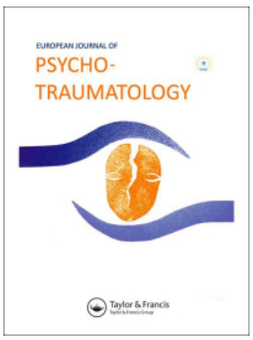

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COVID-19-related distress is associated with analogue PTSD symptoms after exposure to an analogue stressor

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ABSTRACT

Background: The COVID-19 outbreak in early 2020 was associated with an immediate increase in mental health problems in a significant percentage of the general population. Therefore, it is crucial to investigate how the COVID-19 pandemic – as a psychosocial stressor – affected the aetiological processes of mental disorders. Previous research has shown that stress potentiates associative (fear) learning and analogue symptoms of posttraumatic stress disorder (PTSD) and that analogue PTSD symptoms can emerge in response to associative learning.

Objective: We investigated whether distress in response to the COVID-19 outbreak support the development of intrusions and rumination after exposure to a non-COVID-19-related analogue trauma. Moreover, we examined if these effects are mediated by the strength of associative learning during analogue trauma.

Method: 122 undergraduate university students participated in an online experiment between March and July 2020. They completed questionnaires measuring distress and rumination related to the COVID-19 outbreak. On a subsequent day, they went through an associative learning task, in which neutral stimuli were paired with the appearance of a highly aversive film clip. Subjective ratings were assessed as indicators of associative learning. On the next day, participants documented film-related intrusions and rumination.

Results: COVID-19-related distress but not rumination was associated with post-film intrusion and rumination load. These effects were mediated by associative learning.

Conclusions: The current findings are in line with the assumptions that stress enhanced both associative learning and PTSD symptoms. Specifically, they indicate that prolonged psychosocial stress – like during the COVID-19 outbreak – is linked to individual differences in memory processing of aversive events. Further confirmatory research is needed to replicate these results.

Malestar psicológico relacionado con COVID-19 se asocia a síntomas de TEPT analógico tras la exposición a un estresor analógico

Antecedentes: El brote de COVID-19 a principios de 2020 se asoció con un aumento inmediato de problemas de salud mental en un porcentaje significativo de la población general. Por lo tanto, es crucial investigar cómo la pandemia de COVID-19, como estresor psicosocial, afectó los procesos etiológicos de los trastornos mentales. Investigaciones anteriores han demostrado que el estrés potencia el aprendizaje asociativo (miedo) y los síntomas análogos del trastorno de estrés postraumático (TEPT) y que los síntomas análogos del TEPT pueden surgir en respuesta al aprendizaje asociativo.

Objetivo: Investigamos si el malestar psicológico en respuesta al brote de COVID-19 contribuye al desarrollo de intrusiones y rumiación después de la exposición a un trauma análogo no relacionado con COVID-19. Además, examinamos si estos efectos están mediados por la fuerza del aprendizaje asociativo durante el trauma analógico.

Método: 122 estudiantes universitarios de pregrado participaron en un experimento en línea entre marzo y julio de 2020. Completaron cuestionarios que midieron el malestar psicológico y la rumiación relacionados con el brote de COVID-19. Al día siguiente, realizaron una tarea de aprendizaje asociativo, en la que se emparejaron estímulos neutrales con la exposición a un clip de película altamente aversivo. Las calificaciones subjetivas se evaluaron como indicadores de aprendizaje asociativo. Al día siguiente, los participantes documentaron intrusiones y rumiaciones relacionadas con la película.

Resultados: El malestar psicológico relacionado con COVID-19, pero no la rumiación, se asoció con la intrusión posterior a la película y la carga de rumiación. Estos efectos fueron mediados por el aprendizaje asociativo.

Conclusiones: Los hallazgos actuales están en línea con las suposiciones de que el estrés

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COVID-19; associative fear learning; fear conditioning; trauma; stress; intrusions; rumination

PALABRAS CLAVE
COVID-19; aprendizaje asociativo del miedo; condicionamiento del miedo; trauma; estrés; intrusiones; rumiación

关键词
COVID-19; 联想恐惧学习; 恐惧条件反射; 创伤; 应激; 闯入; 反刍

HIGHLIGHTS

- High distress related to the COVID-19 outbreak was associated with analogue PTSD symptom development.
- This effect was mediated by the strength of associative learning.
- Prolonged psychosocial stress like the COVID-19 outbreak might impact memory processing of aversive events.

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potenció tanto el aprendizaje asociativo como los síntomas del TEPT. Específicamente, indican que el estrés psicosocial prolongado, como el ocurrido durante el brote de COVID-19, está relacionado con diferencias individuales en el procesamiento de la memoria de eventos aversivos. Se necesita más investigación confirmatoria para replicar estos resultados.

