**Supplemental Information**

**Decontextualized fear memories? Stronger conditioned fear responses during extinction learning and extinction recall in a safe context predict the development of long-term analog intrusions**

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**Supplementary Materials**

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1. **Participants: Study in- and exclusion criteria and sample size**

The final sample consisted of 94 right-handed healthy female students who were recruited via the mailing list of the local university and screened via telephone, before they conducted a comprehensive examination appointment on study day 1, in order to check study in- and exclusion criteria. Participants had to be female, between 18 and 35 years old, right-handed as assessed by the Edinburgh Inventory of Handedness [(Oldfield, 1971)](#_CTVL001fa4af60dcb81463e8a030284d6346522), and had to speak and understand German at a native language level. Further study exclusion criteria were MRI contraindications, the intake of psychoactive or other potentially confounding substances (current and/or regular drug use in the past), color blindness, a current or past psychotherapeutic/psychiatric treatment, or a medical treatment due to an acute or severe chronic physical disease. In order to assess mental health, a trained psychologist conducted the Diagnostic Interview for Mental Disorders (DIPS) for DSM-5 [(Margraf, Cwik, Pflug, & Schneider, 2017](#_CTVL00149a792fd33fa48bc9b6689dd14f7fdec)[; Margraf, Cwik, Suppiger, & Schneider, 2017)](#_CTVL0010181ae9e18404d85b45b505cf4c8fc88) and the Life-Event-Checklist in combination with the Clinician-Administered PTSD Scale for DSM-5 (CAPS-5; [Cwik & Woud, 2015](#_CTVL0016b473df46f4c40c3b67c9c731c8f8118)). The DIPS covers the most important and prevalent mental disorders (e.g., affective, anxiety, obsessive-compulsive, somatoform, and eating disorders as well as disorders associated with psychotropic substances and dependent behavior, including screenings for psychoses and suicidal behavior). It does not comprise less prevalent disorders or personality disorders (except borderline personality disorder) [(Margraf et al., 2017)](#_CTVL00149a792fd33fa48bc9b6689dd14f7fdec). Participants were excluded from further study participation, if they fulfilled the diagnosis of a current or past DSM-5 disorder according to the DIPS. Further study exclusion criteria were the experience of a traumatic event within the last four weeks or personal experiences with physical or sexual violence. Participants were informed that they could terminate the study at any point without negative consequences as well as to see a film clip of physical and sexual violence in the context of the study.

The sample size of an a priori conducted power analysis for the main study question regarding analog intrusions and context-dependent fear conditioning (linear regression analysis with one predictor (Power (1-β)=0.80, α=0.05) with an expected medium effect of ρ=.3) wasN=67. In order to compensate for an estimated drop-out rate of 20% and drop-outs in main outcome measures, the sample size was post-hoc raised to N=94.

**B) Study Procedure**

The whole project consisted of six study days within four weeks (for an overview see Supplementary Figure 1). On study day 1, each participant underwent an interview with a trained psychologist to screen for mental and physical health and further study in- and exclusion criteria (see ‘Participants’). Participants were further asked about sociodemographic variables and filled in questionnaires regarding clinical variables like depression status (measured with the Beck Depression Inventory-II (BDI-II; [Hautzinger, Keller, & Kühner, 2006](#_CTVL001c383937274fe43609668034923d5f0ef))) and mental stress (measured with the Global Severity Index (GSI) of the Symptom Checklist-90-R (SCL-90-R; [Franke, 1995](#_CTVL001174d19c8401246139f159f25b113dc64))). Furthermore, PTSD symptoms in reaction to the most aversive life event and to a traumatic event if existing were assessed by questionnaire.

On study day 2 (1–3 days later), participants conducted the Mnemonic Similarity Task (MST) for objects and scenes [(Stark & Stark, 2017](#_CTVL0014504546db5ae46e59da15509c4704000)[; Stark, Yassa, Lacy, & Stark, 2013)](#_CTVL001dc7ab45e9d1b4996891f6b59c656c6f5) as well as a neuropsychological test battery to measure executive functioning. At the end of study day 2, participants’ emotion regulation abilities and personality traits were measured by questionnaire. Trait anxiety, for example, was assessed with the State-Trait-Anxiety Inventory [(Spielberger, 1983)](#_CTVL0018530687958054e48837aaa7e320fae14).

On study day 3 (conducted 7–10 days after study day 1), participants underwent the first part of an emotion regulation paradigm [(Hermann, Neudert et al., 2020)](#_CTVL00123d3db3467c248bc8ed2d94d1611476c), while the second part of the emotion regulation paradigm took place at the beginning of study day 4 (6–8 days after day 3). On study day 4, after finishing the emotion regulation paradigm, participants started with the fear conditioning paradigm (see Supplement C for further information). They completed the fear acquisition and the extinction training phase. Approximately 24 hours later (on study day 5), participants conducted the second part of the fear conditioning paradigm including retrieval testing in the safe extinction context B (extinction recall) and in the novel context C (fear renewal). Afterwards, participants filled in several questionnaires and rated items regarding emotional state, stress, emotion regulation, sleep and social empathy as well as social support. Next, the trauma film paradigm was conducted. Analog intrusions and memory aspects with regard to the trauma film were measured daily via an online survey between study day 5 and day 6. After one week, on study 6, (short-term) analog intrusions as well as explicit film memory was assessed by questionnaires and different tasks (see supplement D for further information). At the end of study day 6, participants were informed to be contacted after three months, in order to measure long-term effects of the study via online survey. Finally, they were reimbursed for study participation (10 Euros/h; course credits).

