Life meaning and feelings of ineffectiveness as transdiagnostic factors in eating disorder and comorbid internalizing symptomatology – A combined undirected and causal network approach

Franziska Schutzeichel a, b, Lourens J. Waldorp b, Marije aan het Rot a, Klaske Glashouwer a, c, Mirjam I. Frey a, Reinout W. Wiers d, Peter J. de Jong a

a Department of Clinical Psychology and Experimental Psychopathology, University of Groningen, the Netherlands
b Department of Psychological Methods, University of Amsterdam, the Netherlands
c Department of Eating Disorders, Accare Child and Adolescent Psychiatry, Groningen, the Netherlands
d Department of Developmental Psychology, University of Amsterdam, the Netherlands

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ABSTRACT

The field of eating disorders is facing problems ranging from a suboptimal classification system to low long-term success rates of treatments. There is evidence supporting a transdiagnostic approach to explain the development and maintenance of eating disorders. Meaning in life has been proposed as a promising key transdiagnostic factor that could potentially not only bridge between the different eating disorder subtypes but also explain frequent co-occurrence with symptoms of comorbid psychopathology, such as anxiety and depression. The present study used self-report data from 501 participants to construct networks of eating disorder and comorbid internalizing symptomatology, including factors related to meaning in life, i.e., presence of life meaning, perceived ineffectiveness, and satisfaction with basic psychological needs. In an undirected network model, it was found that ineffectiveness is a central node, also bridging between eating disorder and other psychological symptoms. A directed network model displayed evidence for a causal effect of presence of life meaning both on the core symptomatology of eating disorders and depressive symptoms via ineffectiveness. These results support the notion of meaning in life and feelings of ineffectiveness as transdiagnostic factors within eating disorder symptomatology in the general population.

Eating disorders are severe mental disorders characterized by disturbed food-related and body image-related thoughts and behaviors. Epidemiological studies suggest that the lifetime prevalence of eating disorders lies between 1 and 2% in the general population depending on the specific disorder, with increased occurrence for those under the age of 45 years as compared to older individuals (Qian et al., 2013, 2022; Smink et al., 2012). Simulation studies even indicate that the lifetime prevalence of any eating disorder ranges between 14 and 20% (Ward et al., 2019). Patients suffer from a high burden based on, e.g., fertility and general health issues, impaired cognitive and social functioning, and decreased quality of life, which also has a strong impact on caregivers (van Hoeken & Hoek, 2020). These issues are further amplified by the additional comorbidity with other mental disorders, such as anxiety and depression (Vervaet et al., 2021). Treatment options are limited in their effectiveness, causing a detrimental problem due to the almost doubled mortality in individuals with eating disorders relative to the general population (van Hoeken & Hoek, 2020). This underscores the need for improved insight into the working mechanisms of the disorder.

A dire need for a better understanding of eating disorders is also visible in the current classification system. First, disorders belonging to the eating disorder spectrum show heterogeneity in symptoms within diagnostic categories. For example, some patients with Anorexia Nervosa (AN) only show restricted eating, while others also show binging and purging behaviors (Vervaet et al., 2021). Second, patients frequently migrate between supposedly discrete diagnoses, e.g., a drop in body weight could lead from a diagnosis of Bulimia Nervosa (BN) to a diagnosis of AN. A third limitation of the current categorization of eating disorders is the high proportion of unspecific diagnoses: 30–60% of patients are diagnosed with an Other Specified Feeding or Eating Disorder (OSFED; Forbush et al., 2016). Relatedly, there are many common

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factors across the diagnoses, like preoccupation with weight and shape or attempts to restrain food intake, hinting at similar underlying mechanisms in all eating disorder diagnoses. In sum, heterogeneity within eating disorder diagnoses, patients moving from being diagnosed with one eating disorder to another, and the non-specificity of eating disorder symptoms all pose problems for both research and clinical work.

Research has therefore begun to examine eating disorder psychopathology from a transdiagnostic perspective, which rejects the idea of distinct diagnostic categories and often also incorporates other, comorbid symptoms (cf. Solmi et al., 2018; Vervae et al., 2021). The transdiagnostic cognitive-behavioral theory of eating disorders (CBT-E model; Fairburn et al., 2003b) conceptualizes all eating disorders to have the same underlying psychopathology. An overevaluation of eating, body weight, and shape and control thereover is considered as a core onset and maintenance factor within eating disorders that leads to intense concerns about weight, shape, and eating. This core pathology then interacts with restraint, binge eating, and compensatory behaviors, such as excessive workouts or laxative use (Fairburn et al., 2003b). These core symptoms are proposed to be maintained through four additional factors that are present to a varying degree in patients, namely low self-esteem, perfectionism, difficulties with emotion regulation, and interpersonal problems (e.g., Kästner et al., 2019).

