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Lommen, Miriam J. J.; Boddez, Yannick

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Extinction learning as pretrauma vulnerability factor of posttraumatic stress: a replication study

Miriam J.J. Lommen ^{a,*} and Yannick Boddez ^{b,c}

^aDepartment of Clinical Psychology and Experimental Psychopathology, University of Groningen, Groningen, the Netherlands;

^bDepartment of Experimental Clinical and Health Psychology, Ghent University, Ghent, Belgium; ^cCenter for the Psychology of Learning and Experimental Psychopathology, KU Leuven, Leuven, Belgium

ABSTRACT

Background: Learning tasks have been used to predict why some, and not others, develop posttraumatic stress disorder (PTSD) after exposure to a traumatic event. There is some evidence from prospective studies in high risk profession samples that reduced extinction learning might represent a marker or even a vulnerability factor for PTSD development.

Objective: Since the evidence is scarce, the aim of this study was to perform a conceptual replication of an earlier prospective study, testing whether pretrauma extinction learning predicts later PTSD symptom severity.

Method: A sample of 529 fire fighters performed a conditioning task at baseline and filled out questionnaires to assess PTSD symptom severity and neuroticism. At six and 12 months follow-up, exposure to stressful events and PTSD symptom severity were measured.

Results: Results indicate that previous findings were not replicated: although reduced extinction learning was associated with higher PTSD symptom severity at baseline, extinction learning did not predict PTSD symptom severity at follow-up. Only PTSD symptom severity at baseline and stressor severity predicted PTSD symptom severity at follow-up.

Conclusions: Since earlier findings on the predictive value of pre-trauma extinction learning on PTSD symptom severity were not replicated, extinction learning might not be a general risk factor for PTSD for all individuals. More prospective studies including multiple factors seem needed to unravel the complex relationships of these factors influencing PTSD development.

El aprendizaje de extinción como factor de vulnerabilidad pretrauma del estrés postraumático: un estudio de replicación

Antecedentes: Las tareas del aprendizaje se han utilizado para predecir por qué algunos, y no otros, desarrollan trastorno de estrés postraumático (TEPT) después de la exposición a un evento traumático. Existe cierta evidencia de estudios prospectivos en muestras de profesiones de alto riesgo de que el aprendizaje de extinción disminuido podría representar un marcador o incluso un factor de vulnerabilidad para el desarrollo del TEPT.

Objetivo: Dado que la evidencia es escasa, el objetivo de este estudio fue realizar una replicación conceptual de un estudio prospectivo anterior, probando si el aprendizaje de extinción pretraumático predice la gravedad posterior de los síntomas de TEPT.

Método: Una muestra de 529 bomberos realizó una tarea de condicionamiento al inicio del estudio y llenó cuestionarios para evaluar la gravedad de los síntomas del TEPT y neuroticismo. A los 6 y 12 meses de seguimiento, se midió la exposición a eventos estresantes y la gravedad de los síntomas de TEPT.

Resultados: Los resultados indican que los hallazgos anteriores no se replicaron. Aunque el aprendizaje de extinción disminuido se asoció con una mayor gravedad de los síntomas de TEPT al inicio del estudio, el aprendizaje de extinción no predijo la gravedad de los síntomas de TEPT en el seguimiento. Solo la gravedad de los síntomas de TEPT al inicio y la gravedad del factor estresante predijeron la gravedad de los síntomas de TEPT en el seguimiento.

Conclusiones: Dado que los hallazgos anteriores sobre el valor predictivo del aprendizaje de extinción pretraumático sobre la gravedad de los síntomas de TEPT no se replicaron, el aprendizaje de extinción podría no ser un factor de riesgo general de TEPT para todos los individuos. Parece que se necesitan más estudios prospectivos que incluyan múltiples factores para desentrañar las complejas relaciones de estos factores que influyen en el desarrollo del TEPT.

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PALABRAS CLAVE

Aprendizaje de extinción; condicionamiento; Trastorno de estrés postraumático; Trauma; Replicación

关键词

消退学习; 调节; 创伤后应激障碍; 创伤; 重复

HIGHLIGHTS

- Reduced extinction learning correlated with higher PTSD symptom severity at baseline.
- Reduced extinction learning did not predict PTSD symptom severity at follow-up.
- The predictive effect of pre-trauma extinction learning on PTSD was not replicated.

