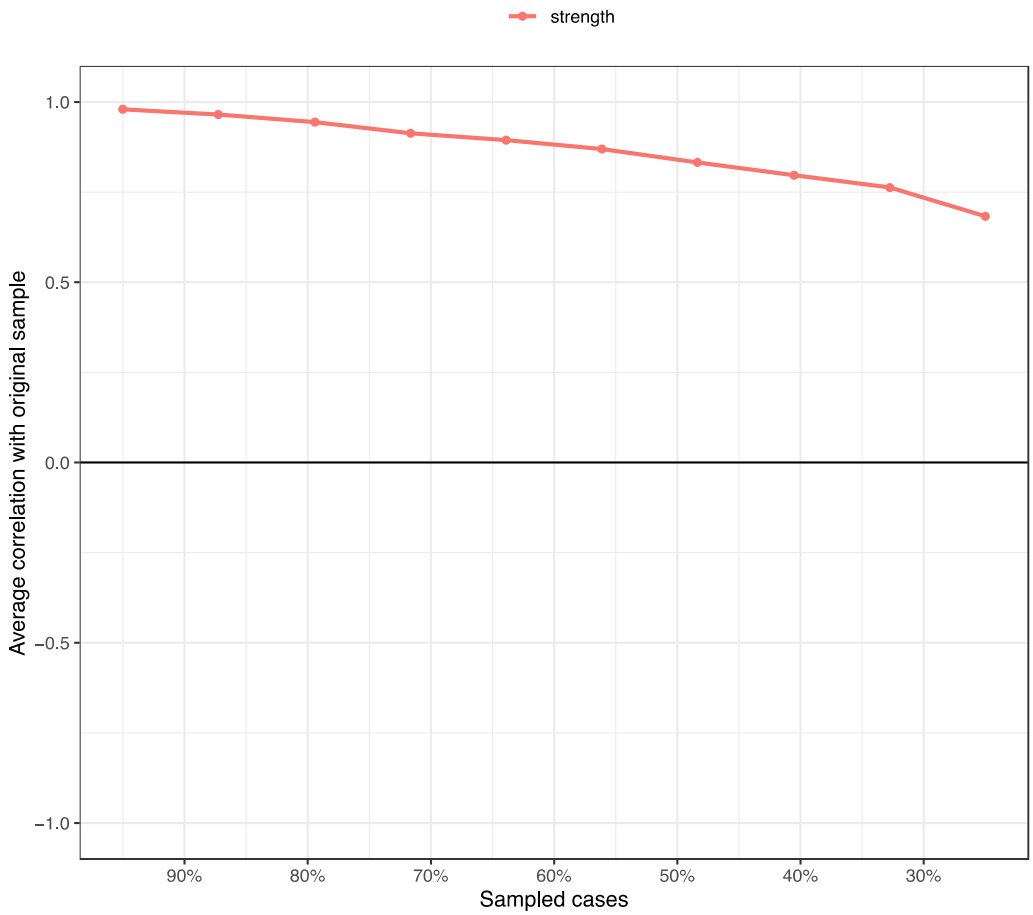
Bootstrapped Confidence Intervals of Estimated Edge-weights for the Estimated Network of PID-5 Trait Facets



Note. The red line indicates the sample values and the grey area the bootstrapped CIs. Each horizontal line represents one edge of the network, ordered from the edge with the highest edge-weight to the edge with the lowest edge-weight. The y-axis labels have been removed to avoid cluttering. Narrower CIs are the more steady and robust estimation of the edge weights.

Figure B2

Robustness of the Centrality Measures of the ED Patients' Maladaptive Personality Network



Note. Robustness of the centrality measures that shows average correlations between centrality measures in the original network with the centrality of sampled networks. In those sampled networks, participants are randomly dropped. If the correlation is strong after dropping a high percentage of participants, the original network's centrality measures can be considered robust.

Figure B3

Stability of the Edge-weights of the Youth ED Patients' Maladaptive Personality Network

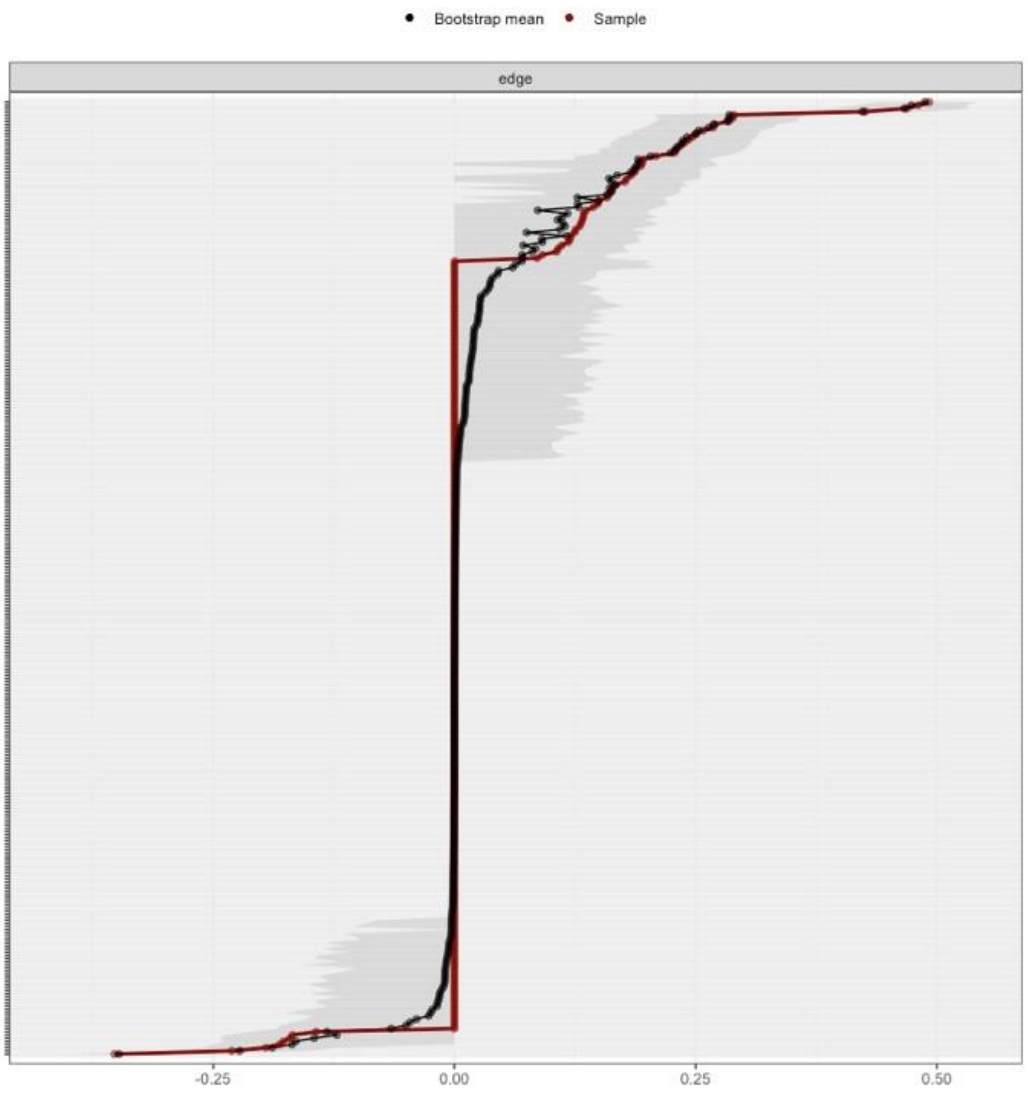


Figure B4

Robustness of the Centrality Measures of the youth ED Patients' Maladaptive Personality Network