COVID-19 相关精神痛苦与类似应激源暴露后的类似 PTSD 症状相关

背景：2020 年初的 COVID-19 爆发与很大一部分一般人群中心理健康问题的立即增加有关。因此，考查 COVID-19 疫情——作为一种社会心理应激源——如何影响精神障碍的病因过程至关重要。先前研究表明，应激会增强联想（恐惧）学习和类似创伤后应激障碍(PTSD)症状，并且类似 PTSD 症状可能会对联想学习做出反应。
目的：我们考查了对 COVID-19 爆发的精神痛苦是否支持非 COVID-19 相关类似创伤暴露后闯入和反刍的发展。此外，我们考查了这些影响是否由类似创伤期间的联想学习强度中介。
方法：122 名本科生在 2020 年 3 月至 7 月期间参加了一项在线实验。他们完成了COVID-19 爆发相关精神痛苦和反刍的测量问卷。随后一天，他们完成了一项联想学习任务，其中中性刺激与高度令人厌恶的电影剪辑的出现配对。主观评分被评估为联想学习的指标。第二天，参与者记录了与电影相关的入侵和反刍。
结果： COVID-19 相关精神痛苦但并非反刍与电影后闯入和反刍载荷相关。这些影响由联想学习中介。
结论：当前研究结果与应激增强联想学习和 PTSD 症状的假设一致。具体来说，他们表明，长期的社会心理应激（像在 COVID-19 爆发期间）与不良事件记忆加工的个体差异有关。需要进一步的验证性研究来重复这些结果。

1. Introduction

The coronavirus disease 2019 (COVID-19) outbreak was associated with an immediate increase in mental health problems in the general population (Lotzin et al., 2021; Robinson et al., 2022; Schäfer et al., 2020) such as heightened distress, anxiety, and depression (Javakhishvili et al., 2022). These findings underline that the COVID-19 outbreak constituted a large-scale psychosocial stressor[1], involving – amongst other things – social isolation, societal uncertainty, and financial insecurity. As such, it may have affected psychopathological processes, predisposing individuals towards the development of mental disorders. Specifically, learning processes involved in anxiety and stressor-related disorders – such as posttraumatic stress disorder (PTSD) – may have been affected by COVID-19-related distress.

This assumption is supported by research identifying previous adversities as one of the most consistent distal predictor of PTSD symptoms (Rattel et al., 2019). That is, experiencing a period of prolonged stress prior to trauma might predispose individuals towards maladaptive processing during and after trauma, resulting in the development of PTSD symptoms. PTSD is hallmarked by recurring, unwanted (intrusive) memories of the trauma, avoidance of trauma-related stimuli, negative alterations in cognitions and mood, and increased arousal and reactivity (APA, 2013). Amongst these core symptoms, intrusive re-experiencing of the trauma is considered to drive PTSD development. This assumption is supported by research showing that early intrusion characteristics (i.e. distress, 'nowness', and lack of context) are specific features of PTSD (Kleim et al., 2013) and are predictors of PTSD symptom severity 6 months later (Michael et al., 2005). Accordingly, it is assumed that these characteristics promote an ongoing sense of current threat and lead to other symptoms like avoidance and rumination that themselves perpetuate PTSD symptomatology (Ehlers & Clark, 2000; Holz et al., 2017).

Associative (fear) learning (or 'fear conditioning') is assumed to be one of the key processes underlying the development of PTSD symptoms (Ehlers & Clark, 2000; Zuj & Norrholm, 2019). During trauma, individuals are assumed to acquire associations between neutral stimuli (conditioned stimuli [CSs]; e.g. approaching headlights) and the traumatic stressor (unconditioned stimulus [US]; e.g. fear of dying during a car crash). After trauma, these CSs that are associated with trauma are assumed to trigger intrusive memories in response to similar stimuli. Correspondingly, studies have demonstrated a link between the strength of associative learning and analogue intrusion development (Franke et al., 2021; Streb et al., 2017; Wegerer et al., 2013). PTSD maintenance is further assumed to be supported by increased generalization and impaired extinction of traumatic associations (Cooper et al., 2022; Duits et al., 2015). Critically, the strength of associative learning varies systematically between individuals (Lonsdorf & Merz, 2017), which may result in interindividual differences in intrusion frequency and distress. Trauma-associated rumination occurs frequently in response to intrusions and is, in turn, assumed to perpetuate intrusive re-experiencing (Holz et al., 2017; Laposa & Rector, 2012; Michael et al., 2005). Though phenomenologically different (Ehlers, 2006), it has been suggested that rumination can also be initiated by memory processes (Watkins & Roberts, 2020) and, thus, could also be affected by differences in associative learning (Hoffman et al., 2019).

A potential mechanism by which the COVID-19 outbreak may have affected mental health is the

modulation of memory processes. Stress has been shown to promote associative learning (Merz et al., 2016; Peyrot et al., 2020) and analogue intrusions (Hilberdink et al., 2022; Schultebraucks et al., 2019) by altering neurochemical processes during memory formation. To our knowledge, no study to date has investigated whether the stress brought about by the COVID-19 outbreak might have affected analogue PTSD symptoms and associative learning. Considering that high-stress levels are assumed to strengthen associative learning, distress and rumination related to the COVID-19 outbreak may have enhanced associative learning during analogue trauma, resulting in more frequent, prolonged, and distressing intrusive trauma memories, also referred to as 'intrusion load' (Rattel et al., 2019). Since intrusions are assumed to have a particularly negative impact on posttraumatic symptom development if they co-occur with rumination about the trauma (Holz et al., 2017), we expected to find similar associations of rumination load.

