Intolerance of Uncertainty, Looming Cognitive Style, and Avoidant Coping as Predictors of Anxiety and Depression During COVID-19: a Longitudinal Study

Nicolette D. Carnahan[1] · Michele M. Carter[1] · Tracy Sbrocco[2]

Abstract

The COVID-19 pandemic has resulted in increased distress and uncertainty. Understanding the progression of mental health and factors underlying the perpetuation of distress during the pandemic is pivotal in informing interventions and public health messaging. This current study examined longitudinal effects of two cognitive vulnerabilities, looming cognitive style, and intolerance of uncertainty, as well as coping styles on anxiety and depression through online questionnaires at two time points in the pandemic, May 2020 ($N = 1520$) and August 2020 ($N = 545$). Depression, but not anxiety, significantly increased across time, which was moderated by coping style. Serial mediation modeling using path analysis demonstrated a significant pathway illustrating increased looming cognitive style in the beginning of the pandemic leads to increased intolerance of uncertainty, avoidant coping, and anxiety later in the pandemic. Results suggest a novel model in conceptualizing anxiety during the pandemic, namely highlighting looming cognitive style as an underlying cognitive vulnerability factor and antecedent of intolerance of uncertainty and illuminating the temporal directionality between looming cognitive style and intolerance of uncertainty. These findings provide important implications regarding intervention and public health messaging with modifiable behavioral and cognitive factors to improve mental health during a pandemic.

Keywords Depression · Anxiety · Coping · Looming cognitive style · Intolerance of uncertainty

✉ Nicolette D. Carnahan
nc9999a@student.american.edu

[1] Department of Psychology, American University, 4801 Massachusetts Ave NW, Washington, DC 20016, USA

[2] Department of Medical and Clinical Psychology, Uniformed Services University, Bethesda, MD, USA

Introduction

The COVID-19 pandemic has led to increased mental health symptoms around the world due to enforced lock downs, chronic uncertainty, and lack of socialization, among other things. There is currently ample evidence to suggest that non-clinical samples of people around the world are suffering from significantly greater levels of anxiety and depression both at clinical and non-clinical levels (Fitzpatrick et al., 2020; Mazza et al., 2020; Sciensano, 2020). There have been a multitude of studies conducted to understand underlying causes of this increase in anxiety and depression, through examining cognitive (e.g., intolerance of uncertainty), behavioral (e.g., coping styles), and demographic (e.g., age, income, race) factors.

There is evidence that the highest levels of anxiety and depression occurred at the start of the lockdown and pandemic (Fancourt et al., 2021) and other evidence suggesting stable psychological impact or worsening impact (Kwong et al., 2020; Planchuelo-Gómez et al., 2020). Even so, longitudinal studies examining mental health symptoms across the pandemic are currently limited, and even more limited in the USA. Thus, the current study will examine anxiety and depression symptoms across two time points in the pandemic, May and August of 2020.

As this study began in the middle of May 2020, in the USA there was an average of 23,946 cases per day and 1324 new deaths per day (CDC, 2020). During this time, the USA was in lockdown and there were high levels of uncertainty throughout the country and the world. In the face of the uncertainty over the rapidly spreading disease, people engaged in various coping behaviors which were either beneficial or detrimental to their mental health. Based on the previous research from the pandemic, the current study examined a serial mediation model assessing underlying psychological processes including the "looming" cognitive style (Riskind & Rector, 2018) and intolerance of uncertainty (Carleton, 2012), and how these impact the way that one copes and lead to anxiety and depressive symptoms. We examined coping style as a moderator for changes in depression to see how coping style at the beginning of the pandemic in May impacts depression scores in August.

Looming Cognitive Style

A potential cognitive vulnerability factor that has yet to be examined during the current crisis is looming cognitive style (LCS). LCS is defined as a maladaptive cognitive style in which individuals interpret and simulate perceptions of ambiguous threats as intensifying and rapidly approaching (Riskind et al., 2000). This construct is relevant to the current pandemic as COVID-19 represents a future threat and is associated with the perception that diseases are rapidly spreading and approaching, even when they are not. This in turn would be expected to accentuate worry and uncertainty. Previous research has shown that this cognitive style is a vulnerability factor for various anxiety subtypes, and that it independently predicts anxiety even when controlling for other related constructs like intolerance of uncertainty (Riskind & Rector, 2018; Yeo et al., 2020). The anxiety resulting from this cognitive style is due to mental simulations and expectations of future threats as rapidly growing,

spreading, increasing in magnitude, and approaching (Riskind & Calvete, 2019), and the LCS is considered a unique component in anxiety etiology not captured by other cognitive vulnerability constructs. LCS has also been repeatedly shown to be related to worry (Riskind & Rector, 2018), such that people with high LCS may imagine more catastrophic images of mundane events as rapidly escalating in threat, which increases perceived threat levels leading to unnecessary worry (Borkovec et al., 1998). Moreover, LCS accounts for unique variance in worry after controlling for anxiety, depression, and intolerance of uncertainty (Yeo et al., 2020), and Atlan-Atalay (2018) found brooding and worry to mediate the relationship between LCS and anxiety.

It would be expected that LCS would be related to uncertainty because threats that are rapidly changing and approaching become more salient as well as more unpredictable. Evidence for this was found in an experimental study by Riskind et al. (1992). This construct is relevant to the current pandemic such that as the pandemic has evolved, the threat approaching so that one could become infected has become increasingly salient with the rising infection and death toll. Thus, LCS warrants attention as an important vulnerability factor to consider when exploring anxiety during the pandemic.

While LCS is primarily considered an anxiety cognitive vulnerability factor, it is assumed that it can predict depression in circumstances where looming threats are perceived as uncontrollable and impossible to evade (Riskind & Rector, 2018; Riskind et al., 2013). This has been supported by a recent meta-analysis by Yeo et al. (2020) which found while LCS was most strongly related to anxiety, it also produced a smaller but significant mean effect size for depression when controlling for anxiety (Riskind et al., 2013). Thus, it is possible that this could be the case for some people during the pandemic as the threat of the virus may have seemed inescapable. Therefore, we tested serial mediation models for both outcomes.