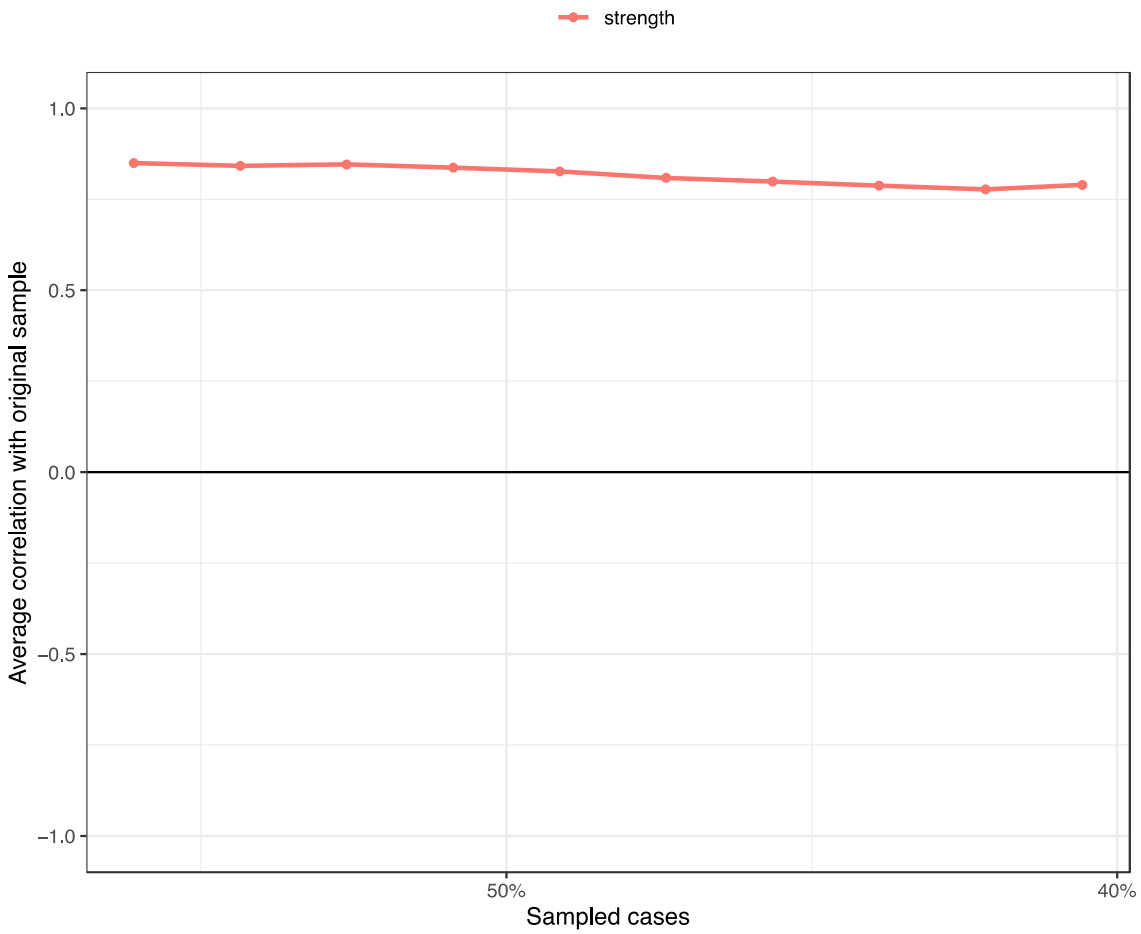


Figure B5

Stability of the Edge-weights of the Adult ED Patients' Maladaptive Personality Network

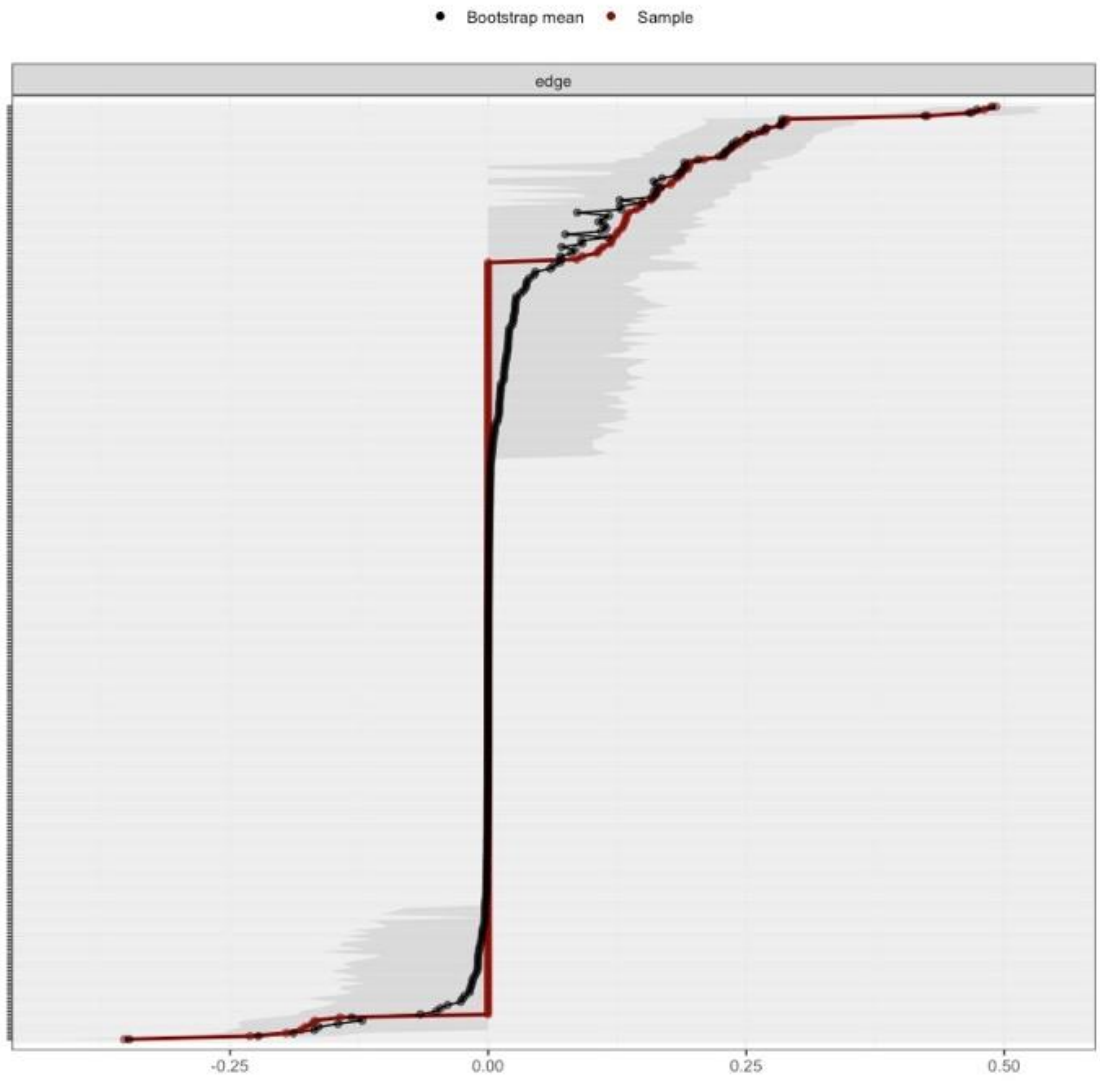


Figure B6

Robustness of the Centrality Measures of the adult ED Patients' Maladaptive Personality Network