**C) Context-dependent fear conditioning paradigm**

**Experimental design**

A 2-day context-dependent differential fear conditioning paradigm adapted from previous studies [(Hermann, Stark et al., 2020](#_CTVL001665d40d2c93443b096479c5e721215e0)[; Hermann, Stark, Milad, & Merz, 2016](#_CTVL001ebd4e83dce304305b202ba76d6177070)[; Milad et al., 2007](#_CTVL0010d1538eafbcc4ee492fe22223ad2213d)[; Milad et al., 2009)](#_CTVL001535f515403934cd5b49a16e61a7dbdff) was conducted. It consisted of fear acquisition in context A and extinction training in context B on a first day, as well as extinction recall in context B and fear renewal in a novel context (context C) one day later. Pictures of different rooms (office room, conference room, and a room with a shelf) were used as contexts A, B and C. The assignment of contexts to experimental phases was counterbalanced and pseudorandomized across participants. Each room showed the same initially turned-off desk lamp. The desk lamp lit up either in blue or yellow, whereby the lamplight colors served as conditioned stimuli (CS). Via a mirror mounted to the head coil, participants were able to watch the pictures presented on a 32’ LCD monitor (NordicNeuroLab Inc., Milwaukee, WI, USA) at the end of the scanner (visual field=28°). Electrical stimulation (1ms pulses with 50Hz for a duration of 500ms) applied via electrodes (Coulbourn Transcutaneous Aversive Finger Stimulator (E13-22)) and positioned at the second and third fingertip of the right hand was used as unconditioned stimuli (UCS). Before the experiment started, the intensity of electrical stimulation was individually adjusted to a level, which was reported as unpleasant but not painful by the participant. The intensity of electrical stimulation was set on average to *M*=1.68mA (*SD*=0.61, range=0.6–4.0mA).

Fear acquisition took place in context A. Each trial began with the presentation of a white fixation cross on a black background (jittered between 0.625 and 2.500s). Then, a picture of a room with a turned-off desk lamp (representing the context) appeared for 3s followed by the same picture with a turned-on desk lamp shining blue or yellow (CS) for 6s. Participants received an electrical stimulation (UCS) after CS+ offset in 62.5% of the trials for a duration of 500ms. The other lamplight color (CS-) was never followed by an electrical stimulation and therefore represented a safety stimulus that should elicit an omission response. The assignment of lamplight color to CS type condition (CS+ or CS-) was pseudorandomized and counterbalanced across individuals. After CS offset, a white fixation cross on a black background appeared up to a total trial duration of 20s. The fear acquisition phase consisted of 16 trials (8 trials for each CS type) arranged in two blocks. Each block comprised half of the CS trials and included the same number of CS+ and CS- trials. The first two and last two trials of the fear acquisition phase consisted of one CS+ and one CS-, respectively. The other CS were presented in a pseudorandomized order (no more than 2 CS+/CS- consecutively). In order to enhance fear learning, the first CS+ during fear acquisition was always reinforced. Additionally, the last CS+ was reinforced, in order to prevent premature extinction learning during the fear acquisition phase. For the fear acquisition phase, participants were instructed about the content and procedures of the trials. Their task was to watch the presentation attentively. They were informed about the possibility to receive an electrical stimulation at the end of each presentation of the turned-on desk lamp or not. They were also told that there might be a relationship such that one color is sometimes followed by an electrical stimulation, while this is not the case for the other desk lamp color. Immediately after the fear acquisition phase, participants were asked via headphones about the discovered relationship between lamplight color and electrical stimulation. Moreover, they were informed about the correct relationship, in order to make all participants aware of CS-UCS contingencies, especially if they could not report the correct relationship (*n*=4). In addition, they rated how often the electrical stimulation followed after CS+ offset (open answer option: *M*=6.13, *SD*=1.61, range: 3–10) and how unpleasant they felt during the first and last electrical stimulation on a 9-point Likert scale with answer options ranging from ‘not unpleasant’ to ‘very unpleasant’ (first stimulation: *M*=7.54, *SD*=1.16; last stimulation: *M*=6.43, *SD*=1.14).

During extinction training in context B, the CS were presented 32 times (16 trials for each CS type) in two blocks without subsequent UCS, in order to extinguish the conditioned fear response. Each block contained half of the CS trials and included the same number of CS+ and CS- trials. The CS were again presented in a pseudorandomized order (no more than 2 CS+/ CS- consecutively) except the first two CS trials of the extinction training phase that consisted of one CS+ and one CS-, respectively. In order to avoid the idea of reversal of CS contingencies, the instruction was given that the relationship between lamplight color and electrical stimulation was going to be stable over the experiment, meaning that if a lamplight color was safe (not followed by an electrical stimulation), it would always be safe. If the lamplight color was sometimes followed by electrical stimulation, it might or might not be followed by electrical stimulation.

One day later (approximately 24 hours), extinction recall in context B and fear renewal in a novel context (context C) took place (each phase: 8 trials for each CS type). The trials for extinction recall and fear renewal were each arranged in two blocks, each consisted of four CS+ and four CS- trials, which were presented in a pseudorandomized order (no more than 2 CS+/ CS- consecutively) except the first two CS trials of each phase that included the presentation of one CS+ and one CS-, respectively. Participants received the same instruction as for the extinction training phase. The finger electrodes were again positioned at the fingertip and they were instructed that if they receive electrical stimulation today, the intensity will be identical to the day before.

