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The network structure of dysfunctional metacognition: Analysis of the MCQ-30

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ABSTRACT

The Metacognitive Control System (MCS) model gives central importance to maladaptive metacognition in psychological vulnerability and disorder. The metacognitions questionnaire 30 (MCQ-30) is widely used to assess such metacognitions and to establish their effects. Previous studies consistently demonstrate that the MCQ-30 consists of five latent factors, with some factors showing wide-ranging positive associations with symptoms and some demonstrating more specific symptom links. Questions remain concerning relationships between MCQ-items (or domains) and the most central of these outside of the latent-factor model. In the present study we set out to explore the internal structure of the MCQ-30 using network analysis and estimated two graphical Gaussian models, one with items- and one with domains, in an unselected sample ($N = 1080$). The robustness and stability of the networks, as well as the node predictability were assessed. Among our observations was that the items of the MCQ-30 appeared to cluster in meaningful substructures, corresponding to metacognitive theory. Furthermore, "need for control" was the most centrally placed domain, suggesting it plays an important role in the network and that its activation has a strong influence on other nodes. The theoretical and clinical implications of the current findings are discussed in light of the metacognitive model of psychological disorder.

1. Introduction

According to the Self-Regulatory Executive Function (S-REF) model (Wells & Matthews, 1994), and the recent extension detailing the metacognitive control system (MCS) component (Wells, 2019), psychological disorder is caused by a perseverative and negative thinking style called the *Cognitive Attentional Syndrome* (CAS) consisting of worry/rumination, threat monitoring and unhelpful coping behaviors. Activation and maintenance of the CAS is a function of metacognition that includes maladaptive declarative and procedural knowledge (e.g. beliefs) about cognition. Furthermore, the presence of maladaptive metacognition in the absence of CAS activation can be considered a marker for psychological vulnerability. Thus, maladaptive metacognition such as metacognitive beliefs are seen as an underlying cause of psychological disorder (Wells, 2019).

Maladaptive metacognitive beliefs (e.g., "Worrying is uncontrollable") are commonly assessed with the Metacognitions questionnaire (Cartwright-Hatton & Wells, 1997) and its shortened version the Metacognitions questionnaire 30 (MCQ-30; Wells & Cartwright-Hatton, 2004). The MCQ-30 consists of 30 items, assessing five domains of metacognitive belief; 1) positive beliefs about worry; 2) negative beliefs about the uncontrollability and danger of worry; 3) cognitive confidence; 4) need to control thoughts; and 5) cognitive self-consciousness. Multiple studies have investigated the psychometric properties of the MCQ-30 and its five-factor structure has been confirmed across countries and cultures, in for example the UK (Spada et al., 2008), France (Baptista et al., 2020), Spain (Ramos-Cejudo et al., 2013), Italy (Quattropani et al., 2014), Poland (Dragan & Dragan, 2011), Norway (Nordahl, Hjemdal, et al., 2019), Serbia (Marković et al., 2019), Greece (Typaldou et al., 2014), Turkey (Tosun & Irak, 2008), Korea (Cho et al., 2012), USA (Fergus & Bardeen, 2019), and China (Zhang et al., 2020). Furthermore, the five-factor structure of the MCQ-30 has also been replicated in clinical populations that include patients with OCD (Grøtte et al., 2016), cardiac patients with anxiety and depression (Faija et al., 2020), patients with epilepsy (Fisher et al., 2016), and patients with at risk mental state for psychosis (Bright et al., 2018).

Research using the MCQ has largely focused on the relative importance of different belief domains in emotional distress (Sun et al., 2017)

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or vulnerability (Nordahl, Hjemdal, et al., 2019; Nordahl, Ødegaard, et al., 2019), often in the context of controlling other belief types postulated in different theoretical models (e.g., Sunde et al., 2021; Fernie et al., 2016; Nordahl et al., 2017; Solem et al., 2009; Johnson et al., 2018). This line of research has demonstrated reliable positive associations between maladaptive metacognitive beliefs and psychopathology (Sun et al., 2017) with the implication that treatment effects might be improved if these beliefs are directly modified with Metacognitive therapy (MCT; Wells, 2009), a notion that is supported in a recent meta-analysis of MCT efficacy (Normann & Morina, 2018).

While there now exists robust evidence that metacognitive beliefs play a role in psychopathology, little research has been conducted on how metacognitive belief items are interrelated and interact with each other. Wells (2019) has described the structure, processes, and content of a *metacognitive control system* (MCS) in detail and argues that modeling of metacognition should begin to explore the interdependence of metacognitive variables and the centrality/generality of some dimensions. In particular, the metacognitive model gives central importance to beliefs and experiences concerned with the controllability of cognition as a general psychological resource and a transdiagnostic variable that contributes to disorder. For example, beliefs concerning the controllability of cognition are considered central to self-regulation and beliefs about lack of control are tightly coupled with increased need for control. Hence, different metacognitive beliefs are likely to be coupled (at item-level or node level) across subcategories in a way not fully captured by the latent factor approach but in a way that could be usefully explored using network analytics.