We tested these assumptions based on data from an analogue study that we conducted online from March to July 2020, i.e. during the first months of the COVID-19 pandemic. During this period, psychological distress was generally increased (Robinson et al., 2022) and the restrictions imposed by the German government to contain infections affected almost all aspects of public life (see Supplementary File 1 for further information). As part of a larger study investigating the effect of a sleep intervention on fear extinction, healthy participants completed questionnaires measuring distress and rumination related to the COVID-19 outbreak (see Section 3.4. and Figure 1 (A) for the general procedure). On a subsequent day, they went through an associative learning task during which they were exposed to an aversive film clip (see 3.4.). Approximately 28 h later, participants were asked to document film-related intrusive memories and ruminative thoughts (see Section 3.5.). We hypothesized that higher COVID-19-related distress and rumination would be positively correlated with associative learning and with analogue PTSD symptoms. Moreover, we hypothesized that the relationship between COVID-19-related distress/rumination and analogue symptoms would be mediated by the strength of associative learning. To account for potential effects of dispositional anxiety, we conducted all mediation analyses including trait anxiety as covariate.

2. Methods

2.1. Participants

One hundred twenty-two undergraduate university students took part in the study. Participants were recruited via online advertisements and their student status was verified by asking them to use their institutional email address. Due to technical errors, responses of 10 participants were not recorded. Moreover, four participants did not show successful contingency learning (see Section 2.3.) and were discarded from further analyses. Thus, our final sample comprised 108 participants (87 females, 21 males). Of these 108, seven participants reported a history of COVID-19 and four reported that either a relative or close friend had been infected (further details are provided in Supplementary File 1). Study eligibility was restricted to individuals meeting the following criteria: normal or corrected-to-normal vision, sufficient German language skills, no current or chronic neurological or psychological disorders, and no lifetime interpersonal trauma exposure. Participants gave written informed consent for participation. All methods were carried out in accordance with the Declaration of Helsinki. The study protocol (A 15-3) was approved by the local ethics committee of the Faculty of Human and Business Sciences at Saarland University.

2.2. Pre-experimental measures

Rumination about and distress caused by the COVID-19 pandemic were assessed using modified versions of the Perseverative Thinking Questionnaire (Ehring et al., 2011) and the Peritraumatic Distress Inventory (Bunnell et al., 2018). Both questionnaires were adapted for a previous publication (Schäfer et al., 2020). Internal consistency of both measures was excellent ($\alpha = 0.91–0.96$) in the sample of Schäfer et al. and good-to-excellent in the current sample ($\alpha = 0.80–0.95$). We further assessed trait anxiety using the State-Trait Anxiety Inventory (STAI; German version by Laux et al., 1981) which revealed excellent internal consistency in the current sample ($\alpha = 0.92$). Sum scores were calculated and used for all further analyses. Data were collected using the online platform SoSci Survey (Leiner, 2014). Descriptive data and items of the COVID-related questionnaires are provided in Supplementary File 1.

2.3. Differential associative learning task

Participants were subjected to a differential associative learning task (Figure 1(B); for details, see Supplementary File 1) adapted from Pace-Schott et al. (2009) using an aversive film clip of a kitchen accident as US (Landkroon et al., 2020). To further increase ecological validity, we used naturalistic stimuli (i.e. everyday objects) as CSs. By using a partial reinforcement schedule (75%), we aimed to limit the reliability with which participants were able to predict the appearance of the US. Such *weak situations* are assumed to increase interindividual variance, which is critical for the differentiation between adaptive and pathological associative learning (Lissek et al., 2006).

