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ORIGINAL ARTICLE

COVID-19 Related Loss is Reliably Associated with Attentional Capture and Facilitation by COVID Related Stimuli: Evidence from the Emotional Stroop Dilution Task

Mikael Rubin[1] · **Travis Evans**[2,3]

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Abstract

Background The losses due to the COVID-19 pandemic has led to widespread impacts on mental health. Although affective attentional processes are implicated in mental health concerns broadly, there has been limited research on the influence of COVID-19 related loss on affective attentional processes. The primary aim of this study was to investigate the impact of a COVID-19 related loss on affective attentional processes.

Methods We recruited participants through Amazon Mechanical Turk in an initial study (Study 1: $n=136$) and pre-registered replication (Study 2: $n=206$). To measure affective attentional processes, participants completed the Emotional Stroop Dilution Task with word stimuli that were either neutral, generally trauma-related, or specific to COVID-19. To quantify affective attentional processes, novel response-based computation with superior psychometric properties and traditional attention bias computation approaches were used.

Results Using response-based measures COVID-19 related loss was associated with greater attention capture and facilitation in response to COVID-19 specific words in Study 1. In Study 2 (pre-registered replication), we again found COVID-19 related loss was associated with high conflict attention capture and facilitation for COVID-19 related stimuli only. No associations between the two studies were replicated with the traditional approach.

Conclusions Taken together, findings from these studies suggest that experiencing a COVID-19 related loss is associated with dysregulation of affective attentional processes, specific to COVID-related stimuli. Future research should examine whether dysregulated affective attentional processes can be addressed (e.g., with attention bias modification) which may be helpful for addressing mental health concerns in the wake of COVID-19 related loss.

Keywords Attention bias · COVID-19 · Emotional Stroop Dilution Task

The COVID-19 pandemic continues to produce complex and multifaceted mental health consequences (Liu et al., 2022). The experience(s) of losing others due to COVID-19 (i.e., COVID-19 related loss) can exert particularly significant impacts on mental health with projections suggesting up to 2 million individuals will be bereaved in the US specifically due to COVID-19 (Boelen et al., 2019; Verdery et al., 2020). Given these significant and extensive mental health consequences, it is critical to characterize factors that contribute to distress and grief associated with COVID-19 related loss. For example, attention bias (preferential attention towards or away from threat/emotionally salient stimuli) is implicated in a range of mental health concerns (Bar-Haim et al., 2007), which may emerge in the wake of a COVID-19 related loss. Specifically, researchers have highlighted greater attention towards emotionally salient information as an important mechanism of mental health concerns including depression (Mennen et al., 2019), anxiety (Mogg & Bradley, 2016), and trauma-related concerns (Cisler et al., 2011). Considering the large number of individuals experiencing COVID-related bereavement, it is

✉ Mikael Rubin
mrubin@paloaltou.edu

1 Palo Alto University, 1791 Arastradero Rd, Palo Alto, CA 94304, USA

2 Dept of Psychiatry, Boston University School of Medicine, Boston, MA, USA

3 VA Boston Healthcare System, Jamaica Plain, MA, USA

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important to understand the role of biased attention and its specificity in COVID-19 related loss. Individuals experiencing bereavement due to a COVID-related loss are likely to encounter COVID-19 related stimuli on a regular basis (e.g., news reports or online articles) and previous research has implicated attentional biases in everyday tasks like reading (Rubin et al., 2022). Given this putative exposure in daily life, attentional bias to COVID-19 specific words among bereaved individuals may maladaptively bias how such information is processed. Attention bias is implicated in a range of other mental health concerns and the presence of COVID-19 specific attention bias among bereaved individuals may serve as a potential risk factor for development of future mental health concerns.

Therefore, understanding how COVID 19-related loss influences attentional processes in response to emotionally salient information may be helpful towards better understanding pandemic-related mental health consequences. However, only one previous study to date has examined attention bias specifically related to COVID-19, which focused on the link between health anxiety and attentional bias to virus-related stimuli (Cannito et al., 2020). In this study, the authors found that greater health anxiety was associated with greater attentional bias towards virus-related stimuli. To the best of our knowledge, however, no research to date has specifically examined the effect of COVID-19 related loss on attentional bias to COVID-related stimuli and whether this effect also extends to more general trauma-related stimuli.