**FMRI data acquisition and analyses**

Functional and anatomical images were acquired using a 3-Tesla whole-body tomograph (Siemens Prisma) with a 64-channel head coil. In order to receive information for unwarping of B0 distortions, a gradient echo field map sequence was conducted before the functional runs on each day. Functional image acquisition consisted of 152 volumes for fear acquisition, 280 volumes for extinction training as well as 280 volumes for extinction recall and fear renewal using a T2\*-weighted gradient echo-planar imaging sequence (EPI) with 42 slices covering the whole brain (slice thickness =3mm; 0.75mm gap; descending slice order; TE=30ms; TR=2.5s; flip angle=81°; field of view=220×220mm; matrix size =110×110; PAT mode GRAPPA, acceleration factor PE 2). The first three volumes were excluded from analyses because of an incomplete steady state of magnetization. For structural imaging, T1-weighted sagittal images were registered (MPRAGE: 0.94mm slice thickness) which were needed for the normalization procedure. All neuroimaging data were analyzed using Statistical Parametric Mapping (SPM12, r7771, Wellcome Department of Cognitive Neurology, London, UK) implemented in Matlab (R2019a; Mathworks Inc., Sherborn, MA, USA). Preprocessing of the data consisted of unwarping and realignment (b-Spline interpolation), slice time correction, co-registration of functional data to each participant’s anatomical image, segmentation of the anatomical image into different tissue types and normalization to the standard space of the Montreal Neurological Institute (MNI) brain. Furthermore, smoothing with an isotropic three-dimensional Gaussian filter with a full-width at half maximum (FWHM) of 6mm was conducted. Five participants were excluded from data analyses due to a framewise displacement [(Power, Barnes, Snyder, Schlaggar, & Petersen, 2012)](#_CTVL001d82fa0daee9a43e99c1cbb19abee04b4) of more than 0.5mm in at least 15% of the volumes of one scanning session (fear acquisition, extinction training, retrieval testing). After preprocessing, first level models were generated separately for fear acquisition, extinction training and retrieval testing (extinction recall and fear renewal). For fear acquisition, the first level model included the following regressors: context alone, blocks of eight trials for CS+ and CS- and blocks of UCS and UCS omission-trials (noUCS-trials). For extinction learning, the regressors consisted of context alone and blocks of eight trials of CS+ and CS- for early/late extinction training. For retrieval testing the model contained the regressor context alone as well as blocks of four trials of CS+ and CS- as regressors for early/late extinction recall and for the early/late renewal phase. The six movement parameters from the realignment step as well as one regressor for each volume with a framewise displacement >0.5mm [(Power et al., 2012)](#_CTVL001d82fa0daee9a43e99c1cbb19abee04b4) were added as regressors of no interest in the first-level models. All regressors of interest were modelled based on a stick function convolved with the canonical hemodynamic response function in the general linear model, without specifically modeling the durations of the different events (i.e. event-related design). Furthermore, a high-pass filter of 128s was used for filtering voxel-based time series and autocorrelation of errors was controlled by an AR(1) process. Contrasts between the CS+ and CS- were calculated on an individual level for fear acquisition, for extinction training (first 8 compared with last 8 CS trials), as well as for early extinction recall and early renewal (first 4 CS trials, respectively). Due to early study drop-out *(n*=6), 88 participants conducted the fear conditioning paradigm. Data of *n*=14 participants were excluded from fMRI analyses because of technical problems during scanning or artifacts (*n*=9) or strong head movement during scanning (*n*=5), resulting in a sample size of *n*=74 for analyses of main effects.

For the analyses of main effects (CS+ minus CS-) of the fear conditioning paradigm, *F*-Tests were performed for each experimental phase during second-level analyses implemented in SPM 12 (r7771). For main effect analyses, we conducted FWE small volume correction for a combined mask of all regions of interest (ROI) to correct for multiple testing. ROIs for the analyses of main effects (CS+ minus CS-) were amygdala, dACC, hippocampus, insula, and vmPFC. Probability masks for amygdala, insula, and hippocampus were taken from the current ‘Harvard-Oxford Cortical and Subcortical Structural Atlases’ provided by the Harvard Center for Morphometric Analysis (http://www.cma.mgh.harvard.edu/) with a probability threshold of 0.5 included in the FSL software package (<http://www.fmrib.ox.ac.uk/fsl/>). Masks for the dACC and vmPFC were constructed with the MARINA software package [(Walter, 2002)](#_CTVL00115cca47538e84e52b0d5a3dbeda74539) and used in previous fear conditioning studies [(Hermann et al., 2016](#_CTVL001ebd4e83dce304305b202ba76d6177070)[; Hermann, Stark et al., 2020)](#_CTVL001665d40d2c93443b096479c5e721215e0). For exploratory whole brain analyses, the significance threshold was set to *p=.*05 on voxel-level corrected for multiple testing (family-wise error (FWE) correction); the minimal cluster size (k) for exploratory whole brain analyses was set to 10 voxels. The peak voxels of the whole brain (WB) analyses were labeled based on the Harvard-Oxford Cortical (Lateralized) and Subcortical Structural Atlas and the Automated Anatomical Labeling Atlas 3.

**Skin conductance responses and analyses**

SCRs were measured during all experimental phases using Ag/AgCl electrodes filled with isotonic (0.05M NaCl) electrolyte medium positioned hypothenar at the left hand. Data were recorded with a sampling rate of 1000Hz. For preprocessing and data analyses Ledalab 3.4.4 written in MATLAB was used, which is available online ([www.ledalab.de](http://www.ledalab.de/)). The raw skin conductance data were down sampled with a sampling rate of 10Hz, and smoothed with a Gaussian kernel of 32mm. For checking data quality, a manual data inspection was conducted. If technical artifacts were visible in data, the affected data section was corrected via the manual interpolation of Ledalab. The data were analyzed via ‘trough-to-peak’-analyses [(Pineles, Orr, & Orr, 2009)](#_CTVL001b02e7bf2f45d4202aacba909054b4c8b). The entire interval response (EIR) was defined as the largest difference between a minimum within a defined time window and the directly following maximum. For CS responses, the time window was set to 0.8–6s after CS onset, while for UCS responses it was set to 0.8–2.5s after UCS onset. Conditioned responses were defined as larger response magnitudes in reaction to the CS+ than to the CS-.

Participants excluded from fMRI analyses were also excluded from the main SCR data analyses, but not vice versa. SCR data had to be discarded because of non-responding during fear acquisition (less than two SCRs >0.02μs in reaction to the UCS after CS+ (*n*=12)), technical problems during measurement (*n*=1), or missing data (*n*=2), reducing the sample size of *n*=74 to *n*=59 for SCR analyses of the main effects of the fear conditioning paradigm.

