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What makes a trauma ‘pathological’? – Perceived peritraumatic threat influences the development of intrusive memories

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Role of Perceived Threat in Intrusion Development

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Conflicts of Interest

PH, HW, JW, TK, EN, JAG, ELB, RJM, and JR have no conflicts of interest to declare.

Abstract

Intrusions are a hallmark symptom of posttraumatic stress disorder (PTSD). While dysfunctional cognitions are known posttraumatic contributors, peritraumatic processes are less understood. Perceived threat, alongside emotional factors, is theorized as significant, but experimental studies are lacking. Using the trauma film paradigm (TFP), we investigated peritraumatic threat's impact on intrusion development. Healthy participants ($N = 93$) viewed different distressing film clips (low, medium, high threat). Differences among the experimental groups were examined in the frequency and distress of intrusive memories, as well as distress and expectations. As hypothesized, the frequency of intrusive memories increased with increasing threat load, as did the distress and expectations related to intrusions. Fear elicited by film clips did not mediate this effect. Perceived threat is a crucial peritraumatic factor in intrusive memory formation, suggesting that a trauma perceived as highly threatening increases intrusion likelihood. Understanding traumatic factors influencing posttraumatic symptoms helps in targeting preventive interventions.

Keywords: perceived threat, intrusions, intrusive memories, trauma film paradigm, posttraumatic stress disorder (PTSD)

Introduction

Posttraumatic stress disorder (PTSD) is a complex, heterogeneous mental disorder, with 55.1% of all PTSD patients showing a unique symptom pattern in one study (Bryant et al., 2022) and 636,120 (mathematically) potential combinations of PTSD symptoms according to the definition of DSM-5 (Galatzer-Levy & Bryant, 2013). However, 95.7% reported intrusive memories, nightmares, or flashbacks, indicating three of five symptoms of the DSM-5 criterion B: intrusion symptoms (Bryant et al., 2022). In line with evidence syntheses concluding that ‘intrusive thoughts’ are often the most central symptoms in PTSD (Birkeland et al., 2020; Isvoranu et al., 2021), a recent large network analyses highlighted the centrality of re-experiencing symptoms in PTSD (Duek et al., 2021). As such, they may be an ‘activator’ of other characteristic symptoms (e.g., hyperarousal and/or avoidance) of PTSD (Bryant et al., 2017; Haag et al., 2017), further supporting its role as the hallmark symptom of PTSD (Brewin, 2015; Iyadurai et al., 2019).

Although about 70% of people experience or witness at least one traumatic event during their lifetime (Benjet et al., 2016; McLaughlin et al., 2013), most of them recover from acute distress and do not develop full-blown PTSD, thereby underscoring the importance of protective and risk factors related to the development and maintenance of trauma-related re-experiencing symptoms (Bonanno et al., 2007, 2011; Marks et al., 2018; Sareen, 2014). In contrast to pretraumatic factors (i.e., before trauma exposure), peritraumatic (i.e., during or immediately after trauma exposure) and posttraumatic (i.e., after trauma exposure) factors and processes are especially important (Marks et al., 2018; Ozer et al., 2003). In addition to posttraumatic factors associated with the development of PTSD-related intrusions, peritraumatic factors have rarely been studied, despite their potential to answer one of the most puzzling questions: What makes a traumatic event ‘pathological?’, or, in other words: What drives intrusions?

The identification of robust peritraumatic predictors for the development of PTSD symptoms would not only illuminate pathological characteristics of traumatic events but would also clarify why some individuals experience strong emotional and cognitive reactions that produce PTSD, whereas others do not. As such, the investigation of peritraumatic factors could enable the identification of those individuals at a heightened risk for developing PTSD symptoms and help develop early preventive interventions.

Most studies examining peritraumatic factors focused on emotional factors (e.g., state anxiety, state dissociation, emotional arousal, disgust, horror) (Bomyea & Amir, 2012; Hagenaars, 2012; Hagenaars et al., 2010; Hall & Berntsen, 2008; Laposa & Alden, 2008; Laposa & Rector, 2012; Măirean & Ceobanu, 2017), cognitive factors (e.g., data-driven processing) (Halligan et al., 2002; Kindt et al., 2008; Morina et al., 2013), or both (e.g., state anxiety and expectations about the intensity and controllability of intrusions) (Herzog, Barth, et al., 2022). However, little attention has been paid to the investigation of perceptual factors during trauma exposure and their relation to both emotional and cognitive factors.

One central factor concerns the relation between peritraumatic threat perception and the development and maintenance of PTSD. Studies highlighted the role of peritraumatic threat perception in the development of PTSD symptoms in civilians (Goral et al., 2020), injured people (Holbrook et al., 2001), firefighters (Pinto et al., 2015), and especially combat-exposed military personnel (Lancaster et al., 2016). In adults exposed to a conflict (i.e., living in areas under missile threat with 15 - 90 s to safely reach shelter during a missile attack), an experience sampling study found that the impact of exposure to rocket warning sirens on the level of peritraumatic stress symptoms during wartime was mediated by subjective sense of threat (Lapid Pickman et al., 2017). These findings clearly highlight the importance of perceived threat intensity during the peritraumatic timeframe in later PTSD symptom development. However,

previous studies are either cross-sectional relying on retrospective reports, or are longitudinal but observational and epidemiologic, providing prospective reports but still lack a control group needed for a proper experimental verification of a to-be-suspected causal relationship. Problems associated with retrospective reports can be dramatic: Longitudinal evidence indicates that posttraumatic psychopathology can inflate the recall of both the frequency of stressors and of threat perception, with PTSD amplifying retrospective reports of both threat (Heir et al., 2009) and combat exposure (Engelhard et al., 2008).

The predictive processing perspective (Kube et al., 2020) has deepened our understanding of re-experiencing symptoms by regarding them as reflecting hyper-precise predictions with regard to the anticipation of threat (resulting from a previous life-threatening event), thereby shaping perceptions toward the continued experience of threat (Kube et al., 2020; Linson & Friston, 2019; Wilkinson et al., 2017). To our knowledge, only one experiment showed that threatening vs. non-threatening stimuli affect information processing differentially, yet in a non-trauma-related context: the authors found that while people usually integrate desirable information over undesirable information into their beliefs, this well-established optimistic update bias (or: positivity bias) vanishes when people are under perceived threat, enhancing the likelihood of responding to warnings with caution in environments rife with threat (Garrett et al., 2018). However, this study used an anticipated uncomfortable, stressful social event as the threat manipulation, not a trauma-analogue stressor paradigm with PTSD-like outcomes.

