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Metacognitive beliefs, maladaptive coping strategies, and depressive symptoms: A two-wave network study of the COVID-19 lockdown and reopening

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ABSTRACT

To address the increased levels of depressive symptoms during the COVID-19 and other pandemics, it is useful to identify the psychological processes that may explain the relationship between pandemic-related stressors and symptoms. In this study, both the combined network of metacognitions and maladaptive coping strategies—derived from the metacognitive therapy model—and the depressive symptoms were studied during the COVID-19 related lockdown and the partial reopening of the Norwegian society about 3 months later. In an online survey, 4936 participants responded at both these time points. They completed the Cognitive Attentional Syndrome-1 and the Patient Health Questionnaire-9. The combined process and symptom networks were estimated. The maladaptive coping strategies worry/rumination, avoidance, and thought suppression and the symptoms depressed mood and worthlessness showed both high strength centrality at the lockdown and, at least, moderate correlations between their change and overall symptom change from the lockdown to the reopening. None of the metacognitive beliefs attained these criteria. From the lockdown to the reopening, no change in strength centrality was observed. The network structure, however, was significantly different across the periods and several different connections (edge weights) between variables were revealed. For instance, low energy showed a stronger connection to anhedonia and a weaker connection to sleep problems during the reopening than during the lockdown. In conclusion, worry/rumination, avoidance, and thought suppression may maintain central depressive symptoms such as depressed mood and worthlessness during the COVID-19 pandemic. These propositions are actionable as they give access to well-established interventions.

1. Introduction

The coronavirus (COVID-19) pandemic and the social distancing protocols used to impede the spread of the virus have been associated with adverse symptoms. Specifically, depressive symptoms are elevated during the previous pandemics (e.g., Brooks et al., 2020) and the present pandemic (e.g., Salari et al., 2020). To understand how pandemic-related stressors influence depressive symptoms and to identify potential targets of intervention, it is useful to study the psychological processes that may explain the relationship between stressors and symptoms. Models of such mechanistic processes are abundant in the psychotherapy literature and models underlying effective therapies may be useful in explaining the occurrence of symptoms during pandemics. Moreover, therapy models give access to individual-level interventions aimed at alleviating symptoms and disorders. Metacognitive therapy (MCT) has shown promising outcomes: a meta-analysis indicated that MCT was superior to both waitlist and cognitive-behavioral therapy (CBT) for anxiety and depression (Normann and Morina, 2018). However, this finding should be interpreted with caution as the number of studies included in the meta-analysis was low and there were variations in the results across the studies. The mechanistic processes proposed in the MCT model have also been supported (Johnson et al., 2018; Hoffart et al., 2018).

A core principle of MCT is that psychological disorder is linked to the activation of a particular maladaptive style of thinking called the cognitive attentional syndrome (CAS). The CAS consists of cognitive perseveration, a thinking style that takes the form of worry or rumination, attentional focusing on the threat, and unhelpful coping behaviors

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that backfire (e.g., thought suppression, situational avoidance, etc.). Maladaptive coping strategies are used as a collective term for cognitive perseveration, threat monitoring, and unhelpful coping behaviors. The CAS is supposed to be a common pathway to most psychological disorders with its specific features being related to specific disorders. In depression, rumination aimed at understanding the reasons for the depressed mood and working out ways to feel better is central (Wells, 2009, p. 198). Other typical processes include worrying about the future of depressive symptoms and threat monitoring of depressive symptoms (Wells, 2009, p. 198). As a way of coping with low energy, many depressed individuals reduce activities and avoid social contact to rest, hoping that this will lead to recovery over time (Wells, 2009, p. 198). The CAS is conceptualized as arising from metacognitive knowledge and beliefs. Two categories of beliefs are important: positive beliefs about the need to engage in aspects of the CAS (e.g., "Worrying helps me cope") and negative beliefs about the uncontrollability and danger associated with thoughts and feelings (e.g., "Worrying too much could harm me") (Wells, 2009, p. 15).

Notably, the MCT model of depression takes the form of a mechanistic cluster theory (Kendler et al., 2011). That is, mechanistic processes and symptoms supposedly cause each other (e.g., depressed mood elicits rumination which, in turn, reinforces mood) and these causal interactions explain the co-occurrence of symptoms. The cluster structure of the MCT model makes it amenable to network analytic techniques focusing on the causal interaction of components of phenomena (Borsboom, 2017). Components (e.g., psychological processes, symptoms) are considered to have different causal roles in the network they constitute. For instance, the MCT model proposes that rumination is a particularly important cause in the depression network, that is, it is strongly connected to other components. The network approach to depression differs from the one traditionally used, in which the global level of depressive disorder is addressed as a latent entity, while not considering the individual depressive symptoms (Borsboom, 2017).

In network analysis, centrality indices such as strength centrality are used to estimate the interconnectedness of components (Opsahl et al., 2010). However, interconnectedness in cross-sectional networks only reflects associations and not causal directions. In other words, components may be central not only because they cause other components but also because they are influenced by them. Thus, centrality indices in cross-sectional networks may reflect causality but they remain ambiguous.

The causal influence of a component is also indicated by the strength of the association between that component's change and the change in the severity of all symptoms in the network when they undergo change because of treatment or removal of stressful circumstances (Rodebaugh et al., 2018). Given that mechanistic processes proposed by the MCT model are supposed to causally interact with symptoms as well as explain the relationships between symptoms, they should be central components of a combined network of such processes and symptoms. Moreover, these processes should change in concert with overall symptom change.