One transdiagnostic factor across the spectrum of mental disorders that has become more prominent recently is meaning in life. Many definitions of meaning in life include concepts such as an experienced sense of coherence, and purpose in life, or well-being (cf. Chu et al., 2020; Marco et al., 2019; Tagay et al., 2014). A low sense of meaning in life has been found to be strongly associated with a variety of psychological factors, including depression and anxiety (Goodman et al., 2018), as well as with a preoccupation with weight and negative eating attitudes (Marco et al., 2017). To explain the relevance of meaning in life in relation to psychopathology further, it has been proposed that meaning in life might help enhance self-control: Evidence indicates that it is easier for an individual to regulate their behavior when there is a feeling of meaning, and when related life goals are clear (Hooker & Masters, 2018). With a sense of meaning in life, unhealthy incentives might be discarded more easily during decision making (Hoorelbeke et al., 2016).

The Meaning-Making Model of Eating Disorders (MMMED; Marco et al., 2020) postulates that when sources of meaning in life from other domains are lacking, such as friends, school, and family, eating- and weight-regulation serve as a short-term substitutional source of life meaning. In the long term, however, this behavior does not provide a positive and satisfying goal engagement. Not only are attempts to reduce weight or to control one’s food intake often unsuccessful, the dissatisfaction in other life domains also typically remains.

Previous research on the relation between life meaning and eating disorder symptoms has provided empirical support for the view that low meaning in life might be involved in eating disorder problems: While allocating the same importance to normative life domains, such as school, life in general, and the self, adolescents with AN showed significantly less (goal) satisfaction with these domains than individuals without AN; the more severe the symptoms, the less satisfaction (van Doornik et al., 2021). It was also demonstrated that an improvement in AN symptoms following treatment at 1-year follow up was paralleled by an increase in satisfaction with normative life domains (van Doornik, Ostafin, et al., 2022).

Ryan and Deci (2000) acknowledge the importance of life meaning for goal pursuit in an extension to self-determination theory (SDT). Specifically, they postulate that individuals experience life meaning via fulfillment of the basic psychological needs of autonomy (personal agency), competence (mastery), and relatedness (connection to loved ones). The basic psychological needs are seen as domains, in which life can be meaningful, similar to the research done by van Doornik et al. (2021). When individuals chronically endure basic psychological need frustration in these domains, it is argued that they develop coping strategies to deal with these deficits (Verstuyf et al., 2012). Previous research has for example shown a connection between daily fluctuations in basic need frustration and fluctuations in binge eating symptoms in young healthy women (Verstuyf et al., 2013).

In line with the inability to reach satisfaction in different life domains, feelings of ineffectiveness are a frequently observed symptom in eating disorder patients (Martini et al., 2021; Olatunji et al., 2018; Schlegl et al., 2021). Ineffectiveness refers to feelings of worthlessness and inadequacy, coupled to a lack of sense of control (Olatunji et al., 2018). It was previously shown that patients with eating disorders score significantly lower on global self-concept measures, entailing higher perceived ineffectiveness than matched healthy controls (Jacobi et al., 2004). Ineffectiveness seems however not specific to eating disorders, as both patients with anxiety disorders and those with depressive symptoms also showed higher ineffectiveness scores than the healthy controls in the same study. Similar findings regarding the transdiagnostic characteristics of ineffectiveness were already observed by Bers and Quinlan (1992). Thus, meaning in life and the related aspects of basic psychological needs and perceived ineffectiveness seem to offer valuable additions to the conceptualization of eating disorders and their comorbid symptoms.

To improve insight into how eating disorder- and meaning-related variables are interconnected, a network approach might be helpful (Borsboom, 2017). Following network theory, rather than as a series of symptoms all caused by an underlying latent variable, mental disorders are defined as systems of interacting symptoms, which activate each other and activation then spreads through the network. Network theory also postulates that comorbidities between disorders are a result of shared symptoms between disorders (Fried & Cramer, 2017). Network analysis offers the possibility to visualize variables, which are called "nodes," and relations between them, based on, e.g., partial correlations, which are then displayed as so-called "edges" between nodes.

In an undirected network investigation of the CB-T-E model, eating, weight, and shape concerns appeared to be a central symptom (Mares et al., 2022) and similarly, Forrest et al. (2018) found overvaluation of the control over weight and shape to be central. Findings from other research indicated that constructs related to body image, like body checking (Forbush et al., 2016) and drive for thinness (Solmi et al., 2018) were crucial within network explorations of the disorder. A recent review on eating disorder networks by Monteleone and Cascino (2021) pointed again towards the centrality of overvaluation of weight, shape, and eating together with concerns about those domains, but also highlighted the importance of disorder non-specific factors, such as perceived ineffectiveness. Other symptoms, including comorbid anxiety and depressive symptoms, were also highly relevant to the networks assessed. The authors argued for a theory-driven inclusion of nodes in future research, as outcomes of network analyses vary strongly as a function of the included variables.