In sum, research suggests that perceived peritraumatic threat during a traumatic event critically influences PTSD symptoms like intrusions, but experimental studies to establish a causal link are lacking. To clarify the development and maintenance of intrusive memories, prospective experimental studies are needed to identify causal mechanisms of action (Arnaudova & Hageraars, 2017; Ehrling et al., 2011). Experimentally, the trauma film paradigm (TFP) is the

most frequently used model to investigate the psychopathology of PTSD under conditions of laboratory control, particularly intrusive memories, (James et al., 2016), in an ethically justifiable way (Holmes & Bourne, 2008). This paradigm permits the manipulation of variables presumptively related the development of intrusive memories and other reactions following trauma. Moreover, investigators can manipulate these variables before, during, and after participants encounter an analogue trauma such as an aversive film clip (James et al., 2016).

In the present experiment, we examined the effect of varying peritraumatic threat perception on the development of intrusive memories after TFP. We hypothesized that the higher the degree of perceived threat induced by the trauma-analogue stressor (i.e., the trauma films), the more likely the respective situational characteristics will be re-experienced in form of intrusive memories in the following week. Using different aversive film clip footage pre-tested for peritraumatic threat perception in an independent sample (Herzog, & McNally, in revision), we assigned participants to one of three experimental conditions: (1) High perceived threat (HPT) group, (2) Medium perceived threat (MPT), and (3) Low perceived threat (LPT) group. Subsequently, the participants recorded the occurrence and intensity of intrusions in a diary during the following week. We expected that the HPT group would experience more intrusive memories over one week than the MPT and LPT group, while the MPT group would report more intrusions than the LPT group ($HPT > MPT > LPT$). For exploratory purposes, we also tested whether the effects of peritraumatic threat perception on the frequency of intrusions and expectations about intrusive memories are mediated by differences in post-film fear – a variable that often fosters intrusion development (Laposa & Alden, 2008).

Methods

This randomized controlled study was preregistered on AsPredicted (Identifier: #87293, Link: https://aspredicted.org/5XL_QV9) and approved by the local ethics committee of the University

Medicine Greifswald (Reference number BB 133/21). All participants were treated in accordance with the ethical guidelines of the German Psychological Society and the guidelines for human studies of the World Medical Association Declaration of Helsinki, and participants provided written informed consent.

Participants

Participants were recruited through a call for participants on social networks (e.g., Facebook, Instagram), and flyers distributed in the University of Greifswald and other public spaces across the city. Individuals expressed their interest by sending an email with their name, age, and field of study or occupation. Inclusion criteria were: age between 18 and 65 years; sufficient German proficiency. In line with other TFP studies (e.g., Herzog, Barth, et al., 2022), the exclusion criteria were quite strict to ensure that no participant with mental disorders or other vulnerabilities would view the aversive film clips. We checked whether individuals met the inclusion and exclusion criteria: First, an online survey pre-screened out people who reported experiencing a trauma in their life as assessed by the *Life-Event-Checklist for DSM-5* (LEC-5; Krüger-Gottschalk et al., 2017; Weathers et al., 2013) and people whose depression score exceeded 10 on the *Patient-Health Questionnaire-9* (PHQ-9; Kroenke et al., 2001; Manea et al., 2012), accompanied by additional telephone-based clinical evaluation if needed. In this online survey, people were also excluded if they had substantial experience working in health care (e.g., nurses, paramedics, etc.), significant visual impairment, a medical history of heart disease or epilepsy, a history of fainting, or were students of psychology and medicine. In addition, we also asked for their consumption of violent visual material, as indicated by mean hours spent watching violent content per week. Ineligible participants were informed via email, whereas suitable participants were invited for a study appointment in the lab via another email sent to confirm study appointments. At the beginning of the first appointment, participants were informed about

the study procedure. Exclusion criteria were verified by clinical interview before the experiment began. This pre-study clinical evaluation consisted of the *Structured Clinical Interview for DSM-5 Disorders* (SCID-5-CV; First et al., 2016), and the *Columbia-Suicide Severity Rating Scale* (C-SSRS; Posner et al., 2011) to exclude people with a current mental disorder and current suicidal thoughts/behavior or non-suicidal self-injury. Individuals scoring positive on these interviews received information about their mental health condition and possible treatment options. To ensure proper application of observer-evaluated measures, the first author (PH) spent four hours of training for all interviewers to administer the SCID-5-CV and C-SSRS.

The sample size was determined via an a priori power analysis using G*Power, Version 3.1 (Erdfelder et al., 2009; Faul et al., 2007). Using a one-way ANOVA to examine differences in the primary outcome (i.e., frequency and severity of intrusions) between the three experimental groups, the power analysis for the main study indicated a minimum sample size of $N = 93$ to detect expected medium to large effects ($f = 0.33$, $\alpha = .05$, test power of $1 - \beta = .80$).

In total, $N = 157$ people were recruited for study participation, of whom $n = 62$ people were excluded after pre-screening and $n = 2$ during the interview screening in the lab. No participant dropped out because of film-related distress. Ninety-five participants were randomly assigned to the experimental groups, but two did not show up or canceled the follow-up appointment. Hence, the data for 93 participants ($n = 31$ participants per group) were analyzed. Each participant received 30€ for completing the study, and 5€/hr if they did not.

The participant flow chart and study design appear in Figure 1.