**Post-hoc ratings**

After the experimental phases, a post-hoc rating was conducted outside the scanner to measure context recognition and UCS expectancy for the extinction context and the novel context. The memory for the contexts (=rooms) was tested by presenting the participants pictures of six different rooms. They had to report which room(s) they saw ‘only yesterday’ (≙ acquisition context A), ‘today and yesterday’ (≙ extinction context B), or ‘only today’ (≙ novel context C) and were further asked in which room(s) they had ever received an electrical stimulation after CS offset. For measuring context recognition, a recognition score was calculated for the acquisition, extinction and novel context as well as for false rooms, and an overall sum score for correct context assignment was calculated. The majority of individuals (*n*=62) were able to correctly classify all presented context pictures.

After the memory test, participants saw pictures of the three rooms (context A, B, C) presented during the experimental phases. They had to rate valence, arousal and fear (not reported here) when the desk lamp was turned off (no CS condition), and when shining blue and yellow (CS condition) for each room on a 9-point Likert scale. To examine UCS expectancy in the different contexts, they also rated how certain they had been that an electrical stimulation immediately appeared in the extinction (context B) and in the novel context (context C) on a 9-point Likert scale (answer options ranging from ‘sure’ to ‘unsure that the electrical stimulation followed’), respectively.

**Main effects of the context-dependent fear conditioning paradigm**

***Fear acquisition in context A***

During fear acquisition individuals showed stronger SCRs to the CS+ compared with CS- (*z=*6.487*, p*<.001) as well as to the UCS after CS+ compared with the omission response after CS- (*z*=6.680, *p*<.001), indicating successful fear conditioning. On the neural level, fear acquisition (CS+ minus CS-) in context A resulted in increased activation in bilateral insula, left amygdala, left dACC, and bilateral vmPFC (see Supplementary Table 3). Moreover, whole brain analyses revealed stronger differential conditioned activation in the caudate and left supplementary motor area as well as in the right thalamus and right cerebellum during fear acquisition. In addition, stronger differential conditioned neural activation was found in the frontal and central opercular cortex regions, in the precuneus as well as in the pre- and postcentral and supramarginal gyrus (see Supplementary Table 3).

***Extinction learning in context B***

There was a decrease in differential conditioned SCRs from early to late extinction training (*z*=3.248, *p*=.001), indicating successful extinction learning. Stronger SCRs for CS+ compared with CS- were found during early (*z=*4.014, *p*<.001), as well as during late extinction (*z*=3.740, *p*<.001), pointing towards conditioned fear expression even during late extinction learning (see Supplementary Figure 4). However, a further post-hoc test comparing the last CS+ and the last CS- trial of the extinction training phase revealed no significant differences in SCRs (*z*=1.207, *p*=.227). On the neural level, there was no significant de- or increase of differential conditioned activation from early to late extinction training in either whole brain or ROI analyses (see Supplementary Table 3).

***Extinction recall in context B***

Analyses showed stronger SCRs for CS+ compared with CS- during early extinction recall (*z=*4.613, *p*<.001, see Supplementary Figure 4) and an increase in differential conditioned SCRs from late extinction to early recall (*z=*3.934, *p*<.001), reflecting spontaneous recovery in the safe extinction context. Extinction recall in context B (CS+ minus CS-) was associated with stronger activation in the bilateral insula and left dACC (ROI; see Supplementary Table 3). Moreover, exploratory whole brain analyses showed stronger activation in the brain-stem, in the left caudate and right thalamus as well as in the left central opercular cortex towards CS+ compared with CS-. Reduced activation towards CS+ compared with CS- was exhibited in the right precentral gyrus during extinction recall for exploratory whole brain analyses (see Supplementary Table 3).

***Renewal in context C***

During early fear renewal, stronger SCRs were found for the CS+ compared with the CS- (*z=*4.799, *p*<.001). There was on trend level an increase in differential conditioned SCRs from late extinction recall to early renewal (*z*=1.769, *p*=.077), indicating a return of fear in the novel context (see Supplementary Figure 4). Early fear renewal (CS+ minus   
CS-) resulted in increased activation in the bilateral insula and the left dACC and in reduced activation in the left vmPFC (ROI; see Supplementary Table 3). Exploratory whole brain analyses revealed stronger activation in the frontal opercular cortex towards CS+ compared with CS- during fear renewal (see Supplementary Table 3).

**D) Trauma film paradigm**

During the paradigm, 88 participants (study dropout, *n*=6) were exposed to aversive film clips of the movie ‘Irreversible’ by Gaspar Noé with explicit depiction of scenes of physical and sexual violence. Respiration, heart rate variability and electrodermal responses were recorded during film viewing and during a resting state period prior to film viewing. As a mood manipulation check, the Positive and Negative Affect Schedule (PANAS; [Krohne, Egloff, Kohlmann, & Tausch, 1996](#_CTVL00145074dca1de84bc1afcedb78a30b0ae3)) was immediately completed before and after film viewing. Participants also conducted a post-hoc film rating (results are presented in Supplementary Table 1). It also showed that none of the participants knew the film. After the post-hoc film rating, participants conducted a monitoring task to assess intrusive memories shortly after film watching. Participants had to close their eyes and to press a button on a key board with their right index finger every time they experienced an intrusive film memory. The button should be pressed as long as the intrusion lasted. In order to get an impression about the development of analog PTSD symptoms within the following week, participants were asked at the end of study day 5 to complete an online survey every evening from 6 pm until midnight of the respective day between study day 5 and 6 (results are presented in Supplementary Figure 3). They received the links for the online survey via email. Intrusive symptoms were measured with an adapted version of the intrusion scale of the Impact of Event-Scale Revised [(IES-R; Maercker & Schützwohl, 1998)](#_CTVL0015e716bec06bc48a7a42aa3baaaf9af15). The instruction part and items of the intrusion subscale of the IES-R were adapted to the analog trauma and consisted of seven items (e.g. ‘Even without intending it, I had to think about the film clips.’). Answers could be given on a 4-level scale (*not at all ‘0’, seldom ‘1’, sometimes ‘3’, often ‘5’*). A sum score was calculated. Furthermore, the number of analog intrusions were assessed by an open question (‘How many film intrusions did you have today in total? *Intrusions are sudden, spontaneously occurring, and uninitiated memories of the film scenes from the study, which can be very vivid and consist of images, sounds, words, phrases, or thoughts and feelings (you had during the film) or a combination thereof.’*). The Memory Characteristics Questionnaire [(MCQ; Hagenaars, van Minnen, Hoogduin, & Verbraak, 2009)](#_CTVL001e6faedc7b63a463d908c80bc82a3cb05) was also used to measure characteristics (re-experiencing and disorganization) of the film memory. Beside analog PTSD symptoms, emotional state, sleep (quality and hours) and the number of social contacts were also assessed each day by single items. In addition, participants who reported intrusions were asked about the content of the intrusion(s) (open answer) as well as the emotional state (valence, arousal, stress) during intrusive memories.

