Psychological Networks can Identify Potential Pathways to Specific Intervention Targets for
Anxiety in Response to Coronavirus Disease 2019 (COVID-19)

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Abstract

Addressing mental health challenges related to the COVID-19 outbreak can be facilitated through research that characterizes the needs of subpopulations and identifies specific pathways to targeted intervention. Toward this aim, we examined the impact of the COVID-19 outbreak on anxiety symptoms among college students ($N = 487$) and explored the relative impact of coping strategies using a psychological network approach, which models complex interactions to identify potential pathways to symptom-level intervention. Although students showed several significant fluctuations in pre- to post-outbreak anxiety symptom levels measured with the GAD-7, anxiety network connectivity was not significantly different across timepoints. Consistent with hypotheses, the post-outbreak symptom+coping network revealed that increased use of the adaptive coping strategies of acceptance, behavioral activation, and values-based action was associated with lower levels of fear, restlessness, and trouble relaxing. The symptom+coping network also revealed that increased use of the maladaptive strategies of excessive cleaning, reassurance seeking, and excessive checking was associated with higher levels of irritability and fear. Surprisingly, the use of reappraisal and avoidance, two strategies with putatively opposing adaptive value, highly overlapped and showed positive associations with fear and irritability. These symptom+coping associations can guide the assessment and treatment of anxiety in the face of COVID-19.

1. Introduction

The outbreak of COVID-19 poses a variety of mental health challenges, including barriers to treatment access as a result of overextended resources, quarantine regulations, and financial burden (L. Yang et al., 2020). Research can help optimize intervention strategies by identifying key targets such as dysfunctional coronavirus anxiety (Lee, Jobe, et al., 2020), suicide (Reger et al., 2020), or loneliness (Jeste et al., 2020) and by characterizing the unique needs of subpopulations, such as patients recovering from COVID-19 (Bo et al., 2020), healthcare workers (Lai et al., 2020), older adults (Y. Yang et al., 2020), and individuals with severe mental illness (Druss, 2020). Toward this broad goal, we investigated the impact of COVID-19 on anxiety symptoms among college students and explored the relative impact of coping strategies, which represent potential pathways to symptom-level intervention.

The structural impact of COVID-19 on millions of college students worldwide (~6% of the U.S. population; National Center for Education Statistics) includes campus closures, sudden transition to online instruction, reduced social interaction, loss of career/internship opportunities, and unprecedented uncertainty about the future. Evidence from past disasters suggests psychological resilience is the norm (Pfefferbaum & North, 2020) and currently available evidence from the COVID-19 outbreak in China indicates low rates of moderate (2.7%) and severe (0.9%) anxiety levels among pre-medical students in that country (Cao et al., 2020). Nevertheless, addressing the psychological impact of these stressors in this sensitive developmental stage is critical (Golberstein et al., 2020). Although the availability of assessment tools and non-pharmacological interventions with relatively low risk profiles can facilitate treatment dissemination, the heterogeneity of psychological responses to environmental stressors underscores the need for precision interventions.

Psychological network approaches can model the complexity of diverse responses to environmental stressors. This approach estimates edges, or connections among psychological features included in the network, as well as a variety of metrics derived from edge estimates, such as the global network connectivity, or the sum of the strength of all network edges. In the context of psychological disorders, the network approach has been framed as a theoretical alternative to the latent disease model (i.e., symptom networks *are* the disorder vs. symptoms in the latent disease model are *indicators* of an underlying disorder). Readers interested in a theoretical, methodological, and empirical overview of the network approach to psychopathology may consult a recent review (Robinaugh et al., 2020). In the current work, we focused on research that examined changes in network structure in the context of environmental stressors and on the use of network metrics as prospective and prognostic markers of the emergence of (or recovery from) stress-related psychopathology. For example, posttraumatic stress disorder (PTSD) symptom networks demonstrated stronger connectivity 12-months after emergency room hospitalization (Bryant et al., 2017), and symptoms with the strongest connections were better predictors of future diagnosis in a distinct sample of assault survivors (Haag et al., 2017). We previously found that change in PTSD symptoms that showed the strongest connections in the pretreatment network was positively associated with overall treatment response (Papini et al., 2020). A similar relation between node- and network-change was observed in the emergence of prolonged grief after the death of a spouse (Robinaugh et al., 2016). Altogether, these studies provide evidence of prospective and prognostic markers in psychological networks.