消退学习作为创伤后应激的创伤前易感因素：一项重复性研究

背景：学习任务已被用来预测为什么有些人，而不是其他人，在经历创伤事件后会发展成创伤后应激障碍 (PTSD)。来自一些高风险职业样本的前瞻性研究证据表明，减少的消退学习可能代表 PTSD 发展的标志甚至易感因素。

目的：由于缺少证据，本研究旨在对早期前瞻性研究进行概念性重复，考查创伤前消退学习是否能预测后期 PTSD 症状严重程度。

方法：529 名消防员的样本在基线时执行了一项调节任务，并填写了问卷以评估 PTSD 症状严重程度和神经质。在 6 个月和 12 个月的随访中，测量了应激事件的暴露程度和 PTSD 症状严重程度。

结果：结果表明，先前的研究结果没有被重复：虽然减少的消退学习与基线时较高的 PTSD 症状严重程度相关，消退学习并不能预测随访时的 PTSD 症状严重程度。只有基线时的 PTSD 症状严重程度和应激源严重程度才能预测随访时的 PTSD 症状严重程度。

结论：由于早期关于创伤前消退学习对 PTSD 症状严重程度的预测价值的研究结果未被重复，因此消退学习可能不是所有个体 PTSD 的一般风险因素。似乎需要更多包括多种因素的前瞻性研究来揭示这些影响 PTSD 发展的因素之间的复杂关系。

1. Introduction

Learning theories provide a powerful framework to understand how psychological disorders like anxiety disorders and posttraumatic stress disorder (PTSD) develop (e.g. Beckers, Krypotos, Boddez, Effting, & Kindt, 2013; Lissek & Van Meurs, 2015; Mineka & Oehlberg, 2008, 2006). In laboratory studies, fear is installed by pairing a conditioned stimulus (CS) with an aversive unconditioned stimulus (US). Due to these pairings, the CS can become a danger signal (CS+) that evokes a conditioned (fear) response (CR). Many laboratory studies also include a control stimulus that is not combined with the US, turning it into a safety signal (CS-). After this acquisition phase, extinction of fear can be tested by presenting the CS+ and CS- without the US. Psychophysiological responses like fear potentiated startle and skin conductance, verbal responses in the form of self-report ratings, and sometimes behavioural responses like avoidance have been used as indices of fear (Beckers et al., 2013).

The research community is highly invested in research about interindividual differences in the extent to which stimulus pairings result in robust fear responding. The idea is that, while holding all other characteristics (e.g. stimulus intensities) equal, some individuals will show more conditioned fear and less extinction as compared to other individuals. This idea could serve as one candidate-explanation for why not everybody who is confronted with an aversive conditioning event goes on to develop anxiety-related complaints in real life (Mineka & Zinbarg, 2006; Vervliet & Boddez, 2020a).

The most recent meta-analysis on fear conditioning indicated that anxiety patients show increased fear responding to the CS- in the acquisition phase and an increased fear response to the CS+ in the extinction phase compared to healthy controls (Duits et al., 2015). The increased responding in the extinction phase might particularly fit the clinical presentation of posttraumatic stress disorder (PTSD), where nearly everyone displays a level of fear after the experience of

a traumatic event (acquisition learning), but only some fail to show natural recovery (extinction learning) and go on to develop PTSD (e.g. Rothbaum, Foa, Riggs, Murdock, & Walsh, 1992).