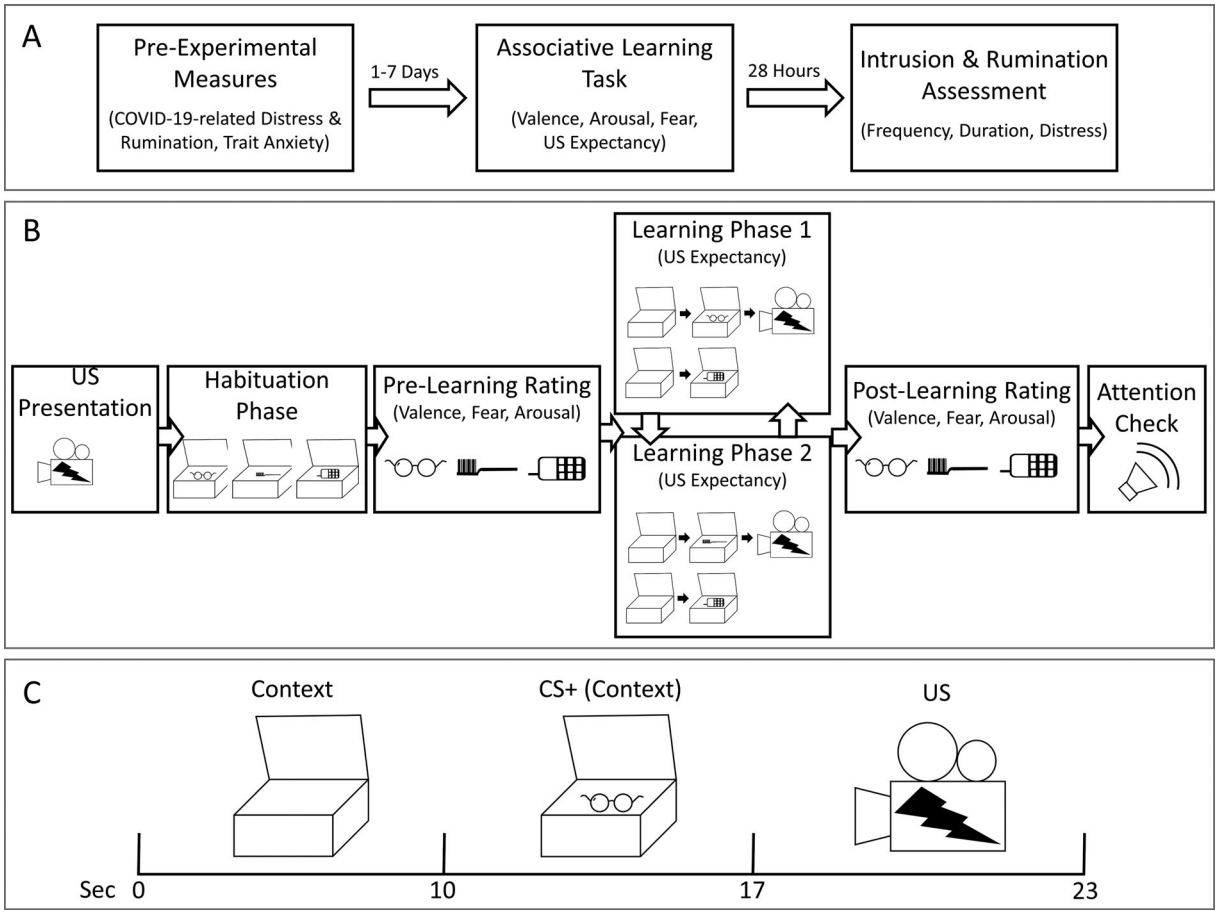

Figure 1. Illustration of the study procedure.

Note. (A) General study procedure. (B) Procedure of the differential associative learning task. (C) Stimulus presentation in a reinforced CS+ trial during the differential associative learning task. CS+ = conditioned stimulus; US = unconditioned stimulus.

Task presentation as well as the assessment of analogue PTSD symptoms (see 3.4.) were conducted via Labvanced (Finger et al., 2017). Following Landkroon et al. (2020), we first presented a full length version of the aversive film clip (10 s) and provided participants with information about the protagonist. Participants were instructed that a short version of the film clip would follow some (but not all) everyday objects that were to be presented on the screen and to pay attention which objects were associated with the clip. After a short habituation phase, participants saw all three objects (brush, cellphone, and glasses) that would be presented in the upcoming learning task and were asked to provide valence, arousal and fear ratings (all rates on a scale ranging from 0 to 100). During the learning phase, one of these objects was presented as the CS− whereas the other two objects were presented as CS+^{1} and CS+^{2}. The two different CS+s were used to implement two separate learning procedures, which was necessary for further manipulations that took place after the assessment of analogue symptoms (see 3.4.). Hence, the learning procedure was divided into two halves. In one half of the procedure, participants saw eight CS− trials and eight CS+^{1} trials, six of which were followed by the US. In the other half of the procedure, participants saw eight CS− trials and eight CS+^{2} trials, six of which were followed by the US. Both halves were presented without interruption and the order of presentation was balanced across participants.

During each trial, participants first saw an empty wooden box, serving as the learning context (10 s; see Figure 1(C) for trial procedure). Subsequently, the CS (brush, cellphone, or glasses) appeared in the wooden box (7 s) and participants were asked to provide their US expectancy rating (0–100). During reinforced trials, the US (6 s) was presented immediately after CS offset. During unreinforced trials, the trial ended after CS offset. At the end of the learning procedure, participants were again asked to provide valence, arousal, and fear ratings for each CS. Since distinguishing between CS+^{1} and CS+^{2} is not relevant for the current research questions, ratings were averaged across both CS+s for further analyses. Successful contingency learning was defined as a non-negative difference between US expectancy during the final CS+ and CS− trial. Post-learning ratings (arousal, valence, and fear) and US expectancy during the final CS+ trial were subjected to correlation and mediation analyses. Additional analyses on post-learning CS difference scores [CS− subtracted from CS+] and CS− are provided in Supplementary File

1. Finally, attention to the experimental stimuli (and whether participants still wore their headphones) was tested by presenting three short tones without prior instruction and subsequently asking the participants how many tones they had heard.