Confirmatory factor analysis is a latent variable technique and as such represents a common factor model where covariation between items is explained by an underlying latent factor. A central issue with latent models is that the items they consist of cannot interact directly or causally with each other since it is assumed that they are independent, conditional on the latent variable which implies that the items arise and vary in intensity only as a function of the underlying latent construct. However, a relatively new statistical approach takes interdependence between items into consideration, offering a means to explore the relationship between them and the internal structure of the items in a network structure. The network approach conceptualizes items (e.g. symptoms, traits, beliefs) as mutually interacting, often reciprocally reinforcing elements of a complex network (Borsboom & Cramer, 2013) and has in recent years gained substantial interest among researchers within the field of clinical psychology (Contreras et al., 2019). This perspective differs from the common factor model as it views syndromes as a product or manifestation of item interrelations, and patterns of covariation are examined with the assumption that items can mutually influence each other, a perspective that could offer an alternative in determining the structure of psychological disorder (Borsboom et al., 2018). In this perspective, each item could cause the release of other items, and the comorbidity between disorders is explained by so called "bridge symptoms" or overlapping items in the networks (Fried et al., 2017). This is a different perspective from latent or common factor models where items are caused by or reflect an underlying latent cause. Hence, the network approach can address questions concerning which and what kind of items are the most central (i.e. "centrality") in the form of being most closely related to other items in the network. Centrally placed items are considered a promising target for interventions as changing those with strong centrality will have the largest impact on other items in the network.

The aim of the present study was to apply psychological network modeling to the construct of metacognitive beliefs as assessed with the MCQ-30 (Wells & Cartwright-Hatton, 2004) as a means to explore the internal structure and the centrality of particular metacognitions as predicted in MCS theory (Wells, 2019). Network components in this study were the metacognitions from the MCQ-30 referred to as nodes. The causal associations between nodes are referred to as edges. Statistically, edges represent partial correlations between two nodes, controlling for the association between all the other nodes, and this approach allows for the importance or centrality of the nodes to be empirically determined.

The first goal was to explore the connections of the MCQ-30 as a network of its items and as a network of its domains comprising the five factors of the MCQ-30. Thus, in the first network, items of the MCQ-30 were used as nodes, and in the second network, the five MCQ-30 subscales were used as nodes. We expected that in the items network, items belonging to subscales in the MCQ-30 would cluster together as they theoretically assess the same factors. The second goal of this study was to assess the robustness and stability of: (i) the item network structure, and (ii) domain network structure. Finally, the third goal was to measure the node predictability of items and domains in their respective networks. The node predictability indicates the absolute measure of interconnectedness and provides an estimate of how much a particular node is influenced by all other nodes assuming that all edges that a particular node shares with other nodes are directed to it (Fried et al., 2018; Haslbeck & Fried, 2017).

2. Methods

2.1. Participants and procedure

The present study was based on an online self-report survey where participants were invited to participate through advertisement on social media assisted by several Norwegian voluntary organizations for mental health. Those who completed the survey were invited to participate in a lottery to win a personal computer. A program called "Select Survey" provided by the Norwegian University of Science and Technology was used to conduct the survey. Participants were gathered at convenience and there were no other exclusion criteria apart from participants had to be 18 years old or above and had to be able to read Norwegian. The research was conducted in accordance with the Declaration of Helsinki and was approved by the Norwegian Regional Committee for Medical and Health Research Ethics (REC; reference: REK-Midt, 2016/705). Upon entering the survey portal, participants were presented with an information sheet that was approved by REC and were informed that proceeding to the main survey would be regarded as a signed informed consent.

A total of 1080 participants were included in the analyses as they completed the MCQ-30 (Wells & Cartwright-Hatton, 2004). In the total sample, the mean age was 28.00 ($SD = 9.66$) years and 823 (76.2%) of the participants were female. As for marital status, 474 (43.9%) reported to be single, 183 (16.9%) reported to be in a relationship, 376 (34.8%) reported to cohabit or to be married, 43 (4.0%) reported to be separated or divorced, two (0.2%) reported to be widowed, and two (0.2%) did not report their marital status. In terms of occupational status, 238 (22.0%) reported they were students, 505 (46.8%) reported working, 27 (2.5%) reported being unemployed, 17 (1.6%) reported they were on short-term sick leave, 142 (13.1%) reported being on long-term sick leave (>1 year), 30 (2.8%) reported they were retired, while 121 did not report their occupational status. Furthermore, 429 (39.7%) reported they had a higher education (completed 3 years or more at a university or equivalent).

2.2. Instruments

The Metacognitions questionnaire 30 (MCQ-30; Wells & Cartwright-Hatton, 2004) is a 30-item self-report scale measuring metacognitive beliefs (i.e., beliefs about cognition). Each item is scored on a 4-point scale ranging from 1 ("do not agree") to 4 ("agree very much"). Higher scores reflect more dysfunction with the item in question. A five-factor structure exists: 1) positive beliefs about worry (e.g. "Worrying helps me to avoid problems in the future"); 2) negative beliefs about the uncontrollability and corresponding danger of worry (e.g. "My worrying is dangerous for me"); 3) cognitive confidence (e.g. "I have a poor memory"); 4) beliefs about need to control thoughts (e.g. "I should be in control of my thoughts all the time"); and 5) cognitive self-consciousness (e.g. "I constantly examine my thoughts"). As outlined in the introduction, multiple studies have reported on the acceptable psychometric properties of the MCQ-30 across different samples.