Several studies have examined the relationship between extinction learning and PTSD in cross-sectional studies. Although a lack of difference in extinction learning between individuals with PTSD compared to trauma-exposed controls without PTSD and non-trauma-exposed controls has been reported (Milad et al., 2008), the majority of studies show reduced fear extinction in individuals with PTSD (Blechert, Michael, Vriends, Margraf, & Wilhelm, 2007; Mineka & Oehlberg, 2008; Norrholm et al., 2011; Orr et al., 2000; Peri, Ben-Shakhar, Orr, & Shalev, 2000). However, the question remains whether reduced extinction learning also represents a pretrauma vulnerability factor for PTSD. Prospective studies with a pretrauma assessment of extinction learning are scarce (for a recent review, see Scheveneels, Boddez, & Hermans, 2021) (for a recent review, see Scheveneels et al., 2021), but do show evidence for reduced extinction learning as a pretrauma predictor of PTSD. In one study, a small sample of 67 firefighter cadets in training was tested using a fear extinction paradigm and were retested after two years of active firefighter duty. Results showed that reduced extinction learning as measured with facial electromyogram (EMG) responses before trauma predicted PTSD symptom severity two years later (Guthrie & Bryant, 2006). A study in a sample of 214 soldiers who were tested before and after deployment to Afghanistan showed that reduced extinction learning, as measured by US-expectancy ratings before deployment, predicted PTSD symptom severity after their return home, even when controlling for well-known risk factors (including already existing PTSD symptoms before deployment, neuroticism and stressor severity; Lommen, Engelhard, Sijbrandij, van den Hout, & Hermans, 2013).

With the recent replication crisis in psychological research in mind (Open Science Collaboration,

2015), pointing at the importance of research on the reproducibility of findings, the aim of the current study was to conceptually replicate the study of Lommen et al. (2013) to test whether reduced extinction of US-expectancies at baseline would predict PTSD symptom severity after trauma, when controlling for pretrauma PTSD symptoms, neuroticism and stressor severity. Higher neuroticism scores have been associated with higher PTSD symptom severity both cross-sectionally and prospectively (Engelhard, Hout, & Lommen, 2009). Prior psychopathology and higher stressor severity have consistently been linked to more severe PTSD symptomatology (Brewin, Andrews, & Valentine, 2000; Ozer, Best, Lipsey, & Weiss, 2008). Moreover, by controlling for PTSD symptom severity at baseline, the study focuses on changes in PTSD symptomatology. We hypothesise that reduced extinction learning at baseline predicts higher PTSD symptom severity at a later point in time, even after controlling for the included risk factors. The sample of the replication study consisted of 529 fire fighters who were tested at baseline and at six months and one year follow-up.

2. Method

2.1. Participants and general procedure

This study is part of a large prospective study on mental resilience in fire fighters. After approval from the national fire brigade, all heads of the 25 fire regions in the Netherlands were approached with oral and written information about this prospective study, after which 11 regions enrolled to this study. Both professionals and volunteers were included. During the summer of 2017, the research team visited the participating fire stations and all who were interested in participating received oral and written information about the study. After providing written informed consent, they filled out a battery of questionnaires on a tablet and performed four computer tasks in a separate room under the supervision of one of the research team members.

A total of 529 firefighters enrolled in the 'baseline' assessment. The majority was male ($n = 502$; 95%), and the mean age of the group was 40 years (range 18–61 years). A total of 42% were deployed as professional, 26% as volunteer, and 32% indicated they worked as professional as well as volunteer. At six and 12 months after the baseline assessment, all participants who participated in the baseline assessment were invited to fill out an online questionnaire at their earliest convenience (with the majority of participants filling it out within two months after the invitation). Firefighter-related potentially traumatising events and PTSD symptom severity were assessed, amongst other measures that are beyond the scope of this article.

This means that the sample includes participants who, besides the baseline assessment, have only participated in the six-month follow-up assessment or only participated in the 12 months follow-up assessment or participated in both the six- and 12-month assessments. See Figure 1 for a flow chart of the study. This study was part of a larger project (16374-O) that was approved by the Ethical Committee Psychology of the University of Groningen, the Netherlands.

2.2. Measures

2.2.1. De novo conditioning task

The same task as in Lommen et al. (2013) was used with one adjustment: because of practical reasons, an aversive International Affective Picture System (IAPS) picture of a burned child (3053; Lang, Bradley, & Cuthbert, 2008) in combination with an International Affective Digitised Sounds (IADS) 2 s sound of a loud scream of 90 Db (277; Bradley & Lang, 2007) was used as US instead of electrical stimulation. Similar to the previous study, pictures of a human face that were individually rated as neutral served as CSs. In the acquisition phase, both the CS+ and CS– were presented 8 times and the CS+ was always followed by the US. Without further instructions, the extinction phase followed, including 16 presentations of both the CS+ and CS–, without presentation of the US. In order to replicate the analyses of Lommen et al. (2013), we focussed on the first four extinction trials in the descriptive statistics and on the first four extinction trials for the analyses to test the hypotheses. US-expectancy ratings were provided within the 8-second CS presentation using a 0 (certainly no sound and picture) to 100 (certainly sound and picture) visual analogue scale (VAS). For more details about the procedure, please see Lommen et al. (2013).