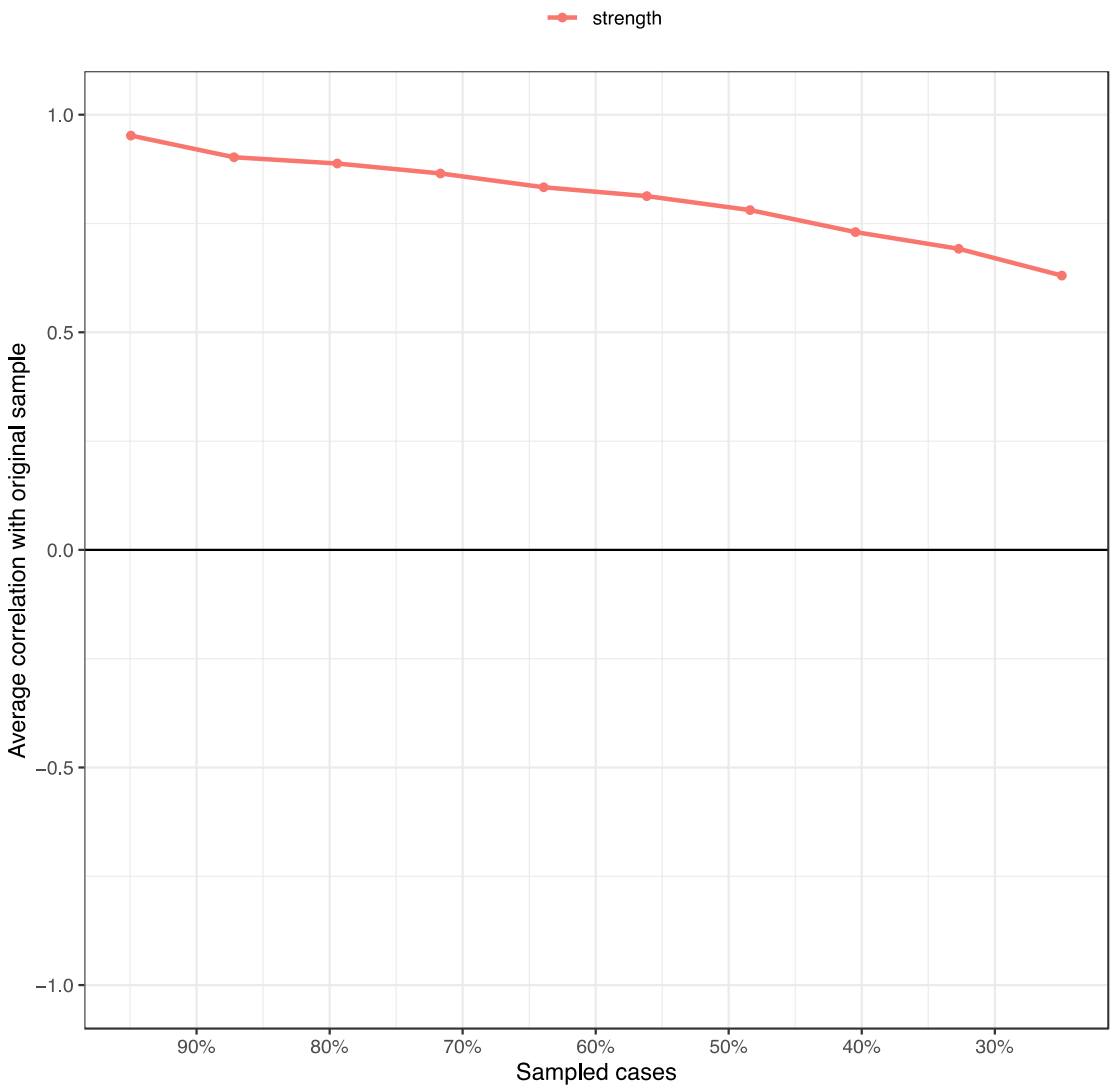


Figure B7

Stability of the Edge-weights of the Maladaptive Personality Network of ED Patients with the Low ED Psychopathology

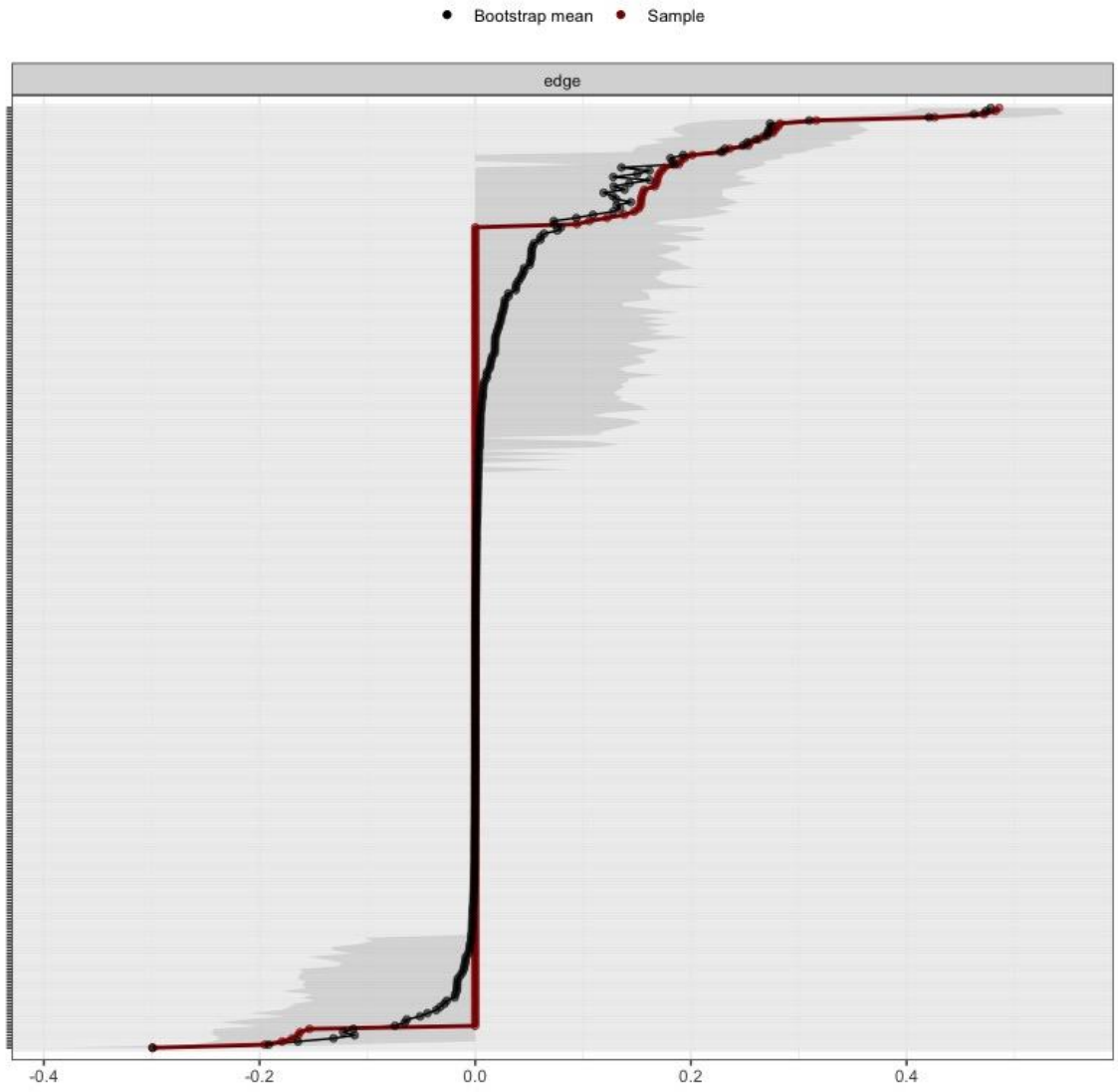


Figure B8

Robustness of Centrality Measures for the Maladaptive Personality Network of ED Patients with the Low ED Psychopathology