After one week (study day 6), 85 participants returned to the laboratory and again rated analog intrusion symptoms (IES-R, number of intrusions) and memory aspects (MCQ) within the last week, in order to have standardized measures and values for short-term analog PTSD symptoms for each participant. The degree of distress through the film during the last week was also rated (rating scale: 0 to 100 percent). Participants were also asked about emotion regulation, emotional state, sleep characteristics, social contacts during the last week by questionnaire or single items. Afterwards, participants underwent the intrusion monitoring task in the same setting and manner as on study day 5. Afterwards, participants completed the recognition memory questionnaire regarding explicit film memory (described in the method section of the article; see supplement E) as well as a questionnaire regarding disorganization of the film (chronical order of film actions) which included ten sentences. Participants should arrange the 10 sentences chronologically according to the sequence of actions in the film. Afterwards, participants also completed a recognition memory task for film scenes developed in analogy to the test phase of the MST [(Stark et al., 2013)](#_CTVL001dc7ab45e9d1b4996891f6b59c656c6f5), in order to measure patten separation/completion processes with regard to the film. Participants were informed to see pictures of film scenes which should be categorized as ‘old’, ‘similar’ or ‘new’ to the film clips they saw during the trauma film paradigm. Study day 6 ended with a short open talk to check impairments in daily life functioning and to offer psychological assistance in the case of high distress due to the film, which was not required by any participant who attended study day 6 (N=85). Two participants (*n*=2) had quit the study during the trauma film paradigm on study day 5 due to high distress. An appointment was made with those participants to check the level of distress through the film and to offer psychological assistance, which was also not required by them. One participant (*n*=1) was not able to attend study day 6 due to another appointment. Data of one participant (*n*=1) had further to be excluded from analyses regarding short-term intrusions due to a missing value in the IES-R. Thus, data regarding short-term intrusions was available from 84 participants. At the end of study day 6, participants were also informed to be contacted after three months for a further online survey to investigate long-term effects of the study. The online survey after 3 months was completed by 65 participants. It included the above-mentioned items and questionnaires for the assessment of analog PTSD symptoms within the last four weeks. Moreover, the questionnaires regarding explicit film memory and film disorganization which were already assessed at study day 6 were also included in the survey as a follow-up assessment. Furthermore, participants filled in a questionnaire regarding emotion regulation during the last four weeks and were asked some questions about stimuli or experimental conditions of paradigms used in the study. Participants who had completed the online surveys each day within one week between study day 5 and day 6 as well as after three months entered the drawing for cash vouchers (20 euros; 10 percent chance of winning).

1. **Questionnaire regarding explicit film memory (English translation)**

For each statement, please tick whether it is ‘true’ or ‘false’ with regard to the content of the film. If you are unsure, please choose the answer option you think is most likely to be true.

The first part of the statements relates to the woman who was the victim of rape in the film***.***

|  |  |  |  |
| --- | --- | --- | --- |
| 1. | The woman was wearing a dress. | **TRUE** | FALSE |
| 2. | The woman had her hair tied in a braid. | **TRUE** | FALSE |
| 3. | The woman had dark hair. | **TRUE** | FALSE |
| 4. | The woman was carrying a handbag. | **TRUE** | FALSE |
| 5. | The woman had a tattoo. | TRUE | **FALSE** |
| 6. | The woman was wearing sneakers. | TRUE | **FALSE** |
| 7. | The woman had a jacket with her. | **TRUE** | FALSE |
| 8. | The woman was wearing a necklace. | TRUE | **FALSE** |
| 9. | The woman had a ring on her finger. | TRUE | **FALSE** |
| 10. | The woman was wearing earrings. | TRUE | **FALSE** |

The second part of the statements relates to the man who raped the woman in the film.

|  |  |  |  |
| --- | --- | --- | --- |
| 1. | The man was wearing a black shirt. | TRUE | **FALSE** |
| 2. | The man had dark hair. | **TRUE** | FALSE |
| 3. | The man was wearing sneakers. | TRUE | **FALSE** |
| 4. | The man was alone in the underpass at the beginning. | TRUE | **FALSE** |
| 5. | The man was wearing a suit. | **TRUE** | FALSE |
| 6. | The man had an earring on one ear. | TRUE | **FALSE** |
| 7. | The man was wearing a bracelet. | **TRUE** | FALSE |
| 8. | The man had a tattoo. | TRUE | **FALSE** |
| 9. | The man had a ring on his finger. | **TRUE** | FALSE |
| 10. | The man was wearing glasses. | TRUE | **FALSE** |

The third part of the statements relates to spatial and temporal details of the film.

|  |  |  |  |
| --- | --- | --- | --- |
| 1. | The light in the underpass flickered. | **TRUE** | FALSE |
| 2. | The illuminated sign shown said ‘underpass’. | TRUE | **FALSE** |
| 3. | There was trash on the ground in the underpass. | **TRUE** | FALSE |
| 4. | Two people entered the underpass together during the rape and left it unnoticed. | TRUE | **FALSE** |
| 5. | The walls in the underpass were painted in a shade of blue. | TRUE | **FALSE** |
| 6. | Graffiti was partially present on the ceiling of the underpass. | **TRUE** | FALSE |
| 7. | The underpass was accessible from two sides. | **TRUE** | FALSE |
| 8. | There was a trash can in the underpass. | TRUE | **FALSE** |
| 9. | An information sign hung at the exit of the underpass. | TRUE | **FALSE** |
| 10. | Rails of a train station could be seen above the underpass. | TRUE | **FALSE** |

Note: The correct answer is presented in bold type for each item.