2.2.2. Extinction learning

Because there are many possible operationalizations of extinction learning that may influence the outcome of the study (e.g. Lonsdorf, Merz, & Fullana, 2019), we a-priori decided to stay as close as possible to the study of Lommen et al. (2013) in order to replicate these findings. Extinction learning was operationalised as the difference between the US-expectancy rating to the first and fourth CS+ trial in the extinction phase (cf., Lommen et al., 2013), with higher values indexing more extinction learning. We focused on the first four trials in order to replicate the method in Lommen et al. (2013). Furthermore, Lommen et al. (2013) showed that the predictive power of extinction learning decreased when the number of included trials increased, showing no predictive effect anymore when six or more trials were included. This is in line with the idea that also individuals who show reduced extinction learning can reach full extinction learning

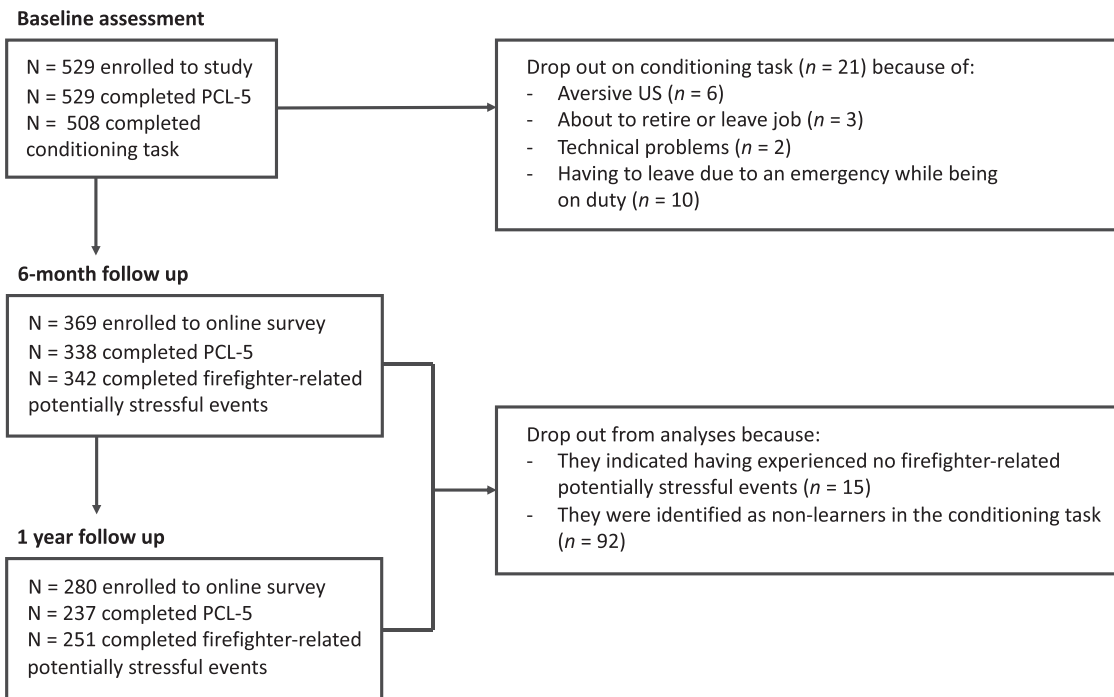


Figure 1. Flow chart.
Note. PCL-5 = PTSD checklist for the DSM-5.

with an increased number of extinction trials (Norholm et al., 2011).