Wang et al. (2020) found psychomotor symptoms to be central in the network of depressive and anxiety symptoms during the COVID-19 outbreak. The centrality of these symptoms decreased after the peak of the pandemic, while low energy showed increased centrality. The global strength (interconnectedness) of the network did not decrease; thus, not supporting the general tenet of network theory that overall symptom reduction is associated with less interconnectedness of symptoms (Borsboom, 2017). In this study, different samples at the outbreak and after the peak were studied, precluding an analysis of within-person changes. A further limitation was that mechanistic processes were not studied. Thus, the findings have limited actionable clinical implications.

The present study examined the combined network of CAS metacognitive beliefs, CAS coping strategies, and depressive symptoms in the Norwegian population during the period of lockdown and strict social distancing protocols and again during the period of the partial reopening of society and relieved distancing protocols. The research questions (Qs) were:

- Q1 What are the correlations between each component's change and overall symptom change from lockdown to reopening? Among the coping strategies, we expected that worry/rumination, threat monitoring, and avoidance would have at least moderate correlations with overall symptom change.
- Q2 What are the relationships between the components?
- Q3 Which components have the highest strength centrality in the lockdown network? Among the coping strategies, we expected rumination to have the highest strength centrality as well as threat monitoring and avoidance to have higher strength than the remaining strategies.
- Q4 Do the features global strength and structure differ between the lockdown and the reopening network? We expected that the global strength would decrease from lockdown to reopening.

2. Materials and methods

2.1. Study design, participants, and representativeness

The design was a two-wave longitudinal observational survey of the general adult Norwegian population during the COVID-19 pandemic. A lockdown with strict social distancing protocols was implemented in Norway on March 12th, 2020 (see online supplementary material for details). The first period of data collection for the present study lasted seven days between March 31, 2020 and April 7, 2020 (*lockdown*). On June 8th, 2020, the government officials announced the upcoming discontinuation or lightning of most social distancing protocols. Beginning on June 15th, 2020, these changes were implemented. The second wave of data was collected from the same participants who provided data in the first collection, starting one week after the discontinuation date, that is, from June 22, 2020, and lasted three weeks up to July 13 (*reopening*). On March 31st, 2020, and April 7th, 2020, the number of newly infected cases per day were 196 and 221, 7 and 13 for deaths, and that of hospitalized were 38 and 14, respectively. On June 22 and July 13, the corresponding numbers were 6 and 3 for infected cases, 4 and 1 for deaths, and 2 and 2 for hospitalization, respectively (Worldometers, 2020).

The ethical approval of the study was granted by The Regional Committee for Medical and Health Research Ethics and The Norwegian Centre for Research Data (reference numbers: 125,510 and 802,810, respectively), both of which approved the study protocol and analysis plan before data collection.

Eligible participants were individuals who were at least 18 years old and living in Norway and thus experienced identical social distancing protocols. They all provided informed consent to participate in the study. During the lockdown, 10,061 persons completed the survey. During the reopening, 4936 (49.1%) of the original sample responded and these 4936 respondents have constituted the subjects of the present study. In the online supplementary material, the representativity of the studied sample is discussed and the characteristics of the original and the studied sample are presented in Table S1.

2.2. Procedure

Due to the sudden onset of the pandemic and the time-sensitive research aim of measuring mental health during a period with strict and stable social distancing measures, we could not disseminate the survey through conventional methods such as access to registry data. To approach the desired standard of giving the adult Norwegian population an equal opportunity to participate, the survey was disseminated through a Facebook Business algorithm that selects a random sample of the proportion of the adult Norwegian population available on Facebook (3.6 million, 85%). The final number reached through this method

encompassed a random selection of 174,885 of these 3.6 million individuals. To reach the remaining 15%, the survey was disseminated through national and local television, radio stations, and newspapers. Sensitivity analyses of the randomly selected proportion of the sample (i.e., 70%) versus the full sample revealed identical results (Ebrahimi et al., 2021).

2.3. Measures

In addition to questions about demographic characteristics, stressor-related questions about suspicions of being infected, the time staying home with associated reasons, and whether one had been laid off from or lost one's job due to COVID-19 were included.

For the measures of network nodes, the following questionnaires were used. The Cognitive Attentional Syndrome-1 (CAS-1: Wells, 2009) is a 16-item measure purported to assess CAS activation during the last week (see Table 1 for item content). The first eight items assess maladaptive coping strategies for dealing with negative feelings or thoughts. One item that asked about controlling symptoms was considered less applicable in a normal population and, therefore, was not included in the present analyses. Worry/rumination and threat monitoring are rated on 0–8 scales in terms of the amount of time used, while the other coping activities are rated on 0–8 scales in terms of frequencies. The next 8 items measure negative and positive metacognitive beliefs. The subjects rated the degree of conviction in each of them on a 0–100 scale. In the present sample, the internal consistencies of the lockdown scale scores were 0.89 for coping strategies, 0.63 for positive beliefs, and 0.71 for negative beliefs.

The Patient Health Questionnaire-9 (PHQ-9; Kroenke et al., 2001) consists of nine items (e.g., anhedonia: "Little interest or pleasure in doing things") covering the DSM-IV criteria for major depression (American Psychiatric Association, 1994) during the previous two weeks, scored on a 4-point scale: 0 (not at all), 1 (several days), 2 (more than half the days) and 3 (almost every day). Cut-off score for clinical condition is a sum-score $\geq$ 10. The internal consistency at lockdown was 0.91.