2.3. Statistical analyses

Network analyses were performed in R version 4.0.2 (Team, 2020). All analyses codes are available at https://osf.io/cejaf/ (Anyan, 2020).

2.4. Network analysis

Data analyses were conducted with the following R packages: *qgraph* (Epskamp et al., 2012) and *glasso* (Friedman et al., 2008) for network estimation and visualization, *mgm* (Haslbeck & Waldorp, 2016) for node predictability, and *bootnet* (Epskamp et al., 2017) for testing stability of network structure.

2.5. Network estimation

Two network structures were estimated for (i) MCQ-30 items, and (ii) MCQ-30 domains (i.e. subscales). For the item network structure, a regularized partial correlations network was estimated using the correlation matrix of the items of the MCQ-30 as input. For the domain network structure, the correlation matrix of the five subscales of the MCQ-30 was used as input in a separate network analysis. Network analysis was achieved by the estimation of a Gaussian Graphical Model (GGM) that estimates pairwise association parameters between all items (for item network structure) or between all subscales (for domain network structure) (Epskamp & Fried, 2018). To avoid spurious connections, Graphical LASSO was used to regularize the parameters resulting from the GGM. When visualizing network structures, the thickness of an edge represents its weight or strength of association between nodes, ranging from −1 to 1. The Fruchterman-Reingold algorithm (Fruchterman & Reingold, 1991) that places nodes with stronger and/or more connections more closely together was used. The more highly connected nodes, likely to spread activation in the network are more central and important items, while less important nodes with less connections lie on the periphery of the network (Borsboom & Cramer, 2013).

2.6. Network accuracy and stability

The tests of accuracy of edge weights and stability of centrality indices are necessary to be able to safely interpret results from the network structure since inferences are drawn based on the edge weights and node centrality. Network accuracy and stability tests ensure that the estimated network is robust to sampling variations. To evaluate the accuracy and stability in the estimated network structures, two methods proposed in the psychological network analyses literature (Epskamp & Fried, 2018) were used. First, 95% confidence interval bootstrapping was applied to the edge weights to provide estimates of the accuracy of the connections in the network structures. The second method dropped participants and re-estimated the networks by a process of *sub-setting bootstrap*. Then, the stability of the order of the centrality indices was examined. For a centrality index to be considered stable, the order of the centrality index from a network dropping many participants should be highly correlated with the order of the centrality index from the original network. Additionally, the centrality stability coefficient (CS-coefficient), whose value should be at least 0.25 and preferably above 0.50 was used to determine whether the centrality indices can be considered stable. To respond to the third goal of this study, node predictability was computed, which indicates the shared variance of a given node with its surrounding nodes in the network.

3. Results

3.1. MCQ-30 item and domain network

Fig. 1 displays the item network structure of the MCQ-30. A visual inspection of the item network structure shows interesting features that emerged from the way items clustered together. The first is that the items of the MCQ-30 appeared to cluster in clinically meaningful substructures, corresponding to the factors of the MCQ-30. Notably, within-cluster connections were positive and mostly strong. Overall, the items formed the following clusters (i) *cognitive confidence*, CC; (ii) *positive beliefs about worry*, POS; (iii) *need to control thoughts*, NC; (iv) *cognitive self-consciousness*, CSC; and (v) *negative beliefs about the uncontrollability and danger of worry*, NEG. However, MCQ12 ("*I monitor my thoughts*"), originally belonging to the *CSC* factor, in addition to being centrally placed, clustered with items belonging to *NC* factor. Items belonging to *NEG* appeared to subdivide with stronger positive connections between *MCQ9 – MCQ11*, and between *MCQ11 – MCQ21* than between *MCQ9 – MCQ21*. Other connections were between *MCQ15 – MCQ4* and *MCQ4 – MCQ2*. The subdivision in the *NEG* factor suggested that this factor might comprise two sub-factors (i.e., *MCQ9, MCQ11, MCQ21* as one factor and *MCQ2, MCQ4, MCQ15* as another factor). These associations are theoretically coherent and the division between items in the NEG factor has been observed in factor analytic studies where uncontrollability and the danger items sometimes split. Despite the positive connections mostly observed within clusters, negative connections were observed between some items belonging to separate clusters. For example, *MCQ12 – MCQ22* and *MCQ18 – MCQ9* shared a negative connection.

Fig. 2 displays the five-domain network of the MCQ-30. The network is composed of domains positively connecting with each other. *Need to control thoughts*, NC was the most centrally placed domain, sharing especially strong positive connections with NEG and POS. NC was also the only domain that interconnected with all the other four domains. This is also corroborated by NC having the highest betweenness value; hence, acting as the bridge connecting the communities of nodes. NC had the highest values for all the centrality indices, meaning that, NC has strong connections to the nodes nearby, plays an important role in the network and that its activation has strong influence on other nodes in the network. The standardized estimates of betweenness, closeness and node strength centrality indices are displayed in Fig. 3A for the item network structure and Fig. 3B for the domain network structure. For the item network structure, correlations among the centrality indices were moderate to strong (0.44 for betweenness and closeness; 0.46 for strength and closeness, and 0.73 for strength and betweenness). The nodes with the highest node strength were MCQ26, MCQ9, MCQ18, MCQ10 and MCQ30. The nodes with the lowest node strength estimates were MCQ14, MCQ24, MCQ1 and MCQ2 which is not surprising as these nodes show relatively fewer connections and lie at the periphery of the network structure in Fig. 1.