GERMAN VERSION

Bitte kreuzen Sie für jede Aussage an, ob diese in Bezug auf den Inhalt des Films „wahr“ oder „falsch“ ist. Wenn Sie sich unsicher sind, entscheiden Sie sich bitte für die Antwortoption, die Sie für am wahrscheinlichsten halten.

Der erste Teil der Aussagen bezieht sich auf die Frau, die im Film Opfer einer Vergewaltigung wurde.

|  |  |  |  |
| --- | --- | --- | --- |
| 1. | Die Frau trug ein Kleid. | WAHR | FALSCH |
| 2. | Die Frau hatte ihre Haare zu einem Zopf gebunden. | WAHR | FALSCH |
| 3. | Die Frau hatte dunkle Haare. | WAHR | FALSCH |
| 4. | Die Frau hatte eine Handtasche dabei. | WAHR | FALSCH |
| 5. | Die Frau hatte ein Tattoo. | WAHR | FALSCH |
| 6. | Die Frau hatte Turnschuhe an. | WAHR | FALSCH |
| 7. | Die Frau hatte ein Jäckchen dabei. | WAHR | FALSCH |
| 8. | Die Frau trug eine Halskette. | WAHR | FALSCH |
| 9. | Die Frau hatte einen Ring am Finger. | WAHR | FALSCH |
| 10. | Die Frau trug Ohrringe. | WAHR | FALSCH |

Der zweite Teil der Aussagen bezieht sich auf den Mann, der im Film die Frau vergewaltigte.

|  |  |  |  |
| --- | --- | --- | --- |
| 1. | Der Mann trug ein schwarzes Hemd. | WAHR | FALSCH |
| 2. | Der Mann hatte dunkle Haare. | WAHR | FALSCH |
| 3. | Der Mann hatte Turnschuhe an. | WAHR | FALSCH |
| 4. | Der Mann war zu Beginn alleine in der Unterführung. | WAHR | FALSCH |
| 5. | Der Mann trug einen Anzug. | WAHR | FALSCH |
| 6. | Der Mann hatte einen Ohrring an einem Ohr. | WAHR | FALSCH |
| 7. | Der Mann trug ein Armband. | WAHR | FALSCH |
| 8. | Der Mann hatte ein Tattoo. | WAHR | FALSCH |
| 9. | Der Mann hatte einen Ring am Finger. | WAHR | FALSCH |
| 10. | Der Mann trug eine Brille. | WAHR | FALSCH |

Der dritte Teil der Aussagen bezieht sich auf räumliche und zeitliche Details des Films.

|  |  |  |  |
| --- | --- | --- | --- |
| 1. | Das Licht in der Unterführung flackerte. | WAHR | FALSCH |
| 2. | Auf dem gezeigten Leuchtschild stand „underpass“. | WAHR | FALSCH |
| 3. | In der Unterführung lag Müll am Boden. | WAHR | FALSCH |
| 4. | Zwei Personen betraten gemeinsam die Unterführung während der Vergewaltigung und verließen diese unbemerkt wieder. | WAHR | FALSCH |
| 5. | Die Wände in der Unterführung waren in einem Blauton gestrichen. | WAHR | FALSCH |
| 6. | An der Decke der Unterführung waren Graffitis teilweise vorhanden. | WAHR | FALSCH |
| 7. | Die Unterführung war von zwei Seiten begehbar. | WAHR | FALSCH |
| 8. | Ein Mülleimer befand sich in der Unterführung. | WAHR | FALSCH |
| 9. | Ein Informationsschild hing am Ausgang der Unterführung. | WAHR | FALSCH |
| 10. | Oberhalb der Unterführung sah man Schienen eines Bahnhofs. | WAHR | FALSCH |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Supplementary Table 1  *Post-hoc film rating: Affective and behavorial responses during film viewing* | | | | |
|  | whole sample  (*n*=85) | group differences | | |
| INT (*n*=30) | NO-INT  (*n*=35) | *test statistics*  *(two-sided)* |
| *M (SD)* | *M (SD)* | *M (SD)* |
| How well were you able to concentrate on the film scenes? “not at all” (1) to “very well” (9) | 7.96 (1.107) | 8.00 (1.029) | 8.23 (0.817) | *t(63)*=-1.000*, p=.*321 |
| How often did you look away or close your eyes while watching the film? (number) | 2.55 (2.937) | 2.36 (2.525) | 2.30 (2.277) | *t(63)=*0.095*, p=.*925 |
| Please indicate your emotional state while film viewing:   * Valence: "feeling uncomfortable" (1) to "feeling comfortable" (9) * Arousal: "feeling calm" (1) to "feeling excited" (9) * Stress: “not at all” to “very strong” (9) | 1.55 (0.838)  7.65 (1.270)  6.89 (1.793) | 1.57 (0.884)  7.74 (1.120)  7.31 (1.586) | 1.63 (0.850)  7.53 (1.224)  6.67 (1.788) | *t(63)*=-0.286*, p=.*775  *t(63)*=0.720*, p=.*474  *t(63)*=1.548*, p=.*127 |
| How strongly did you identify with the female victim? “not at all” (1) to “very strong” (9) | 6.02 (2.127) | 5.66 (1.984) | 6.33 (2.106) | *t(63)*=-1.331*, p=.*188 |
| How strongly did you commiserate with the female victim? “not at all” (1) to “very strong” (9) | 8.00 (1.528) | 7.97 (1.543) | 8.00 (1.390) | *t(63)*=-0.078*, p=.*938 |

*Note.* Data are presented for the whole sample and for each group separately (INT=intrusion group: women with long-term intrusions in response to an experimental trauma; NO-INT: women without long-term intrusions).