2.4. Assessment of film-related intrusions and rumination

Intrusive memories of the aversive film clip were assessed using the Intrusive Memory Questionnaire (IMQ; Michael & Ehlers, 2007). The IMQ was adapted to assess frequency and duration (in seconds) of intrusions as well as distress (0–100) associated with intrusions since watching the aversive film clip (see also Wegerer et al., 2013). Intrusions were defined as sudden, spontaneous, and non-initiated memories of the film clip. Subsequently, participants completed an adapted version of the IMQ that assessed film-related rumination frequency, duration, and related distress. For further analyses, we calculated intrusion and rumination load by standardizing (z-transformation) and summing the frequency, duration, and distress items. Descriptive statistics are provided in Supplementary File 1.

2.5. Data analyses

Data analyses were conducted using SPSS 25 and the PROCESS macro (Hayes, 2017). Univariate mixed analyses of variance (ANOVAs) were conducted to test differential CS responding during the associative learning task. Bivariate Pearson correlation coefficients (r) were used to quantify the relationship between COVID-19-related measures, post-learning CS+ ratings, and analogue PTSD symptoms. Whenever COVID-19-related measures were significantly correlated with analogue PTSD symptoms, we conducted mediation analyses to examine whether the effect of COVID-19-related distress and rumination on analogue symptoms was mediated by the strength of associative learning. Trait anxiety and attention-check scores (dummy-coded) were included as covariates in all mediation analyses. To this end, we employed Hayes's PROCESS macro using 5.000 bootstrap resampling for calculation of confidence intervals (Hayes, 2017). Incomplete cases were assessed and excluded separately for each subanalysis. The alpha level was set to .05 for all analyses.

3. Results

3.1. Manipulation checks

ANOVAs including the within-subject factors CS (CS+, CS−) and Time (pre-, post-learning) and valence, arousal or fear ratings as outcome revealed significant CS*Time interaction effects (all $p < .001$). Likewise, an ANOVA including the within-subjects factors CS and Trial (1–8) and US expectancy as dependent variable revealed a significant CS*Trial interaction effect ($p < .001$). In all analyses, the effects supported successful differential associative learning as indicated by an increase in arousal, fear and US expectancy and a decline in valence for the CS+ but not for the CS− across the learning task (see Supplementary File 1, for further details). The attention check was successful in 87 participants (81%).

3.2. Correlations between COVID-19-related measures and analogue PTSD symptoms

Analyses revealed significant positive correlations between COVID-19-related distress and film-related intrusion ($r = .23$, $p = .016$) and rumination load ($r = .25$, $p = .009$). COVID-19-related rumination was not correlated with either measure (all $p > .05$; see Table 1).

3.3. Correlations between COVID-19-related measures and post-learning ratings

Analyses revealed significant positive correlations between COVID-19-related distress and post-learning CS+ arousal ($r = .28$, $p = .003$) and fear ratings ($r = .28$, $p = .004$). These associations were neither evident for pre-learning ratings nor for CS difference scores or CS− ratings (all $p > .05$; see Supplementary File 1). COVID-19-related rumination was only correlated with post-learning CS+ arousal ratings ($r = .19$, $p = .047$). No significant correlations were evident for valence or US expectancy ratings (all $p > .05$; see Table 1).

3.4. Mediation models

Mediation analyses with COVID-19-related distress as independent variable, film-related intrusion load as dependent variable and trait anxiety and the attention-check score as covariates showed that the association was fully mediated by the strength of associative learning, as indicated by post-learning CS+ fear and arousal ratings (see Figure 2). That is, participants with greater COVID-19-related distress experienced higher arousal and fear after learning in presence of the CS+, which was in turn associated with a higher intrusion load. The same pattern emerged for film-related rumination load as dependent variable. Analyses of valence ratings revealed that CS+ responses partially mediated the effect of COVID-19-related distress on intrusion load, whereas no mediation effect was found when predicting rumination load. All mediation analyses controlled for potential effects of trait anxiety and attention-check scores. While trait anxiety was not associated with any CS+-related measure, the attention-check score was positively correlated with post-learning valence for CS+.

Table 1. Bivariate associations between COVID-19-related measures, strength of associative learning, and analogue PTSD symptoms.