In previous research, attentional bias was traditionally conceptualized as a static, unidirectional pattern of attention to threat stimuli that was generally characteristic of an individual. For example, an individual might generally exhibit vigilance of attention towards threat, avoidance of attention away from threat, or a lack of bias in either direction, which was presumably consistent across task trials (Cisler et al., 2009). Based on this conceptualization, attentional bias measures were traditionally computed by comparing the average reaction time (RT) on trials in which a threat stimulus is presented compared to the average RT on trials in which a neutral stimulus is presented (i.e., MeanRT[Neutral] - MeanRT[Threat]). Using this traditional computation approach, comparatively faster RT to threat stimuli indicates a general vigilance of attention towards threat, comparatively slower overall RT to threat stimuli indicates a general avoidance of attention away from threat, and comparatively similar overall RT indicates a general lack of attention bias in either direction. However, a growing body of research has challenged this assumption of static, unidirectional patterns of attention bias. Specifically, traditional measures attentional bias exhibit poor psychometric properties and limited clinical validity, which may be due to individuals exhibiting multiple, distinct patterns of attentional bias to threat stimuli across task trials (Chapman et al., 2019; Kruijt et al., 2019; Schmukle, 2005; Zvielli et al., 2015).

Consistent with this view, previous research has developed and validated a response-based computation approach that characterizes the degree to which individuals exhibit multiple, distinct patterns of attentional bias across task trials (Evans & Britton, 2018). In this response-based computation approach, *trial-level* RTs to threat stimuli are individually compared against the mean RT to neutral stimuli to separately characterize the direction and magnitude of attentional bias on each trial (Evans & Britton, 2018). By capturing the trial-level variability of RTs to threat stimuli in this manner, response-based measures dissociate the dynamic nature of attentional biases. Response-based computation approaches produce separate measures that dynamically characterize the magnitude of vigilance *and* avoidance separated across trials, whereas traditional computation approaches produce a single measure that *statically* characterizes the overall magnitude of vigilance *or* avoidance averaged across trials. Compared to traditional computation measures, response-based measures exhibit markedly stronger psychometric properties, demonstrate stronger associations with clinical variables, and provide better insight into the neural mechanisms underlying attentional bias (Evans et al., 2020; Meissel et al., 2022). Therefore, response-based computation may be useful towards more precisely understanding the nature of the relationship between COVID-related loss and attentional biases to COVID-specific and/or trauma-general stimuli.

To address these issues, the current study investigated the influence of a COVID-19 related loss on attentional processes using the Emotional Stroop Dilution Task. Unlike the standard Emotional Stroop task that conflates filtering and cognitive slowing, the Emotional Stroop Dilution Task has been shown to clearly disambiguate attentional capture from emotionally salient words (Reynolds & Langerak, 2015). Additionally, there is evidence that traumatic experiences may bias attentional processes in response to trauma-specific stimuli as well as threatening stimuli more generally (Zinchenko et al., 2017). Based on this finding, we were also interested in characterizing whether COVID-19 related loss was associated with attentional biases exclusively in response to COVID-specific stimuli or extended to trauma-related stimuli more generally. We hypothesized that a COVID-19 related loss would be associated with attention bias to COVID-specific stimuli. As a control analysis, we also explored whether COVID-19 related loss was associated with attention bias to more general trauma-related stimuli. Using the Emotional Stroop Dilution Task and response-based computation approaches, we conducted two independent studies to preliminarily characterize (Study 1) and independently replicate (Study 2; pre-registered) the association between COVID-19 related loss and attentional biases to both COVID-specific stimuli and trauma-general stimuli.

Methods

Participants

Participants were recruited through Amazon Mechanical Turk. A total of $N=343$ individuals completed both studies (study 1 $n=137$, December 2020 and study 2 $n=206$, March 2023). Demographics of participants from both studies are in Table 1. The Palo Alto University Institutional Review Board approved all procedures.