Supplementary Table 2

*Explicit film memory and analog intrusions. Pearson’s r correlations between short-term analog intrusions and explicit film memory as well as group differences in explicit film memory (controlled for age) between women with (INT) and without long-term intrusions (NO-INT) in response to an experimental trauma*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | | short-term analog intrusions (*n*=84) | long-term analog intrusions | | |
| INT  (*n*=30) | NO-INT (*n*=35) | test statistics  (two-sided) |
| explicit film memory | after 1 week | context | *r*=-.062, *p*=.576 | *M*=7.400 *SD*=1.376 | *M*=7.400, *SD*=1.380 | *F*(1,62)= 0.211, *p*=.648 |
| perpetrator | *r*=-.049, *p*=.657 | *M*=7.200, *SD*=1.183 | *M*=7.233, *SD*=1.305 | *F*(1,62)= 0.263, *p*=.610 |
| victim | *r*=.034, *p*=.760 | *M*=7.143 *SD*=0.845 | *M*=6.900, *SD*=1.242 | *F*(1,62)= 1.172, *p*=.283 |
| after 3 months | context | *r*=-.126, *p*=.321 | *M*=6.171, *SD*=1.671 | *M*=6.633, *SD*=1.608 | *F*(1,62)= 1.388, *p*=.243 |
| perpetrator | *r*=.102, *p*=.424 | *M*=7.629, *SD*=1.114 | *M*=7.333 *SD*=1.470 | *F*(1,62)= 1.071, *p*=.305 |
| victim | *r*=-.133, *p*=.296 | *M*=6.857, *SD*=0.879 | *M*=6.833, *SD*=1.085 | *F*(1,62)= 0.054, *p*=.816 |

Supplementary Table 3

*Main effects of the fear conditioning paradigm: Neural activation differences for CS+ minus CS- during fear acquisition in context A (A), during extinction learning in context B (B), during early extinction recall in context B (C) and during early fear renewal in context C (D)*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Brain structure** | ***x*** | ***y*** | ***z*** | ***F*** | ***p*corr** |
| **A) fear acquisition** | | | | | |
| **CS+ minus CS-** | | | | | |
| *\_\_\_\_*L amygdala (ROI) | -16 | -4 | -14 | 30.93 | .002 |
| *\_\_\_\_*R insula (ROI) | 32 | 20 | 6 | 31.65 | .002 |
| *\_\_\_\_*L insula (ROI) | -30 | 26 | 4 | 54.30 | <.001 |
| *\_\_\_\_*L dACC (ROI) | -4 | 8 | 38 | 59.94 | <.001 |
| *\_\_\_\_*R vmPFC (ROI) | 20 | 12 | -14 | 43.67 | <.001 |
| *\_\_\_\_*L vmPFC (ROI) | -20 | 12 | -14 | 31.62 | .002 |
| *\_\_\_\_*L caudate (WB) | -8 | 8 | 0 | 89.96 | <.001 |
| \_\_\_\_L supplementary motor area (WB) | -8 | -4 | 64 | 89.04 | <.001 |
| \_\_\_\_R caudate (WB) | 10 | 10 | -2 | 81.25 | <.001 |
| *\_\_\_\_*L frontal opercular cortex (WB) | -34 | 16 | 10 | 64.48 | <.001 |
| *\_\_\_\_*L precentral gyrus (WB) | -14 | -22 | 40 | 46.12 | <.001 |
| *\_\_\_\_*L amygdala (WB) | -14 | -2 | -12 | 44.69 | .001 |
| *\_\_\_\_*L supramarginal gyrus (WB) | -58 | -24 | 20 | 43.21 | .001 |
| *\_\_\_\_*R thalamus (WB) | 6 | -6 | -2 | 42.45 | .001 |
| *\_\_\_\_*L postcentral gyrus (WB) | -24 | -40 | 68 | 41.19 | .002 |
| *\_\_ \_* L precuneus cortex (WB) | -4 | -46 | 56 | 40.78 | .002 |
| *\_\_\_\_*R cerebellum (WB) | 32 | -48 | -30 | 37.43 | .006 |
| *\_\_\_\_*R central opercular cortex (WB) | 54 | 0 | 8 | 37.06 | .007 |
| *\_\_\_\_*R precentral gyrus (WB) | 50 | 2 | 50 | 35.19 | .011 |
| *\_\_\_\_*L supramarginal gyrus, anterior *\_\_\_\_*division (WB) | -66 | -38 | 30 | 35.12 | .012 |
| *\_\_\_\_*L precuneus cortex (WB) | -14 | -64 | 30 | 33.87 | .017 |
| **CS- minus CS+** | | | | | |
|  | *no significant results* | | | | |
| **B) extinction learning** | | | | | |
| **decrease in CS+E minus CS-** | no significant results | | | | |
| **increase in CS+E minus CS-** | no significant results | | | | |
| **C) early extinction recall** | | | | | |
| **CS+E minus CS-** | | | | | |
| *\_\_\_\_*R insula (ROI) | 32 | 24 | 4 | 49.08 | <.001 |
| *\_\_\_\_*L insula (ROI) | -30 | 26 | 2 | 64.18 | <.001 |
| \_\_\_\_L dACC (ROI) | -2 | 28 | 22 | 35.06 | .001 |
| *\_\_\_\_*L insular cortex (WB) | -30 | 26 | 2 | 64.18 | <.001 |
| *\_\_\_\_*brain-stem (WB) | 8 | -28 | -12 | 59.72 | <.001 |
| *\_\_\_\_*R insular cortex (WB) | 30 | 26 | 6 | 58.05 | <.001 |
| *\_\_\_\_*L caudate (WB) | -8 | 8 | 0 | 40.02 | .003 |
| *\_\_\_\_*R thalamus (WB) | 12 | 0 | 6 | 39.56 | .003 |
| *\_\_\_\_*L central opercular cortex (WB) | -44 | 8 | 0 | 38.20 | .005 |
| **CS- minus CS+E** | | | | | |
| *\_\_\_\_*R precentral gyrus (WB) | 34 | -22 | 50 | 35.84 | .009 |
| **D) early fear renewal** | | | | | |
| **CS+E minus CS-** | | | | | |
| *\_\_\_\_*R insula (ROI) | 32 | 24 | 4 | 28.16 | .004 |
| *\_\_\_\_*L insula (ROI) | -30 | 20 | 8 | 32.68 | .001 |
| *\_\_\_\_*L dACC (ROI) | -6 | 6 | 42 | 29.90 | .003 |
| Rfrontal opercular cortex (WB) | 36 | 26 | 8 | 37.21 | .006 |
| **CS- minus CS+E** | | | | | |
| *\_\_\_\_*L vmPFC (ROI) | -6 | 62 | -2 | 21.54 | .042 |