Measures	1	2	3	4	5	6	7	8	9
1. COVID-19 distress	–								
2. COVID-19 rumination	$r = .75$*	–							
3. Post-ACQ CS+ valence	$r = -.17$	$r = -.06$	–						
4. Post-ACQ CS+ arousal	$r = .28$*	$r = .19$*	$r = -.64$*	–					
5. Post-ACQ CS+ fear	$r = .28$*	$r = .13$	$r = -.63$*	$r = .84$*	–				
6. Post-ACQ CS+ US EXP	$r = .01$	$r = .13$	$r = -.26$*	$r = .24$*	$r = .20$*	–			
7. Intrusion load	$r = .23$*	$r = .08$	$r = -.44$*	$r = .37$*	$r = .44$*	$r = .14$	–		
8. Rumination load	$r = .25$*	$r = .09$	$r = -.37$*	$r = .31$*	$r = .31$*	$r = .14$	$r = .72$*	–	
9. Trait anxiety	$r = .33$*	$r = .34$*	$r = .11$	$r = -.03$	$r = -.05$	$r = -.04$	$r = -.10$	$r = .07$	–

Note. ACQ = Acquisition; US EXP = US expectancy; CS+ = conditioned stimulus (reinforced); US = unconditioned stimulus; * = $p < .05$.

Additional mediation analyses on CS difference scores revealed similar effects for intrusion load as outcome, i.e. differential scores for valence and fear mediated the relationship between COVID-19-related distress and intrusion load. Importantly, both COVID-19-related distress as well as intrusion load were associated with higher (not lower) differential CS ratings. Analyses including rumination load as outcome did not reveal significant mediation effects (details provided in Supplementary File 1).

4. Discussion

The current study investigated whether distress and rumination related to the COVID-19 outbreak was related to more analogue PTSD symptom development in healthy individuals after exposure to a non-COVID-19-related analogue traumatic stressor. Moreover, we tested whether this relationship could be explained by strengthened associative learning.

Our first finding was that COVID-19-related distress was associated with increased intrusion load, which is in line with previous studies showing that a psychosocial stressor before analogue trauma exposure results in higher intrusion load (Hilberdink et al., 2022) and supports the idea that biological stress responses predict subsequent intrusions (Schultebraucks et al., 2019). Moreover, our findings align with the assumption that the COVID-19 outbreak had the potential to increase allostatic load (Fofana et al., 2020). That is, during the time of assessment, the pandemic acted as a prolonged psychosocial stressor that may have surpassed individual recources for adaptive coping. Hence, the current findings indicate that prolonged stress – as evident during the COVID-19 outbreak – may result in an earlier 'tipping point' at which trauma exposure results in PTSD development (Rattel et al., 2019).

We further found that increased distress related to the COVID-19 pandemic was associated with stronger associative learning as indicated by increased post-learning valence, arousal and fear ratings to the CS+. This corresponds with previous findings of stress-induced strengthening of associative learning (Merz et al., 2016; Peyrot et al., 2020). Several experimental investigations have found a positive relationship between differential associative learning and intrusions (e.g. Franke et al., 2021; Streb et al., 2017; Wegerer et al., 2013). In line with these studies, our analyses revealed that associative learning predicts intrusion load, thus, providing further support for the hypothesis that associative learning is a key process underlying intrusion development.

Finally, and most importantly, we found that the relationship between COVID-19-related distress and intrusion load was partly (for valence) and fully (for arousal and fear) mediated by associative learning. As such, the current findings support the assumption that allostatic load enhances maladaptive memory processing which facilitates intrusive memory formation (Schultebraucks et al., 2019). Moreover, our results indicate that associative learning may play a role in the development of posttraumatic rumination, presumably by indirectly affecting the occurrence of intrusions (Holz et al., 2017). However, these results were less consistent since differential CS ratings did not correlate with rumination load. Hence, caution is warranted in interpreting these findings.

In 2020, pandemic-related stressors had a devastating impact on a significant percentage of the general population (i.e. 18%; Lotzin et al., 2021). However, recent research indicates that most of the mental health problems declined over the course of the pandemic (Robinson et al., 2022). Moreover, in some areas, the pandemic had positive side effects on mental health (e.g. digital health care, flexible and remote working options; Javakhishvili et al., 2022). Thus, early warnings of a 'second pandemic' of mental illness (Choi et al., 2020) are, fortunately, not supported by the current data. Our findings might, therefore, reflect a temporary increase of psychosocial stress in the general population elicited by the COVID-19 outbreak in early 2020. Nevertheless, a subgroup of individuals may be at risk for a further increase in mental health problems (Javakhishvili et al., 2022). The current findings, hence, may suggest that chronically heighted distress during the early phase of the COVID-19 outbreak resulted in pathological processing of aversive events in a subgroup of the general population.