Although network analysis has been primarily used to investigate symptom connectivity within or across disorders, more recent work has used the approach to examine symptom-level treatment effects by conducting secondary analyses of clinical trials (i.e., network intervention

analysis; Blanken et al., 2019). A third application involves the inclusion of psychological features that can influence symptoms, including risk and resilience factors (Hoorelbeke et al., 2016), positive and negative emotion regulation strategies (Everaert & Joormann, 2019), rumination and executive control (Bernstein et al., 2017), and attentional biases (Heeren & McNally, 2016). This approach represents a potential bridge between the exploration of symptom relations (i.e., symptom network analysis) and the impact of interventions on symptoms (i.e., network intervention analysis) because it can elucidate links between symptoms and the psychological mechanisms through which they may be optimally targeted by treatment. For example, positive reappraisal showed connectivity to only two of the 42 depression and anxiety symptoms in the estimated network, suggesting that this emotion regulation strategy may not equally impact symptoms of these disorders (Everaert & Joormann, 2019). On the basis of this finding, Everaert and Joormann (2019) provided an example of a testable prediction about which symptoms to target with which strategy based on their network analysis: “If patients display symptoms related to negative expectations about the future (e.g., pessimism, fear of the worst happening), then treatments may adopt a symptom-focused strategy and increase positive reappraisal use (e.g., through cognitive restructuring) to obtain relief in these specific symptoms” (p. 10). As such, data-derived hypotheses generated via network analysis of symptom-mechanism interactions can function as an intermediate low-burden step that can guide the development of precision clinical trials, which require focalized targets, adaptive approaches, and precise measurement of mechanisms and outcomes (Lenze et al., 2020).

In line with this prior work, the present study applied psychological network methods to explore the potential impact of the COVID-19 outbreak on anxiety symptoms and coping strategies among college students as they adapted to campus closure and the transition to online

coursework. Our aims were (1) to examine longitudinal changes (pre- to post-outbreak) in anxiety symptom levels and overall network connectivity, and (2) to examine the relative impact of adaptive and maladaptive coping strategies on the post-outbreak anxiety symptom network. Together, these aims can provide insight into the specific features of anxiety that may have been impacted by the outbreak and identify potential pathways for optimizing symptom-level intervention strategies.

2. Materials and Methods

2.1. Participants and measures

Participants were undergraduate students who participated in the online surveys for research credit as part of an introductory course ($N = 487$; female: 288 [59.14%]; mean age = 19.65, $SD = 2.14$; self identified as White = 186 [38.19%], Hispanic or Latino origin = 111 [22.79%], Asian = 105 [21.56%], Black or African American = 25 [5.13%]). All participants provided written, informed consent, and the Institutional Review Board of The University of Texas at Austin approved all procedures. Data collection began at the onset of the University's campus closure in response to COVID-19, and continued through the end of the semester (*post-outbreak*; March–May 2020). Anxiety symptoms (i.e., anxiety, uncontrollable worry, generalized worry, trouble relaxing, restlessness, irritability, and fear) were assessed with the GAD-7 (Spitzer et al., 2006), which measures frequency on a Likert scale from “not at all sure” to “nearly every day” (range: 0-3). For a majority of these participants ($n = 443$; 90.97%), GAD-7 data from the beginning of the semester (*pre-outbreak*; January 2020) was available.

At the post-outbreak time point, we also measured use of adaptive and maladaptive coping strategies that represent common techniques or targets of two evidence-based psychotherapy approaches for treating anxiety: Cognitive Behavioral Therapy (Barlow et al.,

2017) and Acceptance and Commitment Therapy (Hayes et al., 2006). Adaptive coping strategies were: *reappraisal*, *behavioral activation*, *values-based action*, and *acceptance*. Maladaptive coping strategies were *avoidance*, *excessive checking*, *excessive cleaning*, and *reassurance seeking*. Table 1 includes the questions used to measure the frequency of use of these strategies, on a Likert scale from “none of the time” to “all of the time” (range: 0-4).