Table 1 Demographic Summary

	Sample 1 (n=75)	Sample 2 (n=91)
	Mean (SD)	
Age	41.24 (12.53)	35.40 (8.58)
DASS-21 Anxiety subscale	26.05 (11.87)	33.41 (8.58)
DASS-21 Depression subscale	28.03 (12.58)	33.60 (9.27)
DASS-21 Stress subscale	27.97 (11.70)	33.47 (9.16)
	No. (%)	
Sex assigned at birth (female)	34 (45.3)	34 (37.4)
Ethnicity (Hispanic)	16 (21.3)	15 (16.5)
Race		
Hispanic	4 (5.3)	0 (0)
Black or African American	2 (2.7)	3 (3.3)
Asian	2 (2.7)	0 (0)
White	61 (81.3)	83 (91.2)
Multiple	44 (58.7)	5 (5.5)
American Indian or Alaska Native	1 (1.3)	0 (0)
Native Hawaiian or Other Pacific Islander	1 (1.3)	0 (0)
Education		
Doctoral degree	3 (4.0)	0 (0)
Master's degree	17 (22.7)	22 (24.2)
Some graduate work	2 (2.7)	9 (9.9)
BA or BS (undergraduate degree)	31 (41.3)	47 (51.6)
Some college	11 (14.7)	5 (5.5)
High School degree or GED	10 (13.3)	6 (6.6)
Some high school	1 (1.3)	2 (2.2)
Knows someone who died from COVID-19	36 (48.0)	57 (62.6)

Procedure

In both studies, participants were recruited and initiated participation through the Amazon Mechanical Turk study portal. Participants first provided informed consent, then completed a demographics questionnaire, several specific items related to their experiences during the COVID-19 pandemic, and the Depression Anxiety and Stress Scale. Several attention check items were used, if participants did not complete the attention check correctly they were no longer able to participate in the study. Participants were then redirected to *PsyToolkit* (Stoet, 2010, 2017) to complete the Emotional Stroop Dilution Task.

Measures

Depression, Anxiety, and Stress Scale (DASS-21)

The DASS-21 is a 21-item self-report questionnaire designed to measure the severity of a range of depression and anxiety symptoms. For each symptom, individuals report severity over the course of the previous week. Each item is scored from 0 (did not apply to me at all over the last week) to 3 (applied to me very much or most of the time over the past week; Henry & Crawford, 2005). For the depression, anxiety, and stress subscales alphas were 0.94, 0.94, and 0.94 for study 1 and 0.85, 0.88, 0.86 for study 2.

COVID-19 Related Loss

Participants were asked to endorse if they had experienced a loss related to COVID-19 (yes/no). In Study 2 participants were also asked to indicate the participant's precise relationship with the individual(s) who died due to COVID-19.

Attention Bias Task

We adapted the Emotional Stroop Dilution Task from Reynolds and Langerak (2015). In this task, a colored rectangle is presented centrally on the screen for 2000ms with a color word and distractor word (trauma-related, COVID-related, or neutral) located directly above or below the colored rectangle (see Fig. 1). Congruent trials are when the color word and the colored rectangle are the same and incongruent trials are when the color word differs from the colored rectangle. Prior to each trial, a fixation cross was presented centrally on the screen for 500ms and trials were separated by an intertrial interval of 1000ms. The task was deployed using *PsyToolkit* (Stoet, 2010, 2017), which is a free online Experimental Task Builder (psytoolkit.org).

Prior to completing the task, participants received instructions and completed a brief series of 8 practice trials.