In respect of the domain network structure, correlations among the centrality indices were very strong (0.89 for betweenness and closeness; 0.70 for strength and closeness, and 0.89 for strength and betweenness). Fig. S2A and S2B in the Supplementary Material display results from the domains network accuracy and stability analyses, which all show highly accurate and stable centrality indices with substantial intercorrelations between them.

3.2. Node predictability

Despite the popularity of the node strength centrality, it is less informative compared with node predictability when considering interconnectedness in a network structure. The node strength provides relative importance whereas the node predictability provides an absolute measure of interconnectedness of network nodes (Fried et al., 2018). Thus, node predictability shows which nodes (i.e. MCQ-30 items

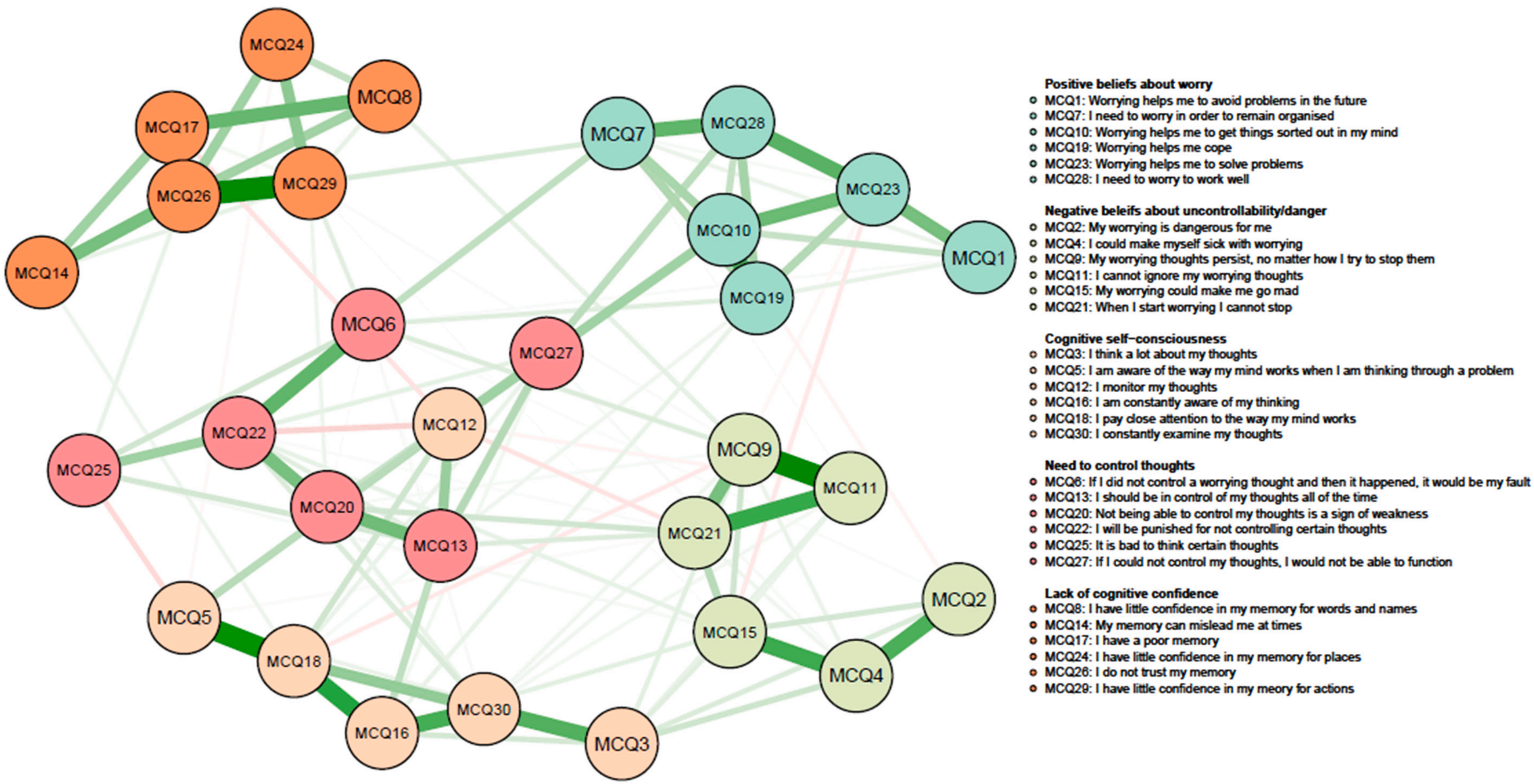

Fig. 1. A network of 30 items for the MCQ-30. Green edges (i.e., connections) represent positive associations and red edges represent negative association. The thicker the connection, the stronger the association between nodes.