2.3. Posttraumatic stress

The Dutch version (Boeschoten, Bakker, Jongedijk, & Olf, 2014) of the PTSD checklist for the DSM-5 (PCL-5; Weathers et al., 2013) was used as a self-report measure to assess PTSD symptom severity. The scale includes 20 items representing the DSM-5 criteria of PTSD, which are rated on a scale from 0 (*not at all*) to 4 (*extremely*). At the 'baseline' assessment, participants were asked to fill out the questionnaire with regard to the life event troubling them the most and at the follow-up assessments, they were asked to fill the PCL out regarding the most stressful firefighter-related experience. By using any event as index event at baseline, we made sure to control for any existing PTSD symptomatology. The sum score with the highest value (either at six months or one year follow-up) was used as a major outcome variable. The PCL-5 has been shown to be a valid and reliable measure of PTSD in first responders (Morrison, Su, Keck, & Beidel, 2021). Cronbach's alpha at baseline assessment, six months and one year follow-up were .93, .94 and .95, respectively.

2.4. Stressful events

To assess firefighter-related potentially traumatising events, a scale was created in collaboration with several fire fighters who, based on their experience as a fire fighter and supervisor, made a list of events,

specific for their work, which they would regard as potentially traumatising events or having the potential to have an emotional impact (e.g. victim of a fire with severe burns, suicide of an adult, suicide of a child, death of a colleague during an incident). The final questionnaire consisted of 21 predefined events and one open question for events that were not covered in the 21 items. For each event, participants indicated whether or not they had experienced the event in the past half year/year (six months and one year follow-up, respectively). The highest reported sum score was used (range 0–22) in the analyses.

2.5. Neuroticism

The Dutch version (Sanderman, Arrindell, Ranchor, Eysenck, & Eysenck, 1991) of the Eysenck Personality questionnaire – neuroticism subscale (EPQ-N; Eysenck & Eysenck, 1975) was used to assess neuroticism. This self-report questionnaire includes 22 items that can be answered with yes (1) or no (0). The sum score was used, where higher scores represent a higher score on the neuroticism scale. Cronbach's alpha at baseline assessment was .87.

3. Results

3.1. Descriptives

At 1 year follow-up, on average, participants ($n = 251$) reported having experienced five different firefighter-related potentially stressful events ($M = 5.49$, $SD = 3.56$) in the past year. A total of 46.2% reported the

confrontation with a fatal accident, 48.2% was confronted with suicide of an adult and 5.5% of a child. Taking the six-month follow-up into account and using the highest number of reported incidents, 386 participants could be included in the analyses, with an average number of five different firefighter-related potentially stressful events ($M = 5.13$, $SD = 3.43$). Of these 386 participants, 15 did not report any stressful event and were for this reason excluded from the analyses. PCL scores at baseline at the highest score of the follow-up assessments were both skewed to the right and the square root transformed variable was used in the analyses.

3.2. Learning curves in conditioning task

Of the 508 participants who finished the de novo conditioning task, 92 were excluded from the analyses as they were identified as non-learners (last CS+ of the acquisition phase < 60 ; cf., Lommen et al., 2013). Having excluded non-learners and participants without any firefighter-related potentially stressful events during the testing period, the learning curve of the remaining participants is shown in Figure 2. As expected, the acquisition phase showed a significant Trial (8; acquisition trial 1–acquisition trial 8) \times CS type (2; CS+; CS–) interaction, $F(7) = 303.61$, $p < .001$, partial $n^2 = .55$ and also the extinction phase showed a significant Trial (8; extinction trial 1–

extinction trial 8) \times CS type (2; CS+; CS–) interaction, $F(7) = 75.12$, $p < .001$, partial $n^2 = .21$.

3.2.1. Manipulation check

We checked whether stressful events predicted PCL at follow-up, when controlling for PCL at baseline. This indicated that a higher number of stressful events was indeed predictive of PCL at follow-up, $\beta = .18$, $t = 3.63$, $p < .001$, when controlling for baseline PCL score, $\beta = .50$, $t = 10.08$, $p < .001$.

3.2.2. Correlations

Correlations among psychometric variables showed that PCL at baseline, neuroticism and stressful events were positively associated with PCL at follow-up. However, extinction learning was not (see Table 1). Extinction learning correlated negatively with PCL at baseline, indicating reduced extinction learning to be associated with higher PTSD symptoms severity at baseline.