2.4. Statistical analysis

Statistical analyses were performed in R (version 4.0.2; R Core Team, 2019). Paired t-tests were used to examine changes from lockdown to reopening. These changes had non-skewed distributions and Pearson's *r* was used to compute the correlations between item changes and changes in the PHQ-9 sum score. When computing the correlation between a depression item and the PHQ-9, that item was removed from the PHQ-9 sum score. However, some of the item distributions during the lockdown and the reopening were skewed. Consequently, Spearman correlations were used to estimate the network (Isvoranu and Epskamp, 2021). Given the large number of participants in the present study, an unregularized method referred to as the Graphical Gaussian Model ModSelect Algorithm (i.e., ggmModSelect) in the R-package qgraph (Epskamp et al., 2012) was used in line with recent recommendations (Fried et al., 2020; Williams and Rast, 2018; see online supplementary material for details and for R code).

Of node centrality indices (Opsahl et al., 2010), strength centrality was emphasized as it is proportional to the extent to which a given node uniquely explains the variance of nodes to which it is connected. It is calculated as the sum of the edge weights that connect that node to the other nodes in the network. The centrality indices were standardized to z-scores.

For methods and results for the accuracy of edge weights, the stability of centrality indices, and the bootstrapped difference tests

Table 1
Descriptive statistics for the network variables and the scales.

Construct/nodes	Lockdown	Reopening				
	Mean (SD)	Mean (SD)	T-test	*P*	*g*	r*
Coping strategies						
Worry/rumination	3.24 (2.07)	2.66 (2.07)	−22.18	<0.001	−0.28	0.45
Monitor threat	2.55 (1.96)	1.78 (1.86)	−30.33	<0.001	−0.40	0.34
Avoid situations	1.92 (2.04)	1.70 (1.98)	−8.46	<0.001	−0.11	0.32
Suppress thoughts	2.58 (2.21)	2.17 (2.12)	−14.47	<0.001	−0.19	0.30
Use alcohol/drugs	0.67 (1.43)	0.53 (1.24)	−8.85	<0.001	−0.10	0.18
Ask for assurance	0.93 (1.58)	0.88 (1.56)	−2.28	0.011	−0.03	0.18
Control emotions	2.45 (2.23)	2.08 (2.19)	−12.55	<0.001	−0.17	0.27
Metacognitive beliefs						
Worry harmful	44.97 (32.11)	41.45 (32.23)	−8.05	<0.001	−0.11	0.11
Worrying helps me cope	25.77 (23.41)	24.72 (23.05)	−3.06	0.001	−0.05	0.04
Strong emotions dangerous	21.82 (24.72)	20.13 (24.70)	−5.16	<0.001	−0.07	0.12
Focusing threat keeps safe	22.36 (24.31)	20.65 (23.35)	−5.03	<0.001	−0.07	0.03
Thoughts uncontrollable	23.40 (25.48)	22.12 (25.72)	−3.90	<0.001	−0.05	0.17
Control thoughts important	46.24 (30.75)	40.84 (30.55)	−12.82	<0.001	−0.18	0.09
Some thoughts lose mind	28.44 (32.12)	28.72 (32.23)	0.72	0.236	0.01	0.19
Analyzing I find answers	56.27 (30.43)	56.94 (30.35)	1.61	0.054	0.02	0.01
Depression symptoms						
Anhedonia	0.95 (0.87)	0.78 (0,80)	−14.34	<0.001	−0.20	0.50
Depressed mood	0.87 (0.87)	0.76 (0.81)	−9.56	<0.001	−0.13	0.54
Sleep problems	1.04 (1.01)	1.02 (0.95)	−1.60	0.055	−0.02	0.38
Low energy	1.29 (0.89)	1.17 (0.86)	−9.40	<0.001	−0.14	0.50
Appetite problems	0.93 (0.98)	0.83 (0.92)	−8.35	<0.001	−0.11	0.35
Worthlessness	0.83 (0.94)	0.81 (0.91)	−1.87	0.031	−0.02	0.47
Trouble concentrating	0.85 (0.94)	0.71 (0.87)	−11.18	<0.001	−0.15	0.42
Psychomotor problems	0.36 (0.69)	0.32 (0.64)	−4.69	<0.001	−0.06	0.27
Suicidal ideation	0.20 (0.57	0.23 (0.60)	4.41	<0.001	0.05	0.33
Scale scores						
Coping strategies	16.15 (11.95)	13.35 (11.94)	−21.58	<0.001	−0.23	0.71
Positive metacognitions	37.66 (18.32)	35.79 (18.68)	−11.82	<0.001	−0.10	0.61
Negative metacognitions	29.66 (20.89)	28.11 (21.16)	−8.04	<0.001	−0.07	0.69
Depression symptoms	7.32 (5.69)	6.63 (5.66)	−6.53	<0.001	−0.12	0.74

Hedges *g* was used as effect size measure. *The correlations between item change and change in sum of depression symptoms from lockdown to reopening. When computing the correlation between a depression item and the depression sum score, that item was removed from the sum score.

between edge weights and between node strengths, see Supplementary Material and Supplementary Figs. S1, S2, S3, and S4. The edge weights were accurate and the centrality indices were stable.

Finally, the estimated networks during the lockdown and the reopening were compared using the network comparison test (NCT; Van Borkulo et al., 2017). The NCT is a permutation-based hypothesis test for invariance of network structure, global strength of connections, and edge estimates. There were no data missing in our set because the online survey system comprised of mandatory fields of the response.