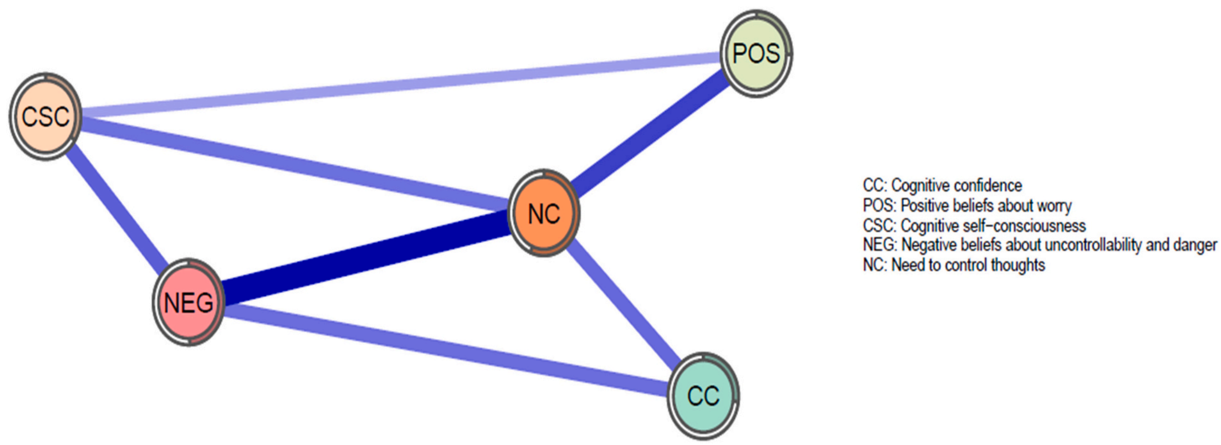

Fig. 2. Five-domain network of MCQ-30. Each node represents a factor (i.e., domain) of the MCQ-30. Blue edges (i.e., connections) represent positive associations. The thicker the connection, the stronger the association between nodes. The pie chart surrounding the nodes represents node predictability (percentage of shared variance with all connected nodes). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

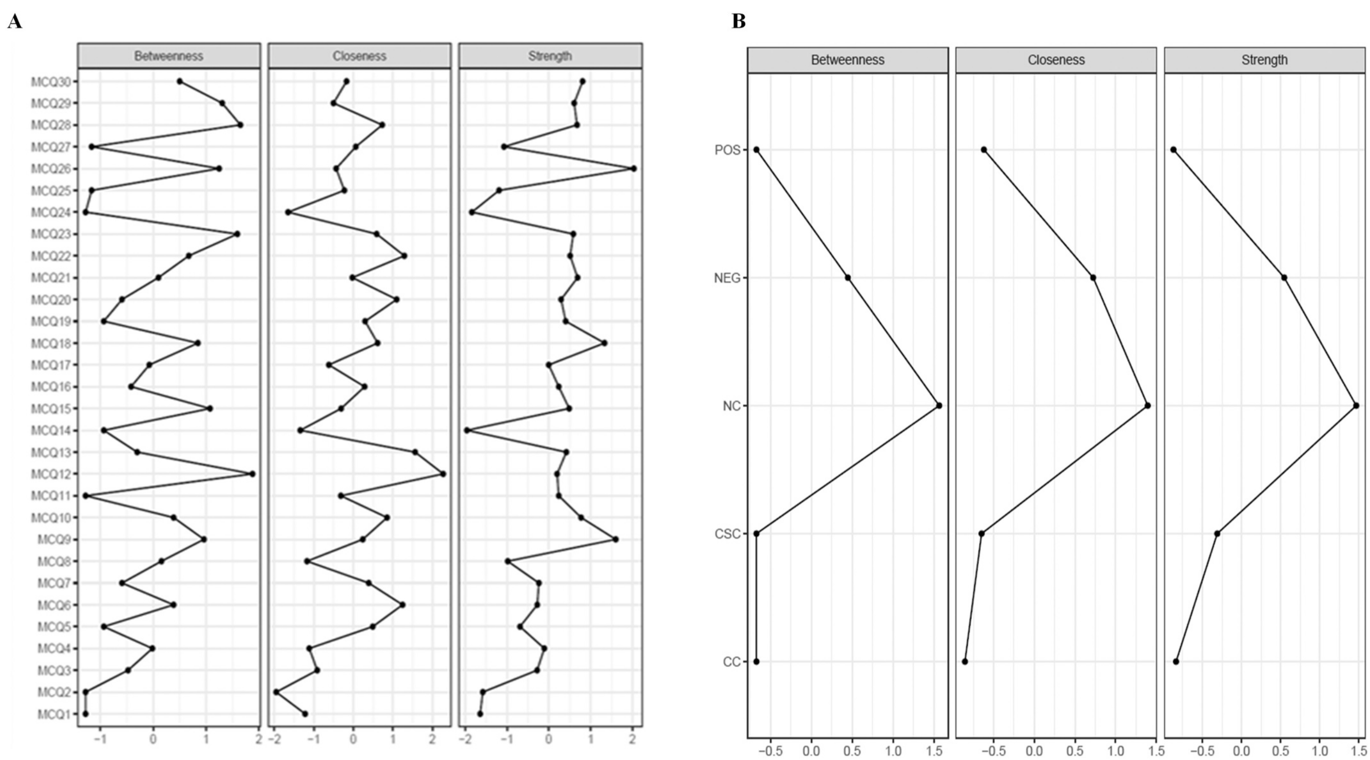

Fig. 3. **A**. Betweenness, Closeness and Strength centrality estimates for the item network structure. **B**. Betweenness, Closeness and Strength centrality estimates for the domain network structure.