2.2. Analyses

2.2.1. Pre- to post-outbreak changes in anxiety symptom levels and network connectivity

All analyses were conducted in *R* version 3.6.1 (R Core Team, 2017); package versions used are provided for each analysis. To test the hypothesis that the COVID-19 outbreak would be associated with increases in symptom severity we used paired *t*-tests comparing pre- to post-outbreak levels of anxiety symptoms and total severity, calculated by summing all symptoms (*stats* v3.6.1; R Core Team, 2017). For these analyses we report uncorrected *p*-values from the two-tailed tests but note that the Bonferroni-corrected threshold for the eight comparisons is .006. To test the hypothesis that the COVID-19 outbreak would be associated with increased connectivity in the anxiety symptom network, we used the network comparison test which is a two-tailed permutation test that compares the global strength of networks estimated on randomly regrouped participants across the two time points (*NetworkComparisonTest* v2.2.1; van Borkulo et al., 2015). The procedure is repeated 1,000 times, yielding a distribution allowing a test of the null hypothesis. Global strength connectivity was considered significantly different at $p < .05$.

2.2.2. Association of coping strategies with anxiety symptoms

Data from the post-outbreak phase were used to construct a symptom+coping network. This allowed us to test the hypothesis that greater use of the adaptive coping strategies of reappraisal, behavioral activation, values-based action, and acceptance would be associated with

lower severity of anxiety symptoms, and that greater use of the maladaptive coping strategies of avoidance, excessive checking, excessive cleaning, and reassurance seeking would be associated with higher severity of anxiety symptoms. To increase interpretability and parsimony of the symptom+coping network, we took a two-step approach. First, redundant nodes were identified using the weighted topological overlap approach and combined using latent variable scoring (*EGAnet* v0.9.3; Golino et al., 2020). Next, partial correlation networks were estimated in a nonparametric bootstrapped procedure with 1,000 replications (*bootnet* v1.3; Epskamp & Fried, 2018). Following recent recommendations for reducing bias and increasing the stability and replicability of edge weight estimates, networks were estimated without regularization using Spearman correlations (Fried et al., 2020; Williams et al., 2019). Edge weights were extracted with 95% confidence intervals to assess relations between coping strategies and anxiety symptoms after controlling for all other nodes in the network. Edges with confidence intervals that did not cross zero were significant at the $p < .05$ level; nonsignificant edges were pruned from the network.

3. Results

3.1. Pre- to post-outbreak changes in anxiety symptom levels and network connectivity

Table 1 provides item-level descriptive statistics of study measures. Relative to the beginning of the semester, most GAD-7 symptoms were significantly *lower* in the post-outbreak assessment, as indicated by the mean difference estimates [95% CI] for anxiety = -0.21 [-0.30 to -0.11], $p < .001$; uncontrollable worry -0.35 [-0.45 to -0.25], $p < .001$; generalized worry -0.24 [-0.33 to -0.14], $p < .001$; and restlessness -0.22 [-0.31 to -0.13], $p < .001$. Irritability was the only symptom that increased, 0.19 [0.09 to 0.29], $p < .001$, and the remaining two symptoms (fear and trouble relaxing) showed nonsignificant fluctuations across time (both $ps > .05$). Overall anxiety,

indexed by the GAD-7 total score, decreased, $-0.95 [-1.43 \text{ to } -0.47]$, $p < .001$, but network connectivity, or the strength of symptom co-activation, was not significantly different across assessments (2.93 vs 2.97 ; $p = .54$). Together, these results suggest that changes in symptoms across time did not significantly alter global strength connectivity in the network.

3.2. Association of coping strategies with anxiety symptoms

In the post-outbreak assessment, high degree of overlap was detected among anxiety symptoms (anxiety/uncontrollable worry/generalized worry and restlessness/trouble relaxing), two adaptive strategies (behavioral activation/values-based actions), two maladaptive strategies (reassurance seeking/excessive checking), and two strategies with putatively different adaptive value (reappraisal/avoidance). Figure 1 shows the network graph plotted using *qgraph* v1.6.5 (Epskamp et al., 2012). After combining the overlapping nodes, the final symptom+coping network contained four anxiety symptom nodes and five coping strategy nodes connected by 16 significant edges out of 36 potential edges. Anxiety nodes had strong positive connectivity with each other, suggesting co-activation of symptoms. Connectivity was also observed across many coping strategies, suggesting that they are not used in isolation.