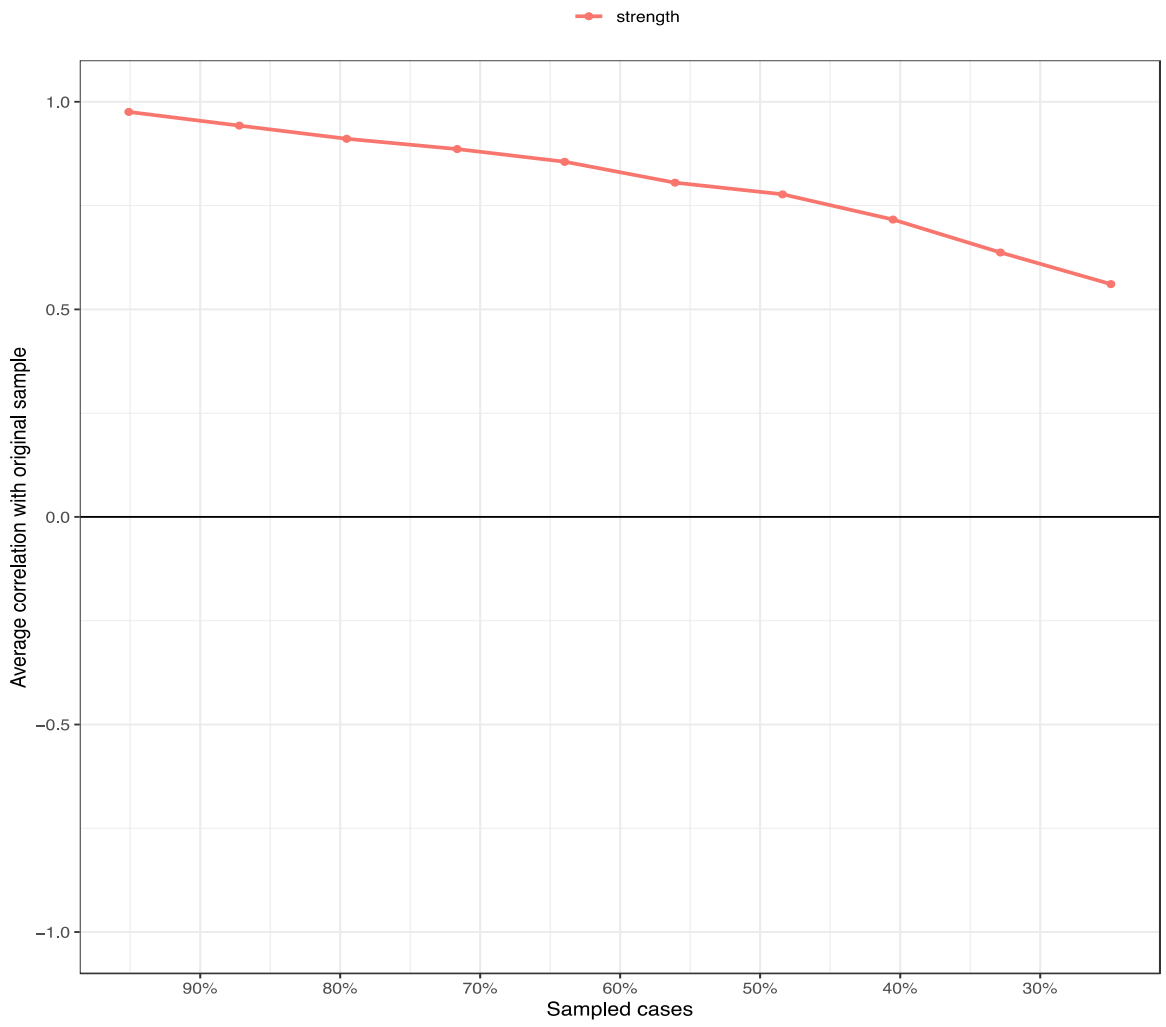


Figure B9

Stability of the Edge-weights of the Maladaptive Personality Network of ED Patients with the High ED Psychopathology

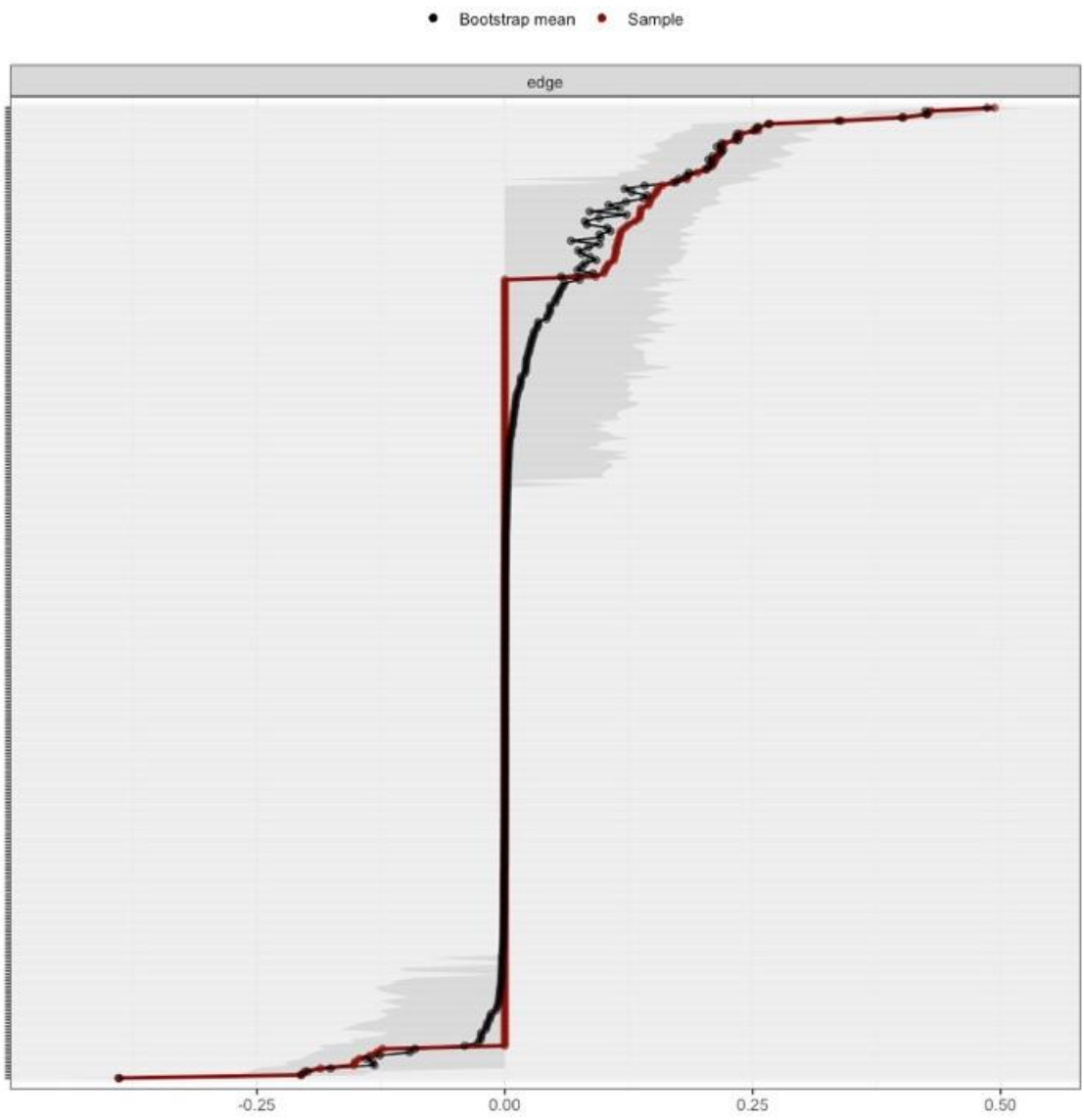
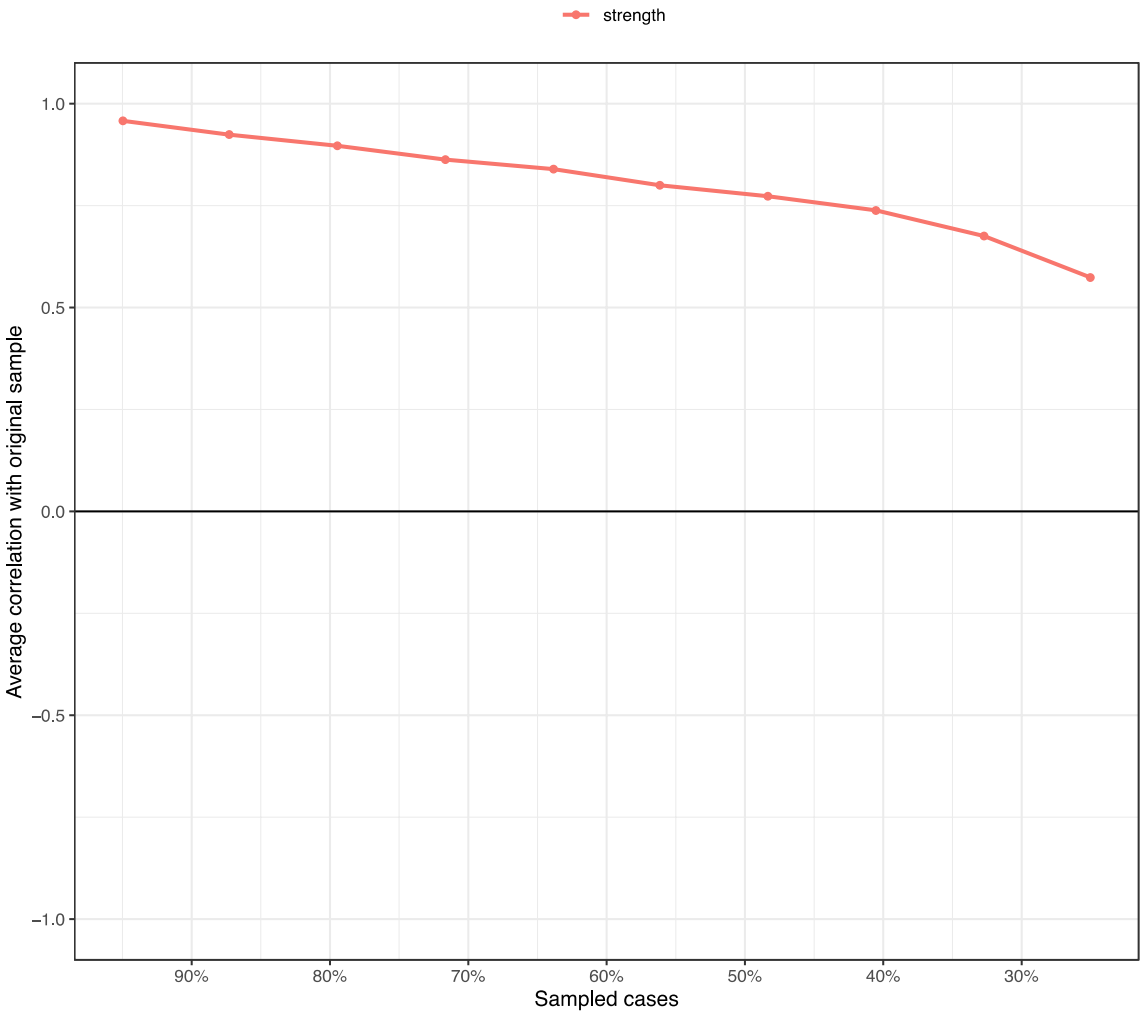