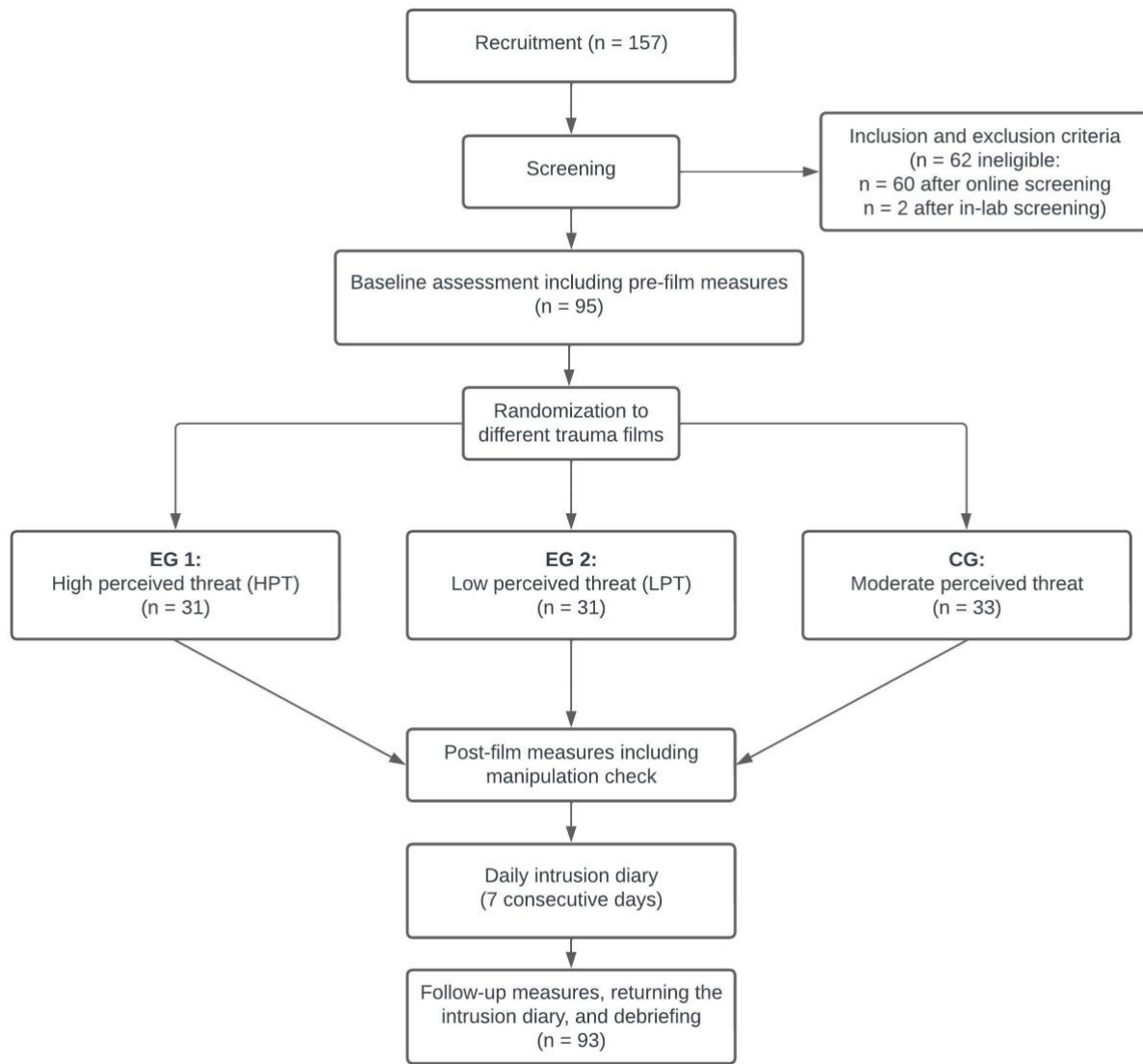


Figure 1. Participant flow chart depicting study design of the experimental paradigm to investigate perceived threat in the development of intrusive memories

Procedure

The participants were informed that the study's purpose was to examine how violent film material is remembered over a week. Following previous TFP studies (e.g., Herzog, Barth, et al., 2022), the standardized study protocol had three parts consisting of the first appointment in the laboratory, the daily diary phase of 7 consecutive days, and the second appointment in the

laboratory. In the first appointment, participants completed several computer-based baseline (sociodemographics) and pre-film measures (fear/anxiety), watched the randomly assigned trauma film, and completed computer-based post-film measures (fear/anxiety, perceived threat, expectations, other follow-up questions). After participants completed the pre-film questionnaires, we randomly assigned them to one of three experimental conditions (see section trauma film) through the implemented randomization procedure of the survey software which used an urn model without replacement. Thus, the investigator did not know the result of the randomization for a given participant. In each experimental condition, they were equally instructed to watch the film as if they were a witness present at the scenes or a bystander and were asked not to close their eyes or distract themselves while watching the trauma film. Subsequently, the lights were turned off and headphones were used during the trauma film. After the trauma film, participants were again asked to complete the computerized post-film questionnaires without the experimenter being present, and the 7-day daily intrusion diary was explained in detail and handed out to the participants. One week later, the participants returned to the laboratory for the second appointment, where they completed follow-up measures (distress, laboratory assessment of intrusions), returned their daily intrusion diary, and were fully debriefed.

Trauma film: Mean of experimental manipulation

To experimentally manipulate the perceived threat in this TFP study, we compared three conditions by selecting different trauma films based on a preliminary study in an independent sample prior to this experiment (Herzog, & McNally, in revision). The participants watched a trauma film rated as high vs. medium vs. low threatening in the high perceived threat (HPT) group, medium perceived threat (MPT) group, and low perceived threat (LPT) group, respectively. Each film consisted of two scenes that differed with respect to the peritraumatic

threat perception, but were balanced in duration conditions (< 1 min difference). In the HPT condition (6:35 minutes), the trauma film consisted of one excerpt from the film ‘Irreversible’ (Noé, 2002), which shows a scene of sexualized violence of a man against a woman (3:50 min), and a film clip (‘Texting while Driving’) depicting a car accident because of texting while driving (2:45 min) (Watkins-Hughes, 2009). In the MPT condition (5:37 minutes), the trauma film consisted of two film clips: an excerpt from the film *Maniac* (Khalfoun, 2012) depicting physical violence between a man and a woman, followed by a car accident (2:42 min), and an excerpt from the film *Antichrist* (von Trier, 2009) showing a scene of sexualized violence of a woman against a man (2:55 min). In the LPT condition (5:35 minutes), the trauma film consisted of an excerpt from the film *Hardcore Henry* (Naishuller, 2015) showing a military conflict where two parties engage in combat with firearms in an unfinished building, resulting death and injuries (2:14 min). Additionally, excerpts from self-recorded and replayed real-life film footage of car accidents retrieved from Youtube (e.g., “first person car crash”) (3:21 min) were added to this condition. All films were presented on a computer screen (Dell-Flat-Panel-Monitor, S2716DG, 27 inches) at approximately 1.5 meters. Participants heard the original soundtrack of the film scenes through headphones (AKG K) whose volume was kept constant.