Intolerance of Uncertainty

An additional vulnerability factor highlighted in the current literature for experiencing anxiety and depressive symptoms during the pandemic is intolerance of uncertainty (IU). IU is defined as the tendency to react negatively to uncertain situations on a cognitive, emotional, and behavioral level due to a set of negative beliefs about uncertainty and its implications (Buhr & Dugas, 2009). This cognitive bias specifically is the tendency to believe uncertain situations are stressful and should be avoided and may lead to the inability to act in an uncertain situation (Carleton, 2012). IU has been strongly linked to worry, such that it is considered a fundamental cognitive process involved in excessive worry beyond the effects of anxiety and depression (Buhr & Dugas, 2002, 2009). For example, Ladouceur et al. (2000) found that through an experimental manipulation of IU, increases in IU led to greater worry and decreases in IU led to less worry. Moreover, Chen et al. (2018) found that trait IU is an important cognitive vulnerability for both increased anxiety and worry. Furthermore, IU has been examined as a transdiagnostic vulnerability factor and trait IU has been found to be elevated in multiple diagnoses in comparison to a

non-clinical population, including depression, social anxiety, GAD, panic disorder, OCD, and agoraphobia (Mahoney & McEvoy, 2012; Carleton et al., 2012). Just as with the LCS, we will examine IU in a model with both state anxiety and depression as the outcome variable.

Several recent studies have found IU to be a significant predictor of psychological distress during the COVID-19 pandemic (Mertens et al., 2020; Rettie & Daniels, 2020); an interesting finding by Satici et al. (2020) with a Turkish sample demonstrated a serial mediation model in which the relationship between IU and mental well-being was serially mediated by rumination and fear of COVID-19. Another recent study by Smith et al. (2020) found that IU moderated the effect of social isolation on psychological distress such that higher levels of social isolation were related to worse mental health outcomes and the strength of this relationship was greater with increased levels of IU. Of particular relevance to the current study, Rettie and Daniels (2020) showed that IU may lead to more avoidant coping and less approach coping leading to increased symptoms of anxiety and depression. Importantly, Freeston et al. (2020) have proposed a model regarding distress over the coronavirus epidemic which regards uncertainty and threat perception as distinct interacting constructs, such that appraisals of threat may be increased by IU (Freeston et al., 2020). Moreover, Rettie and Daniels (2020) found that IU may lead to maladaptive behaviors aimed at decreasing anxiety such as reassurance seeking and avoidance to reduce feelings of uncertainty about threats. The current study extended Rettie and Daniels (2020) model by including LCS as well as IU in a serial mediation model.

Serial Relationship Between Intolerance of Uncertainty and Looming Cognitive Style

In the current study, we conducted a serial mediation model, and it was of interest to specifically examine the temporal directionality between IU and LCS to determine whether one precedes the other, as there are arguments that both could have an innate hardwired basis. The arguments that LCS has an innate basis as a warning signal include the facts that (a) all species of animals, including humans and even young infants exhibit innate fear and defensive reactions to rapidly approaching "looming" stimuli (Riskind, 1997); (b) looming stimuli automatically produce attentional capture in humans as well as better memory than static or receding stimuli (Franconeri & Simons, 2003); and (c) looming stimuli evoke fear reactions as well as distinct signatures of brain activation, even when equated for physical proximity (Mobbs et al., 2010). By the same token, there are arguments that IU has an innate basis (Brosschot et al., 2016; Carleton, 2012). For example, Brosschot et al. (2016) argue that IU is an innate property of all human beings and that it is alleviated as we learn that situations are safe. However, they state that for those people who are unable to perceive safety in situations, this generalized unsafety continues for uncertain situations, leading to anxiety and stress. The authors argue that the perception of threat does not maintain anxiety and worry, rather continuously not perceiving safety perpetuates anxiety and the resulting chronic physiological response. Carleton (2012) explains that the activation of the autonomic nervous system is adaptive

against predators when exploring a novel environment and thus makes sense from an innate survival perspective. Given the arguments from an evolutionary perspective for the precedence of both the cognitive constructs, we examined their temporal precedence in serial models. That is, we examined two possible reciprocal serial relationships, one which LCS predicts IU and one in which IU predicts LCS.

Coping

We also wished to examine both cognitive constructs in relation to coping styles. Coping styles have been found to significantly impact psychological outcomes during the COVID-19 pandemic around the world (Rettie & Daniels, 2020; Wang et al., 2020; Minahan et al., 2021; Dawson & Golijani-Moghaddam, 2020). The primary coping styles addressed in the literature include avoidant coping (behaviors individuals engage in to avoid thinking or having feelings about a stressor such as distraction, substance use, and venting) and approach coping (behaviors individuals engage in to actively cope such as finding emotional support, cognitive reframing, and acceptance) (Dawson & Golijani-Moghaddam, 2020). Consistently, the literature has demonstrated the significant impact of avoidant coping, such that it leads to increased psychological distress during the pandemic, while approach coping has had significantly weaker associations with psychological distress around the world (Dawson & Golijani-Moghaddam, 2020; Wang et al., 2020). Interestingly, Minahan et al. (2020) found that avoidant coping more strongly mediated the relationship between pandemic related stress and depression in younger versus older adults. Notably, they reported that older adults may have unique adaptive positive coping behaviors. Rettie and Daniels (2020) found that maladaptive coping partially mediated the relationship between IU and depression and generalized anxiety. Indicating that more maladaptive coping may come from difficulty tolerating the high levels of uncertainty during the pandemic. The link between LCS and avoidant coping would also be theoretically expected (Riskind & Rector, 2018) and consistent with findings that LCS predicts fears of losing control over anxiety and other intense emotion (Riskind & Kleiman, 2012). Therefore, due to this fear, it is reasonable to predict that one would engage in avoidant coping to avoid these intense emotions.

Current Study

Based on the previous literature during the COVID-19 pandemic and the preliminary longitudinal mental health findings around the world, the current study investigated moderation and mediation models examining factors influencing anxiety and depression during the pandemic at one time point as well as over time. Due to mixed findings to date and limited studies on mental health across the pandemic, we examined changes in anxiety and depression across time during two time points in the pandemic. We chose to examine state anxiety in particular as we felt this would best capture people's anxiety in the moment as opposed to trait anxiety, especially as we wanted to examine this anxiety over time. Moreover, we examined coping style as a moderator for the change in depression scores across time (see Fig. 1), as coping
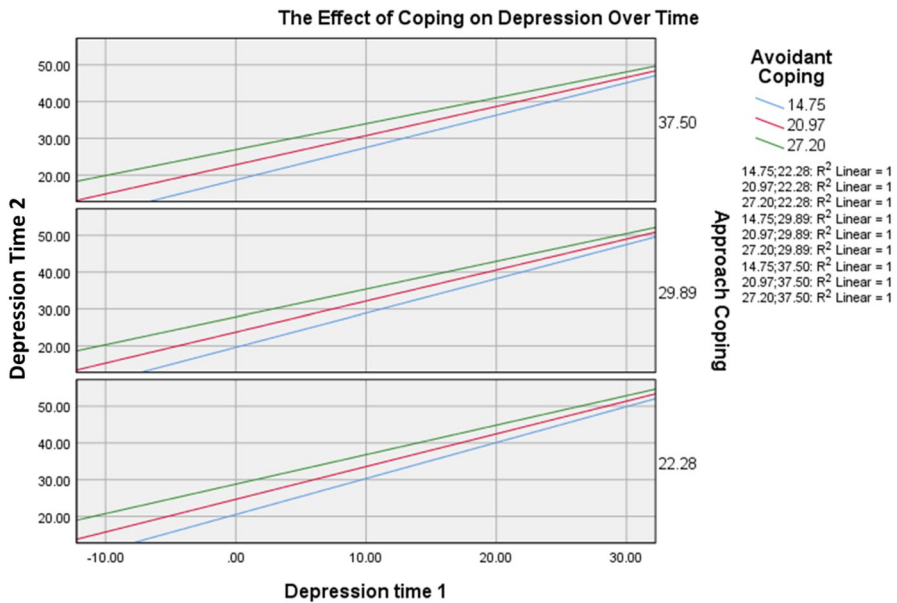
Fig. 1 Moderation of the relationship between coping style and depression over time