3. Results

3.1. Pandemic-related characteristics of participants

At lockdown, 1749 (35%) of the 4936 participants reported suspicion related to them being infected by COVID-19 during the previous two-week period while 6 (0.001%) other individuals had become infected with COVID-19 during the pandemic. During the reopening, the corresponding numbers were 1726 (35%) and 26 (0.5%). During the lockdown, the majority (n = 3,916, 79%) of the sample had stayed at home for at least 10 days of the previous two weeks. During the reopening, 3892 (79%) individuals reported that they had stayed home for most of the days during the whole lockdown period since March 2020. The number of respondents who were partly or fully laid off from work or dismissed because of COVID-19 was 533 (11%) during the lockdown and 203 (4%) during the reopening. Those who responded at T2 reported significantly ($P < 0.001$) less maladaptive coping strategies, negative metacognitive beliefs, and depression symptoms at T1 than those who did not respond at T2 (Hoffart et al., 2022).

3.2. Descriptive statistics of the network variables

The descriptive statistics of the CAS-1 variables and the PHQ-9 symptoms during the lockdown and the reopening are reported in Table 1. Answering the first research question, the correlations between item change and PHQ-9 sum change from lockdown to reopening revealed that the CAS coping strategies worry/rumination, threat monitoring, avoidance, thought suppression, and most of the depressive symptoms showed at least moderate ($r \geq 0.30$) correlations between their change and overall symptom change. The expectations that worry/rumination would have a higher correlation with overall symptom change than the other coping strategies (all zs > 2.46) and that threat monitoring and avoidance would have higher correlations than the remaining strategies (all zs > 3.00) were mainly supported. One exception was that thought suppression did not differ from threat monitoring and avoidance according to this test (both zs < 0.53).

3.3. Estimated network

Answering the second research question, the partial correlation networks during the lockdown and the reopening are visualized in Figs. 1 and 2., respectively. During the lockdown, there were 106 significant ($P < 0.05$) connections. This large number is related to the large power of the study and here only those that have an edge weight greater than 0.05 will be noted. Across the coping strategies and depression constructs, there were notable connections between worry/rumination and the following symptoms: depressed mood (0.22), worthlessness (0.17), sleep problems (0.08), and anhedonia (0.06). Threat monitoring was negatively connected to worthlessness (−0.06). Avoidance of situations was connected to anhedonia (0.07), worthlessness (0.08), and

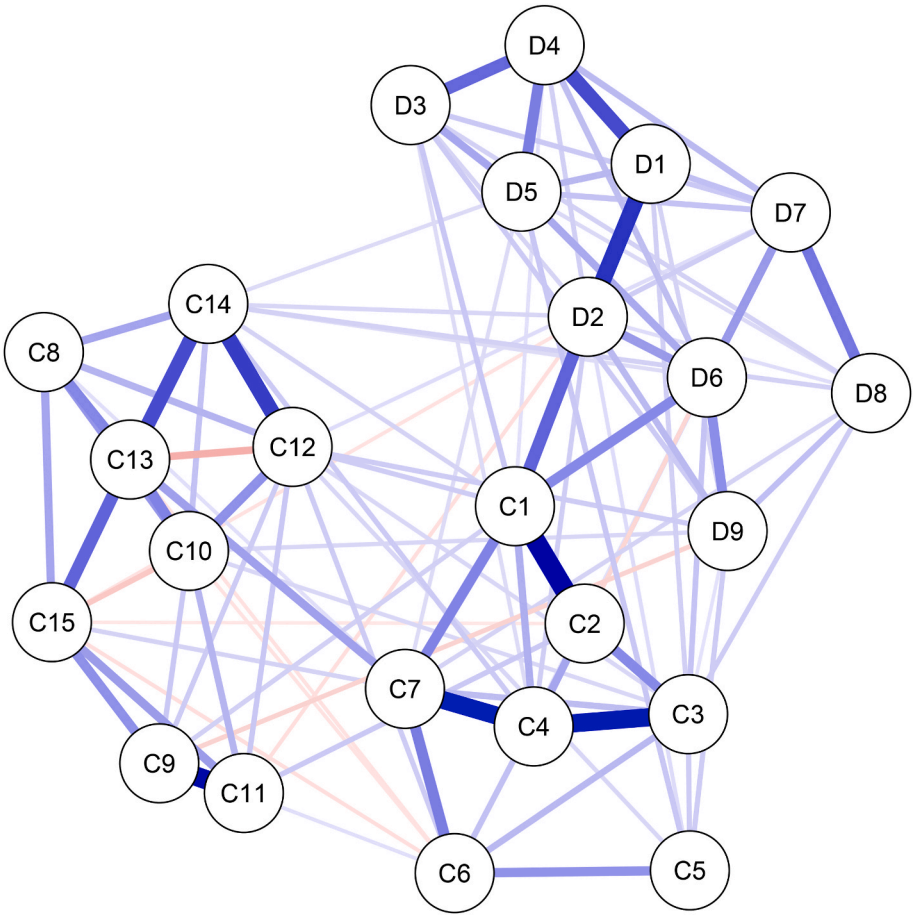

Fig. 1. Network of metacognitive variables and depressive symptoms at lockdown.
C1 = Worry/rumination, C2 = Monitor threat, C3 = Avoid situations, C4 = Suppress thoughts, C5 = Use alcohol/drugs, C6 = Ask for assurance, C7 = Control emotions, C8 = Worry harmful, C9 = Worrying helps me cope, C10 = Strong emotions dangerous, C11 = Focusing on threat keeps me cope, C12 = My thoughts are uncontrollable, C13 = Control my thoughts is important, C14 = Some thoughts lose my mind, C15 = Analyzing my problems I find answers, D1 = Anhedonia, D2 = Depressed mood, D3 = Sleep problems, D4 = Low energy, D5 = Appetite problems, D6 = Worthlessness, D7 = Trouble concentrating, D8 = Psychomotor problems, D9 = Suicidal ideation. The blue edges denote the positive correlations and the red edges denote the negative correlations.