Measures

Diary assessment of intrusive memories. The frequency of intrusive memories was assessed with the *daily intrusion diary* (Herzog, Barth, et al., 2022) and was our primary outcome measure. Participants completed a pen-and-paper daily diary for 7 days noting three times a day (morning, afternoon, evening) any intrusive memories related to the trauma film. For each intrusive memory, they were asked to indicate the quality (image, thought, or both) as well as the intensity and distress caused by the intrusion, both rated on a Likert scale from 0 (“not at all”) to 10 (“extremely”). In addition, the participants noted the content of the intrusion and the situation

in which the intrusion occurred. Following previous procedures (e.g., Herzog, Barth, et al., 2022), we pre-specified ‘valid’ intrusions of all intrusive memories in the diary if it had not been 1) indicated with no distress [< 1], 2) popped out as a result of active thinking or rumination or through active communication, or 3) described as nonspecific thoughts and/or images. The intrusion frequency was summed over 7 days with higher sum scores reflecting a higher frequency of intrusions. A diary compliance rating was used in the follow-up appointment where participants rated on a scale from 0 to 10 how accurate they were in noting intrusions in the intrusion diary. In line with the values of diary compliance ratings reported in other studies (Herzog, Barth, et al., 2022; James et al., 2015), participants filled out the diary conscientiously and noted almost all intrusions accurately ($M = 8.23$; $SD = 1.57$).

Distress caused by the trauma film. Following previous TFP studies (Herzog, Barth, et al., 2022; Kube et al., 2022), we used an adapted version of the *Impact of Event Scale-Revised* (IES-R; Maercker & Schützwohl, 1998) to assess distress caused by the trauma film as our secondary outcome measure. At the follow-up appointment seven days after watching the trauma film, participants were asked to rate 22 items measuring distress related to contents of the trauma film (e.g., “Pictures about the film popped into my mind.”) on a 4-point Likert scale ranging from 0 (“not at all”), 1 (“rarely”), 3 (“sometimes”) to 5 (“often”), indicating how often each response occurred over the last week. The IES-R consists of three subscales: “intrusion”, “hyperarousal”, and “avoidance” with total scores ranging from 0 to 110 and higher values reflecting higher distress. Additionally, the sum score for the intrusion subscale was calculated separately, with total scores ranging from 0 to 35 (Items 1, 3, 6, 9, 14, 16, 20). In this sample, the internal consistency was Cronbach’s $\alpha_{\text{total}} = .85$ of the total scale and Cronbach’s $\alpha_{\text{intrusion}} = .79$ of the intrusion subscale.

Laboratory assessment of intrusive memories. Intrusive memories were recorded in the laboratory in the follow-up measurement by using the *Intrusion Provocation Task* (IPT; Çili & Stopa, 2015) which is a simple and feasible way to assess intrusions in the peri-intrusion window (Lau-Zhu et al., 2018) in addition to participants' self-reports by daily diary. In the IPT, participants were presented with a ten-second long neutral still image from each of the film clips, instructed to think non-purposefully for the next two minutes and report any intrusions by raising a finger, with the investigator counting how often the participant lifts the finger to indicate the intrusion frequency.

Perceived threat. The perceived threat evoked by the trauma films was assessed using the *Perceived Threat Questionnaire* (PTQ) consisting of 7 items (Herzog, & McNally, in revision). Participants were asked to rate how threatened they felt by the film scenes on a 5-point Likert scale ranging from 1 ("strong rejection") to 5 ("strong agreement"). A total score was computed by summing the ratings on all seven items, resulting in scores ranging from 7 to 35 with higher scores indicating higher levels of perceived threat. For exploratory analyses, two additional 2 items measured the probability "How likely do you think it is that you could experience the events you just saw in the film scenes in general?", and "How likely do you think it is that you could experience the events you just saw compared to other people your age?" on a slider scale ranging from 0 – 100%. As the preliminary study showed that the probability items (items 8 and 9) did not differentiate sufficiently between the levels of perceived threat, they were excluded from the analysis of perceived threat. An internal consistency analysis in our sample revealed a Cronbach's $\alpha = .81$. The PTQ served as a manipulation check.

Fear/Anxiety. The *Positive and Negative Affect Schedule-Expanded Form* (PANAS-X; Watson & Anna Clark, 1999) is a self-report measure designed to assess affect. This scale consists of 20 affect-related words and participants indicate the extent to which they "feel this way right now"

on a 5-point Likert scale ranging from 1 (“very slightly or not at all”) to 5 (“extremely”). The *PANAS-X fear subscale* is frequently used in experiments employing the trauma film paradigm. In our study, the Cronbach’s α for the fear subscale ranged from $\alpha = .76$ (pre-film fear) to $\alpha = .87$ (post-film fear). Convergent validity was ensured by a significant correlation between the PANAS-X fear subscale with the German version of the 20-item *State scale of the State-Trait-Anxiety-Inventory* (STAI-S; Laux et al., 1981; Spielberger et al., 1970) prior ($r = .71, p < .01$) and after watching the trauma film ($r = .79, p < .01$), which can be considered high according to Cohen (1988).

Expectations about Intrusive Memories Scale. Expectations about the intensity and controllability of intrusions were assessed post-film with the *Expectations about Intrusive Memories Scale* (EIMS; Herzog, Barth, et al., 2022). This 12-item scale measures the participants’ anticipated intensity of possibly occurring intrusions (e.g., “Whenever I experience intrusive memories over the next week, it will cause me severe distress.”) and their ability to control them (e.g., “Whenever I experience intrusive memories over the next week, I will be able to cope with them well.”). A total score is computed by summing up item scores, with higher scores indicating more positive expectations. Internal consistency in our sample was Cronbach’s $\alpha = .86$ for the full 12-item scale, and Cronbach’s $\alpha = .88$ for the optimized 10-item scale used previously (Herzog, Barth et al., 2022). We used the latter version.

Sociodemographic characteristics. Participants were asked about their age, gender, highest educational degree, and current employment status.

Follow-up Interview. On a 11-point Likert scale ranging from 0 (“not at all”) to 10 (“very well”), participants indicated in the follow-up interview how unpleasant and distressing they experienced the trauma film, how well they could identify with the victims and how well they

could concentrate on the trauma film. Furthermore, they were asked if they used any strategy to distract themselves from watching the film (e.g., looking away, closing their eyes).

Statistical Analyses

We performed all statistical analyses in IBM SPSS ® Statistics (Version 29) and the PROCESS Makro Version 4.3 (Hayes, 2023). We used *Microsoft Excel* for the analysis of diary data and the online software *Lucidchart* for the creation of figures (i.e., participant flow chart and mediation models).