has been found to significantly impact mental health during the pandemic (Wang et al., 2020; Minahan et al., 2021). In further specifying potential causal factors of increased mental health symptoms, we examined serial relationships for underlying vulnerability factors, namely, LCS and IU, that predict anxiety and depression symptoms during the pandemic to test the temporal directionality of their relationships. As noted, we explored LCS and IU as antecedent factors that would influence anxiety and depression, as well as their serial relationships. IU and LCS were expected to be serially mediated with avoidant coping to lead to increases in psychopathology symptoms (see Fig. 2).

Method

Participants

For time 1, participants were 1520 adults (819 women, 695 men, 4 non-binary, 2 other; 67.7% Caucasian, 9.1% African American, 8% Hispanic/Latinx, 11.4% Asian/ Asian American, 5.5% Native American, 0.9% Pacific Islander, 2.4% Other; 31% 18–30 years, 29.5% 31–40 years, 18% 41–50, 12.6% 51–60, 7.2% 61–70, 1.5% 71–80, 0.2% 81 and older) and were recruited from Amazon's Mechanical Turk (MTurk) and snowball sampling on social media. The data from 1517 participants who completed the study were used. For time 2, participants were 545 adults (321 women, 221 men, 2 non-binary, 1 other; 78.5% Caucasian, 6.7% African American, 5.1% Hispanic/Latinx, 8.4% Asian/Asian American, 1.7% Native American, 0.2%
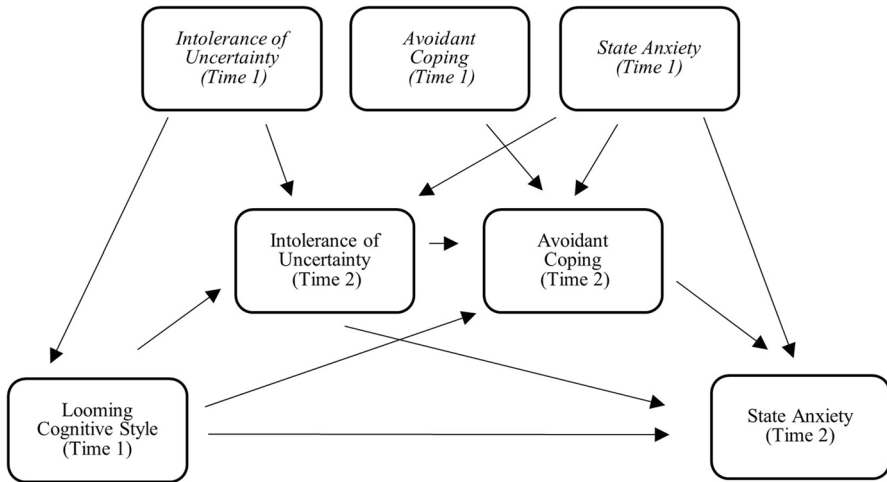
Fig. 2 Serial mediation of the relationship between factors for state anxiety. Only significant pathways were added to the figure for the control variables. The control variables are italicized

Pacific Islander, 1.9% other; 20.5% 18–30 years, 26.5% 31–40 years, 17.6% 41–50, 14.7% 51–60, 11.6% 61–70, 2.1% 71–80, 0.2% 81 and older). There were some significant differences between the participants who completed time 2 and those who did not. Specifically, those who only completed time one had significantly greater depression scores, $t(1503) = 9.63$, $p = < 0.001$, IU scores, $t(1505) = 4.81$, $p = < 0.001$, avoidant coping scores $t(1504) = 10.06$, $p = < 0.001$, and state anxiety scores, $t(1506) = 4.74$, $p = < 0.001$. However, there were no significant differences between the two groups on LCS or approach coping scores. The reduction in participants at time 2 limits some of the generalizability of the results and should be interpreted with the participant differences and sample size in mind. All participants agreed to give their consent to participate and agreed to an online consent form. Participants were given 50 cents for compensation on MTurk or participated for no compensation through social media. The specific inclusion criteria for the study included being at least 18 years of age and currently living in the USA.

Measures

Center for Epidemiologic Studies Depression Scale Revised (CESD-R) (Radloff, 1977) is a 20-item self-report scale measuring depressive symptoms. The items are on a 4-point scale from *rarely or none of the time* to *all of the time*. (e.g., "I felt fearful"). The measure displayed excellent internal consistency with the current sample (time 1: $\alpha = 0.97$; time 2: $\alpha = 0.96$), and good test–retest reliability (0.81).

Spielberger State-Trait Anxiety scale (STAI) (Spielberger et al., 1970) has two subscales, STAIS and STAI-T with 20 items each. We used the STAIS, which is on a 4-point scale from 1 *(not at all)* to 4 *(very much so)*. The STAIS subscale assesses state anxiety levels (e.g., "I feel calm"). The STAIS displayed excellent

internal consistency (time 1: $\alpha = 0.95$; time 2: $\alpha = 0.96$) in the current study, and good test–retest reliability (0.75).

Brief COPE Inventory (Carver, 1997) is a 28-item scale assessing coping strategies for a stressful life event with two subscales measuring avoidant and approach coping styles (e.g., "I've been making jokes about it"). The scale also includes 14 subscales measuring specific coping strategies that we did not include in this study. Items are on a 4-point scale from (*I haven't been doing this at all)* to (*I've been doing this a lot*). We edited the instructions for this inventory to make it specific to the COVID-19 pandemic (specifying **ways** people have been coping with the stress in their life since the COVID-19 pandemic began). In this study, the avoidant coping subscale displayed good internal consistency (time 1: $\alpha = 0.89$; time 2: $\alpha = 0.78$) and good test–retest reliability (0.74) and the approach coping subscale displayed good internal consistency (time 1: $\alpha = 0.87$).