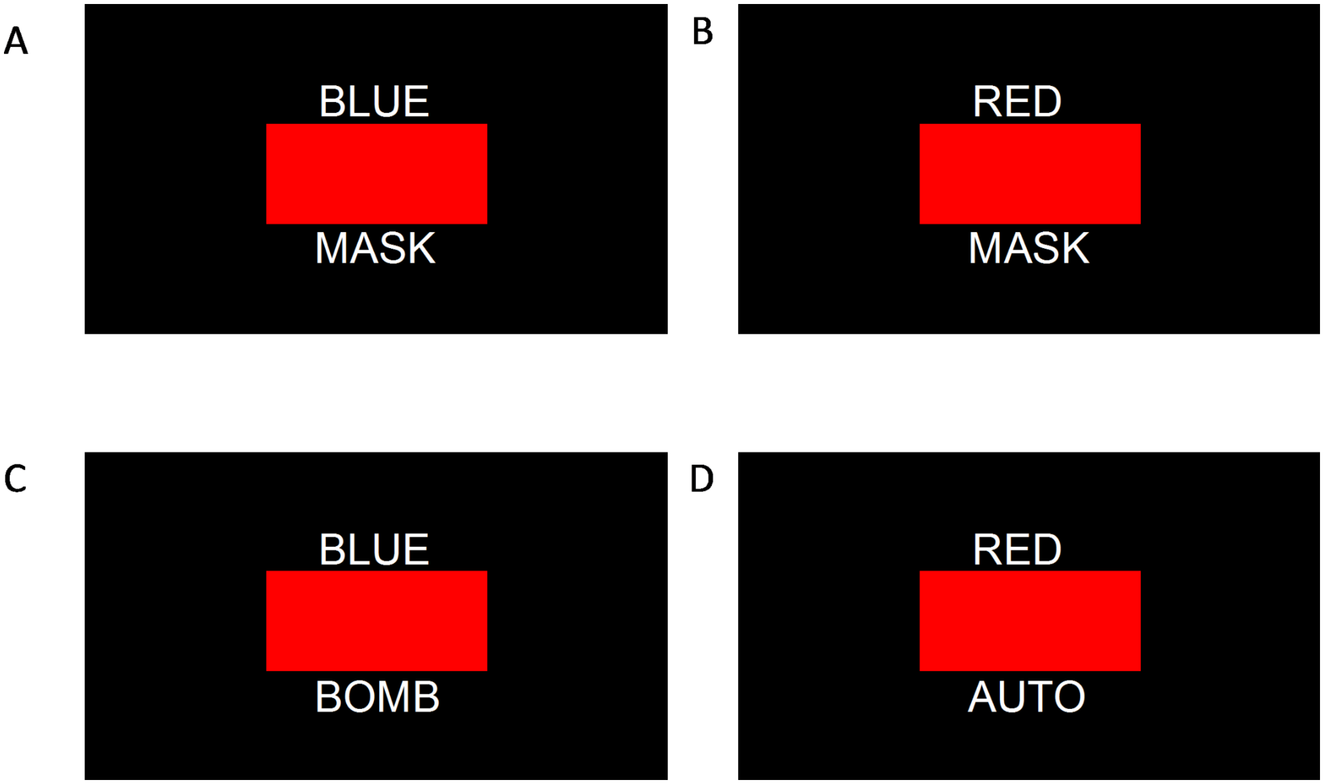

Fig. 1 A range of trial types from the ESDT task (**A**) COVID-19 related high conflict trial (**B**) COVID-19 related low conflict trial; (**C**) trauma-general high conflict trial; (**D**) low conflict neutral trial
Note. These images were created for descriptive purposes and do not perfectly reflect the dimensions of the task – to properly view the task please use the link to a sample of the task: https://www.psytoolkit.org/c/3.4.4/survey?s=ZcBgR

Participants then completed the full task in which192 trials were presented in random order. Distractor word type (trauma-related, COVID-related, or neutral) and congruence were evenly split between 64 trials for each word type with half of those trials congruent and half incongruent. Further, the location on the screen (top/bottom) was counterbalanced for every trial. A sample of the task can be viewed here (https://www.psytoolkit.org/c/3.4.4/survey?s=ZcBgR). The experiment is made available in the supplementary materials and can easily be uploaded to *PsyToolkit* to generate an identical experiment or modified as needed.