Although networks and derived centrality measures can be useful, it is unclear whether highly central nodes are associated with effective ways to intervene, i.e., to impose changes in the network and hence improve the situation for patients (e.g., Bringmann et al., 2019). A clearer picture can be obtained with a method that interprets an edge between two nodes as a causal effect, referring to a change in a putative effect after changing the putative cause. Such a network is often called a causal network (Spirtes et al., 2000; Pearl, 2009; Glymour et al., 2019). One of the issues with interpreting an edge as a causal relation is the difficulty to exclude all possible confounds (Gillies, 2019). However, some causal discovery algorithms, like Fast Causal Inference (Spirtes et al., 2000), search for evidence of possible confounds in a manner that is similar to looking for correlated residuals in multivariate normal regression models. Only for those edges for which there is no evidence for potential confounds, the algorithms then support a causal claim. Typically, not all potential confounds can be resolved and, in those cases, no causal claim is made for that edge. Therefore, the final network often contains both causal and non-causal claims. We explain this
algorithm in more detail in the Supplementary material.

While this approach is rather new in the field of psychology, it has been widely used in different fields. For example, Shen et al. (2020) tested whether causal discovery algorithms based on cross-sectional data can replicate the “gold standard” in Alzheimer’s disease regarding biomarkers as predictors for cognitive performance. The resulting graphs nearly coincided with this gold standard, indicating a suitability for these types of analyses to detect plausible structures. In clinical psychology, a causal discovery algorithm for cross-sectional data was first used by Anker et al. (2019), showing causal connections from social anxiety via drinking to cope (with negative emotions) to actual drinking behavior. A differentiation thus must be made between undirected and causal network models.

While previous network studies have already assessed the comorbidity between eating disorder symptoms and anxiety and depression (e.g., Forrest et al., 2019; Solmi et al., 2018), transdiagnostic symptoms extending the boundaries of specific disorders, which would explain the high comorbidity with other mental disorders, such as anxiety and depression, have so far been largely neglected in the network approach of eating disorders. Therefore, the current study included ineffectiveness and life meaning in addition to variables critical from the CBT-E perspective, to examine which factors are most strongly involved in eating disorder and comorbid symptomatology. We investigated four groups of variables within this study: CBT-E core symptoms, CBT-E maintaining factors, meaning-related factors, and symptoms of comorbid internalizing psychopathology. Given the need for a large sample in network analysis and considering the perspective of psychopathology being dimensional in nature (cf. Labey et al., 2021; Wright et al., 2013) we sampled from the general population. With this study, we aim to answer the following questions.

1) When assessing the mechanisms of the CBT-E model, can we observe a similar pattern as reported in previous studies, specifically a central role of weight, shape, and eating concerns?

2) What is the role of meaning-related factors, i.e., presence of life meaning, perceived ineffectiveness, and the basic psychological needs of autonomy, competence, and relatedness, in a transdiagnostic eating disorder network?

3) How do symptoms of comorbid internalizing psychopathology relate to this network?

The network approach offers the possibility to get a clearer picture of connections between different symptoms while accounting for influences of other measured variables. While most previous studies have included undirected networks, in the present study a causal network model was added to get additional insight into the causal status of the associations between variables in the network (Eberhardt, 2016).

1. Method

1.1. Participants

In total, 531 participants took part in the study. To ensure a heterogeneous sample, no selection criteria were applied other than age above 16 years and fluency in either English, Dutch, or German. Participants were recruited by undergraduate students at the University of Groningen within their own social networks, as well as through social media and SurveySwap. We did not assess race and ethnicity in light of national and EU laws stipulating that these special categories of sensitive data should not be processed unless absolutely necessary. Given our sampling strategy, participants were expected to be predominantly Caucasian. There was no compensation for participation.

Three participants were excluded because of double-entries, and 26 more because of failure to pay sufficient attention to the questionnaires, as indicated by a wrong answer to at least one of three requested item responses (i.e., selecting a predetermined answer to a specific item upon request), leaving N = 501. Most participants chose the Dutch version of the survey (49.3%), followed by the English (30.3%) and German versions (20.4%). With a range from 16 to 75 years old, the language groups differed significantly in age, with M(age) = 24.82 years (SD = 6.72) for the English sample, M(age) = 31.38 years (SD = 15.69) for the Dutch sample, and M(age) = 35.41 years (SD = 16.45) for the German sample. There were no significant differences between the samples in gender distribution (overall 66.7% female, 23.8% male, 1.8% other, 7.7% no indication) or BMI, with an overall range between 16.6 and 54.9 (M = 24.11, SD = 4.86).