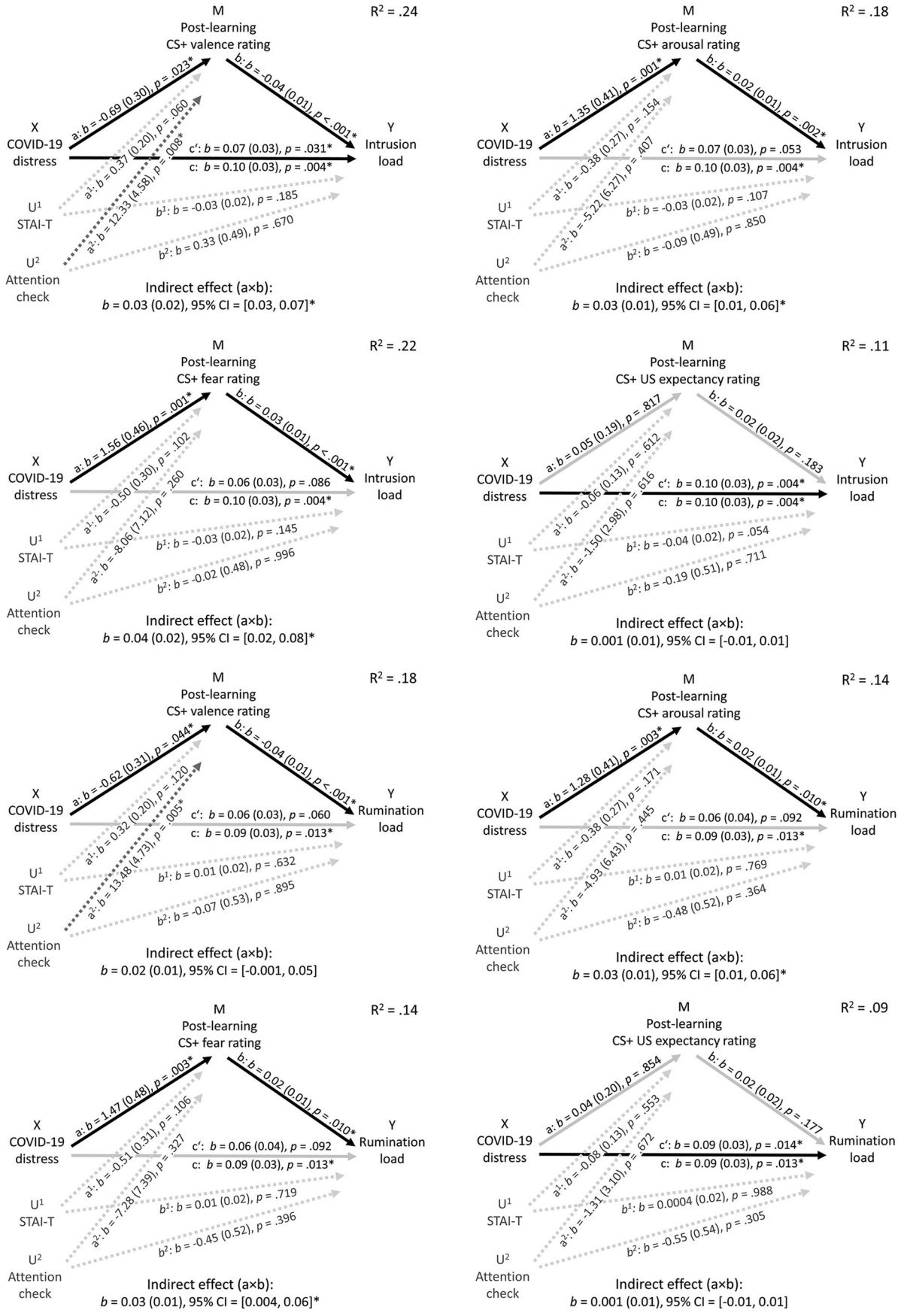

Figure 2. Mediation models.

Note. Mediation models examining the effect of COVID-19-related distress (X) on analogue symptoms (Y) mediated by the strength of associative learning (M). All models included the covariates (U) trait anxiety and attention-check scores. Path c shows the total effect of X on Y, and path c′ shows the effect after controlling for M. Standard errors are given in parentheses. CI = confidence interval (bias-corrected); CS+ = conditioned stimulus; STAI-T = trait anxiety. *$p < .05$.

Despite remarkably consistent associations between COVID-19-related distress and analogue PTSD symptoms, no correlations were evident between COVID-19-related rumination and analogue intrusion and rumination load. Although it may appear counterintuitive that rumination related to the COVID-19 pandemic was not related to film-related rumination, it is important to differentiate between rumination as a pathogenic process and rumination as a symptom of PTSD. Rumination as a pathogenic process has been shown to enhance depressive affect, whereas worry enhances anxious affect, which in turn is known to strengthen fear associations (Gazendam & Kindt, 2012; McLaughlin et al., 2007). Hence, COVID-19-related rumination may be more relevant for explaining depressive symptoms, whereas only COVID-19-related anxiety may be involved in modulating the strength of associative learning. Correspondingly, previous research has shown that rumination related to analogue trauma – but not trait-rumination – was correlated with analogue intrusive memories (Holz et al., 2017; Laposa & Rector, 2012; Sopp et al., 2020). Our measure of COVID-19-related distress may thus have assessed anxious responses to COVID-19, whereas COVID-19-related rumination may have measured responses relating to depression.