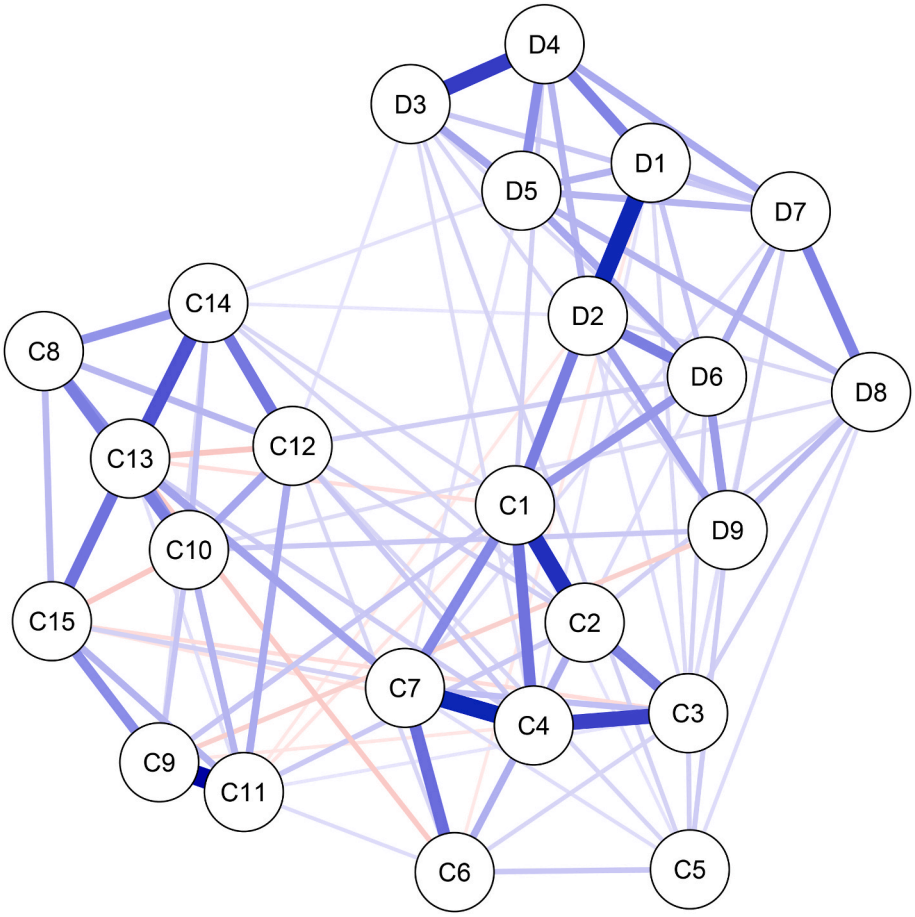

Fig. 2. Network of metacognitive variables and depressive symptoms at reopening.
C1 = Worry/rumination, C2 = Monitor threat, C3 = Avoid situations, C4 = Suppress thoughts, C5 = Use alcohol/drugs, C6 = Ask for assurance, C7 = Control emotions, C8 = Worry harmful, C9 = Worrying helps me cope, C10 = Strong emotions dangerous, C11 = Focusing on threat keeps me cope, C12 = My thoughts are uncontrollable, C13 = Control my thoughts is important, C14 = Some thoughts lose my mind, C15 = Analyzing my problems I find answers, D1 = Anhedonia, D2 = Depressed mood, D3 = Sleep problems, D4 = Low energy, D5 = Appetite problems, D6 = Worthlessness, D7 = Trouble concentrating, D8 = Psychomotor problems, D9 = Suicidal ideation. The blue edges denote the positive correlations and the red edges denote the negative correlations.

psychomotor problems (0.07). Thought suppression was connected to depressed mood (0.07), use of alcohol/drugs to appetite problems (0.08), suicidal ideation (0.07), and controlling emotions to psychomotor problems (0.06).

Across the metacognitive beliefs and symptoms, the belief that some thoughts could make one lose one's mind was connected to depressed mood (0.06). Several beliefs were connected to suicidal ideation: that strong emotions are dangerous (0.06), that one's thoughts are uncontrollable, and that worrying helps one cope (−0.06). Across metacognitive beliefs and coping strategies, the positive metacognitive belief that it is important to control one's thoughts was connected to the strategy to control emotions (0.14).

Within the metacognitive beliefs construct, strong connections appeared between the positive beliefs that worrying helps one cope and focusing on threats keeps one safe (0.36), between the negative beliefs it was that one's thoughts are uncontrollable and that some thoughts may make one lose one's mind (0.28), between the positive belief that controlling thoughts is important and the negative belief that some thoughts may make one lose one's mind (0.25), and between the positive beliefs that controlling one's thoughts is important and analyzing one's problems will help one find answers. Within the coping construct, strong connections appeared between worry/rumination and threat monitoring (0.37), suppressing thoughts and avoiding situations (0.33), and suppressing thoughts and controlling emotions (0.33). Within the MDD construct, the strongest connections appeared between anhedonia and depressed mood (0.30), low energy and anhedonia (0.26), low energy and sleep problems (0.22), and trouble in concentrating and psychomotor problems (0.20).