The global EDE-Q scores ranged from 0 to 6, with a mean value of 1.61 (SD = 1.29). The distribution was skewed to the right with a skewness value of 1.05 and a kurtosis of 0.56. Within the sample, 22.1% (24.6% of women and 9.2% of men) scored above an EDE-Q global score of 2.5, that has been found to reflect the optimal cut-off score differentiating between the clinical and non-clinical range (cf. Ru et al., 2015).

1.2. Material

The following questionnaires and their subscales were used to assess the different nodes in the network according to the presented theoretical framework. Specific affiliations of each questionnaire or subscale to the nodes, as well as reliabilities and descriptive scores can be found in Table 1. Cronbach’s α values were above 0.7 for all scales, indicating at least acceptable reliability.

1.2.1. Eating Disorder Examination-Questionnaire

The Eating Disorder Examination Questionnaire 6.0 (EDE-Q; Fairburn & Beglin, 2008) assesses range and severity of ED symptoms with 22 items on four subscales, namely Restraint, Shape concerns, Weight concerns, and Eating concerns, over the previous four weeks. Items are autonomously answered on a 7-point Likert scale with options from 0 (not one day) to 6 (every day). An average score per subscale was calculated. Higher values indicated larger symptom severity. Based on the EDE-Q model (Fairburn et al., 2003b) and in line with Hoiles et al. (2012), the three sub-scales Shape concerns, Weight concerns, and Eating concerns were averaged into one score to index the core pathology of eating disorders.

1.2.2. Eating Disorder Inventory-2

Four subscales of the Eating Disorder Inventory-2 (EDI-2; Garner, 1991) were used to further measure parts of the transdiagnostic model, namely Bulimia (seven items) for assessing binge-/overeating and compensatory behavior (intention to purge) separately, combined Interpersonal distrust (seven items) and Social insecurities (eight items) for assessing interpersonal difficulties in line with the CBT-E model, and Ineffectiveness (10 items). EDI-2 questions are answered on a 6-point Likert scale from 1 (never) to 6 (always). We averaged the answers per subscale, thus higher values indicated more severe symptoms.

1.2.3. Meaning in Life Questionnaire

The Meaning in Life Questionnaire (MLQ; Steger et al., 2006) measures Search for and Presence of meaning in life with five questions for each of the two subscales. Items are answered on a 7-point Likert scale from 1 (absolutely untrue) to 7 (absolutely true). Average scores for the two subscales were calculated. A high score meant either a high presence of life meaning, or a stronger search for life meaning, depending on the subscale.

1.2.4. Balanced Measure of Psychological Needs

The basic psychological needs of autonomy, relatedness, and competence (Ryan & Deci, 2000) were assessed with the 18-item Balanced Measure of Psychological Needs (BMPN; Sheldon & Hilpert, 2012). Each subscale consists of six items, which are answered for the past 28 days on a 5-point Likert scale ranging from 1 (no agreement) to 5 (much agreement). A separate average score for each of the three
subscale was determined, where higher values illustrated greater need satisfaction.

1.2.5. Depression Anxiety Stress Scales-21

The 21-item Depression Anxiety Stress Scales (DASS-21; Lovibond & Lovibond, 1995) measure self-reported symptoms across the past week on a 4-point scale from 0 (did not apply to me at all) to 3 (applied to me very much). The DASS-21 yields mean subscale scores for anxiety, depression, and stress with a higher score reflecting greater symptom severity.

1.2.6. Rosenberg Self-Esteem Scale

The Rosenberg Self-Esteem Scale (RSES; Rosenberg, 1965) is a commonly used measure to assess self-esteem. It utilizes 10 items to which responses are given on a 4-point Likert scale ranging from 1 (strongly agree) to 4 (strongly disagree). After reverse coding positively phrased items due to the reversed scaling, the scores can be summed, yielding a higher score for participants high on self-esteem.

1.2.7. Clinical Perfectionism Questionnaire

The Clinical Perfectionism Questionnaire (CPQ) was developed by Fairburn et al. (2003a) to measure clinical perfectionism. It consists of 12 items regarding perfectionistic strivings over the past month. A 4-point Likert scale ranging from 1 (almost never) to 4 (almost always) is utilized for which responses are given on a 4-point Likert scale ranging from 1 (strongly agree) to 4 (strongly disagree). After reverse coding positively phrased items due to the reversed scaling, the scores can be summed, yielding a higher score for participants high on perfectionism.

1.2.8. Difficulties in Emotion Regulation Scale

The Difficulties in Emotion Regulation Scale (DERS) assesses mood dysregulation through 36 items (Gratz & Roemer, 2004). Answers on a 5-point Likert scale ranging from 1 (almost never) to 5 (almost always) were averaged. The higher the value, the more difficulties with emotion regulation the participant experiences.