*Note.* The significance threshold was set to *p*≤.05 (FWE-corrected). The peak voxels of the whole brain (WB) analyses were labeled based on the Harvard-Oxford Cortical (Lateralized) and Subcortical Structural Atlas and the Automated Anatomical Labeling Atlas 3. For main effect analyses, we conducted FWE small volume correction for a combined mask of all regions of interest (ROIs) to correct for multiple testing. Results from ROI analyses are indicated with (ROI). All coordinates (x, y, z) are given in MNI space. L=left, R=right.

Supplementary Figure 1

*Overview of study days: Main procedures and variables.*



Supplementary Figure 2

*Schematic representation of the fear conditioning design*

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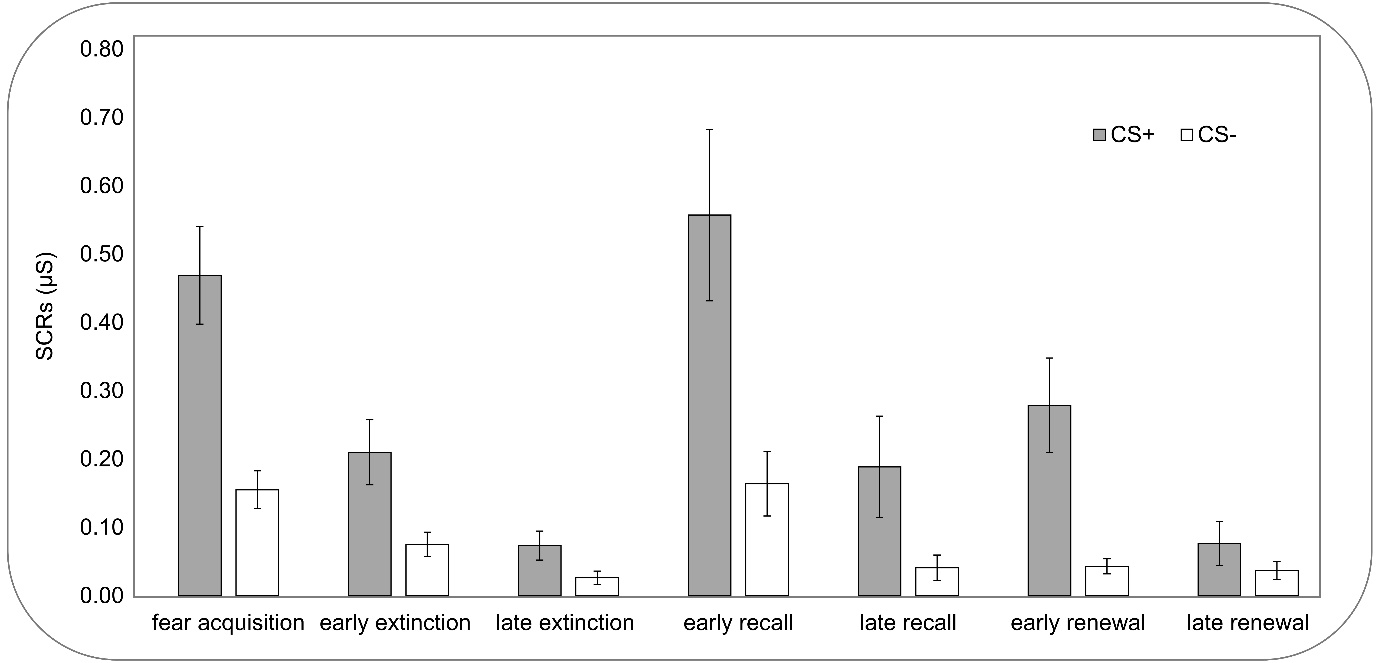
Supplementary Figure 3

*Development of daily rated analog intrusive symptoms in response to the trauma film between study day 5 and study day 6 (starting at the evening of study day 5)*

*Note.* Data are presented for the whole sample and for each group separately (INT=intrusion group: women with long-term intrusions in response to an experimental trauma; NO-INT: women without long-term intrusions). Sample size varies (*n*=59–68) due to missing data or data exclusion due to incorrect conduction of the survey (*n*=15). Error bars depict standard errors of the mean.

Supplementary Figure 4

*Skin conductance responses (SCRs) towards the CS+ and the CS- during fear acquisition in context A, (early/late) extinction training in context B, (early/late) extinction recall in context B and (early/late) renewal in context C*



*Note.*Error bars depict standard errors of the mean.Supplementary Figure 5

*Mask for the bilateral dorsal anterior cingulate cortex (first row). Combined mask (second and third row) with all secondary regions of interest (insula=green; amygdala=red; vmPFC=yellow; hippocampus=blue). Coordinates (x, y, z) are given in MNI space.*



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