3.2.3. Predicting PCL at follow-up

In order to keep the analyses similar to the study being replicated here (Lommen et al., 2013), regression analysis with PCL at follow-up ($M = 1.39$, $SD = 1.44$) as dependent variable and extinction learning as independent variable was run (model 1), even though the correlation between extinction learning and PCL at follow-up was not significant in the current sample. Result showed that extinction learning did not predict PCL at follow-up (see Table 2). When adding PCL at

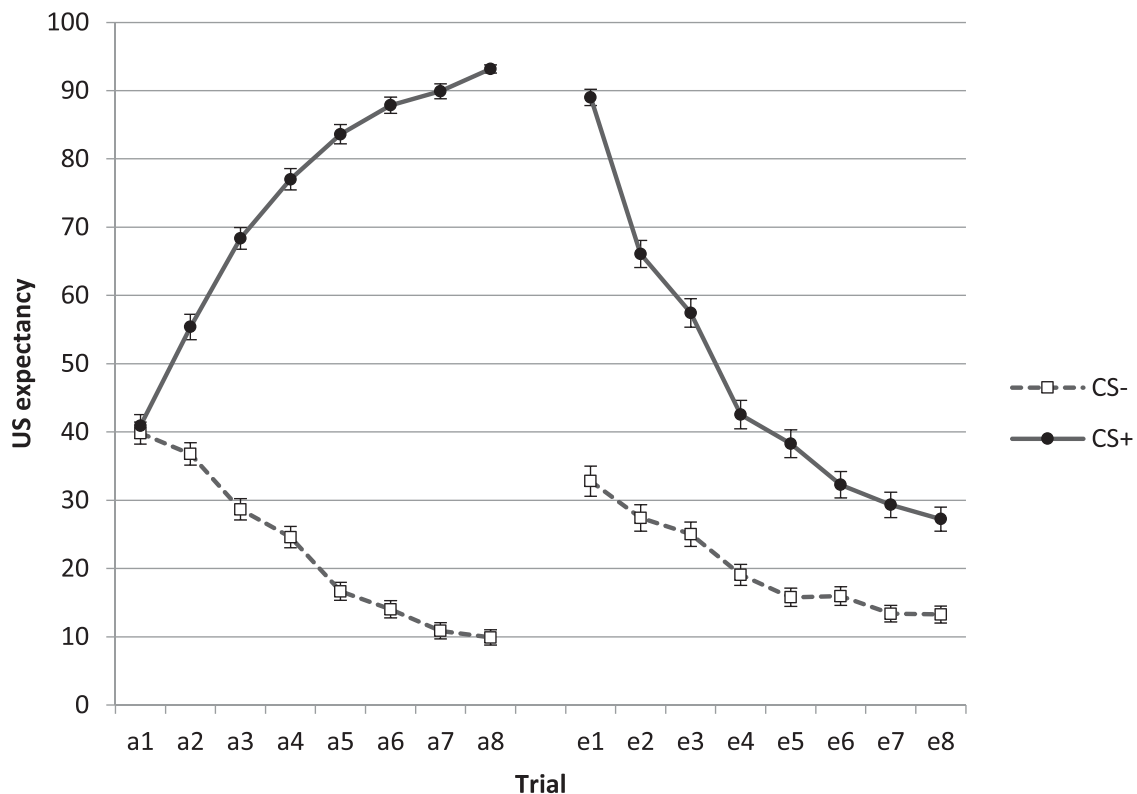


Figure 2. Acquisition and extinction learning curves. Note. a1–a8 represent acquisition trials, e1–e8 represent extinction trials.

Table 1. Pearson correlations among psychometric variables.

	1.	2.	3.	4.	5.	<i>M</i> (<i>SD</i>) ^a
1. PCL at follow-up	1					1.39 (1.44) ^b
2. Extinction learning	.05	1				47.31 (40.17)
3. PCL at baseline	.52***	-.10*	1			1.69 (1.44) ^b
4. EPQ-N	.33***	-.06	.53***	1		3.44 (3.72)
5. Stressful events	.25***	-.07	.13*	<.01	1	5.25 (3.24)

Note. ^a *n* = 287 based on included cases in regression analyses.

^b representing square root transformed scores.

* *p* < .05; ** *p* < .01; *** *p* < .001.

baseline, neuroticism and stressful events to the regression (model 2), the model explained 33% of the variance in PCL at follow-up. As expected, PCL at baseline and stressful events contributed significantly to the model. In contrast to the predictions, neuroticism did not significantly contribute to the model. Even though extinction learning was not a significant predictor in model 1, in model 2 extinction learning did contribute to the model, in the opposite direction as predicted.