1.3. Procedure

The study was approved by the Ethics Committee of the Faculty of Behavioral and Social Sciences of the University of Groningen.

Participants were provided with a link to an online survey platform (Qualtrics) to either a Dutch, English, or German version of the study, depending on their preferred language. They completed the questionnaires on their own electronic devices. The survey was divided into four blocks: The first one required participants to read the information letter and give informed consent, the second consisted of the life meaning and eating disorder questionnaires, the third one entailed all other questionnaires, while the fourth one enquired about demographic data (age, gender identity, height, weight). The questionnaires were randomized within block two, three, and four. Between each block, motivational pictures and indications of study progress were shown. In the end, participants were thanked and could exit the screen. The survey took approximately 30 min to complete.

1.4. Network analysis

1.4.1. Data Preparation

The data was cleaned, and total/average scores for the nodes included in the network as indicated in the Materials section were calculated in SPSS 26. In total, 5.13% of data was missing in the sample and, given the partly randomized order of questionnaire completion, missingness at random was assumed (Rubin, 1976). Descriptive statistics and data normality were assessed. The latter was tested with Kolmogorov-Smirnov tests (p < 0.05), indicating non-normal distributions for all nodes except for interpersonal problems. The values per node were transformed into standardized values for the network analysis. An overview of Pearson’s correlations between the nodes is available in the supplementary materials.

1.4.2. Estimation Method and Statistical Packages

We conducted all network analyses in R version 4.2.1. All R code can be found in the supplementary materials. The estimateNetwork function was used for network estimation in the bootnet package (Epskamp et al., 2018). A partial correlation, i.e., undirected network was estimated for the whole sample using the ggmModSelect model search algorithm in R (R Core Team, 2022). After a regularized estimation for a starting structure in a stepwise model search, the algorithm assesses a range of possible network models and selects the one with the best Bayesian Information Criterion (BIC; Isonorou et al., 2022). Rank-correlation and pairwise complete observations were applied to handle non-normal distributions of the variables and missing data, respectively. The coloblind theme in the qgraph package (Epskamp et al., 2012) was used to
visualize the network. The layout was automatically determined based on the Fruchterman-Reingold algorithm (Fruchterman & Reingold, 1991) and no specific minimum, maximum, or cut values were set.

1.4.3. Centrality Indices
We investigated node strength with the qgraph package as a centrality measure to assess how strongly a node is directly connected to other nodes (Costantini et al., 2015), thereby giving us an indication on the node’s importance within the network. Strength values are indicating the sum of absolute edge weights. We also assessed bridge centrality with the bridge function in the networktools package (Jones et al., 2019) based on theoretically determined communities of nodes (CBT-E core symptoms, CBT-E maintaining factors, meaning-related factors, comorbid psychopathology) to investigate the nodes’ bridging properties, especially those of life meaning and ineffectiveness. Bridge centrality values indicate the absolute sum of edge weights between two communities.

1.4.4. Accuracy and Stability
The accuracy of edge weight estimates (i.e., how prone they are to sampling variation) was assessed through the routine implemented in the bootnet package. A nonparametric bootstrap was applied with 1000 bootstrap samples. This bootstrapped was also used to assess the significance of differences between edge weights.

Case-drop bootstrapping based on 1000 bootstraps in the bootnet package was applied to assess accuracy of node centrality and bridge centrality values. We further used the strength boot-trapped differences test in the same package to assure interpretable differences in node and bridge centrality.

To assess the stability of node strength centrality estimates, the correlation-stability coefficient (CS-coefficient) was determined. It represents the maximum proportion of cases that can be dropped while retaining with a 95% probability that the correlation between sample centrality indices and bootstrapped centrality indices is 0.7 or higher. According to Epskamp et al. (2018), the CS-coefficient should be above 0.25 to be interpretable and preferably above 0.5.

1.4.5. Predictability
We further assessed the predictability of each node from all other nodes within the undirected network according to Haslbeck and Waldorp (2018) with the ggraph package. Estimating predictability allowed us to 1) make inferences about the practical relevance of edges, 2) estimate how efficient an intervention on a certain node would be, and 3) assess whether different aspects within the network are self-determined or determined by factors not included in the network.

1.4.6. Causal Network Modeling
Additionally, we examined the data using the Fast Causal Inference (FCI) algorithm implemented in the pcalg package (Kalisch & Bühlmann, 2014) with α = 0.1. The FCI algorithm is a constraint-based algorithm; from a fully connected undirected graph it constructs a directed graph by removing relations between variables that are redundant as they are explained by other relations between variables (conditional independence). Then, a set of orientation rules is applied as has been detailed elsewhere (Glymour et al., 2019), by which the remaining edges receive arrowheads in the appropriate direction if there is enough evidence. As the FCI function cannot handle missing data, we first made use of the mice package (van Buuren & Groothuis-Oudshoorn, 2011) using predictive mean matching and 50 iterations to impute missing data. Distributions of the imputed data were largely in line with the original data. The FCI network was plotted using igraph (Csardi & Nepusz, 2006). Stability of edges was assessed using subsampling in which 500 subsamples were created using 80% of the total sample size, and an edge remained in the graph if it is present in at least 75% of all 500 subsamples. Thus, the resulting plot indicated solely edges that were present in those subsamples.