Pre-processing. The final data set included $N = 93$ participants (see also the participant flow chart in Figure 1). According to Tabachnick & Fidell (2019), all scales included in statistical analyses were examined for outliers and extreme values using descriptive analyses and box-whisker plots. As a result, data from individual participants were only excluded from further analyses when their values on the dependent variable were implausible or (probably) caused by measurement errors.

Induction of fear/anxiety through the trauma film paradigm. To examine the validity of the TFP as implemented in the present study, the pre- to post-film differences of the state fear and anxiety measures were computed with *t*-tests for dependent samples and, respectively, the effect size. For further investigation, a one-way analysis of variance (ANOVA) was used to check whether the three experimental groups differed significantly in post-film fear.

Manipulation check. We tested through a one-way ANOVA whether the three experimental groups differed in their perceived threat, as assessed with the PTQ. If the manipulation was successful, there would be the highest perceived threat in the HPT group and the least perceived threat in the LPT group, as indicated by significant differences in corresponding post-hoc analyses.

Group differences. A one-way ANOVA was performed to determine differences between the experimental groups in the primary outcome, i.e., the frequency of intrusions. Possible group differences in secondary outcomes, that is, the distress caused by the trauma film, participants' responses to the intrusion provocation task and their expectations about intrusive memories were also examined using ANOVAs.

Mediation analyses. For exploratory purpose, we conducted mediation analyses in the overall sample independent of group. As proposed in previous work (Herzog, Barth, et al., 2022; Laposa & Rector, 2012), a slightly different operationalization of the primary outcome was used for the mediation analyses. In particular, the dependent variable composed a multimethod combination of the frequency of intrusions assessed in the diary (intrusion frequency) and the intrusion subscale of the IES-R (intrusion distress). After transforming the sum scores of both measures into standardized variables ($M = 0$, $SD = 1$), we combined the z-scores additively into one intrusion score with higher values reflecting a more pronounced experience of intrusions. Multiple linear regression models were calculated in the assumed path models with the independent variable (X) perceived threat and the post-film fear entered as the mediator variable (M). The dependent variable (Y) was defined as the intrusion experience in the first mediation analysis, while expectations about intrusive memories were used in the second mediation analysis.

Results

Participants

Most of the participants were comparably young ($M = 23.8$ years, $SD = 6.2$), male (58.1%), single (57%) without children (93.5%), and German (97.8%) without a migrant background (90.3%). With respect to the highest educational level, most of the participants hold a General Certificate of Education Advanced Level (GCE A-Levels, 91.4%). In Table 1, the

373 sociodemographic characteristics of the sample, separated by experimental condition, are
374 displayed.

Table 1

Sociodemographic characteristics of the total sample (N = 93) and each experimental condition

Variable	HPT <i>n</i> = 31	LPT <i>n</i> = 31	MPT <i>n</i> = 31	Total <i>n</i> = 93
Age, <i>M</i> (<i>SD</i>)	24.6 (6.6)	23.3 (4.7)	23.5 (4.9)	23.8 (6.2)
<u>Range</u>	<u>18-55</u>	<u>18-38</u>	<u>18-55</u>	<u>18-55</u>
Sex, <i>N</i> (%)				
Female	14 (45.2%)	12 (38.7%)	13 (41.9%)	39 (41.9%)
Male	17 (54.8%)	19 (61.3%)	18 (58.1%)	54 (58.1%)
Nationality, <i>N</i> (%)				
German	30 (96.8%)	31 (100%)	30 (96.8%)	91 (97.8%)
Other	1 (3.2%)	--a	1 (3.2%)	2 (2.2%)
Migrant background, <i>N</i> (%)				
yes	6 (19.4%)	--a	3 (9.7%)	9 (9.7%)
no	25 (80.6%)	31 (100%)	28 (90.3%)	84 (90.3%)
Children, <i>N</i> (%)				
yes	1 (3.2%)	2 (6.5%)	3 (9.7%)	6 (6.5%)
no	30 (96.8%)	29 (93.5%)	28 (90.3%)	87 (93.5%)
Relationship status, <i>N</i> (%)				
single	18 (58.1%)	16 (51.6%)	19 (61.3%)	53 (57.0%)
permanent partnership	12 (38.7%)	13 (41.9%)	10 (32.3%)	35 (37.6%)
married	1 (3.2%)	1 (3.2%)	2 (6.5%)	4 (4.3%)
other	--a	1 (3.2%)	--a	1 (1.1%)
School leaving qualification, <i>N</i> (%)				
secondary school diploma	--a	3 (9.7%)	1 (3.2%)	4 (4.3%)
vocational baccalaureate	1 (3.2%)	1 (3.2%)	2 (6.5%)	4 (4.3%)
high school diploma	30 (96.8%)	27 (87.1%)	28 (90.3%)	85 (91.4%)
Employment status, <i>N</i> (%)				
full-time	--a	2 (6.5%)	2 (6.5%)	4 (4.3%)
part-time	4 (12.9%)	4 (12.9%)	4 (12.9%)	12 (12.9%)
not employed	16 (51.6%)	17 (54.8%)	14 (45.2%)	47 (50.5%)
training	8 (25.8%)	6 (19.4%)	8 (25.8%)	22 (23.7%)
other	3 (9.7%)	2 (6.5%)	3 (9.7%)	8 (8.6%)
Cultural background, <i>N</i> (%)				
European	31 (100%)	31 (100%)	30 (96.8%)	92 (98.9%)
Other	--a	--a	1 (3.2%)	1 (1.1%)

Note. *M* = Mean, *SD* = Standard Deviation, *N* = Number, --a = characteristic did not occur

Implementation of the trauma film paradigm (TFP)

Across the groups, a $t(92)$ -test = 2.59, $p = .006$, $d_z = 0.27$, showed that *post-film state fear* ($M = 9.43$, $SD = 3.63$) increased significantly compared to *pre-film state fear* ($M = 8.47$, $SD = 2.61$) on the state fear measure (PANAS-X fear subscale). A one-way ANOVA showed no statistically significant differences between the groups in post-state fear, $F(2, 90) = 2.87$, $p = .06$, $\eta^2_p = .06$. As a robustness check for the effects of the TFP on fear, a $t(86)$ -test = 6.22, $p < .001$, $d_z = 0.67$, indicated that *post-film state anxiety* ($M = 69.77$, $SD = 28.13$) was higher than *pre-film state anxiety* ($M = 53.94$, $SD = 18.80$) on the state anxiety measure (STAI-S).