Data Analysis

Data Preparation

Data cleaning procedures were conducted in R. We first cleaned reaction time data following methods based on Evans and Britton (2018): removing trials < 150 ms or > 2000 ms as well as trials in which participants made an incorrect response. Following these data cleaning procedures, we also cleaned reaction time data for trials +/- 2.5 SDs of each participant's overall mean reaction time. Participants with fewer than 50% of trials remaining after data cleaning procedures were excluded from further analyses. The majority of excluded participants "timed out" (i.e., took longer than 2000ms) on most task trials, which indicates that most excluded participants simply did not attempt to complete the task. As a result, most participant exclusions reflected a lack of task compliance, rather than reflecting difficulty with completing the task itself. Additionally, participants needed at least two trials for each RB-AB index in order to be included in the analyses, which is the minimum number of trials necessary to compute internal consistency estimates.

Response-Based Computation

In contrast to traditional computation approaches, response-based computation is performed by comparing RTs on individual trials against a participant's mean RT during the reference condition. In the context of the Emotional Stroop Dilution Task, the neutral distractor condition serves as the reference for computing attentional bias. Specifically, trial-level RTs are measured for each congruent *threat* trial in which the color word matches the target square color is simultaneously presented with a threat word (e.g., "virus"). These congruent *threat* trial RTs are then individually compared against that participant's mean RT on congruent *neutral* trials in which the color word also matches the target square color, but is instead simultaneously presented with a neutral word (e.g., "vault").

On congruent trials, cognitive load/conflict is low due to a match between the color word and target square color. Conversely, for incongruent trials, the cognitive load/conflict is high due to a mismatch between the color word and target square color.

In this manner, trial-level difference scores are computed that indicate the attentional capture due to the threat word while controlling for the degree of cognitive load induced by color words either matching or not matching the target square color. When RTs are slower on threat trials compared to mean neutral RT, this may indicate that threat words captured attention away from the target square resulting in slower response times (e.g., Attention Capture Trial = $RT_{ThreatCongruentTrial} > RT_{NeutralCongruentMean}$). Conversely, when RTs are faster on threat trials compared to mean neutral RT, this may indicate that threat words facilitated attention towards the target square resulting in faster response times (e.g., Facilitation Trial = $RT_{ThreatCongruentTrial} < RT_{NeutralCongruentMean}$).

After coding each trial as an attention capture trial or facilitation trial, trial-level difference scores are subsequently averaged *within* the assigned response-based conditions. Specifically, we separately averaged trial-level difference scores to create a total of four measures including: low conflict facilitation, low conflict attention capture, high conflict facilitation, and high conflict attention capture.

Table 2 Response-based Computation Summary Data

	Sample 1 (n = 75)		Sample 2 (n = 91)	
	No loss (n = 39)	Loss (n = 36)	No loss (n = 34)	Loss (n = 57)
General Trauma Stimuli				
Low conflict attention capture	93.40 (42.52)	137.74 (59.34)	123.07 (64.62)	141.22 (59.27)
Low conflict facilitation	138.60 (77.85)	198.15 (86.2)	185.82 (115.63)	189.28 (90.67)
High conflict attention capture	171.85 (125.22)	248.36 (157.23)	215.11 (161.11)	213.17 (135.83)
High conflict facilitation	113.42 (65.48)	170.2 (90.63)	142.58 (71.61)	176.62 (89.03)
COVID-19 Specific Stimuli				
Low conflict attention capture	93.27 (38.12)	134.37 (52.75)	120.67 (61.86)	142.98 (58.28)
Low conflict facilitation	123.43 (54.38)	193.99 (85.58)	158.2 (85.91)	185.72 (88.92)
High conflict attention capture	149.02 (59.20)	228.36 (99.39)	184.5 (103.66)	210.64 (76.13)
High conflict facilitation	112.6 (50.77)	176.81 (77.76)	140.44 (57.23)	177.73 (80.82)

Finally, for ease of interpretation, response-based measures were converted to absolute values such that larger values indicated a greater magnitude of each response type.

Traditional Computation

After the data cleaning procedures, traditional attention bias was calculated for the participants also included in the response-based analyses. The approach to the traditional attention bias metric is to calculate the mean difference between the threat and neutral trials for each individual. In the Emotional Stroop Dilution task, congruence/incongruence reflect traditional Stroop effects (i.e., Incongruent RT > Congruent RT). A similar approach was taken to test the traditional computation approach with distinguishing between low/high conflict trials. As with response-based computation, a negative score suggested facilitation (faster response times for the threat conditions compared to neutral condition), whereas a positive score suggested attentional capture (slower response times for the threat conditions compared to neutral condition).