2. Results

2.1. Network Visualization
The visualized network is presented in Fig. 1. Absolute edge weights varied from 0.09 (compensatory behavior (purging)) to 0.56 (self-esteem – ineffectiveness). As some edges are not visible due to the automatic layout settings, see Table 2 for a full overview of edge weights. Like in other network studies, findings are based on exploratory analyses and must be considered within the specific research context.

2.2. Centrality Indices
Fig. 2 presents the results of the node centrality analysis. Strength values varied between 0.48 (compensatory behavior (purging)) to 1.41 (weight shape eating concerns). Other nodes with centrality >1.0 were ineffectiveness (1.32), mood intolerance (1.28), depression (1.26), self-esteem (1.15), and stress (1.07).

Fig. 3 presents the results of the bridge centrality analysis. Bridge centrality values varied between 0.09 (compensatory behavior (purging)) and 0.99 (ineffectiveness). Other nodes with bridge centrality >0.7 were mood intolerance (0.79), self-esteem (0.77), and depression (0.71).

2.3. Results of Accuracy and Stability Checks
Results from the nonparametric bootstrap indicate substantial overlap between the 95% confidence intervals for the different edges, so the edge weights should be interpreted with caution. Visual representations of edge weight and (bridge) centrality stability together with figures indicating significant differences between edge weights, centrality indices, and bridge centrality indices can be found in the supplementary materials.

The node and bridge strength centrality estimates were found to be stable, with a value of 0.60 for both node and bridge strength.

2.4. Predictability
In Fig. 1 the node predictability ($R^2$) is displayed via pie charts around each node. The more filled the borders are, the higher the node predictability. The nodes that can be predicted best ($R^2 > 0.7$) from the network structure are ineffectiveness ($R^2 = 0.82$), self-esteem ($R^2 = 0.80$), depression ($R^2 = 0.73$) and mood intolerance ($R^2 = 0.70$). Weight shape eating concerns is close to these values with $R^2 = 0.65$. An overview of all $R^2$-values is available in the supplementary materials.

2.5. Causal Network Modeling
The causal network including only stable edges is visualized in Fig. 4. An overview of edges with evidence for causality can be found in Table 3. All edges in the causal network model were also present in the undirected network model, but not necessarily vice versa (e.g., absence of edge between ineffectiveness and self-esteem in the causal model).

3. Discussion
In this study, we examined eating disorder symptomatology together with symptoms of comorbid internalizing psychopathology and meaning-related factors in the general population via undirected and causal network modeling. We investigated four communities of variables within the networks: core symptoms from the CBT-E model, maintaining factors from the CBT-E model, meaning-related factors, and comorbid psychopathology. The three main questions were 1) whether we can reproduce previous network findings regarding the centrality of weight, shape, and eating concerns from a transdiagnostic eating disorder perspective, 2) which role meaning-related factors have in a transdiagnostic eating disorder perspective.
network, and 3) how comorbid symptoms of anxiety and depression fit into the network.

3.1. Weight, Shape, and Eating Concerns (Question 1)

In line with prior network models (Forbush et al., 2016; Forrest et al., 2018; Mares et al., 2022; Solmi et al., 2018), we found support for the CBT-E model in both types of networks with weight, shape, and eating concerns being a central factor. It showed high centrality values, serving as a link between the eating disorder symptoms of restraint, binge eating, and compensatory behavior, and several other nodes within the network, most notably ineffectiveness. Importantly, concerns over weight, shape, and eating also have direct (causal) effects on each of the other CBT-E core factors, while separating them from the rest of the directed network. Thus, consistent with the CBT-E model, this pattern of findings points to weight, shape, and eating concerns as representing the underlying main pathology of eating disorder symptomatology, which, in turn, may give rise to other eating disorder symptoms, such as binge eating, restraint, and compensatory behavior.

The results also showed evidence for a causal relation from weight, shape, and eating concerns to the proposed eating disorder maintaining factor of perfectionism. These findings are plausible when considering that CPQ-items such as “Over the past month, have you pushed yourself really hard to meet your goals?” seem to measure state perfectionistic behaviors and cognitions rather than character traits. Hence, when individuals are overly focused on their weight and shape, they might then act accordingly, i.e., with a strong perfectionistic mindset, to achieve body- and eating-related goals.