In the follow-up interview, participants across all groups reported that they perceived watching the trauma film as somewhat unpleasant ($M = 4.88$, $SD = 3.34$), while the degree of distress elicited by the trauma film was low ($M = 2.12$, $SD = 2.25$). The mean self-reported concentration during the trauma film was high ($M = 8.62$, $SD = 1.29$). Identification with the victims in the trauma film was low ($M = 3.29$, $SD = 2.64$). In this sample, only 10.8% of the participants reported to have been familiar with at least one of the film scenes in their respective condition, whereas most participants (89.2%) were unfamiliar with them. Most participants reported that they did not look away at all (79.6%), whereas 17.2% looked away one to three times, and only 3.2% five times during the trauma film. Although 88.2% participants reported not having closed their eyes while watching the trauma film clips, 10.8% did so one to two times and 1.1% did so five times. The results of the open exploratory question on distraction strategies indicated that most participants did not use any strategy with a minor part mostly using cognitive soothing and contextualizing the aversive experience (e.g., “It’s just a movie.”)¹.

¹ In the debriefing interview, most of our sample did not question the provided study rationale, and no participants uncovered the real objective of the study (i.e., examining the effects of perceived threat on intrusive memories). Answers to post-experiment questions indicated that no participant was able to determine the true hypotheses of the study; most guessed that the study’s purpose was about “new interventions for PTSD”.

Manipulation check

The descriptive statistics of the variables for the manipulation check as well as the primary and secondary outcomes of the total sample and separated by experimental condition are depicted in Table 2. The one-way ANOVA indicated significant group differences in perceived threat, $F(2, 92) = 9.62, p < .001, \eta^2_p = .18$, supporting that the intended manipulation was successful in differentially altering participants' threat perception. Bonferroni-adjusted post-hoc analysis revealed significant differences in perceived threat between the LPT group and the HPT group ($M_{diff} = -4.68$ [95% CI, -7.47 to -1.89], $p < .001$) and MPT group ($M_{diff} = -3.90$ [95% CI, -6.69 to -1.11], $p = .003$). However, no differences were found between the MPT group and the HPT group ($M_{diff} = -0.77$ [95% CI, -3.56 to 2.02], $p > .05$).

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Table 2

Descriptive statistics of the total sample (N = 93) and each experimental condition

Variable, <i>M</i> (<i>SD</i>)	HPT <i>n</i> = 31	LPT <i>n</i> = 31	MPT <i>n</i> = 31	Total <i>n</i> = 93
<i>Manipulation check</i>				
Perceived Threat (PTQ) Items 1-7	15.90 (4.79)	11.23 (4.38)	15.13 (4.31)	14.09 (4.90)
Item 8	29.13 (17.58)	17.32 (20.90)	10.45 (14.13)	18.97(19.19)
Item 9	20.23 (16.20)	13.55 (13.56)	9.94 (17.20)	14.57 (16.20)
<i>Primary Outcome</i>				
Frequency and severity of intrusive memories (Daily intrusion diary)	4.26 (3.64)	1.00 (2.14)	3.39 (4.16)	2.88 (3.66)
<i>Secondary Outcome</i>				
Distress (IES-R)	7.84 (6.86)	3.06 (5.28)	10.57 (13.47)	7.12 (9.60)
Distress (IES-R subscale intrusions)	6.97 (4.84)	3.42 (3.92)	5.70 (5.36)	5.36 (4.91)
Intrusion Provocation Task (IPT)	7.00 (4.98)	4.16 (3.60)	4.63 (3.30)	5.27 (4.19)
Expectations (EIMS)	33.26 (5.43)	36.55 (3.85)	32.93 (5.87)	33.97 (5.99)

Note. *M* = Mean, *SD* = Standard Deviation, *n* = Number. PTQ = Perceived Threat Questionnaire with scores ranging from 7 to 35 (Items 1-7), and scores ranging from 0-100% (Item 8 and Item 9). IES-R = Impact of Event Scale - Revised with scores ranging from 0 to 110 for the total scale, and scores ranging from 0 to 35 for the intrusion subscale.

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Group differences in primary and secondary outcomes

Diary intrusive memories. Participants reported a mean of $M = 2.88$ ($SD = 3.66$) intrusions during the subsequent week after viewing the trauma film. The one-way ANOVA showed significant differences between the experimental groups in the frequency of valid intrusions over a week, $F(2, 87) = 6.80$, $p = .002$, $\eta^2_p = .14$. A Tukey HSD post-hoc test indicated that the HPT group ($M = 4.26$) reported significantly more intrusions than the LPT group ($M = 1.00$; $p = .002$), but no differences were found between the MPT group ($M = 3.39$) and the other groups (HPT group vs. MPT group: $p = .463$; MPT group vs. LPT group: $p = .050$).

Distress caused by the trauma film. The one-way ANOVA revealed significant differences between the experimental conditions for the distress caused by the trauma film in the total IES-R score, $F(2, 89) = 5.228$, $p = .007$, $\eta^2_p = .11$, and the IES-R intrusion subscale, $F(2, 86) = 4.345$, $p = .016$, $\eta^2_p = .10$. Using the IES-R intrusion subscale, the Tukey HSD post-hoc comparison test showed a significant difference between the HPT and the LPT group ($p = .011$), but not between the other groups (HPT group vs. MPT group: $p = .551$; MPT group vs. LPT group: $p = .150$).²

Laboratory intrusive memories. The one-way ANOVA indicated significant group differences in the intrusion provocation task, $F(2, 89) = 4.39$, $p = .015$, $\eta^2_p = .09$. A Tukey HSD post-hoc test revealed that the HPT group reported significantly more intrusions in the IPT than the LPT group ($p = .019$), but no differences were found between the other groups (HPT group vs. MPT group: $p = .063$; MPT group vs. LPT group: $p = .892$).

Expectations about intrusive memories. The one-way ANOVA showed statistically significant differences between the experimental groups in expectations, $F(2, 91) = 4.70$, $p = .011$, $\eta^2_p = .09$. Post hoc comparisons using the Tukey HSD test indicated that the mean EIMS of the HPT and

² Post hoc comparisons using the Tukey HSD test indicated that the total distress by the trauma film was significantly higher in the MPT group as compared to the LPT group ($p = .006$), but no differences were found between the other groups (HPT group vs. LPT group: $p = .107$; HPT group vs. MPT group: $p = .480$).

the MPT group were both significantly lower than that of the LPT group (HPT group vs. LPT group: $p = .035$; MPT group vs. LPT group: $p = .019$), but no difference was found between the MPT and the HPT group ($p = .967$).