Data Analysis

The analyses were conducted using the *brms* package (Bürkner, 2018) in R. Data, syntax, and model outputs are available on https://osf.io/u8eq9/. To address our research questions, we conducted a series of Bayesian multivariate models with a lognormal family link to address the skew of the reaction time data. The primary question of interest was related to the role of a COVID-19 related loss on attention bias. To this end we fit a model with a COVID-19 loss (yes/no) predicting each of four attentional indices (trauma-related attention capture/facilitation and covid-related attention capture/facilitation) for both *low conflict* and *high conflict conditions*. Additionally, we fit models with each of the DASS-21 subscales (anxiety, depression, stress) as continuous covariates. We used weakly informative priors centered on zero, based on general reaction time distributions.

Results

Table 2 summarizes the mean reaction time indices across studies. There was evidence of a traditional Stroop effect (difference between congruent and incongruent trials was approximately 50ms across studies). Consistent with previous research, response-based attention bias (RB-AB) indices were largely found to be reliable across the studies. Almost all RB-AB indices demonstrated acceptable (> 0.70) internal reliability based on Cronbach's alpha, if somewhat more marginal split-half reliability (see Supplementary Table 1).

All traditional attention bias indices indicated unacceptable internal reliability (all αs < 0.35; far lower than the RB-AB indices). In study 1, experience of a COVID-19 related loss was associated with greater anxiety $d = 1.34$, 95% Confidence Interval (CI) (0.83, 1.84), depression $d = 1.03$, 95% CI (0.55, 1.51), and stress $d = 1.24$, 95% CI (0.75, 1.74). In study 2, however, COVID-19 related loss was not associated with greater anxiety d = -0.23 (-0.66, 0.19), depression d = -0.32 (-0.75, 0.11), and stress d = -0.17 (-0.60, 0.25) with all 95% CIs crossing zero.

Study 1

Response-Based Computation

Using neutral trials as a reference, we found that experience of a COVID-related loss was associated with a large increase in high conflict attention capture from both trauma-related $b = 0.40$, 95% CI (0.07, 0.73) and COVID-specific $b = 0.41$, 95% CI (0.21, 0.60) stimuli, which corresponded to an absolute magnitude difference score of approximately 65ms. Results for high conflict facilitation also showed strong associations with trauma-related stimuli $b = 0.48$, 95% CI (0.17, 0.79) and COVID-specific $b = 0.47$, 95% CI (0.28, 0.66) stimuli, corresponding to a difference of approximately 60ms.

Using neutral trials as a reference, COVID-related loss predicted a large increase in low conflict facilitation to trauma-related $b = 0.41$, 95% CI (0.17, 0.65) or COVID-specific $b = 0.47$, 95% CI (0.24, 0.69), corresponding to an absolute magnitude difference score of approximately 60ms. Similarly, COVID-related loss also predicted greater low conflict attention capture towards both trauma-related words $b = 0.40$, 95% CI (0.19, 0.61) and COVID-specific words $b = 0.37$, 95% CI (0.17, 0.57), which corresponding to an absolute magnitude difference score of approximately 40ms.

Traditional Computation

There was no evidence of COVID-related loss being associated with traditional attention bias at low conflict to general trauma-related b = -0.02, 95% CI (-1.95, 1.94) or COVID-19 specific b = -0.09, 95% CI (-2.04, 1.84) stimuli or at high conflict for trauma-related $b = 6.51$, 95% CI (-29.41, 42.01) or COVID-19 specific $b = 0.79$, 95% CI (-24.58, 26.08) stimuli.

Specificity of COVID-related Loss on Attentional Processes

When controlling for general symptoms of stress, anxiety, and depression, we observed similar relationships between COVID-related loss and attention to *COVID-specific* stimuli all effects remained (no 95% CIs crossing zero). However, controlling for these general symptoms attenuated the relationships between COVID-related loss and attention to *trauma-general* stimuli (all 95% CI's crossing zero), with the exception of high conflict facilitation, which remained meaningfully distinct from zero.