Intolerance of Uncertainty Scale-Short Form (IUS-12) (Carleton et al., 2007) is a 12-item scale with two subscales measuring prospective anxiety and inhibitory anxiety (e.g., "Unforeseen events upset me greatly"). Items are on a 5-point scale from 1 (not *at all characteristic of me)* to 5 (*entirely characteristic of me)*. The IUS-12 displayed excellent internal consistency (time 1: $\alpha = 0.92$; time 2: 0.93) and good test–retest reliability (0.78) in the current study.

Looming Maladaptive Style Questionnaire Revised (LMSQ-R) (Riskind et al., 1992) is a questionnaire assessing the cognitive style or tendency to perceive threatening situations as rapidly growing and increasing in danger over time even when they are not. There are 6 vignettes with 3 questions per vignette on a 5-point scale with different anchors based on the question (e.g., "Suppose that you get odd heart palpitations while talking to someone about a financial problem. You have never had palpitations where your heart skipped around like this and you could be developing a heart murmur."). There are two subscales examining the cognitive style on physical threat and social threat. The LMSQ displayed excellent internal consistency (time 1: $\alpha = 0.91$; time 2: 0.94) and moderate test–retest reliability (0.62) in the current study.

Procedure

In May 2020, participants chose to participate in the study by either clicking on the study on MTurk or on a social media platform where it was advertised. They were first presented a consent form and then a battery of questionnaires including a demographic questionnaire, the CESD, STAIS, LMSQ-R, Brief COPE, and the IUS-12. The questionnaires were randomized to prevent any order effects. After that, if they were on MTurk, they were sent their compensation for their participation. If they were recruited via snowball sampling, they were directed to another survey detached from their data asking if they would like to be contacted in a few months for a follow-up study. If they consented to being contacted, they were asked to provide an email for the survey to be sent to in a few months. In August 2020, participants who participated in May were eligible to participate in the second part of the study on MTurk or were emailed the follow-up link if they had previously consented. They

were given the same battery of questionnaires and the same protocol occurred following completion of this portion of the study as in the first part of the study regarding compensation and follow-up contact.

Data Analysis

The data analysis plan for the current study included: paired samples *t*-tests to assess changes in anxiety and depression over time, a moderation model using PROCESS model 2 (Hayes, 2013) to assess coping as a moderator for depression longitudinally, and finally path analysis using SPSS AMOS to examine a serial mediation model between LCS, IU, avoidant coping, and psychological outcomes. Model fit for the path analysis was determined with the absolute fit indices: RMSEA < 0.06 and chi-square fit index, and the incremental fit index: CFI > 0.95 (Hu & Bentler, 1999; Alavi et al., 2020). The chi-square in relation to degrees of freedom should have a higher *p*-value to indicate better model fit; however, the limitation to this index is the sensitivity to sample size and model size (Alavi et al., 2020). It is likely with larger sample sizes to get a significant *p*-value. Thus, we will consider all three fit statistics in considering the acceptability of the model fit (For Pearson's correlations and descriptive statistics for all variables in the study see Tables 1 and 2).

Results

Longitudinal Analyses

We examined psychological outcome variables, namely depression and anxiety symptoms, across time within subjects to see if there was a significant change during the pandemic. A paired samples *t*-test was conducted to compare depressive symptoms across time and there was a significant difference in the scores at time 1, ($M = 13.93$, $SD = 15.07$) and time 2, ($M = 34.69$, $SD = 16.78$); $t(505) = -46.53$, $p = 0.000$. Another paired samples *t*-test was conducted to compare general anxiety symptoms across time and there was not a significant difference in the scores at time 1, ($M = 39.03$, $SD = 14.36$) and time 2, ($M = 38.66$, $SD = 14.49$); $t(499) = 0.82$, $p = 0.42$. The stability of anxiety scores may be due to pandemic fatigue, defined as mental and physical exhaustion and a move to chronic rather than acute stress (Murphy, 2020). This chronic stress may lead to increased depressive symptoms while keeping anxiety scores stable. The finding that increased depression increased across time informed our subsequent moderation analysis strategy.

In examining the significant increase in depressive symptoms across time, we conducted a moderation analyses using PROCESS model 2 (Hayes, 2013) to examine the impact of the type of coping on depression across time. In the moderation model, we examined the impact of avoidant and approach coping on depressive symptoms across time. Simple slopes for the association between depression at both time points were tested for low (−1 SD below the mean), moderate (mean), and high (+1 SD above the mean) levels of both approach and avoidant coping. Each of

Table 1 Correlation table

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. State anxiety (time 1)	—													
2. Depression (time 1)	0.65	—												
3. Intolerance of uncertainty (time 1)	0.49	0.556	—											
4. Avoidant coping (time 1)	0.48	0.68	0.520	—										
5. Approach coping (time 1)	− 0.08	0.15	0.18	0.42	—									
6. Spiritual well-being (time 1)	− 0.601	− 0.34	− 0.18	− 0.08	0.38	—								
7. Looming cognitive style (time 1)	0.19	0.19	0.40	0.16	0.13	− 0.045	—							
8. Health anxiety (time 1)	0.54	0.52	0.45	0.43	0.08	− 0.30	0.28	—						
9. Depression (time 2)	0.62	0.81	0.43	0.53	− 0.04	− 0.46	0.13	0.53	—					
10. Avoidant coping (time 2)	0.45	0.58	0.38	0.74	0.16	− 0.26	0.06	0.38	0.65	—				
11. Approach coping (time 2)	− 0.15	− 0.05	0.02	0.15	0.60	0.30	0.10	− 0.05	− 0.02	0.27	—			
12. Looming cognitive style (time 2)	0.18	0.18	0.37	0.16	0.09	− 0.01	0.62	0.24	0.17	0.15	0.078	—		
13. State anxiety (time 2)	0.75	0.64	0.45	0.43	− 0.15	− 0.57	0.14	0.55	0.69	0.50	− 0.12	0.22	—	
14. Intolerance of uncertainty (time 2)	0.45	0.43	0.78	0.39	0.08	− 0.29	0.39	0.41	0.48	0.43	0.08	0.44	0.49	—

Table 2 Overall means and standard deviations of variables

Measure	Time 1: M (SD)	Time 2: M(SD)
STAIS	39.3 (14.4)	38.7 (14.5)
LMSQ-R	61.6 (13.0)	62.0 (13.8)
IUS-12	33.1 (13.0)	33.5 (11.1)
Brief COPE (approach)	30.0 (7.6)	29.7 (7.4)
Brief COPE (avoidant)	21.0 (6.2)	21.1 (6.2)
CESD-R	13.9 (15.0)	34.7 (16.8)