To increase the understanding of the change in the predictive value of extinction learning once the other risk factors were added, a regression analysis excluding the extinction learning variable was run (model 3). This model explained 31% of the variance in PCL at follow-up, in which values of the risk factors seem comparable to the model in which extinction learning was included (see Table 2). These results seem to suggest that the addition of extinction learning does not impact the predictive value of the other risk factors, whereas the other way around it does. In order to exploratorily investigate possible interactions, two-way interaction terms of extinction rate in combination with PCL at baseline, neuroticism and stressor severity were added to the regression analyses, but none of these reached significance (all *p*'s > .58).

4. Discussion

The aim of this study was to conceptually replicate the Lommen et al. (2013) study, testing whether reduced

Table 2. Regression analyses predicting PTSD symptom severity at follow-up, with corresponding model information and beta weights.

	Model		Beta weights	
	<i>R</i> ² (<i>F</i>)	<i>F</i>	<i>β</i>	<i>t</i>
Model 1	<.01 (<.01)	0.65		
Extinction learning			.05	0.82
Model 2	.33 (.49)	34.53		
Extinction learning			.12	2.37*
PCL at baseline			.46	7.92***
EPQ-N			.10	1.69
Stressful events			.20	3.96***
Model 3	.31 (.46)	34.53		
PCL at baseline			.45	7.71***
EPQ-N			.09	1.59
Stressful events			.19	3.75***

Note. * *p* < .05; ** *p* < .01; *** *p* < .001

extinction learning in a high risk profession sample would predict later PTSD symptom severity after experiencing a stressful event, when controlling for existing PTSD symptoms, neuroticism and stressor severity. The original study was conducted in a sample of soldiers before and after their deployment to Afghanistan, while this replication study used a sample of fire fighters who were followed for a year. The finding of Lommen et al. (2013) that reduced extinction learning predicted subsequent PTSD symptoms, even after controlling for existing PTSD symptoms, neuroticism and stressor severity, was not replicated in the present study.

Reduced extinction learning at 'baseline' was associated with higher PTSD symptoms at baseline but unrelated to PTSD symptoms in the following year. Reduced extinction learning did not predict PTSD symptom severity in this sample when it was included as the only predictor in the analyses. Surprisingly though, when controlling for PTSD symptom severity at baseline, neuroticism and stressor severity, extinction learning became a significant predictor, in the opposite direction as expected: Reduced extinction learning predicted lower PTSD symptoms. Higher PTSD symptom severity at baseline and higher reported stressor severity over the year predicted higher PTSD symptom severity in the period of one year follow-up. Notably, neuroticism correlated positively with PTSD symptom severity both at baseline and follow-up, but did not predict unique variance in PTSD symptom severity at follow-up when PTSD symptom severity at baseline and neuroticism were also included in the model.

How to interpret these results? First of all, the finding that extinction learning did not correlate to PTSD symptom severity at follow-up and was not significant when predicting PTSD symptom severity on its own questions the weight of the finding that it became a significant predictor, in the opposite direction than expected when other risk factors were included. To stay as close as possible to the analyses performed in the study, we tried to replicate here, we ran a model with control variables and the non-predictive extinction rate variable, whereas usually, the extinction rate variable would have been deleted from the predictive model due to its insignificant contribution.

The current results could also be seen as an indication that looking at extinction learning as a predictor of PTSD symptom severity might not do enough justice to the complexity of PTSD and its development. Extinction learning anomalies might only lead to PTSD symptomatology in combination with certain environmental influences and personal characteristics. Note, however, that the present study included variables from each of these factors. In the original study (Lommen et al., 2013), reduced extinction