Mediation models

The results of the mediation models are visualized in Figure 2. The mediation analysis showed that the perceived threat (X) significantly influenced the intrusion experience (Y) by explaining 37% of the variance. This finding was not mediated by post-film state fear (M), as shown by a significant direct effect of perceived threat on the intrusion experience (see Figure 2A). In addition, the results revealed that perceived threat (X) significantly impacted the formation of negative expectations (Y), while this was also not mediated by post-state fear (M), indicating a distinct influence of perceived threat on the development of expectations beyond fear – as an indicator of emotional arousal – per se (see Figure 2B).

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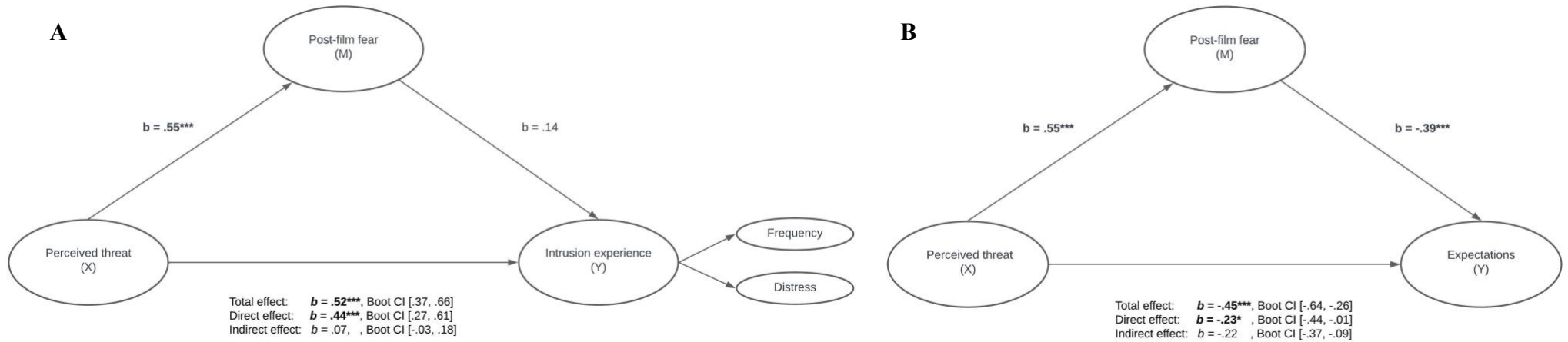


Figure 2. Mediation models of perceived threat via post-film fear on intrusion experience (A) and expectations (B)

Note. b = unstandardized regression weight, boot CI = bootstrapping confidence intervals (5000 samples, 95%),

Significance (1-sided) $*p < .05$, $**p < .01$, $***p < .001$. Significant results in bold.

Discussion

We experimentally investigated the role of perceived threat in the development of intrusive memories – a core feature of PTSD. Using the trauma film paradigm in a healthy sample, we manipulated perceived threat by randomly assigning participants to view one of three validated trauma film clips varying in the ability to induce threat (Herzog, & McNally, in revision) and examined whether this manipulation of threat (high vs. medium vs. low threat) influenced the frequency of intrusions over the subsequent week. Moreover, we investigated whether the perceived threat had also exerted differential effects on distress caused by the trauma film, laboratory intrusion assessment, and expectations related to intrusive memories – a factor that has been shown to mediate the relationship between post-state anxiety and intrusive memory development (Herzog, Barth, et al., 2022). In addition, we examined whether the level of post-film fear mediated the effects of perceived threat on the intrusion experience and expectations.

As the experimental groups differed significantly in their experience of intrusive memories over the following week for the diary and for the laboratory-based provocation task, our results support the main hypothesis: The level of perceived threat during trauma exposure influenced the development of intrusive memories, with higher levels of perceived threat leading to more intrusions over one week after watching the trauma film. In addition to the frequency of intrusions, we also found that higher levels of perceived threat led to more negative expectations about intrusive memories and more distress caused by the trauma film over a week.

In line with the experimental group comparisons, a subsequent mediation analysis in the total sample (taking into account the threat actually experienced individually) showed that this relationship was not mediated by the level of fear elicited by the trauma film, as the direct effect of perceived threat on intrusive memory development was still significant when entering the potential mediator of fear into the model. Interestingly, we found in a second mediation analysis

that the effect of perceived threat on the formation of expectations regarding the intensity and controllability of intrusions was not mediated by fear level either. Both findings together provide support for the assumption that people perceiving a situation or event as highly threatening not only develop more pronounced negative expectations about the intensity and uncontrollability of intrusions but also have a higher risk for the development of intrusive memories.

Our results underline the particularly role of perceptual and cognitive factors in the development of psychopathology following adverse life events (Herzog, Kube, et al., 2022), but also question the exclusive use of fear/anxiety measures as manipulation checks in the TFP. By extending the result of a previous trauma-analogue study showing that perceived threat was related to immediate outcomes (Herzog, & McNally, in revision) with delayed responses (i.e., intrusions), we showed that perceived threat should be used as an important criterion in the selection of trauma films in the TFP to improve its ecological validity. In fact, the results showed that we can differentially manipulate participants' threat perception as reflected in the significant manipulation check using the PTQ, indicating large effects on perceived threat among conditions. Also, the findings of the follow-up interview and diary compliance ratings corroborate the effectiveness of our implementation of the TFP procedure, consistent with other studies (e.g., Herzog, Barth, et al., 2022; James et al., 2015).

Our findings not only underscore the role of perceived threat as an important specific peritraumatic factor in the development of intrusions, but also clearly emphasize a situational feature that makes a traumatic event 'pathological' for the individual: threat (Jones, 2021). As such, our results align well with current theories from neuroscience and computational psychiatry: Predictive processing theories highlight the influence of prior beliefs on symptom perception in PTSD, with threat being a particular important feature (Kube et al., 2020; Linson & Friston, 2019; Wilkinson et al., 2017), but also further support cognitive theories emphasizing the

“sense of current threat” (Ehlers & Clark, 2000). Thus, this study adds experimental evidence to the findings of previous observational studies showing that perceived threat not only correlates with PTSD symptoms in firefighters (Pinto et al., 2015), but also predicted PTSD symptoms during warzone deployment in soldiers (Lancaster et al., 2016) and after serious traumatic injuries (Holbrook et al., 2001). Moreover, our results indicate that perceived threat could be a relevant factor in determining the formation of negative expectations, thereby extending a previous TFP study demonstrating that a higher level of post-state anxiety was associated with more negative expectations, which in turn predicted a stronger experience of intrusive memories (Herzog, Barth, et al., 2022). Indeed, dysfunctional expectations were closely related to PTSD symptoms in a clinical sample (Herzog, Kaiser, et al., 2022).