The scores for participants who participated in both time points for each dependent measure. STAIS (Spielberger State-Trait Anxiety Inventory State subscale); LMSQ-R (Looming Maladaptive Style Questionnaire Revised); IUS-12 (Intolerance of Uncertainty Scale-Short Form); Brief COPE (Brief COPE Inventory); CESD-R (Center for Epidemiologic Studies Depression Scale Revised)

the simple slopes tests revealed a significant positive association between depression across time and approach and avoidant coping, but the depression scores were most strongly related for low levels of avoidant and approach coping, $B = 0.9782$, $SE = 0.05$, $p = 0.000$, 95% CI = 0.8800, 1.0763 and had the lowest effect at high levels of both avoidant and approach coping, $B = 0.7052$, $SE = 0.05$, $p = 0.000$, 95% CI = 0.6132, 0.7972. Thus, when someone engages in low levels of both styles of coping at time one, depression at time two is the most impacted such that low levels of avoidant coping and low levels of depression at time one leads to significantly fewer depressive symptoms at time two, and low levels of approach coping at high levels of depression at time one leads to significantly more depressive symptoms at time two (see Fig. 1).

Serial Mediation Model

We tested two models of anticipated relationships to predict a causal chain between the variables from LCS to IU to avoidant coping to psychopathology outcomes as well as from IU to LCS to avoidant coping to psychopathology outcomes using path analysis in AMOS. Due to some missing data points, which included missing or skipped questions on measures, we used regression imputation in order to run the bootstrapping analyses and serial mediation estimand. People who did not complete time 2 data collection were excluded from the model. Thus, the sample size for the AMOS models was 481 after removing outliers and participants with less than 90% of the survey completed.

In our first model, we tested the serial mediation model examining the hypothesis that increased levels of LCS at time 1 would lead to increased levels of IU at time 2 which would lead to increased avoidant coping at time 2 and result in increased anxiety and depression at time 2. We tested two models, one looking at state anxiety as the dependent variable and one with depression scores as the dependent variable. We controlled for IU at time 1, avoidant coping at time 1, and state anxiety or depression at time 1 and covaried the control variables. We controlled for state anxiety at time 2 for the depression model due to the high correlation between anxiety

and depression in order to uniquely examine the effects of the serial mediation model on the outcome of depression.

In the first model with anxiety scores as the dependent variable (see Fig. 2), the fit was excellent, chi-square = 0.039, df = 1, p = 0.843; RMSEA = 0.00; CFI = 1.0. We used the serial mediation estimand for AMOS with bootstrap analyses to test the overall serial mediation path between variables and this was significant, B = 0.004, SE = 0.002, p = 0.003, 90%, CI = 0.001, 0.009, indicating that the path between LCS at time 1 to IU at time 2 to avoidant coping at time 2 to state anxiety scores at time 2 was significant (see Table 3 for pathway estimates). The effect sizes for the endogenous variables were LCS = 0.16, IU = 0.63, avoidant coping = 0.59, state anxiety = 0.62.

In the first model with depression scores as the dependent variable, the fit was not acceptable, chi-square = 37.76, df = 4, p = 0.000; RMSEA = 0.133; CFI = 0.985. Due to the model not having an acceptable fit according to the absolute fit indices, we did not interpret the results. Of note, when we did not control for state anxiety the model fit was acceptable, likely due to the overlap in variance between the two constructs.

In our second model, we tested the serial mediation model examining the hypothesis that increased levels of IU at time 1 would lead to increased levels of LCS at time 2 which would lead to increased avoidant coping at time 2 and result in increased anxiety and depression at time 2. We did two models, one looking at state anxiety as the dependent variable and one with depression scores as the dependent variable. We controlled for LCS at time 1, avoidant coping at time 1, and state

Table 3 Pathways

Path	Estimate	S.E	P-value	Result
IU –> LMSQ	0.498	0.054	***	Significant
CopAv –> LMSQ	−0.161	0.096	0.095	Not significant
LMSQ –> IU 2	**0.077**	**0.026**	**0.003**	**Significant**
IU –> IU 2	0.684	0.035	***	Significant
CopAV –> IU 2	0.097	0.058	0.095	Not significant
STAIS–> IU 2	0.058	0.026	0.027	Significant
IU 2 –> CopAv 2	**0.102**	**0.027**	*******	**Significant**
Cop Av –> CopAv 2	0.64	0.034	***	Significant
IU –> CopAv 2	−0.023	0.028	0.411	Not significant
LMSQ–> CopAv 2	−0.04	0.015	0.01	Significant
STAIS –> CopAv 2	0.048	0.015	0.002	Significant
CopAv 2 –> STAIS 2	**0.484**	**0.103**	*******	**Significant**
LMSQ –> STAIS 2	−0.007	0.035	0.845	Not significant
IU 2 –> STAIS 2	0.268	0.061	***	Significant
STAIS–> STAIS 2	0.632	0.035	***	Significant
CopAv –> STAIS 2	−0.152	0.101	0.131	Not significant
IU –> STAIS 2	−0.091	0.062	0.145	Not significant

IU, intolerance of uncertainty; *CopAv*, avoidant coping; *LMSQ*, looming cognitive style; *STAIS*, state anxiety 2). ***Significant at .001 level. Bolded rows indicate serial mediation paths

anxiety or depression at time 1. We again controlled for state anxiety at time 2 for the depression model to uniquely examine the effects of the serial mediation model on the outcome of depression.

In the second model with anxiety scores as the dependent variable, the model did not have as good of a fit as the previous model, chi-square = 60.82, $df = 1$, $p = 0.000$; RMSEA = 0.353; CFI = 0.959. Due to the model not having an acceptable fit according to the absolute fit indices, we did not interpret the results.

In the second model with depression scores as the dependent variable, the model did not have as good of a fit as the previous model, chi-square = 75.91, $df = 4$, $p = 0.000$; RMSEA = 0.194, CFI = 0.964. Due to the model not having an acceptable fit according to the absolute fit indices, we again did not interpret the results.

Discussion

The current study investigated anxiety and depression longitudinally across two time points during the COVID-19 pandemic and the cognitive vulnerability and behavioral factors that influenced psychological well-being. This is also the first study to examine the serial relationships between the LCS and IU in predicting anxiety and depression outcomes. We specifically tested a serial mediation model two ways in which we examined LCS and IU as primary predictors at time one to examine temporal directionality between the two. We found that the model with the best fit and significant serial mediation was LCS at time one leading to increased IU at time 2 leading to more avoidant coping at time 2 resulting in increased anxiety and depression symptoms at time 2.