Figure B10

Robustness of Centrality Measures for the Maladaptive Personality Network of ED Patients with the High ED Psychopathology



Appendix C (the Network Comparison Test)

Network Structure Invariance

Networks, and between the networks of ED patients with the low and high ED psychopathology was tested with the network structure invariance using the package network comparison test (NCT) in R statistics (Van Borkulo, 2016). There was a statistically significant difference in the overall structure between the youth and adult patients' networks ($M = .27$, $p < .05$, see figure C1). There was not statistically significant difference in the overall structure of the networks of the ED patients with the low and high ED psychopathology ($M = .22$, $p > .05$, see figure C2).

Figure C1

Network structure invariance for the networks of the youth and adult ED patients

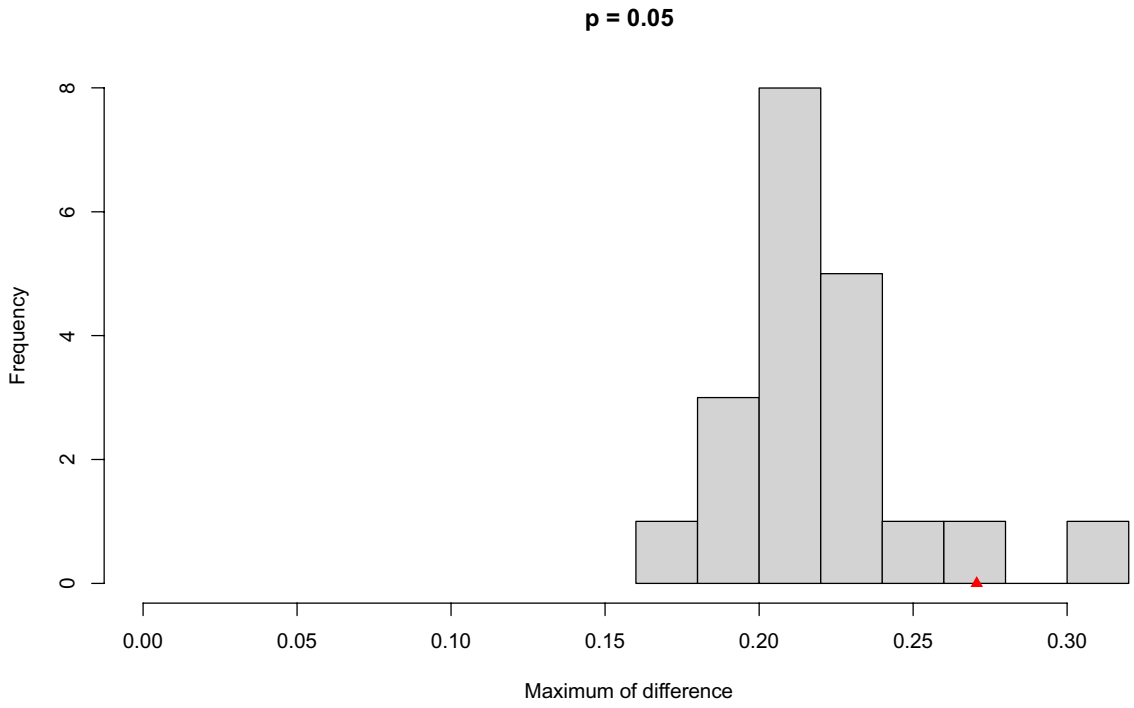
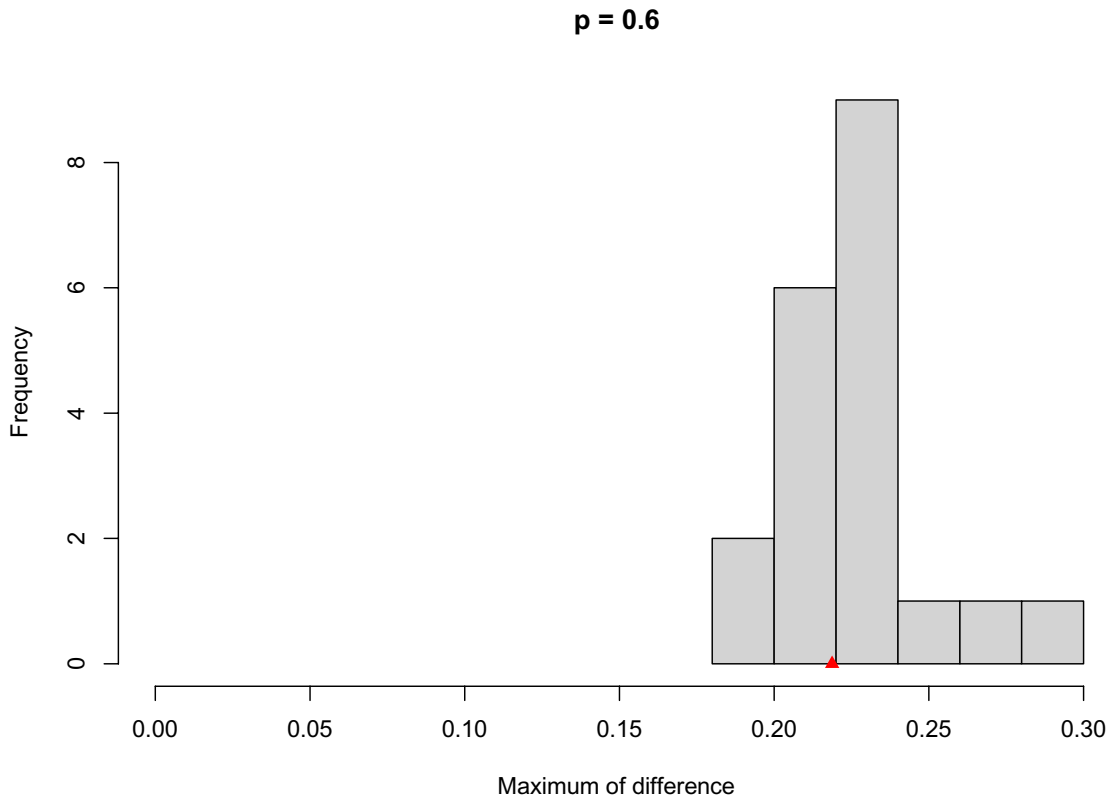


Figure C2

Network structure invariance for the networks of the ED patients with the low and high ED psychopathology



Global Strength Invariance

Difference in the global strength between the networks of youth and adult ED patients, and between the networks of ED patients with the low and high ED psychopathology was tested with the global strength invariance in the NCT package in R statistics. There was no significant difference in the global strength between the youth (S = 11.68) and adult (S = 10.33) network (S = 1.35, p > ,05, see figure C3). There was also no significant difference in the global strength between the networks of the ED patients with the low (S = 9.78) and high (S = 11.67) ED psychopathology (S = 1.89, p > ,05, see figure C4).