All in all, these findings were largely in line with the CBT-E model and once more demonstrate the importance of eating, weight, and shape concerns as core eating disorder symptomatology (Forbush et al., 2016; Forrest et al., 2018; Monteleone & Cascino, 2021).

3.2. Meaning-Related Factors (Question 2)

Ineffectiveness showed high centrality and bridge centrality values and directly connected with all communities: CBT-E core symptoms, proposed maintaining factors, and symptoms of comorbid internalizing psychopathology. Most notably, ineffectiveness had a direct effect on depression symptoms and eating, weight, and shape concerns, which is in line with findings regarding heightened ineffectiveness scores for both patients with eating disorders and patients with depression symptoms (Jacobi et al., 2004). This gives rise to the concept of ineffectiveness as a “hub” symptom that links meaning in life to both eating disorder symptoms and symptoms of depression, which then even further connects to stress and anxiety.

Taking a step back, it seems to be that presence of life meaning is the driving force behind feelings of ineffectiveness. Interpersonal problems influence the presence of life meaning, which is in accordance with previous research, indicating that people generally derive meaning from interpersonal connections (Hicks & King, 2009; Stavrova & Luhmann, 2015). In addition, interpersonal problems affect the satisfaction with the basic psychological need of relatedness and seem to undermine self-esteem (e.g., Pelletier Brochu et al., 2018), which then fuels mood intolerance (e.g., Garofalo et al., 2016). While the CBT-E model implies bidirectional influences of mood intolerance, binge eating, and compensatory behavior, in our study there was no connection between binge eating and compensatory behavior and no direct links were found between compensatory behavior and mood intolerance in either one of the networks. The absence of this connection might be explained by the low prevalence of compensatory behavior in the sample and the corresponding skew, which could have been a result of the limited scope of conceptualizing compensatory behaviors solely as thoughts about purging to lose weight. Future (replicational) research should include a more comprehensive measure of compensatory behaviors, e.g., also including laxative misuse and excessive exercise. More generally, the

Fig. 1. Network of Eating Disorder and Comorbid Psychopathology Including a Visualization of Node Predictability. Note. Blue edges represent positive associations; red edges represent negative associations. Pie charts around each node indicate R²-values, representing predictability from the network structure. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)
The current findings support the notion that interpersonal problems, self-esteem, mood intolerance, and perfectionism are indeed additional maintaining factors to eating disorder symptomatology as proposed by the CBT-E model. While only perfectionism directly relates to the CBT-E core symptom of eating, weight, and shape concerns in the causal model, the other maintaining factors show several connections within both networks, with self-esteem and mood intolerance being high on centrality values and interpersonal problems indirectly affecting weight, shape, and eating concerns. These factors therefore still seem relevant in terms of activation and maintenance of various symptoms in the network.

Our data further suggest that in addition to the interpersonal domain, the basic psychological need of competence directly affects presence of life meaning, which is in line with previous literature indicating that individuals derive meaning from different domains (Goodman et al., 2018; van Doornik et al., 2021). The basic psychological need of autonomy on the other hand was detached from presence of life meaning and feelings of ineffectiveness, showing stable associations only to perfectionism and the other basic psychological needs. In general, the causal pathway from the basic psychological need of competence via presence of life meaning, ineffectiveness, and depressive symptoms to satisfaction with the basic psychological need of relatedness suggests that meaning-related factors can act both as antecedents and consequences of psychopathology symptoms. Thus, the current study showed that the inclusion of transdiagnostic factors beyond the classic symptoms of eating disorders and internalizing pathology must be considered in order to understand comorbidity between symptoms.

3.3. Comorbid Symptoms of Anxiety and Depression (Question 3)

The investigation of the position of comorbid internalizing symptoms within a transdiagnostic eating disorder network revealed a strong association among symptoms of anxiety, stress, and depression, even when factoring in other model variables. The high predictability of all three comorbid psychopathology nodes indicated that the variables included in the networks entailed most of the critical information to predict symptoms of anxiety, stress, and depression. Regarding the connection between comorbid symptomatology and the maintaining factors of the CBT-E model, we found a likely causal pathway from stress to mood intolerance. This finding accords well with previous research indicating that stress negatively influences individuals’ abilities to regulate emotions effectively and positively (Kim et al., 2013; Kinner et al., 2014).
Depressive symptoms were high on centrality values, and the only type of comorbid symptoms showing direct connections to meaning-related factors. The causal pathway from depression to the satisfaction with relatedness might be explained by social avoidance (Fernandez-Theoduloz et al., 2019), negative interpretation bias (Everaert et al., 2017), and rejection from others due to expressions of negative affect (Segrin, 2010) decreasing the satisfaction with current relationships. As previously mentioned, depression was further influenced by ineffectiveness and then causally connected to stress and anxiety. Thus, in this transdiagnostic network, once depressive symptoms are activated, they seem to lead to decreases in relatedness and increases in mental health problems like anxiety and stress. It seems that internalizing symptoms do not affect eating disorder symptoms, but rather they stem from the same mechanism of perceived ineffectiveness.