Consistent with hypothesis, significant edge estimates (i.e., partial r with [95% CI] that did not cross zero, $p < .05$) showed that increased use of the adaptive strategies of behavioral activation/values-based action was associated with lower levels of fear, $-.13 [-.20 \text{ to } -.05]$, and acceptance was associated with lower levels of restlessness/trouble relaxing, $-.13 [-.21 \text{ to } -.04]$, after controlling for all other relations in the network. In contrast, increased use of maladaptive strategies of reassurance seeking/excessive checking was associated with higher levels of fear, $.21 [.12 \text{ to } .29]$ and excessive cleaning was associated with higher levels of irritability, $.17 [.08 \text{ to } .26]$.

.25]. Reappraisal/avoidance was positively associated with fear, .13 [.04 to .22], and with irritability, .12 [.03 to .20].

4. Discussion

Several key findings can be highlighted from our analyses of anxiety symptoms and coping strategies in a diverse sample of university students. Surprisingly, severity of most GAD-7 anxiety symptoms was *lower* post-outbreak relative to the January 2020 baseline; only irritability showed an increase. Moreover, we did not find evidence of increased connectivity among symptoms in the early stages of the pandemic's impact relative to a January 2020 baseline. Together, this suggests that changes in the severity of individual nodes occurred without significant changes in the overall connectivity of the GAD-7 network. If COVID-19 outbreak and its related consequences played a role in the observed longitudinal fluctuations of anxiety, these findings indicate a differential impact on specific features of anxiety. For example, frustration around online coursework, interference in social life, or reduced independence among students who had to move back home, may have contributed to increases in irritability, even if these changes also contributed to decreases in anxiety, worry, and restlessness. Future follow-up assessments may help clarify whether the response to this stressor changes over time.

Nevertheless, a substantial minority of students reported severity in the moderate (18.89%) or severe (8.21%) range, which are substantially higher rates than those reported in the cohort of undergraduates in China (Cao et al., 2020). Connections between coping strategies and symptom levels in the symptom+coping network suggest clinically intuitive avenues for optimizing treatment. For example, individuals experiencing fear may benefit from psychoeducation around the paradoxical impact of reassurance seeking and excessive checking,

and strategies targeting behavioral activation and valued actions, whereas individuals exhibiting restlessness and trouble relaxing may benefit from acceptance-based strategies.

On the other hand, the strong overlap between reappraisal and avoidance is more challenging to interpret. In-depth measurement may be necessary to tease apart these two strategies (see 4.1. Limitations). Within our analysis, the combined avoidance and reappraisal node's positive connectivity with both fear and irritability indicates its influence in the network may have been maladaptive. This may have resulted from a blurring of the boundary between the way these two strategies were executed in this sample; perhaps reappraisal ultimately functioned as an avoidance strategy or had avoidance as its goal (e.g., trying to think about the situation differently vs trying to think about something different when confronted with the situation). Alternatively, it could indicate that when attempts to avoid the situation failed, reappraisal was the fallback strategy (or vice versa). Moreover, reappraisal may be a challenging strategy in the context of COVID-19 and successful reappraisal may require clinician-guided cognitive restructuring in order to confer therapeutic benefit.

4.1. Limitations

Our findings should take several limitations into account. Results from the longitudinal and cross-sectional analyses in our study should not be interpreted as evidence of causality. The longitudinal analyses provide empirical evidence of pre- to post-outbreak changes in anxiety that are likely to have multiple causes. The post-outbreak connections between symptoms and coping strategies may be unidirectional in either direction (e.g., fear activates reassurance seeking or reassurance seeking activates fear), bi-directional (e.g., fear and reassurance seeking form a feedback loop), or purely associational (e.g., fear and reassurance seeking are activated by a variable that is not part of the network). Accordingly, the symptom+coping network should be

considered a step toward generating testable causal hypotheses in randomized controlled frameworks (e.g., targeting reassurance seeking will lead to greater reductions of fear vs an alternative treatment strategy). Finally, the pace of research is such that several relevant COVID-19 measures have been published after the initiation of our data collection (e.g., Ahorsu et al., 2020; Arpaci et al., 2020; Lee, Mathis, et al., 2020; Taylor et al., 2020). These can be incorporated into future studies to examine their links to coping strategies and other psychological mechanisms, as well as replicability and generalizability across samples.