Figure C3

Global strength invariance for the networks of the youth and adult ED patients

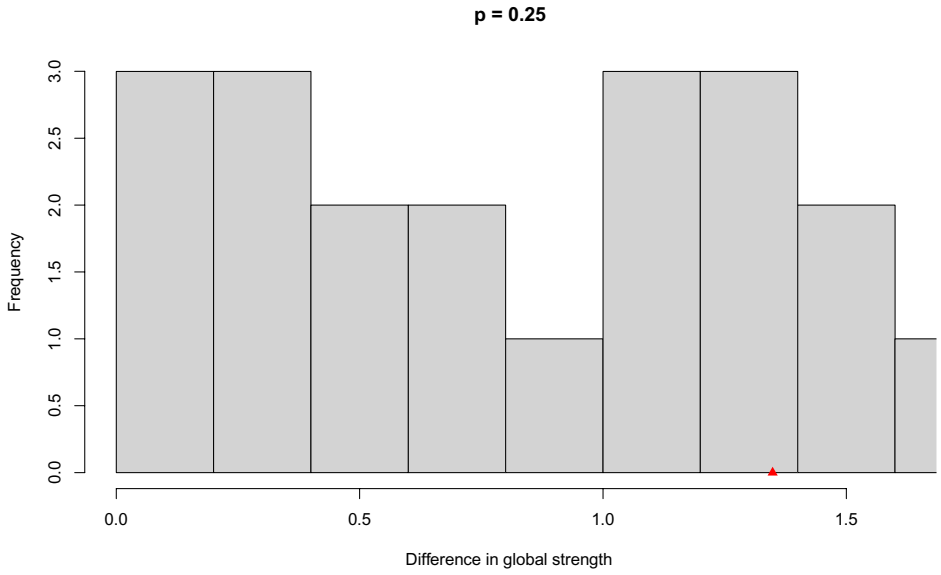
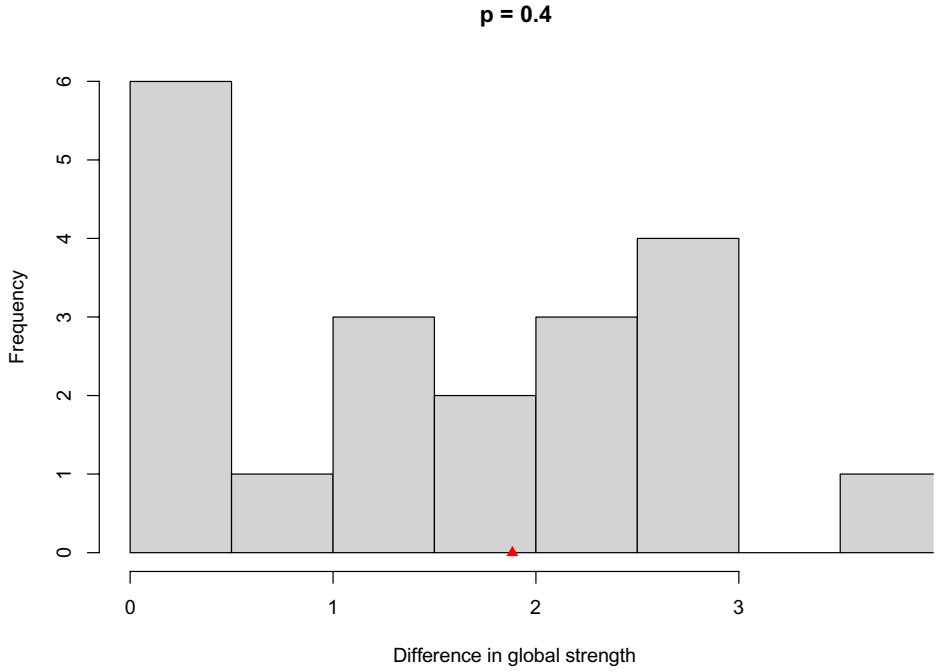


Figure C4

Global strength invariance for the networks of the ED patients with the low and high ED psychopathology



Appendix D (R code)

Uncovering the Structure of Maladaptive Personality in Patients with Eating Disorder: Complementing Network Analysis for the 220-item Personality Inventory for DSM-5 (PID-5)

1) Network of 25 PID-5 personality trait facets in full sample, and separately for youth and adults, and for low and high eating disorder psychopathology)

2) Strength centrality measures

3) Network robustness and centrality stability

4) Compare networks of youth and adult eating disorder patients

5) Compare networks of eating disorder patients with low and high eating disorder psychopathology