or subscales) share the highest or least proportion of variance with surrounding nodes (i.e. R-squared). It is the degree to which a given node can be predicted by all other nodes in the network, not how strongly a node is directly connected with the network (i.e. node strength). In the item network structure, node predictability ranged from 0.46 to 0.99, with an average of 0.83. This means that on average, 83% of variance in the nodes can be explained by neighbouring nodes. MCQ29 ("I have little confidence in my memory for actions") had the highest node predictability (0.99), meaning that it has 99% shared variance with its surrounding nodes. Following MCQ29 were MCQ26 (0.98), MCQ9 (0.97), MCQ11 (0.97) and MCQ21 (0.96). These nodes relate to controllability of thoughts and confidence in cognitive function. The nodes with the lowest node predictability were MCQ27 (0.46), MCQ13 (0.59) and MCQ25 (0.62). In the domain network structure, the node predictabilities were $CC = 0.27$; $POS = 0.25$; $CSC = 0.34$; $NEG = 0.49$; $NC = 0.56$ with an average of 0.39.

3.3. Network stability

Results from the network accuracy and stability analyses are displayed in Fig. 4 panels A and B. The edge weights bootstrap (Fig. 4A) revealed that the item network was fairly, accurately estimated as there were considerable overlaps among the 95% CIs of edge weights. The subset bootstrap (Fig. 4B) for the original item network constructed on the full data with networks estimated on fewer samples showed that the order of node strength centrality is more stable than the orders of closeness and betweenness. This is consistent with the CS-coefficients, which were 0.75 for node strength, 0.52 for closeness and 0.21 for

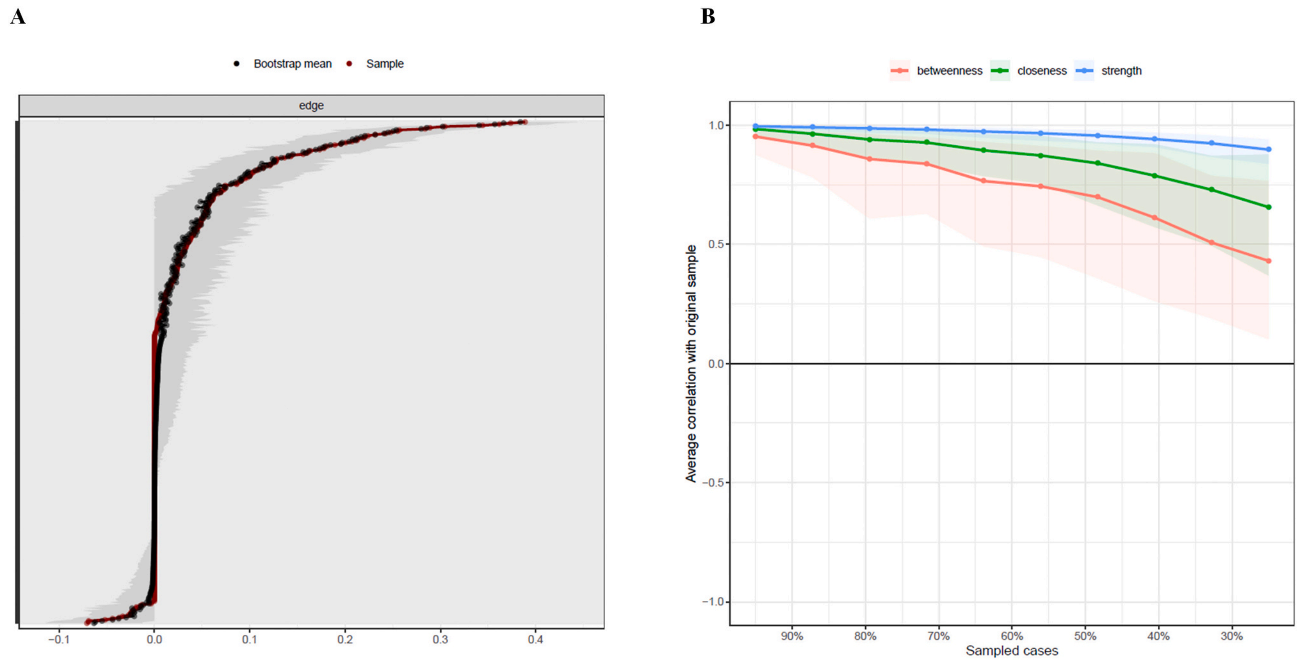

Fig. 4. A. The red lines indicate the sample values while the grey areas indicate bootstrapped confidence intervals. **B.** Stability of centrality indices seem safe for interpretation based on the CS-Coefficients for strength (0.75), closeness (0.52) and betweenness (0.21). The node strength is highly stable, and thus, interpretations of the relative importance of highest and lowest nodes is safe. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