Another inconsistency of the current findings is that US expectancy did not mediate the association between COVID-19-related distress and analogue PTSD symptoms. This lack of significant association could be related to restricted variance, i.e. variance ($SD = 12.09$) was markedly lower for US expectancy than for the other indicators of associative learning ($SD = 19.78–30.60$). This could have prevented finding significant associations. Alternatively, this pattern of results could suggest that the subjective, emotional responses to the CS+ – rather than the expectation of the US – may be relevant for analogue symptom development. Relatedly, it has been proposed that subjective fear – as compared to indirect or (neuro-)physiological measures of fear – may be the most important indicator of clinical anxiety and its successful treatment (LeDoux & Hofmann, 2018). Future research should thus investigate associations between different indicators of associative learning and analogue symptoms in greater depth.

Although providing interesting indications, our study has several limitations that need to be considered. First, we investigated analogue symptoms in a sample of healthy participants of which we did not assess pandemic-related trauma exposure. Thus, interpretation of distress levels and generalization to processes during real-life trauma is restricted and conclusions on psychopathology must be drawn cautiously. For instance, research to date has found mixed evidence whether a general disposition towards stronger associative learning predicts PTSD development, whereas other processes like the capacity to extinguish these associations have been more consistent predictors of PTSD (Scheveneels et al., 2021; but see Lommen & Boddez, 2022). Future research should investigate whether robust markers of PTSD development may be found if associative learning is examined in the context of stress manipulations since the memory processes that are assumed to underlie PTSD development occur during extreme/traumatic stress (Dunsmoor et al., 2022). Furthermore, though experimental analogue studies consistently show a causal link between associative learning and intrusions (e.g. Franke et al., 2021; Streb et al., 2017), recent findings indicate that stronger associative learning may also support the success of extinction learning in some cases (Franke et al., 2021). Such findings emphasize the need for further research examining which mechanisms determine (mal-)adaptive processing of aversive events. Nevertheless, it is promising to see that findings from analogue studies have been shown to replicate also in clinical populations (e.g. Kessler et al., 2018). Another limitation which needs to be considered is that, while causality is established in the relationship between associative learning (including film exposure) and analogue symptoms, this cannot be said for the relationship between COVID-19 distress and associative learning. That is, whether individuals showed enhanced fear learning in response to COVID-19-related distress or whether a disposition towards heightened associative learning caused higher COVID-19-related distress (see Funkhouser et al., 2022; Hunt et al., 2022), cannot be established based on our mediation analyses. Further research is needed to support our hypothesized model, for instance, by examining interindividual differences in associative learning and responses to psychosocial stressors in a cross-lagged panel design. Furthermore, though we controlled for effects of trait anxiety, we cannot rule out the possibility that a third variable influenced our outcomes.

Another limitation of our study is that we conducted all assessments online. Although necessary in light of the public restrictions that were in place during the assessment period, remote testing reduces the possibility to monitor attention and compliance. Although we controlled for potential effects using attention-check scores, we did not assess attention using a standardized tool. Moreover, we cannot rule out that the unstandardized setting increased error variance. Furthermore, it is important to note that, while we assume that biological stress responses to the COVID-19 outbreak promoted associative learning and intrusion (and rumination) development, we did not investigate these mechanisms. Additionally, we consider the COVID-19 outbreak as a prolonged psychosocial stressor without explicitly assessing the timing, intensity, and duration of stress. This is critical

since research suggests a complex interaction between memory processes and stress depending on its intensity, timing, and duration (Merz et al., 2016). Therefore, further research is required to better characterize the impact of prolonged stressors – such as the COVID-19 pandemic – on the individual stress levels as well as their interaction with the memory processes investigated here. Notwithstanding, as one of the first studies to investigate the effects of a large-scale stressor in this context, our results provide important first insights. These findings may also transfer to other large-scale stressors (e.g. the upcoming consequences of the climate change). At the same time, it is important to note that associative learning is not the only process driving PTSD and anxiety symptoms and further research should examine how large-scale stressors affect these processes.

The current findings indicate that psychosocial stress related to the pandemic is related to associative learning and analogue PTSD symptom development. This underlines the importance of investigating stress effects on memory processes that are assumed to underlie PTSD. Further research should study and compare the effects of both experimentally induced and naturalistic stressors – such as the one investigated here. Our findings are in line with the assumption that ongoing psychosocial stress (as evident during the COVID-19 outbreak) puts individuals at risk for maladaptive processing of aversive events, which may subsequently result in symptom development. However, confirmatory research is needed to replicate these results in the context of real-life trauma.

Author contributions statement

E.F., M.R.S., and T.M. conceived and designed the experiment. S.K.S. provided resources and promoted the investigation. E.F. and M.R.S performed the experiment and analysed the data. E.F. wrote the first draft of the manuscript and M.R.S. provided critical revisions. All authors read, edited and approved the manuscript for publication.

Note

1. While the outbreak likely constituted a psychosocial stressor for the general population, it is important to note that it may additionally qualify as a traumatic stressor in individuals who experienced a severe course of illness or the sudden loss of a loved one or worked as healthcare professionals.

Disclosure statement

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Data availability statement

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