learning predicted later PTSD symptom severity, and its predictive value remained unchanged when controlling for PTSD symptomatology at baseline, neuroticism and stressor severity. In the present study, extinction learning as the only predictor in the model did not predict later PTSD symptom severity, but when PTSD symptomatology at baseline, neuroticism and stressor severity were included, increased extinction learning predicted higher PTSD symptom severity. The latter is in contrast to what would be expected theoretically and also to previous findings showing deficits in extinction learning to be associated with PTSD symptomatology (Blechert et al., 2007; Guthrie & Bryant, 2006; Mineka & Oehlberg, 2008; Norrholm et al., 2011; Orr et al., 2000; Peri et al., 2000). Furthermore, it seems to be in contrast to the finding that reduced extinction learning was associated with increased PTSD symptom severity at baseline. All in all, it can be concluded that the findings of Lommen and colleagues (2013) were not replicated in the current sample. It should be noted that this study is limited to the use of US-expectancies only. Although it has sufficient external validity as verbal outcome measure in fear conditioning (Boddez et al., 2013), a combination of several measures including a physiological one would have been preferable. There are several other explanations that could explain why extinction learning did not predict PTSD symptom severity in the current sample.

First of all, the time of assessment differs in this study from the original study. In the Lommen et al. (2013) study, soldiers were tested before and after their 4-month deployment, which made it very likely that if soldiers would experience PTSD symptoms, the posttest was close enough to the experience to pick up on the PTSD symptoms, even if these symptoms would be temporarily (considering the high natural recovery rate in PTSD). In the present study, fire fighters were included of whom it was unpredictable when and if they would be exposed to potentially traumatic events. Because the assessments were on average completed every six months, but for some only after a year, it is likely that PTSD symptoms that were temporarily present were not picked up on, as the PCL was filled out with respect to the past month only. Although this can be seen as a limitation of the present study, it could also be argued that it is clinically more relevant to see whether extinction learning has predictive value for more long-lasting PTSD symptoms.

Second, the US in the current study (aversive picture combined with a loud scream) differed from the US used in the study aimed to replicate (electrical stimulation; Lommen et al., 2013). In contrast to the previously used US, the US in this study was not adapted to an individual level of aversiveness and may have led to more variation in subjective aversiveness. Post-hoc checks indicate that the aversiveness of

the (universal) combined US in the current sample were rated as more aversive than the individualised US in the 2013 paper, but the standard deviation is similar. Since the aversiveness of the US might influence the strength of conditioning (Vervliet & Boddez, 2020a), this might have led to different responses in the conditioning paradigm. Nevertheless, this discrepancy in methodology is unlikely to explain the difference in results, as the graphical displays of the US expectancies throughout the acquisition and extinction phase look very similar for the two studies.

Third, the PTSD symptom severity was very low in the present sample. Even though this might be expected in high risk professions and low PTSD symptom severity rates were also found in the original study, there might not have been enough variation in PTSD symptom severity to explain, making it less likely for predictors with small effects to be detected.

Fourth, although soldiers and fire fighters are both in high risk professions, they might differ on many aspects, making it possible for a factor like extinction learning to be a predictor in one sample but not the other. As extinction learning might not be a necessary or sufficient condition by itself in the development of PTSD (De Houwer, 2020; Vervliet & Boddez, 2020b), other protective and risk factors might be needed to understand the aetiology of PTSD. Possibly, there are differences in the presence of these protective and risk factors between the military and fire fighters, affecting the role of extinction learning on PTSD development. For example, social support as an established protective factor (Ozer et al., 2008) might facilitate extinction learning (Hornstein, Haltom, Shirole, & Eisenberger, 2018), and social support might differ between soldiers and firefighters (Geuzinge, Visse, Duyndam, & Vermetten, 2020).

In sum, extinction learning was not a predictor of PTSD development in a sample of fire fighters and fails to replicate earlier findings in which the same analyses were performed in a sample of soldiers (Lommen et al., 2013). The results show that reduced extinction learning might not be a general risk factor PTSD for all individuals, and multiple factors seem to be relevant and influencing each other, emphasising the need for more prospective studies unravelling these relationships. Potentially this could ultimately lead to risk profiles fostering targeted prevention and the development of personalised treatment protocols.

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Data availability statement

Basic, share upon request: Data available on request from the authors. The data that support the findings of this study are available from the corresponding author, [MJLL], upon reasonable request. The research cannot be made publicly available as permission for this was not asked from the participants in the informed consent form.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Miriam J.J. Lommen  <http://orcid.org/0000-0001-8845-4338>

Yannick Boddez  <http://orcid.org/0000-0002-8067-5969>

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