3.4. Centrality

Answering the third research question, the strength, closeness, and betweenness centrality z-scores during the lockdown and the reopening are presented in Figs. 3 and 4, respectively. During the lockdown of the CAS-1 coping strategies, worry/rumination had very high strength ($z > 1.0$). Avoidance, suppressing thoughts, and controlling emotions had high strength ($z \geq 0.5$). The metacognitive beliefs that thoughts are uncontrollable, that controlling them are important, and that some thoughts may make one lose one's mind had high strength. Of the MDD symptoms, the depressed mood had very high strength and worthlessness had high strength. Visual inspection shows that the strength centrality profile during the reopening was very similar. The expectations that worry/rumination would have the highest strength among the coping strategies and that threat monitoring and avoidance would have higher strength than the remaining strategies were partly supported (see Fig. S4). Different from what was predicted, threat monitoring had lower strength than avoidance, thought suppression, and controlling emotions.

3.5. Comparison of lockdown and reopening networks

Answering the fourth research question, the difference in global strength between the lockdown (global strength = 11.19) and reopening (global strength = 10.84) networks was not significant ($P = 0.07$). Thus, the hypothesis that the global strength would decrease was not supported. The value of the maximum difference M in any of the edge weights of the networks was significant ($M = 0.076$, $P < 0.02$), indicating that the network structure was different across the periods. The Holm-Bonferroni corrected P values per edge indicated several different

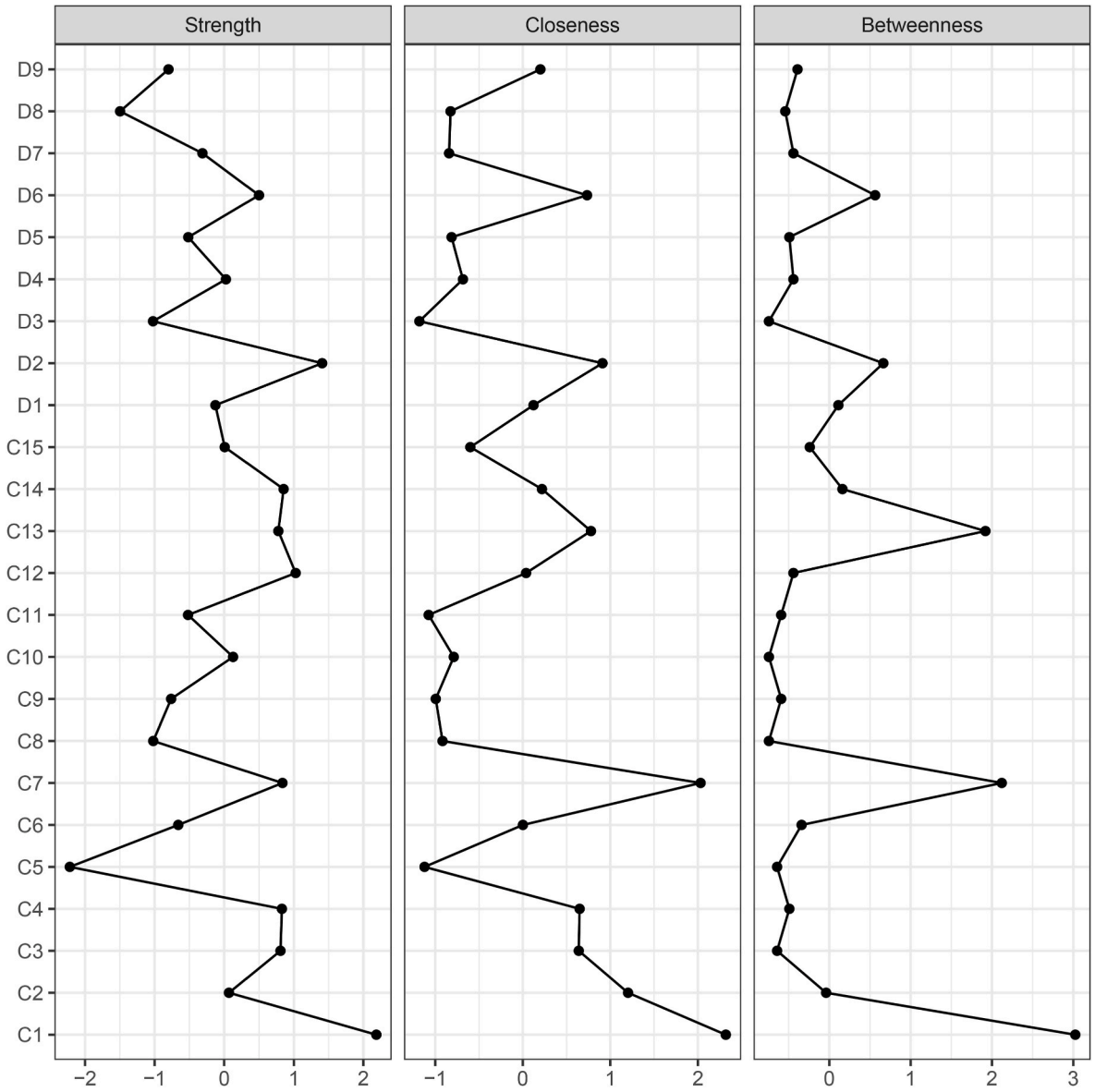

Fig. 3. Strength, betweenness, and closeness centrality at lockdown. All measures are Z-standardized. C1 = Worry/rumination, C2 = Monitor threat, C3 = Avoid situations, C4 = Suppress thoughts, C5 = Use alcohol/drugs, C6 = Ask for assurance, C7 = Control emotions, C8 = Worry harmful, C9 = Worrying helps me cope, C10 = Strong emotions dangerous, C11 = Focusing on threat keeps me cope, C12 = My thoughts are uncontrollable, C13 = Control my thoughts is important, C14 = Some thoughts lose my mind, C15 = Analyzing my problems I find answers, D1 = Anhedonia, D2 = Depressed mood, D3 = Sleep problems, D4 = Low energy, D5 = Appetite problems, D6 = Worthlessness, D7 = Trouble concentrating, D8 = Psychomotor problems, D9 = Suicidal ideation.