betweenness. The node strength is highly stable, supporting interpretations of the relative importance of highest and lowest nodes. The Supplementary File contains additional accuracy and stability analyses for the item network structure, including the test for significant differences for all edges (i.e., edge weights difference test, Fig. S1A) and the test for centrality differences for all nodes (i.e., centrality difference tests; Fig. S1B). CS-coefficients in the domain (i.e. subscale) network structure was 0.75 for all the centrality indices, supporting the claim that edge weights estimation is highly precise, and the centrality indices in the domain network are also highly stable. See Fig. S2A and S2B in the Supplementary File for 95% CI bootstrapping of edge weights and stability of the order of the centrality indices in the domain network. Further, Fig. S3A and S3B display results from the edge weights and nodes difference tests, respectively.

4. Discussion

In the present study we set out to examine the item- and domain (subscale) network structure of the MCQ-30 (Wells & Cartwright-Hatton, 2004) using network analysis to allow a mapping of interrelationships and centrality of maladaptive metacognitions assessed with MCQ-30. While previous studies have evaluated the MCQ-30 from a sum-score, common-cause perspective, the network approach allows for the inspection of patterns of covariation with the assumption that items can mutually influence each other since it is assumed that they are independently conditional on the latent variable (Epskamp et al., 2018). Thus, taking a network approach has the potential to provide a more detailed item-level perspective of internal structure and centrality of items and domains that may have clinical implications.

The strongest edges in the items network of the MCQ-30 indicated that the observed beliefs clustered together in a way that correspond to the theoretical constructs hypothesized in the metacognitive model (i.e. positive meta-beliefs, negative meta-beliefs, cognitive confidence, need for control, cognitive self-consciousness) and were mostly positively connected to each other. There was one exception, node MCQ12 ("*I monitor my thoughts*") clustered with items belonging to the need for control factor rather than the cognitive self-consciousness factor that it is designed to represent, and it shared strong edges with need for control items. This observation suggests a high degree of mutual interaction between need for control items and the MCQ12 item ("*I monitor my thoughts*"). From a theoretical perspective, this makes sense; if you believe your thoughts must be controlled, monitoring them is sensible so that you can detect and apply control. This finding is also similar to a study by Johnson and Hoffart (2018) which found that a negative metacognitive belief predicted threat monitoring at the within-person level among comorbid anxiety patients. Observations like these demonstrate how items across hypothesized latent categories can interact taking all correlations in the network into account (partial correlation) and thus how the network approach has the potential to provide a nuanced perspective on the structure within networks.

Furthermore, items that assess beliefs about uncontrollability and danger of worry separated in two clusters of three items (item 9, 11, 21, and item 2, 4, and 15) that correspond to uncontrollability of worrying on the one hand and the danger of worrying on the other. In line with the metacognitive model, this observation suggests that beliefs about the uncontrollability and danger represent separate constructs while they also are closely connected and have strong mutual influences on each other (Wells, 2009). For example, in the metacognitive model of Generalized anxiety disorder (GAD) (Wells, 1995, 2009), it is specified that beliefs about uncontrollability of worry are a necessary causal factor and are often accompanied by beliefs about dangerousness of worrying that increases anxiety further. Moreover, beliefs about the uncontrollability of worrying are hypothesized to play a role across most types of psychological disorders while beliefs about the dangerousness of worrying are more specific (Wells, 2009). Hence, moving beyond the factor score approach when exploring the role of negative metacognitive beliefs in disorder and vulnerability might enable more precise evaluation of metacognitive theory. For instance, Johnson and Hoffart (2018) used a network approach and reported that a metacognition ("I cannot control my thoughts") was a mechanism of change in comorbid anxiety patients treated with metacognitive therapy.

Node strength quantifies how well a node is directly connected to other nodes and is therefore considered important in terms of influencing the network as a whole and could therefore serve as an important target in treatment. The two nodes with the highest node strength, and therefore potential important targets to affect the whole MCQ-30 item structure were MCQ26 *("I do not trust my memory")* and MCQ9 *("My worrying thoughts persists, no matter how I try to stop them")*, while the nodes with the least strength were MCQ14 *("My memory can mislead me at times")* and MCQ24 *("I have little confidence in my memory for places")*. This observation implies that targeting item 26 and 9 is likely to have the largest impact on the whole network of MCQ-30 items, while targeting item 14 and 24 will to a lesser degree have an impact on the network. Moreover, assessment of node predictability showed that on average, 83% of variance in nodes could be accounted for by neighbouring nodes. Given the intended conceptual overlap within MCQ-30 subscales, this observation is not surprising.