5. Conclusions

Despite the abovementioned limitations, our findings highlight the utility of applying network analysis to increase precision in our understanding of the interactions between anxiety symptoms and coping strategies. Although we did not find evidence of post-outbreak increases in anxiety symptom severity (with the exception of irritability) or overall network connectivity, a meaningful proportion of students had moderate to high levels of anxiety post-outbreak, and individual symptoms showed differential relationships to several adaptive and maladaptive coping strategies. Beyond these results, our study highlights the utility of a network approach that combines symptoms and mechanisms to identify potential cognitive and behavioral pathways for optimizing treatment.

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Figure 1. Symptom+Coping Psychological Network in Response to COVID-19

Edge thickness and labels correspond to the strength of the positive (solid edges) or negative (dashed edges) partial correlations between anxiety symptoms (red nodes), adaptive coping (green nodes), maladaptive coping (blue nodes), or a combined (mal)adaptive node (yellow). Edge estimates with CIs that crossed zero were pruned from the network.

Table 1. Descriptive Statistics of Measures.

Network node name: survey item text	Pre-outbreak M (SD)	Post-outbreak M (SD)
GAD-7 (range: total 0 - 21; item 0 - 3)	<i>n</i> = 443	<i>N</i> = 487
Total score (sum of items)	7.50 (5.61)	6.48 (5.28)
Anxiety: <i>Feeling nervous, anxious, or on edge</i>	1.32 (1.03)	1.10 (0.95)
Uncontrollable worry: <i>Not being able to stop or control worrying</i>	1.14 (1.08)	0.79 (0.94)
Generalized worry: <i>Worrying too much about different things</i>	1.30 (1.05)	1.07 (0.98)
Trouble relaxing: <i>Trouble relaxing</i>	1.07 (1.02)	0.96 (0.94)
Restlessness: <i>Being so restless that it's hard to sit still</i>	0.85 (0.97)	0.61 (0.87)
Irritability: <i>Becoming easily annoyed or irritable</i>	1.01 (0.94)	1.18 (0.99)
Fear: <i>Feeling afraid as if something awful might happen</i>	0.81 (0.99)	0.77 (0.96)
Coping with COVID-19 Anxiety (range 0 - 4)		
<i>Adaptive strategies</i>		
Acceptance: <i>I accepted my anxiety about COVID-19 instead of trying to reduce, avoid, or control it.</i>	-	1.37 (1.18)
Reappraisal: <i>I tried reducing my anxiety by changing the way I think about the COVID-19 situation.</i>	-	1.24 (1.07)
Valued actions: <i>I tried reducing my anxiety about COVID-19 by focusing on engaging in things that are important to me, including hobbies, relationships, organizations, religion, or work.</i>	-	2.01 (1.27)
Behavioral activation: <i>I tried reducing my anxiety about COVID-19 by establishing a daily routine.</i>	-	1.56 (1.36)
<i>Maladaptive strategies</i>		
Excessive cleaning: <i>I tried reducing my anxiety by washing my hands, using hand sanitizers, or taking extra showers, even when I had little reason to believe that I may have been exposed to COVID-19.</i>	-	2.09 (1.4)

Excessive checking: <i>I tried reducing my anxiety by checking myself for symptoms of COVID-19 or mentally reviewing past situations to check whether I may have been exposed to the virus.</i>	-	0.95 (1.07)
Avoidance & suppression: <i>I tried avoiding anxiety by not thinking, reading, or talking about anything related to COVID-19.</i>	-	1.18 (1.21)
Reassurance seeking: <i>I tried reducing my anxiety about COVID-19 by seeking to be reassured by others that everything was going to be OK.</i>	-	1.18 (1.12)

Note. The pre- to post-outbreak analysis included 443 participants with data at both time points, whereas the symptom+coping network included the full sample ($N = 487$) at the post-outbreak timepoint.

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