Load packages

```
library(psych)
library(ggplot2)
library(summarytools)
library(corrplot)
library(rpart)
library(rpart.plot)
library(haven)
library(varImp)
library(lavaan)
library(qgraph)
library(mlVAR)
library(bootnet)
library(igraph)
library(reshape)
library(glasso)
```

```
library(NetworkComparisonTest)


### DATA

# delete all data that is currently loaded in the R environment

rm(list= ls ())


## Read in SPSS data file

setwd("~/Desktop")


# read full data

Gvantsa <- read_sav("Gvantsa.sav")


# see summary of data variables


View(dfSummary(Gvantsa))


# change variable's names for PID-5 items

colnames(Gvantsa)[colnames(Gvantsa)=="AnhedoniaPID5.1"] <- "AH"  #Anhedonia (DE)

colnames(Gvantsa)[colnames(Gvantsa)=="AnxiousnessPID5.1"] <- "AN"  #Anxiousness (NA)

colnames(Gvantsa)[colnames(Gvantsa)=="AttentionseekPID5.1"] <- "AS"  #Attentionseek (AN)

colnames(Gvantsa)[colnames(Gvantsa)=="CallousnessPID5.1"] <- "CN"  #Callousness (AT)

colnames(Gvantsa)[colnames(Gvantsa)=="DeceitfulnessPID5.1"] <- "DF"  #Deceitfulness (AT)


colnames(Gvantsa)[colnames(Gvantsa)=="DepressivityPID5.1"] <- "DE"  #Depressivity (DE)

colnames(Gvantsa)[colnames(Gvantsa)=="DistractabilityPID5.1"] <- "DS"  #Distractability (DI)

colnames(Gvantsa)[colnames(Gvantsa)=="EccentricityPID5.1"] <- "EC"  #Eccentricity (PT)

colnames(Gvantsa)[colnames(Gvantsa)=="EmoLabPID5.1"] <- "EL"  #EmoLab (NA)
```

```
colnames(Gvantsa)[colnames(Gvantsa)=="GrandiosityPID5.1"] <- "GR"  #Grandiosity (AN)

colnames(Gvantsa)[colnames(Gvantsa)=="HostilityPID5.1"] <- "HO"  #Hostility (NA)
colnames(Gvantsa)[colnames(Gvantsa)=="ImpulsivityPID5.1"] <- "IM"  #Impulsivity (DI)
colnames(Gvantsa)[colnames(Gvantsa)=="IntimityAvPID5.1"] <- "IA"  #IntimityAv (DE)
colnames(Gvantsa)[colnames(Gvantsa)=="IrresponsibilityPID5.1"] <- "IR"  #Irresponsibility (DI)
colnames(Gvantsa)[colnames(Gvantsa)=="ManipulativenessPID5.1"] <- "MA"  #Manipulativeness (AN)

colnames(Gvantsa)[colnames(Gvantsa)=="PerceptDysregPID5.1"] <- "PD"  #PerceptDysreg (PS)
colnames(Gvantsa)[colnames(Gvantsa)=="PerseverationPID5.1"] <- "PE"  #Perseveration (NA)
colnames(Gvantsa)[colnames(Gvantsa)=="RestrAffectivityPID5.1"] <- "RA"  #RestrAffectivity (NA)
colnames(Gvantsa)[colnames(Gvantsa)=="RigPerfectionismPID5.1"] <- "RI"  #RigPerfectionism (DI)
colnames(Gvantsa)[colnames(Gvantsa)=="RiskTakingPID5.1"] <- "RT"  #RiskTaking (DI)

colnames(Gvantsa)[colnames(Gvantsa)=="SepInsecurityPID5.1"] <- "SI"  #SepInsecurity (NA)
colnames(Gvantsa)[colnames(Gvantsa)=="SubmissivenessPID5.1"] <- "SB"  #Submissiveness (NA)
colnames(Gvantsa)[colnames(Gvantsa)=="SuspiciousnessPID5.1"] <- "SU"  #Suspiciousness (DE)
colnames(Gvantsa)[colnames(Gvantsa)=="UnusualbelandexpPID5.1"] <- "UB"  #Unusualbelandexp (PS)
colnames(Gvantsa)[colnames(Gvantsa)=="WithdrawalPID5.1"] <- "WI"  #Withdrawal (DE)

# Excluding data that is not related to PID-5 items
excl_vars <- names(Gvantsa[c(1:233, 259:376 )])
dataset_study <- Gvantsa[,!(names(Gvantsa) %in% excl_vars)]

# See summary of data concerning PID-5
view (dfSummary(dataset_study))

# Specify group (trait domain) membership for each PID-5 item (trait facet level)
```

```
group <- list(c(2,9,11,17,18,21,22), c(1,6,13,23,25), c(8,16,24), c(3,4,5,10,15), c(7,12,14,19,20))
names(group)=c("Negative Affect.","Detachment", "Psychoticism", "Antagonism", "Disinhibition")
names = colnames(dataset_study)

# Estimate network of 25 trait facets of all sample of ED patients
set.seed(1)
Tot_network <- qgraph(input = cor_auto(dataset_study), groups=group, layout ="spring", graph =
"EBICglasso", legend = TRUE, sampleSize = nrow(dataset_study), threshold = TRUE, filetype = ".png", esize =
11, color=c("orange", "red", "blue", "green", "purple"))
Layout <- averageLayout(Tot_network)

# Show the number of edges and edge-weight measures (partial correlation per connection)
summary(Tot_network)
print(Tot_network)

# Calculating strength centrality of the network of all sample of ED patients
centralityPlot((Tot_network), include = "Strength", orderBy="Strength", scale="z-scores")
centralityTable(Tot_network)
cor_auto(dataset_study, detectOrdinal = TRUE, ordinalLevelMax = 7, npn.SKEPTIC = FALSE, forcePD =
FALSE, missing = "pairwise", verbose = TRUE)

# Stability analysis of the network of all ED patients' sample
# EBICglasso
set.seed(123)
TotNW <-estimateNetwork(dataset_study, corMethod = "cor_auto",  default = "EBICglasso", threshold =
TRUE)
```

Edge-weight accuracy of the network of all ED patients' sample *(Edge weight accuracy was estimated by drawing 1000 bootstraps to construct 95% confidence intervals around the edge weights)*

```
set.seed(123)
boot1 <- bootnet(TotNW, statistics = "edge", nBoots = 1000, nCores = 4)
plot(boot1, labels = FALSE, order = "sample")
summary(boot1)
View(boot1)
print(boot1)
```

Centrality stability of the network of all ED patients' sample *(A stability test was estimated on strength centrality by using the correlation-stability (CS) coefficient with 1000 bootstraps. The CS coefficient gives an estimate of the maximum number of cases that can be omitted from the dataset, so that with 95% probability the correlation between original centrality indices and recalculated indices of networks based on subsets is 0.7 (default) or higher)*

```
set.seed(123)
boot2 <- bootnet(TotNW, nBoots = 1000, statistics = "Strength", type = "case", nCores = 4)
corStability(boot2, cor = 0.7, statistics = "all", verbose = TRUE)
print(boot2)
plot(boot2)
plot(boot2, labels = TRUE, statistics = "Strength")
summary(boot2)
```

Create new datasets according age group for youth and adult ED patients' samples

Create new dataset of youth ED patients' sample and exclude data not related to PID-5 items

```
youth_netw <- Gvantsa
youth_netw <- subset(youth_netw, Agegroup== 1)
```

```
excl_vars <- names(youth_netw[c(1:233, 259:376)])
youth_netw <- youth_netw[,!(names(youth_netw) %in% excl_vars)]
```

Estimate network of 25 trait facets of youth ED patients' sample

```
set.seed(1)
Youth_NW <- qgraph(input = cor_auto(youth_netw), groups=group, layout=Layout, graph = "EBICglasso",
legend = TRUE, sampleSize = nrow(youth_netw), threshold = TRUE,  esize = 20, color=c("orange", "red",
"blue", "green", "purple"), theme = "classic")
Layout <- averageLayout(Youth_NW)
```

Calculating strength centrality of the network of youth ED patients' sample

```
centralityPlot((Youth_NW), include = "Strength", orderBy="Strength", scale="z-scores")
centralityTable(Youth_NW)
```

Stability analysis of the network of youth ED patients' sample

EBICglasso *(youth ED patients' sample)*

```
set.seed(123)
Youth_NW <-estimateNetwork(youth_netw, corMethod = "cor_auto",  default = "EBICglasso", threshold =
TRUE)
```

Edge-weight accuracy of the network of youth ED patients' sample *(Edge weight accuracy was estimated by drawing 1000 bootstraps to construct 95% confidence intervals around the edge weights)*

```
set.seed(123)
boot_youth1 <- bootnet(Youth_NW, statistics = "edge", nBoots = 1000, nCores = 4)
plot(boot_youth1, labels = FALSE, order = "sample")
summary(boot_youth1)
print(boot_youth1)
```

Centrality stability of the network of youth ED patients' sample *(A stability test was estimated on strength centrality by using the correlation-stability (CS) coefficient with 1000 bootstraps. The CS coefficient gives an estimate of the maximum number of cases that can be omitted from the dataset, so that with 95% probability the correlation between original centrality indices and recalculated indices of networks based on subsets is 0.7 (default) or higher)*

```
set.seed(123)
boot_youth2 <- bootnet(Youth_NW, statistics = "strength", nBoots = 1000, type = "case", nCores = 4, caseMin = 0.439, caseMax = 0.595)
corStability(boot_youth2, cor = 0.7, statistics = "strength", verbose = TRUE)
print(boot_youth2)
plot(boot_youth2)
```

Create new dataset of adult ED patients' sample and exclude data not related to PID-5 items

```
adult_netw <- Gvantsa
adult_netw <- subset(adult_netw, Agegroup== 2)
excl_vars <- names(adult_netw[c(1:233, 259:376)])
adult_netw <- adult_netw[,!(names(adult_netw) %in% excl_vars)]
```

Estimate network of 25 trait facets of adult ED patients' sample

```
set.seed(1)
Adult_NW <- qgraph(input = cor_auto(adult_netw), groups=group, layout=Layout, graph = "EBICglasso", legend = TRUE, sampleSize = nrow(adult_netw), threshold = TRUE,  esize = 20, color=c("orange", "red", "blue", "green", "purple"), theme = "classic")
```

Calculating strength centrality of the network of adult ED patients' sample

```
centralityPlot((Adult_NW), include = "Strength", orderBy="Strength", scale="z-scores")
centralityTable(Adult_NW)
```