A secondary finding is that depression scores significantly increased from May 2020 to August 2020, while anxiety scores did not significantly differ across time. We believe this may be due to the increases in cases and deaths over time which may have led to people feeling hopeless about the pandemic situation as the months of lockdowns continued. Moreover, this hopelessness in combination with the sustained social isolation over time and decreased behavioral activation is more likely to increase depressive symptoms than anxiety symptoms. The absence of a change in anxiety reflects consistent concern across time and pandemic fatigue as previously discussed (Murphy, 2020). The significant change in depression likely indicates that participants were depleted by the sustain social isolation and restrictions as well as more convinced of an eventual negative outcome. Additionally, it is important to note that the participants who completed both times had significantly lower depression and anxiety scores at time 1 than the group that only completed time 1. Thus, it is possible that we could have seen a different pattern of results for the participants who did not complete time 2.

Moderation Model

We also found a significant moderation model for avoidant coping and approach coping. For people who were initially at lower levels of depression, higher levels of

avoidant coping predicted higher levels of subsequent depression. For people who were initially at high levels, on the other hand, those who used less approach coping increased in later depression. These findings are consistent with previous studies that have found avoidant coping to significantly increase distress during the pandemic (Dawson & Golijani-Moghaddam, 2020; Rettie & Daniels, 2020; Wang et al., 2020); however, it builds upon these studies in examining the interaction of avoidant coping with approach coping on depression longitudinally. This novel model exemplifies the importance of coping behaviors in the beginning of the pandemic and the impact of these behaviors on later depressive symptoms. Also, on top of the lockdown and social isolation which already prevents engagement in activities, avoidant coping may lead to decreased behavioral activation which would then lead to significantly more depressive symptoms whereas this may not be the case for anxiety symptoms.

Serial Mediation Model

We further examined a serial mediation model, adding onto the Rettie and Daniels (2020) model, we explored the relationship between LCS, IU, avoidant coping, and symptoms of psychopathology (depression and state anxiety). We tested this model with both LCS at time 1 and IU at time 1 as the first predictor in the model due to both of these constructs having theoretical arguments for an evolutionary basis (Carleton, 2012; Riskind et al., 2000). Interestingly, when we ran these models in AMOS, the models with IU at time 1 as the primary predictor did not have an acceptable fit according to some metrics. In contrast, we found a better fit and significant serial mediation pathway with LCS at time 1 predicting increased IU at time 2 leading to increased avoidant coping at time 2 and therefore increased anxiety at time 2. The same model with depression as the outcome variable did not have a good fit once we controlled for state anxiety, indicating that the model captures the underlying mediating factors for anxiety and not depression during the pandemic. This finding is not surprising given the evidence that LCS is a more specific vulnerability factor for anxiety than depression (Yeo et al., 2020).

Our findings support the argument that detecting and overestimating the growing intensity and approach of a threat may have an evolutionary basis (Yeo et al., 2020) and when one has the tendency to view stimuli as more intense and rapidly approaching, this may lead to more uncertainty and discomfort with that uncertainty. Thus, the potential costs are greater which then leads to avoidant coping and further distress. This ties into the suggestion by Carleton (2012) that uncertainty is critical in the context of potential danger and our model is illustrating that LCS is representing the possibility for danger. This then theoretically is logical that LCS would precede IU. Yeo et al. (2020) note the dynamic features of threat appraisal that are emphasized in LCS where it has been shown to predict anxiety above and beyond IU (Riskind et al., 2007) which is a more static perception of threat. Thus, our findings support that LCS sets the stage for the perception that there is the possibility of a danger or a threat (even if one does not actually exist) and within this stage, this then leads to difficulty with the uncertainty about the threat, and as Brosschot et al.

(2016) argue, the concern about one's safety once the context for that threat has been established.

As noted, this is the first study to our knowledge to examine the relationship between LCS and IU in a single model in a longitudinal study. There have been very few studies to examine these two constructs together, and the studies to date have examined the predictive utility of each construct side by side and have found slightly different findings for each construct (Hong, 2013; Riskind et al., 2007). The findings of this study support the role of IU on anxiety symptoms during the pandemic and they further show that the LCS may be important antecedent that can influence IU. Understanding the temporal relationship between the two variables is important in conceptualizing the etiology of anxiety as both constructs are significant and influential underlying cognitive vulnerability in the anxiety literature. This is not only useful from a theoretical standpoint, as outlined above, but also for treatment for anxiety. It is worth noting that during the pandemic there was a large threat that was legitimately rapidly approaching and dangerous in which there was a lot of uncertainty. Thus, it is important to interpret these results in the context of the COVID-19 pandemic and recognize there may have been other effects on the variables that we did not control for such as COVID-19 diagnosis, grief due to COVID-19-related deaths, and other major events during 2020 in the USA.

We replicated and added onto Rettie and Daniels' (2020) model, and the novel findings of this study are the first to look at the construct of LCS in the context of COVID-19 anxiety and depression. A strength of the study was that we used a large and diverse sample and utilized prospective analyses. Cross-sectional studies cannot distinguish temporal precedence and directionality; therefore, it is important to use prospective studies to examine longitudinal processes. We found that depression scores longitudinally were moderated by coping style, and we found that LCS longitudinally led to increased IU which then cross-sectionally led to increased avoidant coping and anxiety symptoms.

Clinical Implications

Our findings can be generalized to therapists working with patients during the COVID-19 pandemic or future pandemic situations. Having identified both cognitive (LCS and IU) and behavioral (coping) factors associated with the exacerbation of psychopathology during a pandemic suggests that therapists treating people with anxiety or depression could intervene in multiple ways. Specifically, increasing approach coping behaviors, especially for those with high levels of depression, and decreasing avoidant coping, especially for those with lower levels of depressive symptoms, in the beginning of a pandemic is important to mitigate against significant increases in these depressive symptoms across time. Some specific examples may include encouraging clients to increase their social support system through phone calls to loved ones and decreasing substance use. This information on effective coping could also be spread through public health messaging with simple strategies to mitigate against depressive symptoms (e.g., acceptance, mindfulness, social support).

Moreover, Riskind and Rector (2018) have suggested ways to reduce the experience of rapidly approaching threat in CBT treatment, such as exposure to mental imagery of a threat that is rapidly approaching and growing. Our findings show the temporal relationship between LCS and IU such that targeting LCS in the beginning of the pandemic could then decrease IU over time leading to less avoidant coping and less anxiety. However, even without specifically targeting LCS, there is evidence that CBT decreases dysfunctional looming appraisals which then predicts less anxiety post-treatment (Katz et al., 2017). Thus, traditional CBT treatment in the beginning of a pandemic could mitigate anxiety long term. Our findings highlight the interaction between our cognition, behaviors, and emotions during a pandemic and lend themselves to interventions such as behavioral activation, exposure, and cognitive restructuring for depression and anxiety. Finally, it could be appropriate to target IU directly in treatment through transdiagnostic CBT treatments targeting IU as this would then directly impact coping and anxiety levels (Robichaud & Dugas, 2006).