### 3.4. Strengths and Limitations

The present study represents a first attempt to examine eating disorder and comorbid symptomatology from a combined undirected and causal network perspective. It benefitted from a theory-driven inclusion of eating disorder and often co-occurring symptoms, such as anxiety, depression, and stress. Adding ineffectiveness as a proposed mediating variable also proved to be advantageous for our understanding of comorbidity between eating disorder and internalizing symptoms.

Nonetheless, the current results need to be considered within their limitations. First, as with most network studies, we did not test specific hypotheses about how nodes connect, and hence the current approach can be considered exploratory. However, we used subsampling to prevent certain sample characteristics from dominating the network results and only included connections that were present in a large proportion (at least 75%) of these subsamples. In addition, the centrality values and connections between nodes are largely in line with meta-analytic findings of Monteleone and Cascino (2021), showing that both concerns over eating, weight, and shape and perceived ineffectiveness are central factors within eating disorder networks. Second, edge weights needed to be interpreted with caution, which is why the focus of the discussion is on the presence of edges instead of their weight. Third, the partly fixed order of the instruments might have resulted in some carry-over effects.
that potentially influenced the findings. Future research should therefore use a randomized order of all questionnaires to rule out any systematic bias due to order effects. As a side note, one can always argue for more variables to be added to a network, but including a broad range of eating disorder specific and non-specific factors is already a critical improvement over previous research examining eating disorder network models (Monteleone & Cascino, 2021). The fact that the causal and undirected network showed a large overlap in edges supports the general stability of our findings. Lastly, since we sampled from the general population, our results do not allow us to draw strong conclusions about eating disorder populations. The rather large proportion of participants scoring above the clinically relevant cut-off for eating disorder symptoms (22.1%) suggests however that we included a broad spectrum of eating disorder symptomatology.

3.5. Future Research

Future research should examine this constellation of nodes in a population diagnosed with eating disorders to evaluate whether the structure of and associations within the network are different when eating disorder symptoms are more severe, and which part meaning in life takes in this. To distinguish between-person from within-person effects, panel networks and ecological momentary assessment (EMA) could help to empirically determine the temporal order of activation between nodes, e.g., whether feelings of ineffectiveness indeed precede eating, weight, and shape concerns both over longer periods of time (panel networks) and within specific moments (EMA). Even more importantly, we believe that causal discovery algorithms provide another important step towards establishing appropriate treatment targets. It is further necessary to zoom in on certain connections between nodes with the use of sub-clinical and clinical experimental studies, which might provide relevant information about the causal status of associations within the current symptom network that complements the outcomes of causal discovery algorithms. A meaning-centered intervention (e.g., van Doornik et al., 2023) could deliver valuable insights into whether an increase in life meaning would lead to a reduction in eating disorder symptoms via a decrease in perceived ineffectiveness. No interventions directly targeting perceived ineffectiveness are currently available, although some studies suggest that focusing on other factors such as self-compassion or media literacy can help to improve perceived ineffectiveness (Wilksch & Wade, 2009; Wade et al., 2015). Our findings indicate that increasing a sense of meaning in life might be another important route to decrease feelings of ineffectiveness.

4. Conclusion

This represents the first study investigating the role of meaning-related factors in both an undirected and a directed transdiagnostic eating disorder network. In both types of networks perceived ineffectiveness presented as a common influencing factor between eating disorder symptomatology and symptoms of comorbid internalizing psychopathology. Moreover, results from the causal network indicate that meaning in life has the potential to positively influence feelings of ineffectiveness, thereby conceivably changing other core factors in the network. Thus, the inclusion of both eating disorder and common comorbid symptoms together with putative causal factors such as perceived meaning in life and ineffectiveness, proved beneficial for improving our understanding of the factors involved in the development of eating disorder symptomatology and often co-occurring internalizing symptoms.

CRediT authorship contribution statement

Franziska Schutzechel: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft. Lourens J. Waldorp: Methodology, Software, Formal analysis, Writing – review & editing.

Marije aan het Rot: Conceptualization, Methodology, Writing – review & editing, Supervision. Klasse A. Glashouwer: Conceptualization, Methodology, Writing – review & editing, Supervision. Mirjam I. Frey: Methodology, Investigation, Writing – review & editing. Reinout W. Wiers: Conceptualization, Writing – review & editing, Funding acquisition. Peter J. de Jong: Conceptualization, Methodology, Writing – review & editing, Supervision, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Code is available in the supplementary material.

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Appendix A. Supplementary data

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References