edge weights ($P < 0.01$). Within the depression construct, low energy showed a stronger connection with anhedonia and a weaker connection with sleep problems during the reopening than during the lockdown. Within the beliefs construct, an initially strong connection (0.28) between the belief that thoughts are uncontrollable and the belief that some thoughts may lead to loss of mind was somewhat (−0.07) reduced during the reopening.

4. Discussion

The first aim of this study was to identify the potentially most influential components in the combined network of variables of the cognitive attentional syndrome (CAS) as proposed by the metacognitive therapy model and depression symptoms in the Norwegian population during the COVID-19 pandemic. These variables were measured both during the COVID-19 related lockdown and during the partial reopening of the Norwegian society. The findings supported the hypotheses that among the CAS coping strategies, worry/rumination would have the highest strength centrality and the strongest correlation between its change and overall symptom change from lockdown to partial reopening. As expected, avoidance competed well with the remaining coping strategies in these two respects. Different from what was predicted, threat monitoring had significantly lower strength centrality than the mentioned strategies. Worry/rumination, avoidance, and thought suppression as well as the symptoms depressed mood and worthlessness showed both high strength centrality (>= 0.5 standard deviation over mean strength of the components) and at least moderate ($r \geq 0.30$) correlations between their change and overall symptom change from lockdown to reopening. None of the metacognitive beliefs attained these thresholds. This is reasonable as most of the influence that beliefs have on symptoms is supposed to be mediated through coping strategies (Wells, 2009). Therefore, the beliefs will have less direct connections to symptoms. However, the metacognitive beliefs are grouped together with specific connections, indicating possible pathways between the