Limitation and Future Directions

Despite many novel findings, there are several limitations in our study. First, a convenience and non-clinical sample was used. While there were individuals who scored high on our dependent measures, there was no formal clinical evaluation to determine if participants were clinically depressed or anxious. Furthermore, we utilized all self-report measures which have limitations such as potential social desirability bias, exaggeration, or under reporting. We also recognize that examining the relationship between LCS, IU, avoidant coping, and psychological distress during a pandemic could greatly amplify the scores on these measures and potentially make them more interrelated than outside a pandemic situation. Thus, it would be compelling to test this same model outside of a pandemic to see if the relationships between variables changed. Finally, while recruiting our sample through MTurk may seem like a limitation, there is evidence that the data collected through MTurk is as good or better than data collected with traditional survey methods (Feitosa et al., 2015). Lowry et al. (2016) compared the common critiques of MTurk data collection with traditional data collection and discussed that the same issues can arise, and even more strongly, with traditional survey methods.

Future work in this area could examine the impact of coping behaviors over longer periods in the pandemic to assess mental health outcomes. Additionally, future exploration could examine the mediation and moderation models created in this study with a clinical population to further test the validity of the models. Also, examining the serial mediation model in a non-pandemic time to examine if the relationships between variables still exist in the same way would be interesting. Finally, within these models, it would be interesting to look at more specific types of coping and how those interact with mental health outcomes.

Conclusions

The interesting new findings of this study involved the prospective relationships of LCS, IU, and coping styles on anxiety and depression during the COVID-19 pandemic. The findings add to the emerging anxiety literature during this pandemic. Overall, this study illustrates longitudinal increases in depression across the pandemic in the USA as moderated by coping style, highlighting to importance of behavioral interventions to mitigate long-term distress in a pandemic situation. The study also sheds light on the temporal relationship between LCS and IU during the pandemic, providing a new theoretical link between the constructs and suggesting early cognitive interventions as protective against later anxiety.

Declarations

Conflict of Interest The authors declare no competing interests.

References

Alavi, M., Visentin, D. C., Thapa, D. K., Hunt, G. E., Watson, R., & Cleary, M. (2020). Chi-square for model fit in confirmatory factor analysis. Journal of Advanced Nursing.

Altan-Atalay, A. (2018). Looming cognitive style (LCS), repetitive negative thinking (RNT), and anxiety: A cross-sectional study. *International Journal of Cognitive Therapy, 11*(3), 262–271.

Borkovec, T. D., Ray, W. J., & Stober, J. (1998). Worry: A cognitivephenomenon intimately linked to affective, physiological, and interpersonal behavioral processes. *Cognitive Therapy and Research, 22*, 561–576. https://doi.org/10.1023/A:1018790003416

Brosschot, J. F., Verkuil, B., & Thayer, J. F. (2016). The default response to uncertainty and the importance of perceived safety in anxiety and stress: An evolution-theoretical perspective. *Journal of Anxiety Disorders, 41*, 22–34.

Buhr, K., & Dugas, M. J. (2002). The intolerance of uncertainty scale: Psychometric properties of the English version. *Behaviour Research and Therapy, 40*(8), 931–945.

Buhr, K., & Dugas, M. J. (2009). The role of fear of anxiety and intolerance of uncertainty in worry: An experimental manipulation. *Behaviour Research and Therapy, 47*(3), 215–223.

Carleton, R. N. (2012). The intolerance of uncertainty construct in the context of anxiety disorders: Theoretical and practical perspectives. *Expert Review of Neurotherapeutics, 12*(8), 937–947.

Carleton, R. N., Mulvogue, M. K., Thibodeau, M. A., McCabe, R. E., Antony, M. M., & Asmundson, G. J. (2012). Increasingly certain about uncertainty: Intolerance of uncertainty across anxiety and depression. *Journal of Anxiety Disorders, 26*(3), 468–479.

Carleton, R. N., Norton, M. P. J., & Asmundson, G. J. (2007). Fearing the unknown: A short version of the intolerance of uncertainty scale. *Journal of Anxiety Disorders, 21*(1), 105–117.

Carver, C. S. (1997). You want to measure coping but your protocol's too long: Consider the Brief COPE. *International Journal of Behavioral Medicine, 4*, 92–100.

Centers for Disease Control and Prevention. (2020). CDC data tracker. https://covid.cdc.gov/covid-data-tracker/#trends_dailytrendscases. February 2020.

Chen, S., Yao, N., & Qian, M. (2018). The influence of uncertainty and intolerance of uncertainty on anxiety. *Journal of Behavior Therapy and Experimental Psychiatry, 61*, 60–65.

Dawson, D. L., & Golijani-Moghaddam, N. (2020). COVID-19: Psychological flexibility, coping, mental health, and wellbeing in the UK during the pandemic. *Journal of Contextual Behavioral Science, 17*, 126–134.

Fancourt, D., Steptoe, A., & Bu, F. (2021). Trajectories of anxiety and depressive symptoms during enforced isolation due to COVID-19 in England: A longitudinal observational study. *Lancet Psychiatry, 2,* 141–149. https://doi.org/10.1016/S2215-0366(20)30482-X.

Feitosa, J., Joseph, D. L., & Newman, D. A. (2015). Crowdsourcing and personality measurement equivalence: A warning about countries whose primary language is not English. *Personality and Individual Differences, 75,* 47–52.

Fitzpatrick, K. M., Harris, C., & Drawve, G. (2020). Fear of COVID-19 and the mental health consequences in America. *Psychological Trauma: Theory, Research, Practice, and Policy, 12*(S1), S17.

Franconeri, S. L., & Simons, D. J. (2003). Moving and looming stimuli capture attention. *Attention, Perception, & Psychophysics, 6*5, 999–1010. https://doi.org/10.3758/bf03194829

Freeston, M., Tiplady, A., Mawn, L., Bottesi, G., & Thwaites, S. (2020). Towards a model of uncertainty distress in the context of Coronavirus (COVID-19). *The Cognitive Behaviour Therapist, 13*

Hayes, A. F. (2013). Introduction to mediation, moderation, and conditional process analysis: Methodology in the Social Sciences. *Kindle Edition*, 193.

Hong, R. Y. (2013). From dispositional traits to psychopathological symptoms: Social-cognitive vulnerabilities as intervening mechanisms. *Journal of Psychopathology and Behavioral Assessment, 35*(4), 407–420.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55.

Katz, D., Rector, N. A., & Riskind, J. (2017). Reduction in looming cognitive style in cognitive-behavioral therapy: Effect on post-treatment symptoms across anxiety disorders and within generalized anxiety disorder. *International Journal of Cognitive Therapy, 10*(4), 346–358.