Study 2

Response-Based Computation

Replicating Study 1, COVID-related loss was associated with high conflict attention capture $b = 0.20$, 95% CI (0.00, 0.39) and facilitation $b = 0.21$, 95% CI (0.02, 0.40) from COVID-specific stimuli, corresponding to absolute difference scores of approximately 35ms. In contrast to Study 1, however, COVID-related loss was not associated with high conflict attention capture or facilitation from trauma-general stimuli $b = 0.18$, 95% CI (-0.08, 0.44), $b = 0.02$ 95% CI (-0.35, 0.40). Moreover, Study 2 did not replicate the other associations between COVID-related loss and attention for low conflict processes.

Traditional Computation

Replicating Study 1, there was no evidence of COVID-related loss being associated with traditional attention bias at low conflict to general trauma-related $b = 0.06$, 95% CI (-1.89, 2.03) or COVID-19 specific stimuli b = -0.07, 95% CI (-1.99, 1.87) or at high conflict for COVID-19 specific $b = 7.30$, 95% CI (-22.58, 37.01) stimuli. However, at high conflict there was an effect detected for trauma-related stimuli $b = 40.88$, 95% CI (5.22, 76.40) that was not observed in Study 1.

Specificity of COVID-related Loss on Attentional Processes

As in Study 1, when controlling for general symptoms of stress, anxiety, and depression, the association between COVID-related loss, findings for COVID-specific stimuli (high conflict attention capture and facilitation) remained significant (i.e., 95% CIs did not cross zero).

Discussion

We found that COVID-19 related loss was consistently associated with attentional bias to COVID-specific stimuli. Across Study 1 and Study 2, we demonstrated and independently replicated that COVID-related loss was associated with high conflict attention capture and facilitation from COVID-specific stimuli. Although we observed some associations between COVID-related loss and attention to more general trauma-related stimuli in Study 1, these relationships were generally attenuated after controlling for anxiety, depression, and stress symptoms, nor were these relationships replicated in Study 2. Taken together, these results suggest that COVID-related loss is most consistently associated with attention capture and facilitation from COVID-specific stimuli, which is specifically observed in the context of high cognitive load. Thus, the influence of a COVID-19 related loss may less consistently extend to other types of attentional dysregulation (e.g., low conflict attention capture/facilitation) or other types of stimuli (e.g., more general trauma-related stimuli). In addition to replicating the association between COVID-related loss and high conflict attention capture from COVID-specific stimuli, we observed that this effect was large (on the order of a 30-60ms), whereas there was no meaningful consistent effect for the traditional attention bias measures. Additionally, we showed that the RB-AB computational approach demonstrated generally acceptable reliability for the Emotional Stroop Dilution Task, whereas traditional AB did not. The stronger psychometric properties of response-based computation measures may facilitate detecting consistent and robust influences of COVID-related loss on attentional processes that are obfuscated by the poor psychometric properties of traditional computation measures. Together, the findings from the current study highlight a specific pattern of attentional bias (greater attention capture/facilitation to COVID-specific stimuli under high conflict conditions) that may be relevant to the larger mental health impact of the pandemic.