In exploring the domain (i.e. MCQ subscale) network, we observed that the five domains were positively connected to each other. The green edges between the domains further suggest a high level of mutual influence among them, meaning that if an individual endorses one cluster of metacognitions, there is a good chance of endorsing other clusters of metacognitions as well. In the domain network, beliefs about the need to control thoughts was the most centrally placed domain showing strong connections to negative- and positive metacognitive beliefs. This could indicate that need for control is a promising target for interventions as change in this domain could provide the strongest effect on the total network. However, in assessing node predictability of the domain network, we found that the variance in the need for control and negative beliefs about the uncontrollability and danger were to a higher degree shared with neighbouring nodes (i.e. each other) than for example the variance in positive metacognitive beliefs and cognitive confidence. Hence, we cannot rule out the possibility that need for control is centrally placed but also a result of neighbouring nodes (e.g., negative metacognitive beliefs about uncontrollability and danger). However, a substantial part of the variance in need for control was not shared with neighbouring nodes. Furthermore, the lower node predictability of positive metacognitive beliefs and cognitive confidence suggest that these domains may need to be directly targeted in interventions as targeting other domains might not be sufficient to modify them. However, these domains are not central to the total network, and they are therefore assumed to be less important targets for intervention compared with need for control and negative metacognitive beliefs that are more centrally placed in the network, and also show the highest node predictability.

In line with metacognitive theory (Wells, 2009; Wells & Matthews, 1994) and studies using confirmatory factor analytic procedures (e.g., Wells & Cartwright-Hatton, 2004; Spada et al., 2008; Nordahl, Hjemdal, et al., 2019; Nordahl, Ødegaard, et al., 2019), our results indicate that the MCQ-30 items cluster in five subcategories and that domains of metacognition are positively correlated (e.g. Nordahl, Ødegaard, et al., 2019). Adding to previous research, we have demonstrated how MCQ-30 items and domains relate to each other in networks, and that these networks are highly stable.

Metacognitive theory (Wells, 2019; Wells & Matthews, 1994) predicts that metacognitions represent latent vulnerability and suggests priority, universality, and specificity of their contributions. The theory also specifies that effective interventions should aim to modify maladaptive metacognitions, help patients discover that they have flexible cognitive control and that they can trust their mind to self-regulate, an emphasis that is supported by the result of the network analysis. Metacognitive therapy and its techniques (Wells, 2009) were specifically designed to achieve these goals and the sequence and emphasis of therapy fits with our results where we observe that (dis)trusting one's memory and the belief that one cannot stop worrying are central items in the item network of the MCQ-30, and that need for control and negative beliefs about the uncontrollability and danger of worrying are central in the domain network of the MCQ-30. In metacognitive therapy, techniques such as such as *detached mindfulness* (DM; Wells, 2005) and the *Attention Training Technique* (ATT; Wells, 1990) are introduced early in treatment and are aimed at the discovery of flexible cognitive control and at weakening beliefs about uncontrollability. Furthermore, in line with our findings and metacognitive theory (Wells & Matthews, 1994), change in beliefs about the need for control (Sunde et al., 2021) and in negative metacognitive beliefs about the uncontrollability and danger of worrying (Solem et al., 2009; Nordahl et al., 2017; Johnson et al., 2018) are associated with symptom improvement.

The present study has several limitations that must be acknowledged. First, the sample was gathered at convenience and consisted of substantially more females than males. We had little information about the mental health status of our participants, and there is a possibility that metacognition structure and interconnectedness will vary with distress levels. However, robustness and stability analyses were conducted and indicated that the network structure and centrality results could be interpreted, but we must be cautious about generalisation of the results to other samples such as diagnostic groups and males. For example, some studies indicate that there are gender differences in MCQ-30 scores (Spada et al., 2008) while others report no difference (Wells & Cartwright-Hatton, 2004). Previous research indicates measurement invariance for a latent MCQ-30 model among men and women (Fergus & Bardeen, 2019), but gender differences can be further explored with network analyses in samples with a more balanced gender distribution. We have demonstrated that items in the MCQ-30 seem to influence each other across theoretical categories, and that some domains (e.g., need for control) are more central than others (e.g., positive beliefs). We suggest that network analysis could provide further insights in terms of exploring network structure and connectivity of metacognitive control system variables (Wells, 2019), an approach that might be informative across different disorders. Further research should therefore explore the network structure of metacognitive beliefs and strategies in clinical samples and should also include disorder specific metacognitions, for example though-fusion-beliefs in OCD and beliefs about rumination in depression (Wells, 2009), when appropriate.

Cross-sectional network analysis does not allow directional causal inference (Epskamp et al., 2018) so there is a need to employ longitudinal designs to explore the temporal relations between metacognitive domains. Taking such an approach can provide insights into the organization of metacognitive beliefs and how they relate to the cognitive system and emotional distress symptoms.

5. Conclusion

The present study is the first to use network analysis to investigate the relationships between metacognitive belief items and domains assessed with the MCQ-30. The results indicate that items of the MCQ-30 separate into theoretically meaningful clusters in line with metacognitive theory. Furthermore, items and domains corresponding to the control of cognition were centrally placed in the network and indicate that targeting these may play an important role in the structure of the present networks. These observations are in line with metacognitive theory and the priorities and sequence of techniques currently used in metacognitive therapy, however further studies should investigate the network structure of metacognitions in clinical samples and in longitudinal data.

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.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

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