Kwong, A. S., Pearson, R. M., Adams, M. J., Northstone, K., Tilling, K., Smith, D., & Timpson, N. J. (2021). Mental health before and during the COVID-19 pandemic in two longitudinal UK population cohorts. *The British Journal of Psychiatry, 218*(6), 334–343.

Ladouceur, R., Gosselin, P., & Dugas, M. J. (2000). Experimental manipulation of intolerance of uncertainty: A study of a theoretical model of worry. *Behaviour Research and Therapy, 38*(9), 933–941.

Lowry, P. B., D'Arcy, J., Hammer, B., & Moody, G. D. (2016). "Cargo Cult" science in traditional organization and information systems survey research: A case for using nontraditional methods of data collection, including Mechanical Turk and online panels. *The Journal of Strategic Information Systems, 25*(3), 232–240.

Mahoney, A. E., & McEvoy, P. M. (2012). A transdiagnostic examination of intolerance of uncertainty across anxiety and depressive disorders. *Cognitive Behaviour Therapy, 41*(3), 212–222.

Mazza, C., Ricci, E., Biondi, S., Colasanti, M., Ferracuti, S., Napoli, C., & Roma, P. (2020). A nationwide survey of psychological distress among Italian people during the COVID-19 pandemic: Immediate psychological responses and associated factors. *International Journal of Environmental Research and Public Health, 17*(9), 3165.

Mertens, G., Gerritsen, L., Duijndam, S., Salemink, E., & Engelhard, I. M. (2020). Fear of the coronavirus (COVID-19): Predictors in an online study conducted in March 2020. *Journal of Anxiety Disorders, 74*, 102258. https://doi.org/10.1016/j.janxdis.2020.102258

Minahan, J., Falzarano, F., Yazdani, N., & Siedlecki, K. L. (2021). The COVID-19 pandemic and psychosocial outcomes across age through the stress and coping framework. *The Gerontologist, 61*(2), 228–239.

Mobbs, D., Yu, R., Rowe, J. B., Eich, H., Feldman-Hall, O., & Dalgleish, T. (2010). Neural activity associated with monitoring the oscillating threat value of a Tarantula. *Proceedings of the National Academy of Sciences of the United States of America USA 107*(47), 20582–20586

Murphy, J. F. A. (2020). Pandemic fatigue. *Irish Medical Journal, 113*(6), 90.

Planchuelo-Gómez, Á., Odriozola-González, P., Irurtia, M. J., & de Luis-García, R. (2020). Longitudinal evaluation of the psychological impact of the COVID-19 crisis in Spain. *Journal of Affective Disorders, 277*, 842–849.

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement, 1*, 385–401.

Rettie, H., & Daniels, J. (2020). Coping and tolerance of uncertainty: Predictors andmediators of mental health during the COVID-19 pandemic. *American Psychologist*. https://doi.org/10.1037/amp0000710.

Riskind, J. H. (1997). Looming vulnerability to threat: A cognitive paradigm for anxiety. *Behaviour Research and Therapy, 35*(8), 685–702.

Riskind, J. H., & Calvete, E. (2019). Anxiety and the dynamic self as defined by the prospection and mental simulation of looming future threats. *Journal of Personality Advance Online Publication*. https://doi.org/10.1111/jopy.12465

Riskind, J. H., Kelley, K., Harman, W., Moore, R., & Gaines, H. S. (1992). The loomingness of danger: Does it discriminate focal phobia and general anxiety from depression? *Cognitive Therapy and Research, 16*, 603–622. https://doi.org/10.1007/BF01175402

Riskind, J. H., & Kleiman, E. M. (2012). Looming Cognitive style, emotion schemas, and fears of loss of emotional control: Two studies. *International Journal of Cognitive Therapy, 5*, 392–405.

Riskind, J. H., Kleiman, E. M., Weingarden, H., & Danvers, A. F. (2013). Cognitive vulnerability to anxiety in the stress generation process: Further investigation of the interaction effect between the looming cognitive style and anxiety sensitivity. *Journal of Behavior Therapy and Experimental Psychiatry, 44*, 381–387. https://doi.org/10.1016/j.jbtep.2013.03.002.

Riskind, J. H., & Rector, N. A. (2018). *Looming vulnerability: Theory, research and practice in anxiety*. Springer.

Riskind, J. H., Tzur, D., Williams, N. L., Mann, B., & Shahar, G. (2007). Short-term predictive effects of the looming cognitive style on anxiety disorder symptoms under restrictive methodological conditions. *Behaviour Research and Therapy, 45*, 1765–1777. https://doi.org/10.1016/j.brat.2006.12.007

Riskind, J. H., Williams, N. L., Gessner, T., Chrosniak, L. D., & Cortina, J. (2000). The looming maladaptive style: Anxiety, danger, and schematic processing. *Journal of Personality and Social Psychology, 79*, 837–852. https://doi.org/10.1037/0022-3514.79.5.837

Robichaud, M., & Dugas, M. J. (2006). A cognitive-behavioral treatment targeting intolerance of uncertainty. In G. C. L. Davey & A. Wells (Eds.), *Worry and its psychological disorders: Theory, assessment and treatment* (pp. 289–304). Wiley. https://doi.org/10.1002/9780470713143.ch17

Satici, B., Saricali, M., Satici, S. A., & Griffiths, M. D. (2020). Intolerance of uncertainty and mental wellbeing: Serial mediation by rumination and fear of COVID-19. *International journal of mental health and addiction*, 1–12. Advance online publication. https://doi.org/10.1007/s11469-020-00305-0.

Sciensano. (2020). *COVID-19 gezondheidsenquête: Enkele voorlopige resultaten.* https://www.sciensano.be/sites/www.wiv-isp.be/files/report_final_nl_0.pdf.

Smith, B. M., Twohy, A. J., & Smith, G. S. (2020). Psychological inflexibility and intolerance of uncertainty moderate the relationship between social isolation and mental health outcomes during COVID-19. *Journal of Contextual Behavioral Science, 18*, 162–174.

Spielberger, C. D., Goursuch, R. L., & Lushene, R. E. (1970). *Manual for the state-trait anxiety inventory—Form X*. Consulting Psychologists Press.

Wang, H., Xia, Q., Xiong, Z., Li, Z., Xiang, W., Yuan, Y., …, & Li, Z. (2020). The psychological distress and coping styles in the early stages of the 2019 coronavirus disease (COVID-19) epidemic in the general mainland Chinese population: A web-based survey. *PLoS One*, *15*(5), e0233410.

Yeo, G. C., Hong, R. Y., & Riskind, J. H. (2020). Looming cognitive style and its associations with anxiety and depression: A meta-analysis. *Cognitive Therapy and Research, 44*(3), 445–467.

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.