While there are no specific theoretical models for how the relationship between attentional processes and COVID-19 related loss might contribute to future mental health concerns, some pathways are indicated from other literatures. For example, previous research on anxiety disorders suggests that attention capture from threatening stimuli may facilitate elaborative information processing of stimuli (Cisler & Koster, 2010; Taylor et al., 2016). Similarly, previous research in depression suggests that greater attention capture from sad stimuli may facilitate ruminative processes that maintain the chronicity of depressive symptoms (Koster et al., 2011). Aligned with these theoretical models from other clinical populations, we propose that greater attention capture from COVID-specific words may activate negative emotions and thoughts associated with a COVID-related loss. That this activation may only occur under high conflict aligns with research suggesting that traumatic events limit conflict resolution capacity (e.g., through taxing executive function; Herzog et al., 2019). Considering the extensive content related to COVID-19 across various forms of media, biased attention to COVID-specific content may serve to reinforce negative associations with a loss, which may subsequently disrupt the grieving process. Due to the repetitive nature of these experiences, greater attention capture from COVID-19 stimuli may cumulatively reinforce and maintain chronic levels of distress, which in turn increases the risk of other mental health consequences. For example, an individual may experiences a COVID-related loss, develop greater attentional capture by COVID-related stimuli, and then may incur a greater traumatization risk due either to being sensitized to COVID-related stimuli (by attentional bias) and/or engaging in greater avoidance behavior to manage negative affect in response to COVID-related stimuli. In that way, COVID-related loss in conjunction with attentional bias could (presumably) facilitate the classic feedback loop seen in most anxiety/trauma-based disorders, which may increase the likelihood of developing or exacerbating existing distress-related symptoms. In this manner, dysregulation of attentional processes may play an important role in maintaining distress associated with a COVID-related loss and exacerbate risk for other mental health consequences.

The current study had several limitations that are important to note: first, these studies were cross-sectional, meaning that we cannot decisively conclude that COVID-19 related loss led to *changes* in attentional processes. Second, it is worth noting that this represents the first use of response-based computation for the Emotional Stroop Dilution Task, but this approach has only been previously used with the dot-probe task. Thus, there is limited precedent for using these two approaches in combination and the interpretation regarding attentional patterns may be different due to the way that the Emotional Stroop Dilution Task assesses attentional processes. Nevertheless, it is important to note that we consistently observed acceptable reliability using response-based computation, whereas we consistently observed poor reliability using traditional computation. Third, we did not include a broad assessment of trauma experiences or symptoms of posttraumatic stress disorder more generally, which may additively or interactively contribute to attentional biases following a COVID-19 related loss. Additionally, we recruited participants from Amazon Mechanical Turk, which may explain the high degree of data lost to cleaning procedures. However, this concern is somewhat mitigated given that RB metrics generally exhibited strong psychometric properties that were similar to other research using the RB-AB approach in laboratory studies. Finally, we assessed COVID-19 related loss in a relatively simplistic, binary manner. It is possible that there are a number of factors related to the loss that may be important to consider. Specifically, it may be that in Study 1, which was conducted at the height of the pandemic in late 2020, COVID-related losses were more recent and/or more acutely distressing. In Study 2 , which was conducted in 2023, COVID-related losses may have been less recent and/or less acutely distressing. This is supported by the large differences in depression, anxiety, and stress differences that we found in Study 1 between individuals who had/had not experienced a COVID-19 related loss, which was not observed in Study 2. Thus, we cannot rule out the possibility that recency of COVID-19 related loss impacts attentional biases. Despite these limitations, however, there are several important strengths of the study including a pre-registered replication of study findings and the utilization of the Emotional Stroop Dilution Task that robustly dissociates attentional bias with verbal stimuli. Additionally, controlling for depression, anxiety, and stress did not attenuate any associations between response-based attention bias measures and COVID-19 specific stimuli, suggesting that COVID-19 related loss represented a truly distinct feature associated with attentional processes.

Taken together, our findings highlight that attentional biases may emerge as an additional consequence of the COVID-19 pandemic that has not yet been attended to in the larger literature. Additionally, we found that Response-Based computation measures outperformed traditional AB measures in terms of both internal consistency and clinical validity, which is consistent with previous research using the dot-probe task. Based on these collective results, future research might consider whether attention bias modification strategies might attenuate mental health concerns for individuals that experience a COVID-19 related loss. Development and implementation of such efforts are critical to reduce distress, which may involve public health and related initiatives to address this important issue (Simon et al., 2020). Taken together, our findings suggest that it is important to consider the possibility that the association between COVID-19 related loss and attentional biases represents a potential pathway to future mental health concerns.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10608-023-10426-0.

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Declarations

Conflict of Interest The Authors have no conflicts of interest to report.

Ethics Approval The research was conducted with human participants following IRB review from the institution of the first author.

Informed Consent All participants provided informed consent prior to participating in the study.

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