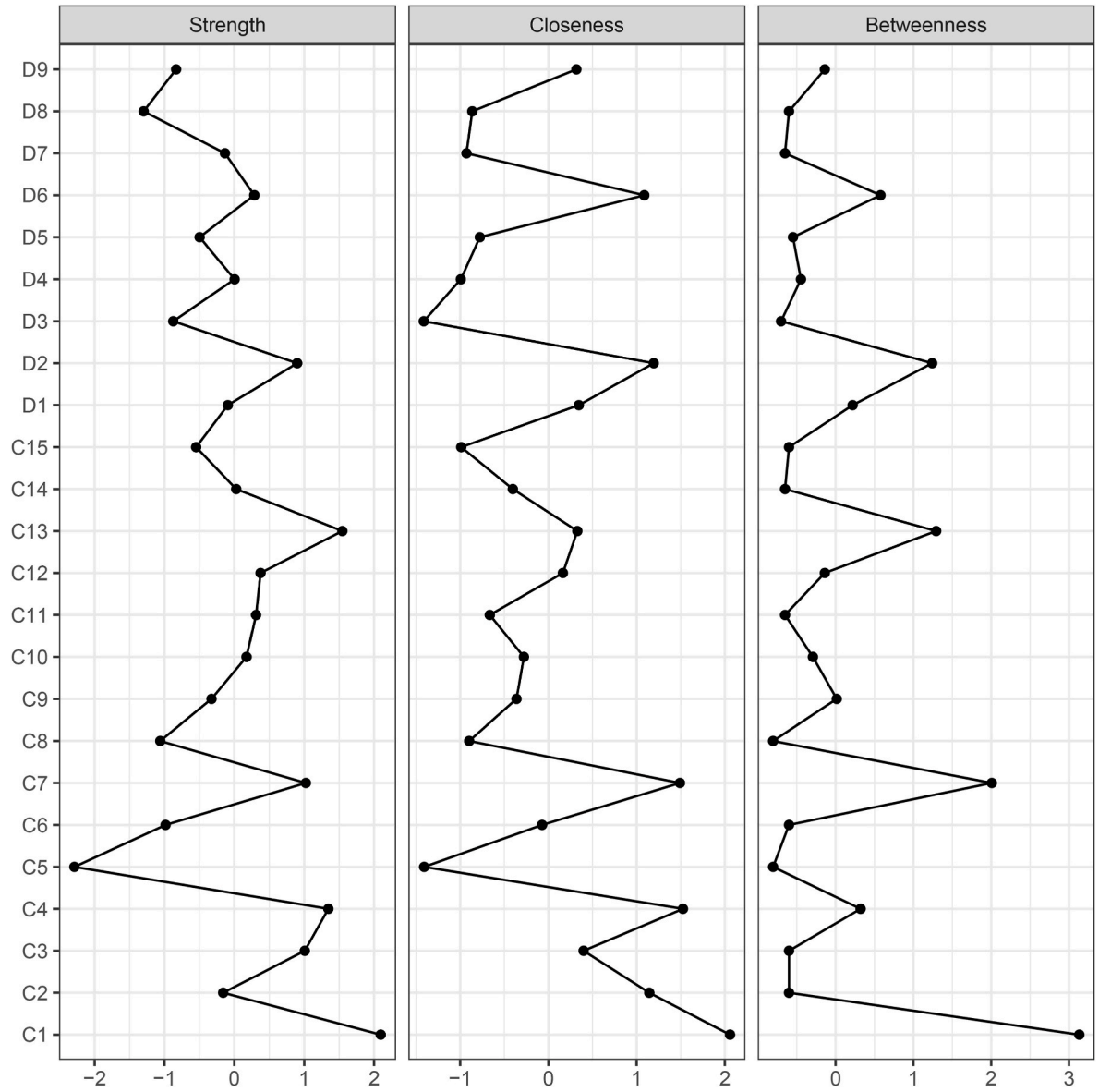

Fig. 4. Strength, betweenness, and closeness centrality at reopening. All measures are Z-standardized. C1 = Worry/rumination, C2 = Monitor threat, C3 = Avoid situations, C4 = Suppress thoughts, C5 = Use alcohol/drugs, C6 = Ask for assurance, C7 = Control emotions, C8 = Worry harmful, C9 = Worrying helps me cope, C10 = Strong emotions dangerous, C11 = Focusing on threat keeps me cope, C12 = My thoughts are uncontrollable, C13 = Control my thoughts is important, C14 = Some thoughts lose my mind, C15 = Analyzing my problems I find answers, D1 = Anhedonia, D2 = Depressed mood, D3 = Sleep problems, D4 = Low energy, D5 = Appetite problems, D6 = Worthlessness, D7 = Trouble concentrating, D8 = Psychomotor problems, D9 = Suicidal ideation.

different types of metacognitive beliefs, which could be a topic for future research.

In addition, Wang et al. (2020) found that depressed mood was central during the COVID-19 pandemic in China but different from our findings, they found that psychomotor problems and suicidal ideation were also central. The larger restrictions of movement and more forceful implementation of the social distancing measures in China may explain the increased centrality of these two symptoms.

Worry/rumination had strong connections to depressed mood and worthlessness but also notable connections to anhedonia and sleep problems. These results are consistent with the metacognitive model and other models (Segerstrom et al., 2000; Nolen-Hoeksema et al., 2008). Rumination is focused on past mistakes, which increases feelings of worthlessness and depressed mood (Wells, 2009, p. 14). Worry and rumination tend to inhibit sleeping patterns (Harvey, 2002). The internal activities of worry and rumination are also mentally draining and might ultimately lead to anhedonia (Wilkinson et al., 2013).

Avoidance was related to depressed mood, worthlessness, and psychomotor problems. Avoidance prevents corrective experiences of negative expectations of pleasure, mastery, and social contact and may thus maintain worthlessness and a depressed mood (Wells, 2009, p. 14). In the direction from symptoms to process, psychomotor problems may promote avoidance of social contact.

Thought suppression was related to depressed mood, worthlessness, and trouble concentrating. Depression is often characterized by intrusive memories of previous shameful and other negative experiences (Reynolds and Brewin, 1999) and attempts at their suppression may paradoxically lead to an increase in their occurrence and thus to a strengthening of depressed mood, worthlessness, and trouble concentrating.

Change in threat monitoring correlated moderately with overall symptom change, but showed less strength centrality than expected. A possible explanation of this pattern of findings is that threat monitoring and symptoms can be more related by being reactive to changes in

external circumstances, such as financial difficulties or infection rates than through direct connections.

Regarding network structure, no change in strength centrality appeared. The network structure, however, was significantly different across the periods and a test corrected for multiple testing revealed several different edge weights ($P < 0.01$). Within the depression construct, low energy showed a stronger connection to anhedonia and a weaker connection to sleep problems during the reopening than during the lockdown. Low energy may lead to anhedonia over time and therefore connect more closely with it. Within the beliefs construct, an initially strong connection between the belief that thoughts are uncontrollable and the belief that some thoughts may lead to loss of mind was reduced. A prolonged experience of uncontrollability without losing one's mind may lead to a disconfirmation of the catastrophic thought.

The limitations of this study included that the variables were assessed by self-report, that the measured depressive symptoms were restricted to those nine defined in the DSM-IV, that only two measurement points were investigated, and the large drop-out rate. Moreover, the survey was open 1 week at lockdown and three weeks after reopening and this may have influenced the results. However, the infection rates were stable within the two assessment periods. Strengths of this study included the large sample size which contributed to the accuracy, stability, and robustness of the network estimates, and the focus on actionable mechanistic processes.

In conclusion, worry/rumination, avoidance, and thought suppression may maintain central depressive symptoms such as depressed mood and worthlessness during the COVID-19 pandemic. These propositions are actionable as they give access to well-established interventions such as worry/rumination suspension and detached mindfulness (Wells, 2009). Future studies should follow Fried et al. (2021) in utilizing an intensive longitudinal design to estimate within-person networks, thereby more forcefully investigating whether the presented central variables may represent causal processes and therefore effective targets for interventions within pandemic settings. A further step could be the study of the influence of the treatment interventions (e.g., attention training) on processes and symptoms in networks (e.g., Lancee et al.,).

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Data availability

Access to the present data may be provided to qualified investigators whose research plans provide a defensible proposal and methodologically sound design with the aims approved by the Regional Committee for Medical and Health Research Ethics (REK), the Norwegian Centre for Research Data (NSD), and other necessary organizations.

Authors' contribution

All authors contributed to the study conception and design and were involved in data acquisition. OE and AH analysed the data. All authors contributed to data interpretation. AH was responsible for the first draft of the manuscript. All authors contributed to critical revision of the manuscript. All authors had access to the data, OE and AH verified the data, and all authors accepted responsibility for the decision to submit for publication.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2022.06.008.

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