Implications

This study demonstrated that perceived threat during exposure to a traumatic event may be a relevant risk factor for the development of intrusive memories. Since this effect was not mediated by post-film fear that is itself considered as an empirically strong risk factor (Laposa & Alden, 2008), it may provide some implications for understanding the traumatic nature of events and situations that may lead to a full-blown PTSD. First, our results suggest that intrusions might emerge not only as a result of unpleasant emotional and cognitive states following the trauma analog event (i.e., the trauma film), but as a result of perceiving a situation or event as highly threatening. The interplay between peritraumatic threat perception and posttraumatic cognitions (i.e., expectations) appears to be a particular mechanism through which a traumatic event or situation becomes ‘pathological’ for the individual person. Depending on the outcome of this process, this can lead to quantitatively strong, yet qualitatively different, emotional reactions. Hypothetically, threat related to one’s life can elicit anxiety, while threat regarding one’s moral beliefs may lead to shame and guilt (Litz et al., 2009).

The current findings may also have some implications for the prevention of persisting intrusions and prolonged avoidance, specifically with regard to secondary prevention (e.g., emergency departments) aiming to reduce the negative consequences of a traumatic event and to foster ‘healthy’ memory formation. Conceivably, in view of the direct effects of perceived threat on intrusions, it might be useful to watchful wait, in particular, those persons who perceived a situation or event as highly threatening – rather than considering only the level of peritraumatic emotional arousal elicited by this specific event. After being replicated in future experimental studies with healthy and clinical samples, the assessment of perceived threat may guide the provision of (psychosocial) emergency care within 24 hours after trauma exposure in terms of a validating possibility of disclosure and psychoeducation about the nature of intrusions (normal) and the role of avoidance (risk factor) for individuals with high perceived threat (and dysfunctional cognitions), with the aim of reducing the risk of developing a full-blown PTSD.

Limitations and future research

To our knowledge, there is no experimental study that has addressed the role of perceived threat as a potential peritraumatic perceptual factor influencing the development of intrusions as a hallmark symptom of PTSD. While our study has some strengths (e.g., randomized controlled study design, highly standardized experimental protocol, preregistered study protocol, pre-tested and data-informed experimental manipulation, adjustment for unspecific intrusive memories), some study-specific limitations must be taken into account when interpreting the findings:

A major limitation of our study is related to the manipulation of our experimental conditions: While we tried to balance the lengths of film material across experimental conditions, the trauma film clips varied +/- 1 minute in length between the experimental conditions with the longest trauma film in the HPT group that may have impacted the outcomes along other film features. Therefore, a potential dose-response relationship should be kept in mind when

interpreting the results, although we did not find differences between the HPT group and the MPT group with the shorter trauma film. Relatedly, the average intrusion frequency – our primary outcome – was somewhat lower compared to mean values of other TFP studies, e.g., $M = 5.5$ as reported by James et al. (2015), $M = 4.64$ as reported by Holmes et al. (2004), and $M = 4.93$ as reported by Herzog, Barth, et al. (2022). This was expected for the mean value across experimental conditions, but remains true with regard to the HPT group with $M = 3.53$ intrusions. Most likely, this was related to the dose of film material participants watched in the experimental conditions: Compared to Herzog, Barth, et al. (2022) (12:39 min), the HPT group watched a trauma film with 6:35 minutes. This presumably led to the lack of differences between the HPT and MPT group, intended to induce a medium level of perceived threat based on a preliminary study in an independent sample (Herzog, & McNally, in revision). Although it could arguably be the case that it might be difficult to manipulate perceived threat in a more nuanced way using trauma films, future TFP studies should also carefully consider the dose of film material presented to participants, keeping in mind also ethical aspects (Takarangi et al., 2023). Another explanation for this finding could be related to gender effects with women identifying more with the victims than men in the HPT group that led to a higher perceived threat in this subgroup, although the identification with the victims in all trauma films was in general low.

A further limitation is the selectivity of the sample: most participants in this study were young students, indicating a comparatively high educational level. Noteworthy, a high level of education is a relevant protective factor with respect to the development of PTSD-related symptoms (Bonanno et al., 2007; Murrell & Norris, 1983), emphasizing a higher resilience in our sample. Although we can compare our results with most other TFP studies that likewise recruited quite similar samples, i.e., young students (James et al., 2016; Marks et al., 2018), persons of other age groups and educational status were clearly underrepresented, limiting the

generalizability of our findings. Future studies should more closely monitor the recruitment process to ensure that a greater diversity is represented in their samples in view of sociodemographic characteristics. When replicated in clinical samples (e.g., traumatized people in the emergency department), our findings increase the hope to develop evidence-based secondary preventive strategies in emergency care, as we are still lacking of effective early psychological interventions after acute traumatization (Roberts et al., 2019).

Conclusions

The present study is the first to examine the potential influence of perceived threat on intrusive memories as a core feature of PTSD using an experimental approach. As such, this study provided some insights into one of the most puzzling questions in trauma research: What drives intrusions and thus makes a traumatic event ‘pathological’ for the individual? According to our findings, perceived threat in the peritraumatic window critically determined the extent to which intrusive memories were formed after exposure to a trauma (alike) event and also the distress related to intrusions, emphasizing threat as a particularly important risk factor on a perceptual level. Watching a highly threatening trauma film resulted in a significant increase not only in post-film fear, but also influenced subsequent intrusive memories over one week, while this effect was not mediated via fear levels, supporting its important role in the development of intrusive memories, above and beyond the level of fear per se. Moreover, perceived threat led to the development of negative expectations regarding the intensity and controllability of intrusions: a posttraumatic factor shown to increase also the risk of PTSD symptoms. Improving our understanding of the processes that contribute to the development of intrusions is crucial to optimize the prevention of PTSD and provide adequate care for those persons at high-risk for developing a full-blown PTSD.

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