Two results for youth and adult ED patients' samples in one centrality plot

```
centralityPlot(list(Youth=Youth_NW, Adult=Adult_NW), orderBy = "Strength", print = TRUE)
centralityTable(Youth_NW, Adult_NW)
```

Stability analysis of the network of adult ED patients' sample

EBICglasso *(adult ED patients' sample)*

```
set.seed(123)
Adult_NW <-estimateNetwork(adult_netw, corMethod = "cor_auto",  default = "EBICglasso", threshold =
TRUE)
```

Edge-weight accuracy of the network of adult ED patients' sample *(Edge weight accuracy was estimated by drawing 1000 bootstraps to construct 95% confidence intervals around the edge weights)*

```
set.seed(123)
boot_adult1 <- bootnet(Adult_NW, statistics = "edge", nBoots = 1000, nCores = 4)
plot(boot_youth1, labels = FALSE, order = "sample")
summary(boot_adult1)
print(boot_adult1)
```

Centrality stability of the network of adult ED patients' sample *(A stability test was estimated on strength centrality by using the correlation-stability (CS) coefficient with 1000 bootstraps. The CS coefficient gives an estimate of the maximum number of cases that can be omitted from the dataset, so that with 95% probability the correlation between original centrality indices and recalculated indices of networks based on subsets is 0.7 (default) or higher)*

```
set.seed(123)
boot_adult2 <- bootnet(Adult_NW, statistics = "strength", nBoots = 1000, type = "case", nCores = 4)
corStability(boot_adult2, cor = 0.7, statistics = "strength", verbose = TRUE)
```

```
print(boot_adult2)
plot(boot_adult2, statistics = "strength")

# Compare networks of youth and adult ED patients' samples
set.seed(123)
youthadult <- NetworkComparisonTest::NCT(Youth_NW, Adult_NW, it = 20, binary.data = FALSE, paired =
FALSE, test.edges = TRUE, edges = "all", progressbar = TRUE, test.centrality = TRUE, centrality = "strength",
nodes = "all")

# Statistics and plot network structure invariance
plot(youthadult, what="network")
plot(youthadult, what="strength")
plot(youthadult, what="centrality")
plot(youthadult, what="edge")
summary(youthadult)
print(youthadult)

# Create new datasets according severity of eating disorder psychopathology for two ED
sample with low and high severity eating disorder psychopathology
# Create new dataset of ED patients' sample with low severity eating disorder
psychopathology and exclude data not related to PID-5 items
low_netw <- Gvantsa
low_netw <- subset(low_netw, GlobCat== 1)
excl_vars <- names(low_netw[c(1:233, 259:376)])
low_netw <- low_netw[,!(names(low_netw) %in% excl_vars)]

# Estimate network of 25 trait facets of ED patients' sample with low severity eating disorder
psychopathology
set.seed(1)
```

```
Low_NW <- qgraph(input = cor_auto(low_netw), groups=group, layout=Layout, graph = "EBICglasso", legend
= TRUE, sampleSize = nrow(low_netw), threshold = TRUE,  esize = 20, color=c("orange", "red", "blue",
"green", "purple"), theme = "classic")
Layout2 <- averageLayout(Low_NW)
```

Calculating strength centrality of the network of ED patients' sample with low severity eating disorder psychopathology

```
centralityPlot((Low_NW), include = "Strength", orderBy="Strength", scale="z-scores")
centralityTable(Low_NW)
```

Stability analysis of the network of ED patients' sample with low severity eating disorder psychopathology

EBICglasso *(sample of ED patients with low severity eating disorder psychopathology)*

```
set.seed(123)
Low_NW <-estimateNetwork(low_netw, corMethod = "cor_auto",  default = "EBICglasso", threshold = TRUE)
```

Edge-weight accuracy of the network of ED patients' sample with low severity eating disorder psychopathology *(Edge weight accuracy was estimated by drawing 1000 bootstraps to construct 95% confidence intervals around the edge weights)*

```
set.seed(123)
boot_low1 <- bootnet(Low_NW, statistics = "edge", nBoots = 1000, nCores = 4)
plot(boot_low1, labels = FALSE, order = "sample")
summary(boot_low1)
print(boot_low1)
```

Centrality stability of the network of ED patients' sample with low severity eating disorder psychopathology *(A stability test was estimated on strength centrality by using the correlation-stability (CS) coefficient with 1000 bootstraps. The CS coefficient gives an*

estimate of the maximum number of cases that can be omitted from the dataset, so that with 95% probability the correlation between original centrality indices and recalculated indices of networks based on subsets is 0.7 (default) or higher)

```
set.seed(123)
boot_low2 <- bootnet(Low_NW, statistics = c("strength"), nBoots = 1000, type = "case", nCores = 4)
print(boot_low2)
plot(boot_low2, statistics = "strength")
corStability(boot_low2, cor = 0.7, statistics = "all", verbose = TRUE)
```

Create new dataset of ED patients' sample with high severity eating disorder psychopathology and exclude data not related to PID-5 items

```
high_netw <- Gvantsa
high_netw <- subset(high_netw, GlobCat== 2)
excl_vars <- names(high_netw[c(1:233, 259:376)])
high_netw <- high_netw[,!(names(high_netw) %in% excl_vars)]
```

Estimate network of 25 trait facets of ED patients' sample with high severity eating disorder psychopathology

```
set.seed(1)
High_NW <- qgraph(input = cor_auto(high_netw), groups=group, layout =Layout, graph = "EBICglasso",
legend = TRUE, sampleSize = nrow(high_netw), threshold = TRUE,  esize = 20, color=c("orange", "red",
"blue", "green", "purple"), theme = "classic")
```

Calculating strength centrality of the network of ED patients' sample with high severity eating disorder psychopathology

```
centralityPlot((High_NW), include = "Strength", orderBy="Strength", scale="z-scores")
centralityTable(High_NW)
```

Two results for samples of ED patients with low and high severity eating disorder pscyhopathology in one centrality plot

```
centralityPlot(list(Low=Low_NW, High=High_NW), orderBy = "Strength", print = TRUE)
centralityTable(Youth_NW, Adult_NW)
```

Stability analysis of the network of ED patients' sample with high severity eating disorder psychopathology

EBICglasso *(sample of ED patients with high severity eating disorder psychopathology)*

```
set.seed(123)
High_NW <-estimateNetwork(high_netw, corMethod = "cor_auto",  default = "EBICglasso", threshold = TRUE)
```

Edge-weight accuracy of the network of ED patients' sample with low severity eating disorder psychopathology *(Edge weight accuracy was estimated by drawing 1000 bootstraps to construct 95% confidence intervals around the edge weights)*

```
set.seed(123)
boot_high1 <- bootnet(High_NW, statistics = "edge", nBoots = 1000, nCores=4)
plot(boot_high1, labels = FALSE, order = "sample")
summary(boot_an1)
print(boot_an1)
```

Centrality stability of the network of ED patients' sample with high severity eating disorder psychopathology *(A stability test was estimated on strength centrality by using the correlation-stability (CS) coefficient with 1000 bootstraps. The CS coefficient gives an estimate of the maximum number of cases that can be omitted from the dataset, so that with 95% probability the correlation between original centrality indices and recalculated indices of networks based on subsets is 0.7 (default) or higher)*

```
set.seed(123)
```

```
boot_an2 <- bootnet(High_NW, statistics = c("strength"), nBoots = 1000, type = "case", nCores=4)
corStability(boot_an2, statistics = "all")
print(boot_an2)
plot(boot_an2, statistics = "strength")
```

Compare networks of two samples of ED patients with low and high severity eating disorder psychopathology

```
set.seed(123)
lowhigh <- NetworkComparisonTest::NCT(Low_NW, High_NW, it = 20, binary.data = FALSE, paired = FALSE, test.edges = TRUE, edges = "all", progressbar = TRUE, test.centrality = TRUE, centrality = "strength", nodes = "all")
```

Statistics and plot network structure invariance

```
plot(lowhigh, what="network")
plot(lowhigh, what="strength")
plot(lowhigh, what="centrality")
plot(lowhigh, what="edge")
summary(lowhigh)
print(lowhigh)
```